

# Teachers' sources of information about climate change: a scoping review

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## Abstract

This paper sheds light on an important and under-researched issue: the sources of information about climate change that teachers use. Utilising a 'scoping review' methodological approach, we analysed over 600 papers to address two main questions: What sources of information about climate change are teachers using? In what ways are teachers using these sources of information? Through our use of inclusive search terms and detailed analysis of papers, we found only 13 studies of relevance, none of which primarily focus on the sources of information teachers use. The 13 studies are all located in the Global North, and within this nearly half are in the USA. Methodologically, all apart from two rely on teachers' reports rather than observation or other methods. Four types of sources of information were frequently mentioned: the internet; government sources; mass media; and professional development courses. The 'superabundance' of information now available to teachers (particularly online), the importance of high-quality information for students' understandings of climate change, and the limited research on the sources of information about climate change that teachers use makes this a significant blind spot for research to address.

**Keywords:** climate change education; information; teachers; curriculum making

## Introduction

Climate change education (CCE) is increasingly seen as a vital component of our response to the ongoing environmental crisis (Reid, 2019). CCE has the potential to make an important contribution in raising awareness, changing behaviours, and empowering the next generation to be responsible, informed, climate-conscious social actors and citizens who engage in, and vote for, greener ways of living and working. The quality of CCE is intrinsically linked to the quality of information about climate change that teachers use in their curriculum making. A 'superabundance of information' (Lankshear, Peters, & Knobel, 2013, p. 27) is available to teachers, but this information is often contested, embedded in digital contexts, and shaped by a wide range of agendas, discourses, and algorithms (Noble, 2018). Therefore, improving our understanding of the sources of information teachers use is an important task for research. In the current paper we contribute to this aim by exploring the existing research through a scoping review, asking: what do we know about the sources of information teachers use? This scoping review (Levac, Colquhoun, & O'Brien, 2010; Pham et al., 2014) takes a slightly different methodological approach to recent review work that has been carried out in CCE, including Monroe et al.'s (2019) systematic review addressing the more general question about the effectiveness of CCE, and Rousell et al.'s (2019) systematic quantitative literature review of CCE research foregrounding children and young people's perspectives. Our scoping review is motivated by the belief that the sources of information teachers use are an important dimension of the epistemic quality of school subjects. In a general sense, sources of information are important because of the way in which we depend on them to form our understandings. As Castree (2014) expresses it:

the vast majority of people's beliefs and sentiments about everything from climate change to their own genes are derivative. They result from an 'epistemic dependence' that makes us all potentially subject to the claims and aims of others. This is a situation in which a relative minority of the global workforce is employed to create information, knowledge, arguments, symbols, etc. to which the majority of people are exposed – and usually reliant upon. (p.xvii)

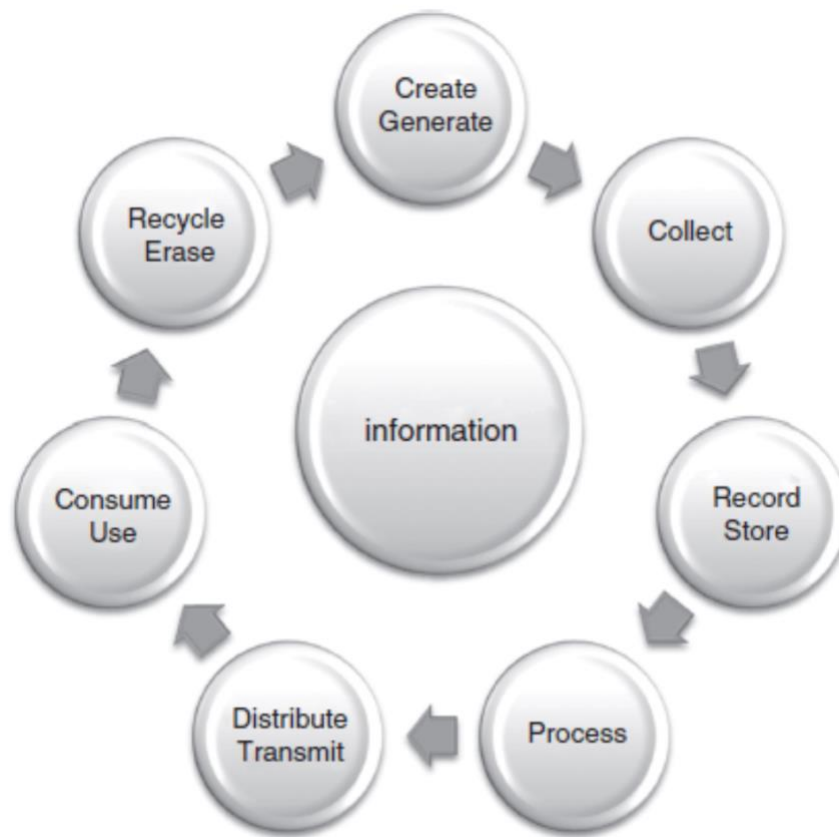
The quality of this information has implications for the quality of people's co-existence at a range of scales and in a variety of contexts, including for equality and justice (Noble, 2018). How sources of information are approached and used by teachers – and their students – is

vitality important and has major consequences for the health of democracy (Wineburg 2018). In the specific issue of CCE, the information teachers access is particularly important because of the recency of climate change knowledge, its inherent interdisciplinarity, susceptibility to conspiracy theories (Runciman, 2015) and the contested digital spaces through which this information is often mediated. The ‘elite’ nature of knowledge about climate change – characterised by the complexity and technicality of narratives ‘imbued with expert authority’ (Mathur, 2015, p.87) – limits its accessibility and increases the contrast between it and everyday forms of knowledge about the environment. Mathur’s work highlights striking examples of the tensions between different sources of knowledge, contrasting epistemologies between communities in Himalayan India and technical accounts (such as that represented through IPCC reports). *Climate translators*, a role which teachers occupy amongst others, are vital for ensuring that the diversity of accounts of climate change are respected (Mathur, 2017). This notion of *translation* evokes movements, the origin and destination of which the teacher needs to be familiar with. And so our argument is not so much that teachers need to avoid certain ‘bad’ sources of information, or to be given approved lists that have been judged worthy. Instead, our argument is that research attention describing and analysing the sources of information about climate change that teachers are using is important and urgent, and may inform subsequent discussion about the ‘appropriateness’ of any particular sources.

The discussion below presents a conceptualisation of information as complex, strongly connected to processes or cycles, and related to knowledge in multiple ways.

## Information

Our conceptualisation of information begins from an understanding of information as a ‘conceptual labyrinth’ (Floridi, 2013, p. 19), or, more technically, a ‘multifaceted and polyvalent concept’. Therefore, the question “what is information?” is misleadingly simple’ (Floridi, 2016, p. 2). One representation of information is presented through its ‘lifecycles’ (Figure 1).



*Figure 1. A typical information life cycle, in Floridi (2013, p.4)*

Information is represented as complex in this account because of the processes through which it moves. These processes, interfaces and frictions are all part of information's history, raising questions about the journeys through which it has travelled: the complexity of the nature of information is constructed through its movements and transformations. In particular, this life cycle representation highlights the multiplicity and complexity of actors and their roles: in what ways have they acted (consuming, distributing, processing, recording, erasing, generating, collecting) on the information? What are the implications of acting in these ways? Particularly in an online context in which information is primarily digitally mediated, the illustration in Figure 1 might be seen in relation to layers of ownership and interfaces between platforms. The 'platformisation' of services and information sharing has implications for the methods through which information might be accessed, the ownership of this information, and the other ends towards which it might be used and monetized (Graham, 2020; Rose, Raghuram, Watson, & Wigley, 2020): 'as information moves from the public sphere to private control by corporations, a critical juncture in the quality of information available and the public's ability to sift and use it is at

stake...' (Noble, 2018, p. 153). Recent analysis of the sharing of misinformation through YouTube videos has highlighted issues of scale and governance (Knuutila et al., 2020). To illustrate the scale: over an eight-month period, misinformation videos identified by Knuutila et al. (2020) were shared almost 20 million times, which is more than the combined shares of the five largest English-language news outlets on YouTube (CNN, ABC News, BBC, Fox News and Al Jazeera). The challenges for governance expose tensions between social media platforms' primary aim as profit making corporations whose business models largely depend on users' attention to drive advertising revenue, and the contrasting demands of their usage as important sources of 'public' information. Ethnographic work in schools (not focused specifically on climate change education) suggests these platforms and online spaces play a significant role in teachers' searches for information and curriculum making (Puttick, 2017).

An important function of information is seen in relation to the development of knowledge: knowledge requires information (Adams, 2016). For example, as Adams argues, 'in order to know that Paris is on the river Seine, one needs to find that out. Finding out is having someone tell, reading in a book, finding on the internet that it is so' (p.321). In curriculum theory and educational research more generally, information and knowledge are used variously as: an interrelated, interdependent pair (Otieno et al., 2014); hierarchically, with knowledge as the higher aim (Bakhurst, 2020); and, interchangeably or synonymously, such as 'information/knowledge' (Alderson 2021, p. 35). Often, and particularly in CCE research, the hierarchical model is used, with information being relegated to something that others deal with, such as journalists. The tenet that what teachers aim to teach is not 'mere information', but 'knowledge' is widely held (Bakhurst, 2020). CCE, and environmental and sustainability education research more generally, adds a further layer to this hierarchy beyond knowledge into action. Many proponents of environmental and CCE contend that this endeavour should address 'more than knowledge and attitudes about climate change' by empowering learners 'to engage in actions to help mitigate or adapt to climate changes' (Monroe et al., 2019, p. 807). For clarity, we are not arguing against such orientations towards action. Rather, our argument is that information is necessary, and undervalued: it is an important area in need of theoretical and empirical attention, particularly in relation to

the ways in which digital and online spaces mediate access to information through increasingly sophisticated algorithms. Therefore, we agree with Floridi's (2013, p. 18) position that: 'we shall be in trouble if we do not take seriously the fact that we are constructing the new environment that will be inhabited by future generations'. This 'environment' refers not to a virtual environment separated from the material, but a hybrid 'infosphere' characterised by ubiquitous connectivity. Such infospheres are vehicles for social, political and economic agendas, particularly in relation to knowledge controversies (Whatmore, 2009, p. 596) in which individuals' and organisations' vested interests are particularly apparent. Almost as an aside, Whatmore (2009) describes one of her own searches for information:

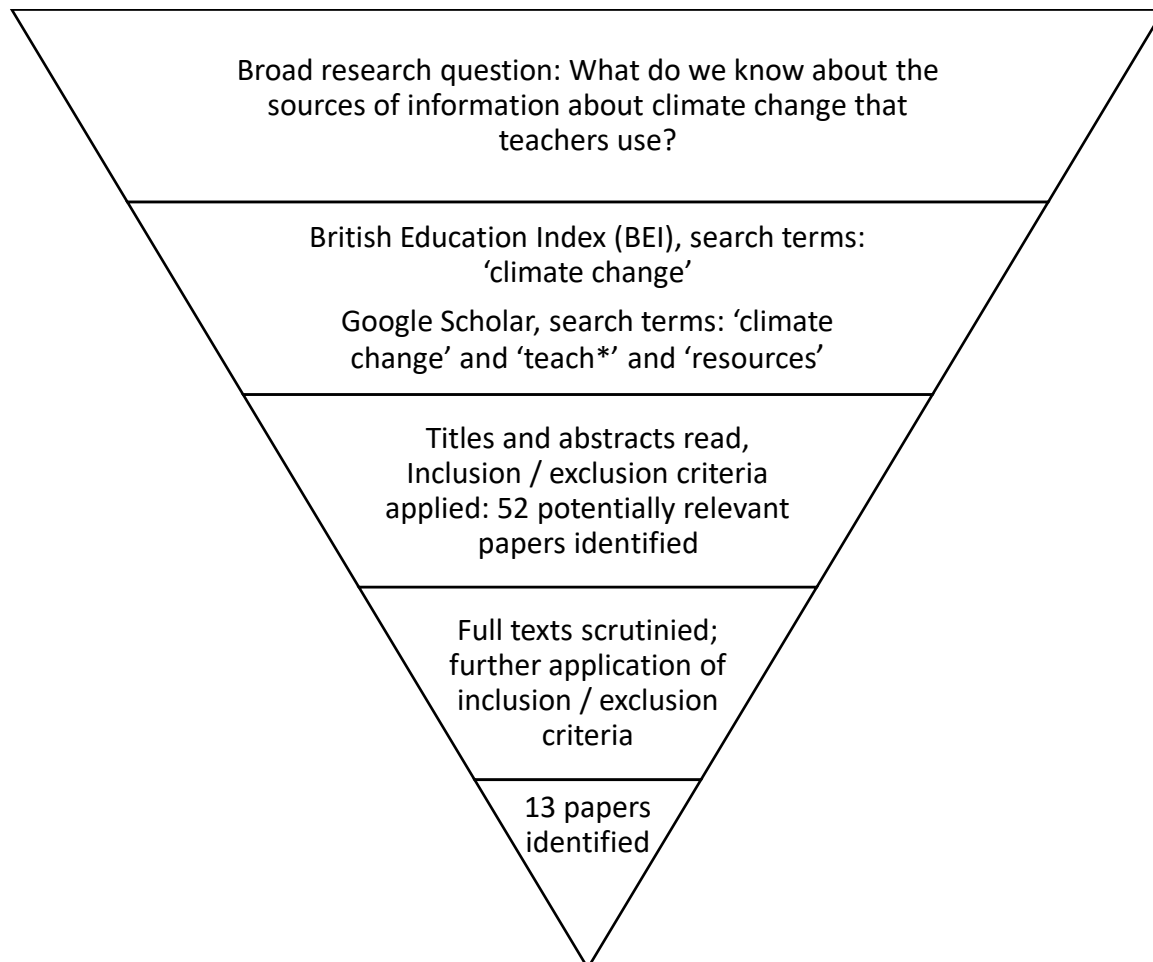
The first version of 'mapping controversies', to which a Google search drew my attention, is a Wiki site on 'mapping con-troversies' which kicks off with this cartoon...The somewhat sketchy and disjointed nature of the material to be found here reflects the Wiki *modus operandi* of open access, such that anyone can edit the material on the site. (ibid. p.590)

Navigating unprecedented quantities of information, sometimes produced and edited anonymously, made visible and accessed through powerful algorithms, is problematic for any topic. These challenges are compounded in the specific context of climate change education. Hence the issue of information is critical in a 'post-truth' age where teachers seem to be increasingly reliant on digitally mediated sources (Walshe & Healy, 2020). Our aim in the current paper is not to make a normative argument about the types of information teachers should be using, but to systematically assess the extent to which research attention has been given to the sources of information about climate change that teachers use.

## Methodology

To address the aim of mapping our current understandings about the sources of information about climate change that teachers use we conducted a scoping review. Scoping reviews are common in the health sciences, and are increasingly used in the social sciences (Pham et al., 2014; Winters, Langer, & Geniets, 2018) to conduct broad and flexible analyses 'mapping'

the literature in order to examine the nature of research activity on a particular topic (Arksey & O'Malley, 2005; Levac et al., 2010). We applied the approach detailed by Levac et al. (2010, p.5), summarised in Figure 2.



*Figure 2 Summary of scoping review process*

### Identifying the research question

The main research question guiding the review was: 'What do we know about the sources of information about climate change that teachers use?' This question was purposefully designed to be broad, allowing for a wide search in the literature and potentially encompassing the complex and multifaceted understanding of 'information' discussed above. The relationships between information, and the different processes and cycles through which it might move, involve its generation, distribution, transformation, collection, storage and erasure. We were interested in understanding what insights research has developed into any aspects of the sources of information about climate change that

teachers use. The overarching research question is further explained by two more specific questions that we hoped to explore:

- a. What sources of information about climate change are teachers using?
- b. In what ways are teachers using these sources of information?

The first of these (a) refers to descriptive lists of specific sources of information (such as a particular textbook, or a specific website), and to categories of these sources (such as textbooks, and websites). The second (b) refers to the processes through which teachers might be making use of sources of information in terms of selecting, curating, recontextualising, storing, presenting, sharing, and so on (possibly including their roles in the cycles of information outlined in Figure 1). The priorities expressed through these questions supported our decision making about the subsequent phases; identifying relevant studies, study selection, and charting the data.

### Identifying relevant studies

The first database we used was the British Education Index (BEI), indexing 310,000 international articles. We used 'climate change' as the search term after trialling of more specific terms (for example, also including 'teachers' and 'information' in addition to 'climate change') failed to return results. The very broad 'climate change' search term gave us confidence that the search would locate studies of potential relevance, reducing the risk of omitting other relevant studies. The search was carried out by both researchers in February and March 2020. A further search was then conducted on Google Scholar in order to capture academic literature and also any relevant grey literature that may not have been found in the BEI.

### Study selection and inclusion criteria

Questions about selection of relevant studies, in terms of balance between feasibility, breadth and comprehensiveness were resolved by the search return of 427 results in the BEI, which made it possible to scrutinise them all to some extent. The number of results also ensured that it was not necessary to input restrictions with regards to the date or type of literature.



The use of search terms in English meant that all results were studies published in the English language.

The search term 'climate change' was too broad for Google Scholar, so the terms "climate change" and "teach\*" and "resources" were used. This returned 79,200 results, of which the first 200 were scrutinised. By this point the results became more obviously irrelevant, relating to climate science more broadly rather than work potentially exploring teachers of climate change.

We developed inclusion and exclusion criteria (Table 1) to guide the next stage of the research: charting the data.

Criterion	Inclusion	Exclusion
Time period	Unlimited	N/A
Language	English	Non-English studies
Type of article	Original research (including empirical studies, reviews and secondary data analysis)	Articles that were not original research
Ethics clearance	Studies with approved ethics notification	Studies without approved ethics notification
Study focus	Teachers and climate change education	All other studies not focusing on teachers
Literature focus	Articles where teachers' sources of climate change information were discussed to some extent (beyond a passing mention)	Articles that on closer inspection did not discuss teachers' sources of climate change information/only had a brief mention of teachers' sources of climate change information
Population and sample	Teachers engaging in climate change education	Students/other groups engaging in climate change education

*Table 1. Inclusion and exclusion criteria*

### Charting the data

As the BEI search returned 427 results it was possible to conduct a detailed analysis, beginning by scrutinising the titles and abstracts of all the search results. For any that showed an indication that they might be relevant to the scope of our review (in accordance with the inclusion and exclusion criteria: Table 1), we read the papers in full. During the full reading of papers, a small number of additional papers were also added to the review by

following references that seemed potentially relevant. The citations were charted during this phase by tabulating in an excel sheet under category headings relevant to the main focus of each paper: 'Teachers and CCE'; 'Secondary Education and CCE'; and 'Education Policy and CCE'.

#### [British Education Index results](#)

Of the 427 search results, 89 were filed under 'irrelevant' and 62 under 'professional publications'. This left 276 results that related in some way to climate change and education. Twenty-six contained a general discussion of climate, environmental and sustainability education. Fifteen related to public education on climate, 13 to climate-related educational policy, and six were book reviews. Ten pertained to the philosophy of climate and environmental education, six to young climate activists, two to citizenship in the light of climate change and one to professional education. Seven papers examined the role of educational technologies in climate education, including the use of video games, online social networks and other environmental education technologies.

The remaining papers mainly focused on young people's perspectives of climate education. Some of these could be sub-divided due to their disciplinary focus, with nine focusing on climate change in science education, seven on drama and dance education, six on arts and humanities, five on geography education, and two on maths education. Twelve were related to informal climate education for young people, and three to participatory climate education. Thirty-four papers explored higher-education and climate change, 54 secondary education, six middle school, 10 primary years and five early years education.

This sorting process left a minority of papers that were most relevant to our research question: 35 papers which specifically explored teachers and climate change education and two papers exploring resources. We read these papers in depth to ascertain if they contained any information regarding the sources of information teachers used.

#### [Google Scholar results](#)

The analysis of the first 200 results on Google Scholar yielded 149 irrelevant results, 47 relevant results, and four duplicated results from the BEI search. Seven of these results were

general discussions of climate change and environmental education, four explored educational technologies for climate change education, one was a book review, one a professional publication, and one was a presentation abstract. Five related to higher education, two to secondary school, two to middle school and two to primary level climate change education from a student perspective. Three discussed informal climate education, three examined climate change as a part of geography education, and one looked at climate considerations in software education. This left 15 papers that focused on teachers and climate change education.

Once we had constructed the spreadsheet with all the categories we moved to a more in-depth stage of the analysis, scrutinising full-texts and updating the spreadsheet to include further relevant information; publication type, date, type of activity, target population, age range of participants, and aims and characteristic of the study in each citation. Crucially, this stage also enabled us to identify whether, and to what extent, the papers discussed the sources of information about climate change that teachers accessed. If any study on closer inspection did not meet the inclusion criteria (Table 1), it was excluded from the scoping review.

Independently, we then extracted the relevant characteristics of each full-text article to develop analytical themes in the literature. We then came together to discuss and agree the following themes which helped in describing and understanding the landscape of this literature: student perceptions; teaching approaches; focus on different phases; sources of information; explanation.

## Findings

The 52 papers found in the literature search discussing teachers and climate change education or resources (37 from BEI and 15 from Google Scholar) contained varying levels of attention to teachers and climate change. Nineteen of the papers contained no discussion of the sources of information about climate change used by teachers. Eighteen contained only a tangential, passing mention of teachers' sources of climate change information. The two resources-focused papers analysed textbooks and educational texts, but not in relation

to teachers' choices about or uses of them. This left 13 (12 articles and one book) that gave some direct attention to the sources of information about climate change that teachers use. The most explicit attention to sources of information in a research question was found in McNeal et al. (2017, p. 1076): 'Where do you get your climate change knowledge and how do you stay current on climate change science?'. The 13 included studies are summarised in Table 2.

<b>(Number) Author</b>	<b>(Year) Location</b>	<b>Study design, methods and sample</b>	<b>Main focus, and attention given to sources of information about climate change used by teachers</b>
(1) Kunkle and Monroe	(2019) USA	Online quantitative survey, with recruitment of 251 participants through seven science educator listservs (for educators interested in climate change) in five South Eastern U.S. states.	Investigation of the impact of 'cultural cognition' (or worldview) on educators' opinions about climate change education. The survey provides insight into teachers' worldviews and suggests that these beliefs significantly influence their teaching about climate change. Sources of information are discussed at a general level in terms of their relative positions within broad worldview level framings.
(2) Sezen-Barrie et al.	(2019) USA	Online survey with open responses for participants to write their arguments (counter-claim; evidence; reasoning) with 24 participants: K-12 teachers in Maryland and Delaware.	Focuses on the ways in which teachers respond to 10 common denial theories about anthropogenic climate change. Their intertextual discourse analysis reviews the epistemic quality of arguments, including reference to the sources of information that teachers use. Summarises sources of information that teachers use (p.855).
(3) Clausen	(2018) Denmark	Case studies of four Danish geography teachers in the lower-secondary school, including videoed classroom observations and semi-structured interviews.	This study explores the pedagogical content knowledge (PCK) of Danish geography teachers in the context of teaching weather formation and climate change. The focus is on pedagogical strategies used with students, with the sources of information informing these strategies being occasionally touched in the course of questions and observations about PCK.
(4) Drewes et al.	(2018) USA	A mixed-methods instrumental case study of one teacher participating in a professional development programme, including: participant observation; journaling of reflections; documentary analysis of lesson plans; lesson observation.	Centred around a professional development programme (the 'Climate Change Academy'), this study asks how concepts 'travel' or are 'mobilized' in different contexts. The case teacher is followed from the professional development to their classroom, showing the ways in which they adapted their local curriculum using new knowledge about climate change, with some of the sources of information used in this being mentioned.
(5) Higde et al.	(2017) Turkey	Quantitative survey of 1277 pre-service science teachers from 12 Turkish universities.	Asking how Turkish pre-service science teachers engage with climate change, and the relationships between their uncertainty beliefs, values, and behaviours. Questions on the popularity of different sources are presented at general levels (such as: television, newspaper, Internet), and the relationships between reported use of different sources and uncertainty beliefs (and others) are analysed.
(6) McNeal et al.	(2017) USA	Phenomenological design using online focus groups (each meeting once) with middle-school science teachers currently teaching climate change in different states.	Purposely including teachers who have chosen to teach climate change, this study explores the motivations of 1277 pre-service science teachers. Includes the most explicit attention to sources of information through their second research question: 'Where do you get your climate change knowledge and how do you stay current on climate change science?' (p.1076).

(7) Seow and Ho	(2016) Singapore	Semi-structured interviews with six current and four pre-service geography teachers.	This study explores how teachers' decisions about climate change teaching, and their beliefs about student readiness to handle controversy within climate change education. The paper discusses sources of information particularly in relation to prescribed textbooks in Singapore for teaching about climate change, and teachers' reported decisions about some sources of information in relation to their beliefs about the purpose of climate change education.
(8) Chang	(2014) Singapore	Series of focus group discussions with (across all focus groups) 40 teachers.	Part of a book-length discussion of climate change education, this particular study was designed to highlight the 'problem areas' of teachers' knowledge about climate change in order to shape professional development. Sources of information are potentially addressed in one of the focus group prompt questions: 'where can you get information/resource you need if you want to teach climate change to your students?'
(9) Iordanou and Constantinou	(2014) Cyprus	Experimental study of 66 Science Education undergraduates, plus a control group. Participants' argumentation skills were assessed through individual writing, and a paired online dialogic argument exercise.	Designed to develop pre-service teachers' evidence-based argumentation skills on the topic of climate change, an Online Learning Environment was created for the study to provide information directly to the pre-service teachers. The analysis focuses on the pre-service teachers' argumentation, and the data generated also gives some insight into their use of these pre-selected sources of information.
(10) Ratinen	(2013) Finland	Questionnaires (open-ended and closed-form) with three groups of pre-service primary teachers (n=275).	Building on critical accounts of primary student-teachers' misconceptions around complex scientific phenomena, this study surveys primary student-teachers' conceptual understanding of the greenhouse effect. Attention is given to sources of information through questions asking where participants learnt about the greenhouse effect.
(11) Johnson	(2011) USA	Surveys conducted by the National Earth Science Teachers Association (n=915).	Presented as workshop paper for a professional body, this study aims to provide an overview of a broad range of issues, including; teacher preparation, professional development, understanding, use of resources, barriers and challenges to climate change teaching, and misconceptions. A small number of survey questions address sources of information, such as: 'Do you feel inundated by information on CC?', and 'How do you like to learn about CC?'.
(12) Wise	(2010) USA	Online survey of Colorado public school science teachers (n=628), combined with qualitative semi-structured interviews with 22 elementary and secondary science teachers	Drawn from a wider survey on 'Teaching About Publicly Controversial Science', including climate change and evolution, this study analysed Earth science teachers' responses to climate change questions, focusing on their general beliefs about climate change education and their pedagogical approaches. Teachers' reports on how they learnt about climate change provides some commentary on the sources of information they have used.
(13) Michail et al.	(2007) Greece	Closed form questionnaire completed by 155 practicing primary school teachers from the urban area of Thessaloniki (Greece).	This study explores primary teachers' knowledge of environmental issues, and their 'images of nature', based on the premise that teachers' own environmental education will strongly affect their teaching of these issues. Asking questions of the sources teachers consult for environmental information offers, at a general level, data relevant to the sources of information about climate change that teachers might use.

Table 2. Included studies

## What sources of information about climate change are teachers using?

None of the papers in this scoping review (Table 2) explored sources of information about climate change in a comprehensive or focussed way. Instead, they provide insights into the sources of information used by teachers either as a sub-set or by-product of their primary areas of interest. Existing accounts predominantly tell us what sources of information about climate change teachers have reported using, and there may be differences between these reports and the actual sources of information they use. Four types of sources were frequently mentioned: the internet; government sources; mass media; and professional development courses. These common areas are discussed further below. Across them, one consistent finding was that all teachers reported using multiple sources of information, and in addition to the four main sources, the wider range included: other teachers; textbooks; teachers' own education and research experience; collaboration with scientists; IPCC (Intergovernmental Panel on Climate Change) reports; journals; and documentaries (such as *An Inconvenient Truth*).

### The internet

Studies from 2010 onwards found the internet reported as the main source of information about climate change that teachers use (Higde et al., 2017; Iordanou & Constantinou, 2014; Johnson, 2011; McNeal et al., 2017; Sezen-Barrie et al., 2019; Wise, 2010). The one earlier study (Michail et al., 2007) provides a striking contrast, finding the internet to be the least used source of environmental information. Of their 150 participants, 46 never or almost never used the internet as a source of environmental information, and only seven out of the 150 used it 'very often'. This finding seems to illustrate the rapid changes in the ways in which we search for information. One further exception to this well-supported finding about the high use of the internet as a source of information from more recent research came from Ratinen's (2013) study. However, this seems to have been caused by their methodological choices: using a similar approach to Johnson's (2011) predetermined list for participants to select from, Ratinen omitted the internet and so it was not available to participants as a possibility.

Over 85% of teachers in Johnson's (2011) study expressed having no difficulties finding good climate change education resources online. However, teachers' views, particularly ideas expressed about teaching 'both sides' of anthropogenic climate change, leads Johnson to question the quality of this information. Making a similar point, Sezen-Barrie et al. (2019) note that those who argued against denial theories of climate change mainly used government agency sources of information, whereas, those who agreed with denial theories cited online sources of information.

#### Government / official sources

Where studies asked explicitly about the use of government agency sources of information, these were highly cited. These included resources from the: NOAA (National Oceanographic and Atmospheric Administration), NASA (National Aeronautics and Space Administration), USGS (United States Geological Survey), and National Geographic. Iordanou and Constantinou (2014) developed an Online Learning Environment through which teachers are guided to specific sources of information, including: Wikipedia entries showing atmospheric CO2 levels; and surface temperature data from the National Academy of Sciences. Sezen-Barrie et al. (2019) contrast the teachers' infrequent use of textbooks as a source of information against their frequent use of Government agencies/NGOs (including; NASA, NOAA, USGS). The Singaporean studies (Seow & Ho, 2016; Chang, 2014) provides a counter-example on textbook use, finding that 'teachers base their teaching on textbooks that are at most five years old' (Chang, 2014, p.88), illustrated by the teacher who 'reported that she would largely use the material in the school textbook because those were more clearly in support of climate change as a serious issue' (p.364).

#### Mass media

Mass media was used as a very broad category, including newspapers, magazines, television (and sometimes also the internet), and was consistently cited as a major source of information about climate change used by teachers. This very broad category illustrates the relative inattention that has been given in these accounts to questions about the sources of information that teachers are using. Sezen-Barrie et al. (2019) use a similar category (news), but with specific reference to the teachers' reports of accessing CNN and Scientific American. Their inclusion of these specific sources seems to portray a more positive angle,



whereas, most were critical of mass media. For example, Michail et al. (2007) argue that by 'using the media as major environmental information sources, in which environmental issues are constructed as environmental risks, teachers are being environmentally educated in lay and not in scientific terms' (p.244). Knowledge about climate change is important for enabling teachers to critically engage with popular narratives constructed through sources of information (Higde et al., 2017).

#### Professional development courses

In contrast to the specific sources of information above (the internet, government / official sources, mass media), professional development courses provide a more structured, formal source that also acts as a source of further sources. Often run by professional associations (McNeal et al., 2017), they included workshops and other relatively short opportunities (Johnson, 2011), through to a week-long residential and online follow-up 'Climate Academy' programme explored by Drewes et al. (2018). Their very specific example analyses a single case study teacher ('Emma'). The sources of information about climate change accessed by Emma are curated and presented by climate scientists, and include proxy data (ice cores, tree rings) and practical, observational sources of information. In-person, contextually-specific professional development opportunities seems to be widely supported (Chang, 2014).

#### In what ways are teachers using these sources of information?

The lack of focussed attention to analysing the sources of information that teachers use means that there is also limited evidence about the ways in which these sources were used. Teachers were described as being 'gatekeepers of information' (Kunkle & Monroe, 2019, p. 634), playing an important role in the curation of information (Clausen, 2018; Sezen-Barrie et al., 2019) to 'mobilize' climate change concepts in situated, context-dependent ways (Drewes et al., 2018; Iordanou & Constantinou, 2014). Knowledge, expertise, and confidence for teaching about climate change are closely related (McNeal et al., 2017), with teachers' subject expertise supporting their reported selections of online information. For example, as one teacher states: 'I have a science background so I can usually pick out the junk from the internet...' (McNeal et al., 2017, p. 1075). More broadly, teachers' beliefs about the purposes of climate change education (Clausen, 2018; Seow & Ho, 2016) and their

worldview commitments (Kunkle & Monroe, 2019) seem to play an important role in determining how they use different sources of information.

These studies also suggest that teachers were not just curators of information, but were themselves also changed by it: believing, feeling, teaching, and acting differently because of the information they saw and heard. Interesting informal examples were reported, such as family members sharing sources of information that led the teachers to: enhance existing lessons; reconsider their position; and limit their teaching of anthropogenic climate change to incorporate 'both sides' (Wise, 2010). Changes in pre-service teachers' attitudes and behaviours were also found in response to mass media narratives and portrayals, and those with weaker subject knowledge and less certainty over environmental issues were affected most (Higde et al., 2017). There are glimpses of the processes through which information might be acted on, stored, processed, disseminated and transformed (Floridi, 2016), but the papers in this review give only hints into what this might involve for climate change education.

## Discussion

Our main research question was: What do we know about the sources of information about climate change that teachers use? Under this, we have asked two sub-questions: What sources of information about climate change are teachers using? In what ways are teachers using these sources of information? The responses that we have generated through this scoping review to the sub-questions offer some insight into the sources of information that teachers are using, and the ways in which they are using them. However, the limited attention that we have found to have been given to sources of information about climate change makes this the most significant finding. Therefore, in this discussion we focus our attention on our main question, raising critical questions about the geographic scope and methodological narrowness of existing studies.

Through our extensive searches across the BEI and Google Scholar, using very inclusive search terms and detailed analysis of papers, we found only 13 articles of relevance.

Therefore, this scoping review suggests that very little research attention has been given to understanding what sources of information about climate change teachers use, or the ways in which these sources of information are used. We found explicit support for this broad claim about a relative lack of empirical attention to teachers' knowledge work and understandings of climate change. In Sezen-Barrie et al.'s (2019, p. 847) terms: "Although there are many theoretical and empirical research studies on what and how students should learn about climate change science...there remains a dearth of studies on in-service teachers' understanding of climate science topics." Who 'we' refers to in our overarching research question is restricted by the exclusion of studies that are not published in English language, but even within this grouping there is a narrow representation of regions studied. There is no attention to countries in the Global South, and nearly half of the papers (six) are based in the USA. Expanding scholarly understandings beyond an Anglo-American dominance (Müller, 2021), rapid population increase and projected trajectories of carbon emissions (Dubah et al., 2018) make CCE in the Global South an urgent global concern. Two are based in Singapore, and each of the other papers are from different countries; Cyprus, Denmark, Finland, Greece, Turkey. The particular skew of these studies adds an additional dimension to our claim about the relative lack of empirical attention to these questions: there is also a relative lack of geographical spread and diversity in the scope of existing accounts. The context of the USA is distinct globally due to the polarisation of public discourse on climate change (Kunkle & Monroe, 2019) that seems to be less common elsewhere (Wang, Corner, & Nicholls, 2020). The US polarisation is illustrated by the difficulties teachers report, such as: 'individuals challenging [teachers] about teaching this science, including threatening behaviour, and occasionally guidance from school administrators to not teach about climate change' (Johnson, 2011, p. 10). Nearly 50% of teachers in Johnson's sample believe they should teach 'both sides' of climate change - a finding strongly supported elsewhere (Wise, 2010) – which, for Johnson, highlights the urgency of finding 'a way to provide accurate, up-to-date information on climate change (and the actual data behind the evidence) to teachers...' (p.14).

As well as the studies being limited in terms of their geographical location, many share a similar methodological design: eleven of the studies explore teachers' reports of the issues through a survey, focus group or interview. Two of these (Higde et al., 2017; Michail et al.,

2007) used only closed questions, and four (Johnson, 2011; Kunkle and Monroe; Ratinen, 2013; Sezen-Barrie, 2019) were predominantly closed. Seow and Ho's (2016) semi-structured interviews, Chang's (2014) in-person focus groups and McNeal et al.'s (2017) online focus groups all used open questions. Wise (2010) used both closed surveys and open semi-structured interviews, and Iordanou and Constantinou (2014) evaluated participants' argumentation through mainly open questions on their pre- and post- intervention surveys. These approaches all give insight into teachers' reports, having potential for indicating what sources of information teachers might be using (although this was rarely a focus). In one example of an explicit question asking about sources of information, Johnson (2011) asked teachers to indicate if they had used resources from a list of organisations. This gives an initial overview of the sources of information teachers report using, but does not differentiate between those who have accessed them once and those who regularly use them. The disconnect between teachers' reported confidence with teaching about climate change and the apparent misconceptions they hold (Johnson, 2011; Wise, 2010) also raises questions about the extent to which the sources may actually have been engaged with.

Moving beyond teachers' reports alone to understand how teachers are using sources of information requires more observational and exploratory methodological approaches. Two papers report multi-method case-studies (Clausen, 2018; Drewes et al., 2018): the only papers to include observations. Therefore, nearly all of what we know about the sources of information about climate change that teachers use is drawn from teachers' own reports. There has been very little observational or other methodological attention generating different types of evidence. The contested nature of knowledge, the particular normative relationship between information and knowledge described above, and the power of metaphors (Castree, 2020) and narratives (Mathur, 2017) around the concept of climate change add to the importance of giving significant research attention to what sources teachers are using and how they are using these sources. The particularity of these existing approaches make broader understandings about teachers' knowledge work and more expansive conceptions of the processes and forms through which this information might be engaged with (Archibald, Lee-Morgan, & De Santolo, 2019), for example as illustrated in Figure 1, urgent tasks for research.

## Conclusions

The findings from this scoping review suggest that limited attention has been given to the sources of information about climate change that teachers use. Given the wide agreement on the importance of high-quality climate change education, and the necessity of high-quality information, this is a significant area in need of research attention. Our review also found a relative lack of geographical spread and diversity in the scope of existing accounts, which is particularly significant because of the global nature of online sources of information. The processes that teachers are connected to and engaging with through their accessing, transforming, and sharing of information are global processes. Analysis of only certain sets of teachers in one broad part of this space (the Global North), and within this a more specific focus on one country (the USA), diminishes the possible scope, breadth and richness of insights that might be possible through more international analyses.

Our argument for the importance of information, and the sources of information about climate change in particular, suggest that existing attention to knowledge and action should be balanced and underpinned by greater attention to sources of information. There are implications of this greater attention for research and teaching. Research might analyse not only teachers' reports on the sources of information they use (although studies explicitly focusing on this as their main point of concern also have the potential to make a significant contribution to our understandings), but, through further observational and other methods, also give insights into their practice. Analysis of the space-times of teachers' knowledge work in curriculum making, particularly enacted online through multiple platforms, would help us to understand the ways in which they navigate increasingly sophisticated algorithms and highly personalised digital spaces to construct their understandings of these issues and to curate sources of information to be stored, processed, transformed, shared, and presented to students. Understanding more about teachers' enactments of these processes would provide teacher educators, policy makers, and also climate scientists with more insight into the ways in which teachers might be better supported to: access and use high-quality sources of information; critically engage with mass media portrayals; and teach students well about the vital issue of climate change so that they might positively engage

with climate change and critically handle the information that is, and will be, presented to them through increasingly powerful and personalised online spaces.

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