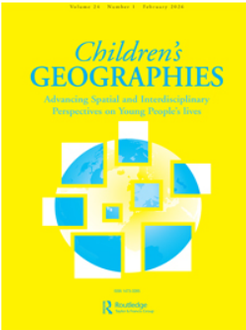

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Is climate literacy an effective proxy for climate change education? Evidence from young people's conceptualisations of climate change in England

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ABSTRACT
Education, including school education, is integral to just responses to global climate change and sustainability crises. Increasingly, national and international surveys seek to assess the 'climate literacy' of young people, including as a mechanism to measure the effectiveness of national education systems for preparing young people. However, these surveys generally ask young people to identify accurate knowledge from a series of definitions, rather than exploring their understanding through open questions. This research analyses 2051 survey responses from students aged 11-14 years in England to the question 'What is climate change? Climate change is …'. Just over half (52.5%) provided responses which broadly included ideas of change or harm to the environment and/or Earth systems, all with reference to temperature. We argue that for young people to develop a lasting and multi-dimensional understanding of climate change, climate change education must extend beyond a narrow focus on geography and science to include a greater range of disciplinary perspectives. Further, we consider whether the global movement towards the measurement of climate literacy through surveys risks underscoring a narrow, predominantly science-based understanding of climate literacy, and away from holistic conceptualisations which attend to affective dimensions, and ideas of justice and equity.

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Climate change; young people; climate literacy; climate change education

Introduction

Climate change is an urgent, global challenge and a risk amplifier that exacerbates inequalities and disproportionately affects those least responsible for its causes (IPCC 2022). Addressing this crisis requires both adaptation and mitigation, both of which depend on education to equip individuals with the knowledge, skills, and understanding to enable an effective response. Education is widely understood as an underused opportunity in policy making to advance climate change adaptation and mitigation (Rickinson and McKenzie 2021) and children's knowledge and perception of climate change is a growing theme in educational research (e.g. Morote and Hernández 2024; Turner and Wilks 2022). At the same time, there is increasing discussion and debate about the place of justice in climate change education including in contexts which are predominantly Anglophone such as England (Rushton, Walshe, and Johnston 2025),

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Scotland (McGregor and Christie 2021) and the USA (Trott 2024). In recent years, children and young people have been at the forefront of global calls for enhanced school-based climate change education in England and beyond (Dunlop et al. 2022). Previous research has argued that formal education systems across the UK do not meet the vision articulated by young people, teachers and teacher educators (Dunlop and Rushton 2022a), including the ways in which orientations towards justice are marginalised in school-based climate change education, including in England (Rushton, Walshe, and Johnston 2025) and Scotland (McGregor and Christie 2021). Furthermore, as children's geographies scholars including Skovdal and Benwell (2021) highlight, young people hold unique perspectives and political agencies which are essential to responding to climate change, and schools and teachers have been recognised as important spaces to nurture and respond to climate crisis activism (Dunlop et al. 2020). Ideas about climate change education which are rooted in children's geographies foreground the voice of children and young people and argue for greater prominence of the affective dimension in education, which authentically enables critical thinking and taking action (Rousell and Cutter-Mackenzie-Knowles 2020).

Increasingly prevalent in the climate change education policy discourse in England (e.g. Fleetwood et al. 2024) and internationally (Simpson et al. 2021) is the idea of climate literacy, which includes being aware of climate change, its anthropogenic causes and mitigation and adaptation responses. For example, the assessment of climate literacy has been proposed as part of the COP29 Presidency, to be undertaken by the Organisation for Economic and Cultural Development (OECD) in partnership with the international Programme of International Student Assessment (PISA) (OECD 2024). Through PISA, the OECD works with countries across the globe to implement three-year cycles of assessment in science, mathematics and reading and this process influences national educational systems, for example shaping curriculum (Eames et al. 2024). The proposal is to identify opportunities to foreground climate literacy in the science domain, but also to develop items which measure climate literacy in the other core domains of mathematics and reading. In England, climate literacy of school leavers (students aged 15–16 years) has been measured recently through a 55-item survey (Fleetwood et al. 2024).

This study analyses young people's understandings of climate change, drawing on survey responses (n = 2051) from school students aged 11–14 years. This age group encompasses students in the first three years of their secondary schooling, where science and geography are both compulsory school subjects in the English National Curriculum (DfE 2013), although only local authority maintained schools are legally required to teach this (DfE n.d.), which is currently 44% of children (DfE 2025a). This study focuses on a group of young people who have not been recruited through climate change education or activism networks and thus provides an important opportunity to consider the understandings of students who have not necessarily had any prior engagement with climate activism (Trott 2024; Dunlop et al. 2020). Furthermore, whilst Fleetwood et al. (2024) have recently provided insights concerning school students' climate literacy, the sample was focused on a smaller group (n = 522) of students aged 15–16 years, and the survey tool asked students to select responses from options provided, rather than providing open-text responses. Therefore, this current study provides a novel opportunity to explore the ways young people articulate their understandings of climate change at an early stage of their secondary school education. It also aims to support educators and education researchers to reflect upon the nature and place of climate literacy in the context of climate change education and the extent to which such education is consistent with ideas of education which value young people's unique perspectives and political agencies (Skovdal and Benwell 2021) and enables critical thinking and action (Rousell and Cutter-Mackenzie-Knowles 2020).

Climate change education and climate literacy

Climate change education is challenging to define given the various ways in which climate change itself is conceptualised and understood, drawing on frames from studies as diverse as

environmental systems, energy studies, and coloniality and, also, given the different ways of considering the purpose of education, including developing a set of capabilities, values, skills or knowledge, including literacy (Eilam 2025). The way that climate change and education are framed shapes the approaches considered through climate change education literature. For example, climate change education through a justice lens pays attention to personal and societal wellbeing, as well as environmental protection (Trott et al. 2023). Disciplinary-based climate change education pays attention to discrete knowledge, practices and principles which comprise climate change as distinct from history, science or French (Eilam 2022). Therefore, a universally accepted definition of climate change education does not currently exist. However, as noted by Clayton (2026), several systematic reviews of climate change education research (e.g. Monroe et al. 2019; Rousell and Cutter-Mackenzie-Knowles 2020; Trott et al. 2023) draw on ideas from Kagawa and Selby (2010), who conceptualise climate change education as an opportunity to engage students in deep reflection, which enables them to envision and actively work towards a better future. Furthermore, there is widespread acknowledgement, including from children's geographies scholars, that climate change education must go beyond developing knowledge and skills and encompass the emotions, critical thinking and opportunities for authentic action (Rousell and Cutter-Mackenzie-Knowles 2020). Despite national and international recognition of the role of education in climate change adaptation and mitigation, meaningful policy action remains limited (Rushton, Walshe, and Johnston 2025). In the context of England, institutional barriers, shifting terminologies and reactive rather than proactive policy responses have further fragmented climate change education policy development (Greer, King, and Glackin 2023) and have largely retained the focus of climate change education on scientific knowledge acquisition (Dunlop and Rushton 2022a; DfE 2025b).

Over the last decade or so, climate literacy is increasingly used in predominantly Anglophone settings in the context of climate change education, including in the USA and England. Ideas of 'climate literacy' bring together concepts of the *climate* as a system with the notion of *literacy* as a way of describing knowledge or understanding in a particular field. Together, climate literacy can be simply articulated as an understanding of how the climate system works and is shaped by and shapes human activity (NAEE n.d.). Arguably, the concept of climate literacy has grown from the term 'environmental literacy,' which has been used since the mid-twentieth century and describes, 'an awareness of and concern about the environment and its associated problems, as well as the knowledge, skills, and motivations to work toward solutions of current problems and the prevention of new ones' (McBride et al. 2013, 3). As McBride et al. (2013) note, as well as environmental literacy, other terms are increasingly used, such as 'ecological literacy' and 'eco-literacy', with usage frequently interchangeable and somewhat confusing. Perhaps in parallel with the increasing focus on climate change education as distinct from environmental education, climate literacy is also more visible in national and international educational discourse, including recent publications by the Organisation for Economic Co-operation and Development (OECD 2024).

In England, the Department for Education commissioned and published a *Climate Literacy Survey* (2024) to assess the level of climate literacy amongst those leaving secondary education (Fleetwood et al. 2024). Climate literacy is understood in this survey through the following topics: the causes of climate change, evidence for and impacts of climate change, mitigation and adaptation solutions, climate change in the UK and, climate change communication (Fleetwood et al. 2024) (Figure 1). Whilst climate action is visible as part of questions which explored school students' understanding of climate change adaptation and mitigation strategies, the concept of equity is entirely absent, and climate justice is only mentioned twice in the report (Fleetwood et al. 2024). Firstly, climate justice is implicitly included in the *causes of climate change* topic, where school students' understanding of which country emits the most carbon dioxide per person from the burning of fossil fuels was assessed as the report notes, 'this links to ideas related to climate justice' (Fleetwood et al. 2024, 21). Secondly, Fleetwood et al. (2024, 71) highlight that whilst respondents demonstrated a good awareness of current emissions of greenhouse gases by countries, there was, 'less awareness of per capita or historical emissions, this could be linked to a poor

Climate literacy topics (Fleetwood et al. 2024)	Climate literacy principles (USGCRP 2024)
Causes of climate change: Understanding weather versus climate, drivers of global climate variance, identifying greenhouse gases and fossil fuels.	*How we know*: Scientists understand the climate system through interdisciplinary observations and modelling.
	Climate change: Greenhouse gases shape Earth's climate.
Evidence for and impacts of climate change: Recognising indicators of a warming climate, understanding future temperature projections and country vulnerability.	*Causes*: Burning fossil fuels and other human activities are causing the planet to warm.
	Impacts: Rapid warming and other large-scale climate changes threaten human and ecological systems.
Mitigation and Adaptation Solutions: Differentiating between the two concepts and identifying relevant strategies.	*Adaptation*: Humans can adapt social, built, and natural environments to better withstand the impacts of climate change.
Climate change in the UK: awareness of the projected impacts of climate change in the UK and adaptation and mitigation solutions.	*Mitigation*: Reducing emissions of greenhouse gases from human activities to net zero by 2050 can help limit global warming and climate change impacts.
Communication: Evaluating scientific consensus, knowledge of key international organizations, and trust in different information sources.	*Hope and Urgency*: A liveable and sustainable future for all is possible with rapid, just, and transformational climate action.
	Equity: Climate justice is possible if climate actions are equitable.

Figure 1. A comparison of climate literacy principles from the USA (USGCRP 2024) and topics from England (Fleetwood et al. 2024).

understanding of issues related to climate justice'. Figure 1 provides a summarised comparison of climate literacy dimensions in the survey from England (Fleetwood et al. 2024) and the USA Climate Literacy Guide for educators, communicators and decision-makers, published by the United States Global Change Research Programme (USGCRP 2024). Across both conceptualisations of climate literacy, shared themes include the causes and impacts of climate change and climate change mitigation and adaptation. However, whilst the survey from England also includes the topics of climate change in the UK and communication, the framework from the USA includes themes of hope and urgency and equity, which explicitly highlight climate justice. Therefore, the climate literacy survey from England (Fleetwood et al. 2024) arguably demonstrates a narrower understanding of climate literacy than that articulated elsewhere, including recently in the USA (USGCRP 2024).

Of the data published in 2024 from the *Climate Literacy Survey*, survey respondents were 522 school students in Year 11 (15-16 years of age) from 23 schools in England (Fleetwood et al. 2024). During January to June 2024, school students completed an electronic questionnaire of 55 items developed by the Royal Meteorological Society and the market research company, Ipsos (Fleetwood et al. 2024). School students were asked to select from responses provided by the survey (e.g. select reasons for global climate variability from five options including 'I don't know') or to complete sentences by choosing words provided rather than writing answers via open text boxes. The survey sought to 'provide a holistic picture of climate literacy amongst school leavers' (Fleetwood et al. 2024, 6) by asking questions which were not linked to any specific curriculum.

Just under half of the respondents (45%) could not recall recent climate change education and 31% were able to correctly define the difference between weather and climate. When asked to identify which of five options provided the 'best definition' of climate change, 44% of respondents identified climate change as 'a large-scale, long-term shift in the Earth's weather patterns and average temperatures.' This is the definition most frequently encountered in the school curriculum in England, capturing both anthropogenic and natural causes of climate change (Fleetwood et al. 2024, 16). A further 44% of respondents identified climate change as 'an increase in global temperature because of changing greenhouse gas concentrations in the atmosphere', which is consistent with the United Nations definition of climate change (Fleetwood et al. 2024, 16).

Given the increasing prevalence of climate literacy as a conceptual framing which is variously understood in education both nationally and internationally, we argue that this provides an appropriate heuristic through which to consider young people's conceptualisations of climate change. As climate literacy is variously understood, consistent with the principles outlined for climate literacy from the USA (USGCRP 2024) we draw on conceptualisations of climate literacy which include dimensions of justice and equity, as well as climate change causes, impacts, mitigation, adaptation and communication. Such a definition is consistent with climate change education which is oriented by children's geographies scholarship, which values and recognises the unique perspectives and political agencies of children and young people in their sense making of their place in the world (Skovdal and Benwell 2021) and attends to the affective dimensions of climate change education (Rousell and Cutter-Mackenzie-Knowles 2020). In what follows, we outline the broad context of school-based climate change education in the study site of England.

School-based climate change education in England

While the National Curriculum is not compulsory for all schools in England (DfE n.d.), teachers have articulated its importance as a lever for supporting them to embed climate change education within their practice (Greer, Sheldrake, et al. 2023), and the recent Curriculum and Assessment Review has outlined the requirement for all schools to follow the national curriculum from 2028 (DfE 2025b). In England at the current time, climate change education is broadly located in secondary science (compulsory 11–16 years) and geography (compulsory 11–14 years) (Department for Education (DfE) 2013; Dawson et al. 2022; Rushton and Walshe 2025a). For example, as a press release published by the DfE in 2013 underlined, climate change is included in the science curriculum for 11–14 year olds, where they learn about, 'the production of carbon dioxide by human activity and the impact on climate' (DfE 2013, n.p.). Furthermore, throughout the geography curriculum, young people will develop:

> A deeper understanding of the different types of weather and climate in particular parts of the world and the processes that give rise to them … Focusing teaching on the essential subject knowledge of climate and weather … will ensure that pupils' understanding of climate change will be based on the factual knowledge … required. (DfE 2013, n.p.)

Almost as soon as the Westminster Labour government was elected in the summer of 2024, the Secretary of State for Education, Bridget Philipson, announced a year-long Curriculum and Assessment Review (CAR) for England, led by Professor Becky Francis (DfE 2024). The final report published in November 2025 arguably strengthens the place of 'climate education' and 'sustainability' in secondary school subjects including design technology, geography and science (DfE 2025b). However, as we have previously noted, climate change and sustainability education is not integrated across the curriculum to include subjects such as English and mathematics, and ideas of justice and action are minimally expressed (Rushton and Walshe 2025b). Therefore, it remains to be seen whether this change will bridge the current gap between climate change education policy and practice in England. For example, whilst the climate change and sustainability strategy in England (DfE 2022) acknowledges the importance of schools accessing funding, sharing best practice and developing networks to enhance climate change education, no universal funding is available (DfE 2022). Furthermore, these unfunded priorities contrast with those of young people (Dunlop et al. 2022) who underline the need for curriculum change so that climate change education moves beyond being focused in geography and science lessons and a persistent framing of 'learning the facts' about climate change as a response to climate and environmental crises (Dunlop et al. 2022; Dunlop and Rushton 2022a). Arguably, the framing of climate change as 'climate science' in the Interim Report (CAR 2025) further underlines science education as the principal domain for school-based climate change education, in contrast to the academic literature which underlines the need for multi-disciplinary approaches (e.g. Rousell and Cutter-Mackenzie-Knowles 2020).

This current research provides an important opportunity to consider young people's ideas of climate change in the context of school-based education in England. Here, we report on findings from an online questionnaire which investigated young people's understandings, ideas and experiences related to climate change education in England. This data was collected after the implementation of the DfE's non-statutory strategy for sustainability and climate change in education (DfE 2022) and before the launch of the Curriculum and Assessment Review (DfE 2024). The findings presented below extend those from our initial analysis (Walshe et al. 2024) and focus on young people's conceptualisations of climate change. Our overarching research question was: *how do young people conceptualise climate change in the context of school-based education? How might this inform our understandings of climate literacy as relevant for educational research, policy and practice?*

Methods

Here we outline data collection, participants, ethical considerations and limitations before summarising the analysis process.

Data collection

Data were collected through an online Qualtrics questionnaire, which could be completed by participants in 30–40 minutes on a range of digital devices. The design, format and piloting process have been previously detailed (Walshe et al. 2024). In summary, the questionnaire comprised 27 items and featured a variety of question types across seven sections: (1) all about you; (2) what do you think about climate change and sustainability; (3) what do you do about climate change and sustainability in school; (4) what do you think about climate change and sustainability in school; (5) what would you like to learn about in relation to climate change and sustainability in school in the future; (6) how do you feel about nature; and (7) all about your life. Data reported in this study were drawn from the open text responses to question nine, which asked participants: '*What do you think climate change is? Climate change is …* '. Participant recruitment took place from March to May 2024, inviting students in England in Years 7–9 (ages 11–14 years) to complete the questionnaire. We chose to focus on the 11–14 year age group, as at this age all secondary school students study both science and geography in England (after which they begin to select a narrower range of subjects). The questionnaire was shared with students via their teachers, who were contacted via a range of networks, social media channels and electronic distribution lists of the first author's institution. Teachers were asked to either administer the survey in a lesson or tutor period, or set it as an independent homework task. Teachers were provided with comprehensive guidance to ensure consistency in delivery. In addition, students received explanatory notes embedded within the survey introduction, which outlined completion procedures and were accompanied by participant information and the consent protocol.

Participants

As reported by Walshe et al. (2024), 2429 responses were received from students across England. The first section of the questionnaire invited participants to provide demographic information; although data were not analysed by demographic characteristic, we report this to contextualise the responses received. Across all responses to the survey which provided demographic information, the sample of students was comprised of a broadly even mix of age groups, with 40% in Year 7, 34% in Year 8 and 25% in Year 9. In terms of gender, the sample of students was 56% girls, 43% boys and 1% non-binary and gender diverse. Concerning ethnicity, 56% of students identified as belonging to white backgrounds, 25% Asian/ Asian British backgrounds, 7% with mixed backgrounds, 5% with Black/ Black British backgrounds and 4% with Arab backgrounds. In total, question nine received 2051 responses (85% of total sample) and broadly speaking the age, gender and ethnicity profiles of those who responded to this question were consistent with

the demographics of the whole survey sample (Walshe et al. 2024) and, more broadly, with ethnic demographics of students attending state-funded secondary schools in England during 2023/2024 (DfE 2024). Concerning parental education, of those who responded to question nine, just under two-thirds (64%) reported that at least one parent or carer went to university. To provide some context, in England, approximately 55.9% of children have a parent who attended university in 2021–2022 (Office for National Statistics 2023).

Students were invited to specify their school and for those who did, the sample of students was drawn from 30 schools. Of these, 24 were state-funded secondary schools (21 academies and three local-authority-maintained schools) and six independent fee-paying schools (Walshe et al. 2024).

Ethical considerations

The research was approved by an Institutional Ethics Committee prior to the commencement of data collection, and voluntary, informed consent was obtained in writing from all participants at the beginning of the survey. Data was managed consistent with the UK GDPR and DPA 2018. Participant data was anonymised before analysis. Questionnaires were administered predominantly by teachers, either during lessons or as a homework activity; therefore, it was important as part of the administration process to explicitly state that the decision to complete the questionnaire (or not) would have no bearing on students' progress or attainment within school. We acknowledge that students might have responded differently were their teacher present or not, and this is a potential limitation of using this approach. Finally, we note that whilst the demographics of survey respondents are broadly representative of student populations in state-funded secondary schools in England, the survey did not access the experiences and ideas of students educated in other settings, including students educated at home or in Special Educational Needs provision (although it is likely that students within mainstream school who were neurodiverse and/or had a disability were surveyed). In the context of our study, the lack of these perspectives is vital to underscore as part of a wider environmental and sustainability educational research context which frequently over-represents the experiences of white, affluent, neuro- and gender-typical groups (Dunlop et al. 2022).

Limitations of the research design

The data collected represents the views and experiences of those who responded to the questionnaire, rather than being generalisable across school students in England. As noted previously, the responses are broadly representative of students who are educated in 'mainstream' formal educational settings, rather than drawing from the range of educational provision across England. Efforts were made to gather responses in schools with varied experiences of climate change and sustainability education and encompass whole classes or year groups such that responses included students with varied perspectives, experiences and engagement with climate change and sustainability. However, although students were incentivised to complete the survey by having the option to opt in to a prize draw for a small voucher if they did, it is possible that those students who chose to complete the questionnaire were those already engaged with climate change and sustainability topics and issues. Furthermore, teachers who elected to share the survey may have been more engaged with climate change and sustainability as part of their professional lives, and this may have influenced which classes they chose to engage with the survey and the responses of students who completed the survey. Finally, a further phase of workshops (for example, see Dunlop et al. 2022) could have further elucidated details as to the varied experiences and perspectives of students, which would likely have provided a fuller understanding than questionnaire responses alone.

Data analysis

Data were analysed using a conventional approach to qualitative content analysis, appropriate when working as a team across a large, shared dataset with phases of inductive and deductive coding (Fereday and Muir-Cochrane 2006) over a period of six months. In the first instance, open-text responses (n = 2051) to question nine were collated and imported into an Excel spreadsheet. These open-text responses (total word count = 25,271 words) were initially reviewed by all three authors to determine the next steps for data analysis. As a result, we agreed that responses should be broadly categorised as to whether they were aligned with widely understood definitions of climate change, including those provided by the United Nations and in the National Curriculum for England (see Fleetwood et al. 2024), as well as those responses that included misconceptions concerning climate change and responses that identified impacts associated with climate change.

Following this initial review, author two conducted a detailed examination of the data against these categories. They also identified responses which were blank, those where students reported being unsure or uncertain, and responses that appeared to be closely aligned to those provided via a search engine or Artificial Intelligence tool. This stage of analysis was reviewed and discussed by all three authors prior to a phase of reliability checking undertaken independently by authors one and three. During this reliability checking phase, authors one and three each randomly sampled ~20% of the responses identified by author two in phase one as being consistent with the school definition of climate change, where misconceptions were evident, or where impacts of climate change were identified. Where there were differences in categorisation (<5% of all responses) these were resolved through discussion.

Deductive phases of analysis were informed by ideas from published literature focused on school-based climate change and sustainability education in England (e.g. Rushton and Walshe 2025a; Howard-Jones et al. 2021) and children and young people's understandings of climate change and sustainability (Walshe et al. 2024; Turner and Wilks 2022). We also approached data analysis inductively, where the coding process involved considering the individual responses provided. As part of this approach, we understood our roles as researchers as organising and interpreting the data points such that we could develop patterns of information, or themes. As a further part of the deductive, analytical process, we drew on our professional lives and experiences as a recent school leaver and Department for Education Youth Focal Point for Sustainability and Climate Change (author two) or secondary school teachers and university-based teacher educators (authors one and three), and as education researchers engaged with climate change education policy (all authors), and how these shaped our engagement with the data.

Findings

The findings presented below extend those from initial analyses previously reported, which provided a broad overview of the young people's experiences of CCSE in England (Walshe et al. 2024). Here, we focus on young people's definitions and conceptualisations of climate change, with an overview provided in Table 1.

Students' 'textbook' definitions of climate change

Across the answers to the question '*What is climate change? Climate change is …*', most students (52.5%) provided responses which broadly included ideas of change or harm to the environment and/or Earth systems, all including references to temperature (Table 1). Of these responses (n = 1077), 31% of the definitions explicitly foregrounded the role of humans and human activity in causing climate change (Table 1). Some of the responses (11.8%) included conceptualisations which were very closely aligned to definitions provided in the National Curriculum for England, which articulates climate change as changes to weather patterns and average temperatures that

Table 1. Students' definitions and conceptualisations of climate change.

Category (number of responses)	Indicative quotes
Changes or harms to the environment/systems, all with reference to temperature (1077)	'Climate change is the physical change in our environment/planet. It is mostly changing the weather and temperature. We as humans have caused it but industrialising our planet and releasing gases such as CO_2 which are harmful to our planet.' 'Multiple things, e.g. ice melting and more natural disasters. This change is caused by lots of gases caused by people that go in the atmosphere. It is also a long-term situation.'
• *Anthropogenic causes foregrounded* (334)	'Humans changing or warming the climate with fossil fuels and similar.' 'The change of climate due to human activity.' 'How humans' actions are negatively impacting the environment.'
• *Closely aligned to the school curriculum definition of climate change*:	
'A large-scale, long-term shift in the Earth's weather patterns and average temperatures' (128)	'Shifts in the temperature and weather patterns that is heating up the earth more and more but slowly.' 'The gradual change in weather patterns and overall world temperatures in response to man-made influences.'
• *Closely aligned to the UN definition of climate change*:	
'An increase in global temperature because of changing greenhouse gas concentrations in the atmosphere' (53)	'The change of the world's temperatures and weather conditions due to global warming caused by human activity such as burning fossil fuels and creating greenhouse gases.' 'Is global warming due to humans releasing gases into the atmosphere (greenhouse gases).'
• *Climate change impacts are identified as being local* (43)	'The environment around us changing for example in London every year the record for the highest temperature in London get breaked and replaced with something else. Nowadays, in summer, we often have heatwaves which were quite uncommon/rare before.'
Potentially generated by AI and/or search engine where this exact phrase was used (40)	'Climate change refers to long-term shifts in temperatures and weather patterns'
Misconceptions are evident (199)	'Where there the temperature goes up though out the years and where all the ice melt because the sun gets hotter.' 'The change in our climate due to causes like nuclear power.'
• *Misconceptions which focused on changes to the weather* (45)	'The weather changing'; 'Change in the weather really fast'; 'Climate change is when the weather can go from hot to cold.' 'I think it is hot weather'.
• *Misconceptions specifically related to the ozone layer* (37)	'The world heating up because of the ozone layer being broken because of CO_2 emissions.' 'Climate change is the weather/temperature and breaking the ozone layer that protects the earth from radiation.'
• *Misconceptions specifically related to litter/rubbish* (21)	'Climate change is when the world changes or gets quite bad because of people littering, throwing rubbish or random things in the ocean.' 'Climate change is where people litter.'
• *Misconceptions specifically framed as denial* (2)	'A think that is meant to happen and has been happening for ages but people decided to make a big thing now.' 'Climate change does not exist.'
Uncertain and/or do not know (73)	'I don't know'; 'I'm not sure'; 'I don't know or care much'; 'I cannot describe it well'.
Emotions (24)	'Stressful and overwhelmed'; 'Sad and needs to stop'; 'the world is dying'.
• *Ideas of care* (7)	'Climate change is when the world … gets quite bad because of people … not taking care of the world.' 'The fact that humans cannot be bothered to think about mother nature and only care about themselves. and they harm the planet. (some intentionally).'
• *Fears for the future* (7)	'It makes me feel worried for the future and what it will be like.' 'A bad change in the climate that will affect our Earth in the near future.'

Notes: Items in italics are sub-categories, not every item included in a category was listed in a sub-category. Please note that whilst we have presented students' responses in some cases in abbreviated form, we have not corrected for spelling and/or grammar.

are large-scale and/or long-term (see Fleetwood et al. 2024, 15) (Table 1). A smaller number of responses (4.9%) featured ideas consistent with the United Nations definition, which explicitly includes greenhouse gas concentrations as the cause of increasing global temperatures (see Fleetwood et al. 2024, 15) (Table 1). Few responses (4%) included a sense of climate change causing local impacts. Also present in the data were a small minority of responses (3.7%) which were likely generated using artificial intelligence (AI) and/or a search engine as they all included the exact phrase, 'climate change refers to long-term shifts in temperatures and weather patterns' (Table 1). While these data are not further interrogated here, they present an interesting potential avenue for future research.

Students' climate change misconceptions, uncertainty and denial

Of the total number of responses to the question '*What is climate change? Climate change is …* ' (n = 2051), 9.7% included answers where misconceptions were partly or wholly evident (Table 1). A minority of students' definitions (2.2%) included misconceptions that understood climate change as interchangeable with the weather or were focused on changes to the weather, without any framing of these changes as long-term and/or linked to greenhouse gas emissions. For example, 'climate change is where the weather changes' and 'the change of the weather'. Whilst this misconception is evident, it is notably smaller than that found in the Climate Literacy Survey 2024, where only 31% of school leavers could identify the difference between weather and climate (Fleetwood et al. 2024); this is despite the fact that students in our survey were younger (ages 11-14, as opposed to 15–16 years).

Misconceptions that incorrectly linked damage or changes to the ozone layer due to human activity as a cause of climate change were present in a minority of responses (1.8%). For example, 'the release of greenhouse gases into the atmosphere makes the ozone layer thick and traps heat in the earth' and 'climate change is where the ozone layer gets destroyed and the sun's UV rays get hotter and affect people. this causes sunburns to people skin and destroyed animals habitat'. Furthermore, a minority of students (1%) correctly identified increased temperatures as a feature of climate change but incorrectly attributed increased litter and rubbish as causes, 'climate change is where the climate's weather and atmosphere warm up due to pollution and littering' and 'the action of the climate changing due to rising temperatures and things like littering' (see Table 1). Across all responses to this question, 3.5% clearly stated that they did not know what climate change was and there was one statement that said that climate change did not exist and one statement where the respondent explicitly stated climate change was not caused by humans.

Emotions, ideas of care and fears for the future related to climate change

Whilst question nine simply asked, '*What is climate change? Climate change is …* ', as opposed to, '*how do you feel about climate change?*', a small minority of responses (1.1%) included answers which shared emotions. These emotions were all framed negatively, with ideas of stress, sadness, death and overwhelm present (Table 1). Within this broadly negative sense, there were two distinct threads; firstly, ideas of care, for example, 'Climate change is one of our main priorities as humans to fix. Climate change is the result of us not taking enough care of our precious Mother Earth and therefore she is suffering the outcome of our actions' (Table 1). Secondly, fears for the future were also present; for example, 'worrying for the future of the planet' and 'climate change is bad, and humans need to put in much more effort to look after the planet; otherwise, future generations will have no home' (Table 1).

As previously reported, two questions in the survey explicitly explored students' emotions in relation to climate change and all respondents provided answers to both of these questions (n = 2429) (Walshe et al. 2024). Question 12 asked students about specific feelings about climate change, where students could select from a range of positive and negative emotions following the prompt of

'*Climate change makes me feel …* '. The emotions most commonly identified by students were negative, with sadness, anxiety and anger most frequently mentioned, with 67%, 65% and 61% of all students respectively suggesting climate change makes them feel that way. Question 13 then asked students to note the extent to which they agreed with statements including '*I worry about what the world will be like in the future because of climate change*'; overall, 36% of all students conveyed that they worry about what the world will be like in the future because of climate change 'a lot' or 'all the time', 50% conveyed that they worry 'a little', and 15% conveyed that they worry 'not at all' (Walshe et al. 2024). For both questions, there were significant gender and socio-economic differences, with girls and those from higher socio-economic backgrounds expressing more negative emotions (Edwards, Perry, and Walshe 2025). It is perhaps then not surprising that similar evidence of fear and concerns for the future were evident within some students' definitions of climate change from the outset of their responses to the survey. Indeed, the fact that some students articulated concern through their definition suggests that they understand and experience climate change in an affective, rather than purely cognitive, way.

Discussion

Of the total number of responses to the survey (n = 2429), 84.4% of respondents chose to answer the question, '*What is climate change? Climate change is …* ', with nearly one in six not providing a response. Of those who chose to answer the question (n = 2051), 52.5% were able to provide responses which included ideas of change or harm to the environment and/or Earth systems, all including references to temperature (Table 1). This means that of the total number of young people aged 11–14 years who responded to the survey, 44.3% demonstrated a secure understanding of climate change. It is important to recognise that one question from a survey, simply worded, '*What is climate change? Climate change is …* ' should not be understood as a comprehensive proxy for climate literacy or climate change education. Furthermore, the format of this question, with an open-text box response, is in contrast to the structured options provided as responses to questions in the climate literacy survey reported on by Fleetwood et al. (2024). However, analysis of the responses to both surveys allows for some general conclusions to be drawn concerning the knowledge and understanding of climate change by those school students aged 11–14 or 15–16 years who completed the respective surveys in 2024. Firstly, of the students who responded to the survey led by Walshe et al. (2024), 44.3% demonstrated a secure understanding of climate change. This level of understanding is substantially lower than that which is evidenced through responses to the climate literacy survey, where 88% of respondents (aged 15–16 years) were able to accurately choose one of the two 'best definitions' from the five provided (which included 'I don't know') (Fleetwood et al. 2024). Arguably, responding to the open question '*What is climate change? Climate change is …* ' is far more challenging than choosing the correct answer from a narrow range of options. Therefore, it is not yet clear whether these results represent a substantial difference in understanding of climate change between students at the end of different phases of secondary education. We also note that the question item style has provided different measurements of climate literacy, which likely do not provide the same opportunity to elicit student knowledge and understanding, and therefore comparisons should be made with caution. However, given that less than half of those respondents aged 11–14 years who responded to the study have a strong grasp of the general concept of climate change, this current research underlines previous studies from England (e.g. Rushton et al. 2023), which highlight the importance of early secondary school education (11-14 years) as an important site for climate change education in school-based education in England, now and in the future.

Secondly, given that 15.6% of all respondents to the survey presented here elected not to answer the question '*What is climate change? Climate change is …* ' and a further 12.8% of all responses included misconceptions, uncertainty or the use of artificial intelligence, over a quarter (28.4%) of school students who completed this survey have notable absences in their climate change

knowledge and understanding. Whilst noting our earlier cautions regarding comparisons of findings across both surveys, the findings from the survey presented here seem to align with those of Fleetwood et al. (2024), who underlined that only 31% of school leavers could accurately define the difference between climate and weather and just 14% could identify large-scale weather patterns such as El Niño being the biggest cause of global climate variability. Given the current focus on climate change in school science and geography in England, the findings from both surveys might suggest that if young people are to develop a more detailed and lasting understanding of climate change, this narrow focus in geography and science is not sufficient. Alternatives to improve climate change education include implementing climate change as a distinct disciplinary-subject in school education (Eilam 2022) and cross-curricular or interdisciplinary approaches which integrate climate change education across school subjects (e.g. Rousell and Cutter-Mackenzie-Knowles 2020).

Thirdly, we note that in the responses provided by school students to the survey reported here, there were very few inclusions of local impacts of climate change (2%), which could suggest that their spatial understandings of climate change are partial. This could be the result of a narrow focus on climate change in school science, rather than a more holistic incorporation of climate change across the curriculum. The lack of understanding of local impacts of climate change is also reflected in a recent survey of teachers from England (Rushton, Walshe, and Johnston 2025) which found that teachers provided few examples that focused on the UK and instead focused on locations that were geographically distant, for example, the Maldives, China and Bangladesh. As Rushton, Walshe, and Johnston (2025) note, this emphasis not only supports a fundamental misconception that climate change is not a local issue, but also raises a concern of climate justice, if the curriculum reinforces ideas that the impacts of climate change are removed from young people in England. Consistent with ideas of climate change education from children's geographies scholars (e.g. Rousell and Cutter-Mackenzie-Knowles 2020), this current study underlines the importance of exploring the ways in which children and young people understand and make sense of climate change, including the spatial dimensions of impact in ways which not only identifies misconceptions but also attends to dimensions of justice and identifies opportunities for action.

Turning to consider the policy context, climate change education in England has tended to frame climate change education as a necessary response to mitigate young people's anxiety about climate change, rather than as a means of mitigating or adapting to the consequences of climate change itself (Dunlop and Rushton 2022a). Such a framing locates children and young people's concern and distress as the core issue rather than arguably unsustainable and unjust consumption, shifting the responsibility away from decision makers and leaders. Whilst emotions play a vital role in how we think about and experience climate change, including climate change science (Ojala 2020), emotions are frequently marginalised in education such that children and young people are unable to fully engage with the affective dimension of education. This is wholly inconsistent with conceptualisations of climate change education which have been previously articulated by children's geographies scholars, who underline the vital need for education to attend to the affective dimension (Rousell and Cutter-Mackenzie-Knowles 2020). Through this research, which analysed over two thousand responses to the question, '*What is climate change? Climate change is …*', we note that whilst this question did not explicitly ask how respondents felt about climate change, a few respondents (1.2%) did share their feelings and emotions from the outset, as part of their conceptualisation of climate change. These feelings were overwhelmingly negative, including experiences of sadness, worry, concerns for a lack of care and fear for the future (Table 1). Broader results from our survey indicate that the majority of students who participated in the survey experience negative emotions related to climate change (Walshe et al. 2024), echoing wider research on climate anxiety in children and young people (e.g. Clayton 2020). In educational settings, particularly formal school-based settings, there are unspoken norms as to how emotions should be experienced or expressed which likely consciously and/or unconsciously shaped the answers provided to this survey. Nevertheless, and consistent with previous research (e.g. McGregor, Christie, and Kustatscher 2024; Dunlop and

Rushton 2022b; Rushton et al. 2023) we argue that by paying closer attention to the emotions which are evident in the experiences and responses of children and young people in the context of climate change, we can better understand and respond as educators, supporting children and young people to think deeply about climate change and to enable them to envision and contribute to a better future (Kagawa and Selby 2010). Indeed, research indicates that concern and anxiety about climate change is not always an unhealthy reaction to climate change or a harmful consequence as climate anxiety can also serve as a motivating factor towards authentic climate action (Davidson and Kecinski 2022; Whitmarsh et al. 2022). In the context of school-based climate change education this further underlines the need for educational spaces which support emotionally-responsive pedagogies which enable children and young people to develop coping potential and transform future expectations (Dunlop and Rushton 2022b). This includes providing children and young people with iterative opportunities in different phases of their education to express and explore both their trust and their distrust in climate change science as a way of developing their coping potential. This is especially important as climate change anxiety, distress and denial fluctuate during adolescence, underlining the importance of (formal) education in paying attention to this dimension of childhood (Veijonaho et al. 2023). Furthermore, as Ojala (2020) outlines, trust in science in the context of climate change has an important role in terms of collective engagement, with young people building hope and engagement through social movements focused on global climate change and sustainability challenges. At the same time, research underlines that there are a minority of children and young people who cope with climate change by minimising the seriousness of the issue, including being distrustful of the science and scientists who outline the evidence of the challenges we face (Ojala 2021), particularly in a 'post-truth' context (Hufnagel 2022). This distrust can be a way of coping with negative emotions related with climate change (Feinberg and Willer 2011) and therefore is vital to consider in the context of climate change education – if there is mistrust in science, the solution is perhaps not simply to teach more science. Whilst the responses to our survey provided very few examples of climate denial, there were examples of uncertainty and as previously noted, over a quarter of all respondents either did not respond, expressed their uncertainty or included clear misconceptions in their responses.

Conclusions

Both internationally and in England, climate literacy and the measurement of young people's climate literacy via responses to surveys is increasingly prominent in educational policy and practice (Fleetwood et al. 2024; OECD 2024). The current context of school education policy in England is one of change to curriculum and assessment frameworks; however, these changes have been framed as an 'evolution' rather than 'revolution' (Francis 2025). Arguably this emphasis on 'evolution' is evident in the Curriculum and Assessment Review's recommendations (DfE 2025b) to partially strengthen the place of climate change and sustainability education in some subjects, with largely absent framings of justice which attend to the affective dimension or support action. Given the findings from this study which suggest that more than half of respondents to the question '*What is climate change? Climate change is…*' do not have a secure understanding, we highlight that an evolution towards more 'climate science' in education is likely to be an insufficient educational response given the urgent global environmental, climate and sustainability challenges we face.

In the context of increasing national and global efforts to assess or measure climate literacy through surveys, we underline the important role of educational researchers in critically evaluating the survey tools used to measure climate literacy. Failure to proactively engage with this global movement towards the measurement of climate literacy through surveys may result in the increased narrowing of how climate literacy is understood, with a focus on understanding the (predominantly science-based) causes and impacts of climate change and knowledge of climate change adaption and mitigation strategies, and away from holistic conceptualisations which attend to affective dimensions, and ideas of justice and equity. Such a trend is perhaps already visible in school-

based education in England where there is increasing focus on 'climate science' and 'climate literacy' in education rather than climate change education or climate justice education. We underline the important contribution that children's geographies scholars continue to make to ideas about and debates across climate change education, including authentically accessing the voices of children and young people, and the ways in which understanding the spatial dimension of their perspectives, experiences and sense making can enable the development of education which better responds to their needs and emotions.

We also reflect on the extent to which climate literacy survey tools provide children and young people with opportunities to share how they experience climate change and reflect on how this makes them feel. What questions might we ask which help us understand what it is for children and young people to be educated *in* a changing climate? (Verlie and Blom 2021) What might the responses to these questions tell us about what is required for education now and in the future? Finally, as educators and educational researchers, do we need to further question ourselves (as well as policy makers) regarding the construction, implementation and interpretation of survey tools such that they seek to understand and engage rather than simply assess or measure? Might this be more consistent with education that responds to the demands of living justly with climate altered futures?

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Data availability statement

The data that support the findings of this study are available from the corresponding author, NW, upon reasonable request.

Institutional review board statement

This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Research Ethics Committee of University College London on 8 January 2024 (reference REC1918, data protection number Z6364106/2023/12/45).

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