



Between evidence and delusion – a scoping review of cognitive biases in Environmental and Sustainability Education

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ABSTRACT

Exposing learners to sustainability-related topics can present affective–motivational challenges for learners, which may prompt cognitive bias. Cognitive bias directly influences how individuals perceive and process sustainability-related information, thereby also influencing sustainability-related behaviour and decision-making. Therefore, cognitive bias may also present a significant obstacle to the purposes of Environmental and Sustainability Education. Notwithstanding its potential relevance, there is no comprehensive understanding of how cognitive bias is currently addressed in Environmental and Sustainability Education. This review scopes scientific literature that addresses cognitive bias in Environmental and Sustainability education, based on SCOPUS, Web of Science and ERIC. We identified 21 articles that matched our search criteria. We identified four superordinate categories of cognitive bias that were addressed in the literature, including bounded rationality, confirmation bias, self-enhancement and ambiguity aversion. Moreover, we distinguished three perspectives from which cognitive bias is discussed in the literature: (i) education to mitigate bias associated with sustainability-related matters, (ii) bias as a barrier to Environmental and Sustainability Education and (iii) bias at the research-paradigm level. The list of identified biases provides evidence that cognitive bias may play an important role in Environmental and Sustainability Education scholarship and practices, which suggests that more research on this topic is needed.

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1. Introduction

Extensive scientific evidence now indicates the worrisome consequences of transgressing planetary boundaries caused by human activity, manifested, for example, in climate change, biodiversity loss, or disturbed biogeochemical cycles (Alvaredo et al. 2017; IPBES 2019; IPCC 2023; Richardson et al. 2023). These crises do not only jeopardise the stability of ecosystems and the services they provide, they also pose imminent threats to global food security, human health and socio-economic stability, and amplify inequalities and exacerbate vulnerabilities, particularly in marginalised communities (IPCC 2023; Oxfam 2023). Despite extensive knowledge on these risks, there has been

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a glaring lack of significant change in our decision-making and behaviour to safeguard natural resources and ensure human existence in a safe operating space (Wiedmann et al. 2020; IPCC 2023; Richardson et al. 2023). More than ever before, humankind is in need of adequate means to address the sustainability-related problems that threaten current and future generations.

An important obstacle to finding and implementing such means lies in the complexity of sustainability-related problems (Patt and Weber 2013). These have been described as ‘wicked problems’: They carry a high level of societal risk, yet they are difficult to solve, because of incomplete or contradictory knowledge, the number of people and opinions involved, the large economic outlay needed to solve them, and their interconnectedness with other problems (Incropera 2015).

Research has repeatedly shown that being exposed to sustainability-related problems may prompt strong affective–motivational reactions in individuals (e.g. Ojala et al. 2021; Korteling et al. 2023; Ojala 2023; Voški et al. 2023). Among other reasons, this is because (1) they confront individuals with their own unsustainable behaviour, which may cause feelings of guilt or shame (Verlie 2019; Frank 2021; Fredericks 2021), (2) the sheer extent of the threat posed by these problems and individuals’ minimal capacity to change them may be emotionally stressful and even overwhelming (Verlie 2019; Ojala et al. 2021; Ojala 2023; Voški et al. 2023), and (3) they are highly complex and uncertain, which conflicts with our psychological need for control and orientation (Grund and Brock 2019; Mälkki and Raami 2019; Korteling et al. 2023). What these affective–motivational challenges have in common is that they risk prompting cognitive bias.

The concept of cognitive bias has been a focus in psychology and education for decades (Klayman 1995; Hilbert 2012). Cognitive bias may have been defined as systematic, universally occurring tendencies, inclinations or dispositions of human judgment and decision-making that may make it vulnerable to inaccurate, suboptimal or incorrect conclusion, especially in uncertain situations (Tversky and Kahneman 1974; Kahneman 2011; Korteling et al. 2023). Other, often intertwined, factors that have been seen as potential contributors to cognitive bias include emotions, individual motivation, cognitive limitations and social pressure (e.g. Kahneman 2011). Throughout recent decades, scholars have identified and defined a plethora of specific biases. For example, Wikipedia’s ‘List of cognitive biases’ now includes more than 200 biases (Wikipedia 2023), such as confirmation bias (i.e. the human tendency to search for, interpret and remember information in such a way that it confirms one’s beliefs or values, Nickerson 1998), the illusion of understanding (i.e. people’s tendency to overestimate the extent or depth of their understanding of a matter, Kahneman 2011) and rationalisation (a process in which people give rational reasons for their behaviour while hiding other unreasonable reasons, Fischer et al. 2013).

Cognitive bias has recently received some attention among sustainability researchers, too. In view of their high potential for triggering strong affective–motivational reactions, scholars have reasoned that cognitive bias may also affect sustainability-related knowledge acquisition, judgment and decision-making (e.g. Edenhofer et al. 2014; Engler et al. 2019; Korteling et al. 2023). For example, Zaval and Cornwell (2016) suggest that bias in judgment prevents rational thinking about climate change, which, in turn, could explain the knowledge–behaviour gap, that is, society’s knowledge of sustainability problems and its frequent failure to address them. Engler and colleagues (2019), Mälkki (2010), Mälkki and Rami (2019), and Grund and Brock (2019) have argued that people are prone to confirmation bias with regard to sustainability-related topics. In consequence, they tend to consult information that protects them from unpleasant emotions and avoid information that confronts them with the actual sustainability crisis. In turn, this tendency may yield a distorted perception of sustainability-related information (Engler et al. 2019) or even a complete denial of the existence and risks of current unsustainability (Groves 2019). Group membership may further contribute to these proclivities, and even lead to increased social polarisation (Engler et al. 2019; Sörqvist and Langeborg 2019; Long et al. 2022). As a consequence, discourse on sustainability-related problems becomes increasingly ‘marked by “framing contexts” that oversimplify the problems and recast them in more emotional and value-laden terms’ (Head 2019, 186),

and characterised by polarisation and conflict. For questions of communication, participation and education related to sustainability, these tendencies present massive challenges to finding urgently-needed solutions to the sustainability-related problems that humankind faces.

Environmental and Sustainability Education (ESE) – here understood as an umbrella term for various educational practices and traditions related to (facets of) sustainability (e.g. environmental education, Education for Sustainable Development, Sustainability Education) (Wals et al. 2017) – has consistently been considered key to changing the current situation (Reid et al. 2021). It seeks to impact learners' values, mindsets and paradigms, stimulates the acquisition of the knowledge and skills needed to become involved in sustainability-related learning and action, and aims to develop learners' self-determination, and by extension, a sense of agency with regard to sustainable development (Wals 2012). It has been argued that a main goal of ESE is to prepare learners to face the 'wicked' aspect that characterises sustainability-related problems (e.g. Barth et al. 2007). This is also where cognitive bias becomes a major concern for ESE.

Cognitive bias is highly relevant to the purposes of ESE. On the one hand, insofar as ESE aims to enable learners to make self-determined and 'informed decisions and take individual and collective action to change our societies and care for the planet' (UN 2015), mitigating bias should be one of the central learning outcomes of ESE learning practices. On the other hand, complex, sustainability-related problems and their 'wicked' character are at the centre of ESE-related learning, especially learning in higher education, which prepares individuals for their future professional life (Lozano et al. 2017; Reimers 2021). Although exposing learners to these problems is meant to stimulate corresponding skills, they may equally present learners with affective–motivational challenges, and thereby prompt biased reasoning, which risks undermining the very purpose of ESE to enable learners to constructively face sustainability-related problems (Mälkki 2010; Ojala 2016; Grund and Brock 2019; Verlie 2019; Frank 2021).

Despite the relevance of cognitive bias to ESE outlined above, little research has been explicitly dedicated to cognitive bias in ESE. Although emotions are receiving growing attention in ESE scholarship and practice (Ojala 2016, 2023; Frank and Stanszus 2019; Grund and Brock 2019; Verlie 2019; Frank 2021; Ojala et al. 2021; Grund et al. 2023), this is not necessarily linked to the question of how emotions influence knowledge acquisition, judgment and decision-making in ESE. Thus, to our knowledge, there is no comprehensive understanding of how (various kinds of) cognitive bias are thought to affect sustainability-related learning, let alone how ESE learning activities, specifically, might address (various kinds of) cognitive bias as a precondition for engaging with complex, sustainability-related problems and performing actions that are consistent with the vision of a sustainable future. As explained above, such an understanding is necessary if ESE scholars and practitioners do not want to risk undermining the very purpose of their educational practices and instead make sure to adequately prepare learners to avoid bias when engaging with sustainability-related topics.

Our article aims to contribute to a better understanding of how cognitive bias is currently addressed in ESE scholarship and practice. For this purpose, we carried out a scoping review that analysed published scholarly literature on the relationship between cognitive bias and ESE. The article is organised as follows: first, we outline the methodological approach and the specific research questions that guide our review; second, we provide the results of our study; third, we discuss our findings; fourth, we identify the (mainly methodical) limitations of our work; fifth, we present our conclusions based on the insight gained from our study.

2. Materials and methods

2.1. Scoping review

Munn et al. (2018) defined a scoping review as an independent scientific method that aims to review a body of literature to identify knowledge gaps, clarify concepts, investigate research

activity, or inform a systematic review. Thus, its overarching purpose is to determine ‘the coverage of a body of literature on a given topic and give a clear indication of the volume of literature and studies available as well as an overview (broad or detailed) of its focus’ (Munn et al. 2018, 2). Armstrong et al. (2011) note that scoping reviews are especially useful if the current understanding of a field does not yet allow for posing more specific questions. As Gutierrez-Bucheli and colleagues (2022) have argued, a scoping review has specific qualities that particularly help us understand bodies of knowledge in the ESE field. For example, educational practice – in contrast to clinical interventions often founding the basis of systematic literature reviews – are often more context-dependent and can be influenced by a variety of factors not directly related to the intervention (Gutierrez-Bucheli, Reid, and Kidman 2022). As the aim of this review is to understand how ESE and cognitive bias are connected in the current literature more broadly, without limiting the research question to a specific effect, research design or approach, a scoping review is an appropriate method for our study.

Although the procedure of a scoping review is not as rigorous as that of a systematic review, nevertheless it must follow some protocol to draw reproducible conclusions, particularly during the process of literature selection (Munn et al. 2018). The guideline followed in this work is set out in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (Page et al. 2021).

2.2. Sampling strategy

To find relevant scientific literature for this scoping literature review, we conducted a database search for titles, abstracts and keywords on Web of Science, SCOPUS and ERIC (Education Resources Information Center) (collection date: 15 January 2023). We chose Web of Science (WoS) and SCOPUS because they are two of the largest and most comprehensive databases for scientific peer-reviewed literature, and many literature reviews rely on these databases (Paul and Criado 2020). ERIC is known as one of the most substantial databases for educational research.

The search string included terms that refer to the concept of cognitive bias in ESE (Table 1). Given the variety of terms used in the literature to specify educational practice (e.g. environmental education, sustainability education, Education for Sustainable Development, climate change education), the search string was formulated in such a way that it included various practices that may be subsumed under the umbrella concept of ESE. As mentioned previously, scholarly work on specific biases has been significantly extended in recent years. Consequently, one cannot assume that authors necessarily use the superordinate term ‘cognitive bias’ or its synonyms (e.g. cognitive distortion) when referring to a specific bias. Therefore, we used a summary chapter on cognitive bias by Pronin et al. (2002) as starting point for choosing the keywords. As our first step, we included seven different terms used for cognitive bias, plus 24

Table 1. Keywords for database search.

Concept	Context
Cognitive bias	Education
Percept × bias	
Information-processing bias	Descriptor: ‘Environmental Education’
Attention bias	
Confirmation bias	
Reactance	
Attribution × bias	
Fundamental attribution error	
False consensus effect	
Cognitive dissonance	
Descriptor: ‘Schemata (Cognition)’	
(Only applicable in ERIC database)	

Note: After the first application, 22 terms were excluded from the list of cognitive biases.

specific biases described by Pronin et al. (2002). After applying our search strategy, we reduced the keywords to a manageable number by excluding those terms that did not lead to additional entries, resulting in three primary terms (i.e. cognitive bias, percept* bias, information-processing bias) and six more specific biases (see Table 1; cf. Appendix A for an overview of excluded terms). We also included the term ‘cognitive dissonance’, even though this term does not describe a cognitive bias (this would be certain kinds of dissonance reduction), but the state that precedes dissonance reduction (Festinger 1957). Finally, we included a so-called descriptor variable, which is used in ERIC to find records associated with specific subject headings that describe the subject matter of a journal article or document (ERIC n.d.a). The descriptor, ‘Schemata (Cognition)’, is part of the ‘Learning and Perception’ category, which is defined as ‘mental images and concepts that provide a cognitive framework by which the individual perceives, understands, and responds to stimuli’ (ERIC n.d.b) and thus refers to cognitive psychological processes that underlie cognitive bias. Using descriptors enables researchers to find articles that do not use the exact wording of the keywords in the search string, while detrimentally producing more results that do not fit the question under investigation. The full search strings may be found in Appendix A.

Since the aim of this review is to scope existing literature that addresses the general relationship between cognitive bias and ESE, we decided to include both empirical and theoretical articles, as long as they were published in peer-reviewed journals. Furthermore, we defined the following terms, to specify content-related eligibility criteria (Table 2): education, environment/environmental, sustainable and cognitive bias. We included only papers published in English.

2.3. Selection of studies

The selection process was executed using PRISMA 2020 guidance (Page et al. 2021), and is depicted in Figure 1. First, we removed duplicates and records that were not peer-reviewed, which yielded 129 records. The titles and abstracts of these records were screened according to the predefined inclusion criteria described in Table 2. We excluded 66 records because they did not meet at least one of the eligibility criteria, leading to 63 full-text articles. Three of these 61 articles could not be obtained, and another was not written in English, resulting in 57 full articles. At that stage, we excluded 38 articles. Eighteen papers were excluded because they were not about cognitive bias but other cognitive processes. Eleven articles were not considered because they were about cognitive dissonance as a state, and not about reducing this state, resulting in bias. Nine studies were excluded because the environmental education context was absent. Finally, 21 papers were eligible for inclusion in this scoping review.

Table 2. Eligibility criteria.

Criteria	Description
Education Environment/Environmental	Articles were included if they explicitly used the term ‘education’ Articles that referred to environment/environmental as ‘the natural world in which people, animals and plants live [...]’ were included (Oxford University Press, n.d.a). We have not considered articles in which the term is used in the sense of (physical) conditions affecting a subject, or the structure within which a user, computer or program operates.
Sustainable	Studies were included when the term ‘sustainable’ was used to describe ‘the use of natural products and energy in a way that does not harm the environment’, but not if it was used only to refer to something that ‘can be continued for a long time’ (e.g. ‘The company acts in a financially sustainable way’) (Oxford University Press, n.d.b).
Cognitive bias	We included papers that explicitly or implicitly referred to some kind of cognitive bias (e.g. ‘[...] people, even in light of contradictory information, tend to hold on to conceptions that flow out of their own experiences’ (Wals 1992).

Note: After the first application, 22 terms were excluded from the list of cognitive biases.

2.4. Data analysis

The final set of articles was analysed with regard to the following eight questions:

1. When was the article published?
2. Which journal was the article published in?
3. Which research discipline(s) is the article assigned to?
4. Was the article empirical or theoretical?
5. What research design was applied?
6. What is the target group studied in the article?

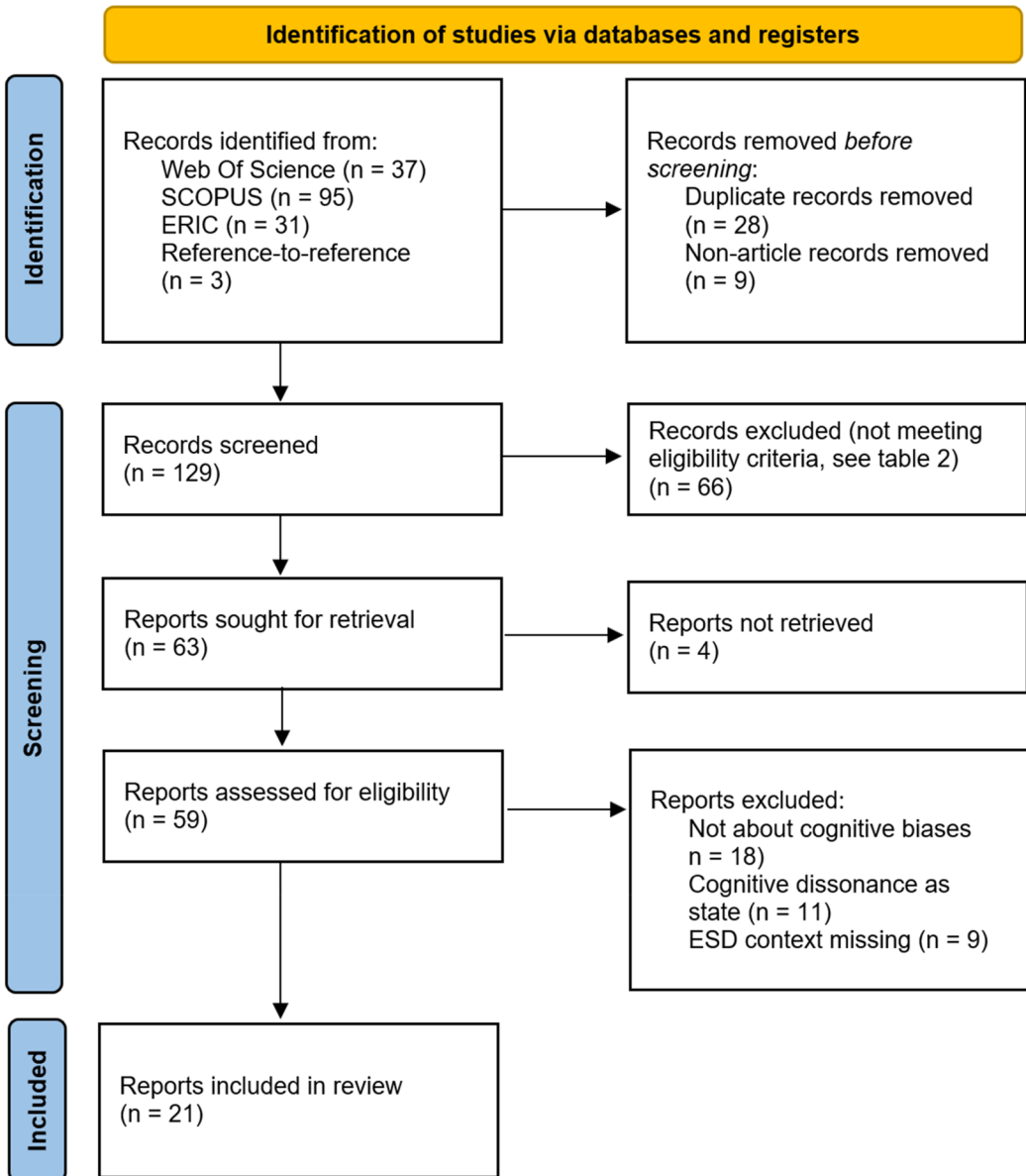


Figure 1. Article-selection process based on PRISMA 2020.

7. Which cognitive biases are addressed?
8. What connections were drawn between cognitive bias and ESE?

We retrieved the articles' metadata (i.e. year of publication, journal, research discipline(s) and country) directly from the database. We identified each article's research focus, type of article, methods, population and perspective by screening it.

To answer research question 7, we extracted all text passages that addressed cognitive bias, both explicitly and implicitly (i.e. describing a bias without naming it). Based on the resulting text corpus, we subsumed the addressed biases under superordinate terms to develop a framework that synthesized the various terminologies and fragmented concepts used in the literature.

For research question 8, we extracted all passages that provided information about how cognitive bias was specifically construed with regard to ESE. We followed the principles of thematic analysis (Braun and Clarke 2006) to inductively generate latent codes that would capture the specific approach to cognitive bias in ESE scholarship and practice. Through an iterative process of developing, discussing and refining codes, three main themes emerged from the literature that described the way cognitive bias was approached in ESE.

3. Results

Table 3 provides an overview of the selected articles. Before, we analyzed the main research questions of how and to what extent cognitive bias and ESE are linked, we conducted a general trend analysis of the papers included in the review.

3.1. Publication year, journals and research disciplines

Research on cognitive bias and ESE dates back to the early 1990s (Figure 2). Remarkably, after this early interest in the topic, until 2012 related research activities did not pick up again. Except for Fritsche's (2020), all articles were published in journals that explicitly covered environmental and sustainability topics ($n=7$), education/educational psychology ($n=5$) or a combination of both ($n=8$). This trend was also reflected in the journals' disciplines (Table 4). Except for Sinatra et al. (2014), whose study was assigned to psychology, and Fritsche (2020), whose study was assigned to Urban Studies, all research papers are assigned to Education ($n=13$) or Environmental Science ($n=12$) (journals could be assigned to more than one field).

3.2. Type of article, research design and perspective

As illustrated in Table 3, the sample consisted of 13 empirical studies and 8 theoretical papers. Most empirical papers ($n=8$) followed a quantitative research design (4 survey studies, 2 experimental studies, 1 intervention study). Four studies were conducted qualitatively, and one study applied mixed methods.

Table 5 shows a diversity of study populations in the empirical articles, which ranged from primary school children to university students, to teachers and employees, to mixed populations and exclusively adult cohorts. Most empirical studies focused on students, with university students being the most frequently addressed population. The role of cognitive bias among in-service teachers was rarely studied (study 5, 12). Three studies (8, 9, 20) did not focus on a specific population.

As Table 6 shows, most articles ($n=16$) look at cognitive bias from a student or learner perspective (that is, a predefined target group that is supposed to be addressed or instructed). Three articles consider cognitive bias among current or future educators. In their theoretical

Table 3. Studies included in this review.

No.	Year	Authors	Journal	Type of article
1	1991	Bardwell, L.	The Journal of Environmental Education	Theoretical
2	1992	Wals, A.E.-J.	Australian Journal of Environmental Education	Empirical
3	1994	Robertson, A.	The Journal of Environmental Education	Theoretical
4	2012	Hovardas, T. and Korfiatis, K.	Environment and Behaviour	Empirical
5	2013	Cincera, J.	Journal of Teacher Education for Sustainability	Empirical
6	2014	Nitsch, U.	Journal of Agricultural and Environmental Ethics	Theoretical
7	2014	Sinatra, G. M., Kienhues, D., and Hofer, B. K.	Educational Psychologist	Theoretical
8	2015	Hansmann, R. and Steimer, N.	Sustainability	Empirical
9	2017	Hansmann, R. and Steimer, N.	Environmental Research, Engineering and Management	Empirical
10	2017	Smith, G.	Schools: Studies in Education	Theoretical
11	2017	Zaval, L. and Cornwell, J. F. M.	European Journal of Education	Theoretical
12	2018	Kunkle, K. A. and Monroe, M. C.	Environmental Education Research	Empirical
13	2019	Carmi, N. and Alkahr, I.	Sustainability	Empirical
14	2019	Charry, K. and Parguel, B.	Environmental Education Research	Empirical
15	2019	Hess, D. J. and Maki, A.	Journal of Cleaner Production	Empirical
16	2020	Ateş, A.	International Journal of Research in Education and Science	Empirical
17	2020	Fritsche, N.-C.	Research in Urbanism Series	Theoretical
18	2021	Frank, P.	International Journal of Sustainability in Higher Education	Theoretical
19	2022	Frank, P., Fischer, D., Stanszus, L., Grossman, P. and Schrader, U.	The Journal of Environmental Education	Empirical
20	2022	Long, D., Henderson, J. and Meuwissen, K.	Educational and Developmental Psychologist	Empirical
21	2022	Welsch, H.	Journal of Environmental Studies and Sciences	Empirical

Note: Articles 7, 12 and 15 were retrieved through reference-to-reference.

articles, Robertson (1994) and Nitsch (2014) deviated from this focus by reflecting on cognitive bias as a result of a particular research paradigm applied in environmental education research.

3.3. Terms used for educational practices

The term most frequently used in the sample of articles was 'Environmental Education'. It was used in three-fourths of the papers. One-fourth of the articles referred to 'Climate Change Education', whereas two articles used the terms 'Education for Sustainable Development' or 'Environmental and Sustainability Education'. 'Ecological Education', 'Science Education', 'Sustainability Education' and 'Urban Design Education' were all used once (see Table 7). One study (Long, Henderson and Meuwissen 2022) looked at how Higher Education more generally affects cognitive bias (note that some articles used more than one term when describing educational practices).

3.4. What cognitive biases are addressed in ESE literature?

One of the key intentions of our review was to understand which biases are addressed in current ESE scholarship. We drew on the conceptualisations suggested by Pronin et al. (2002), and found 23 biases addressed in the body of literature we analyzed. Table 8 provides an overview of these biases, subsumed under four superordinate categories of biases. Next, we will outline in more detail how the individual articles address these biases in ESE. We will structure our findings according to the superordinate categories of (1) bounded rationality, (2) confirmation bias, (3) self-enhancement and (4) ambiguity aversion.

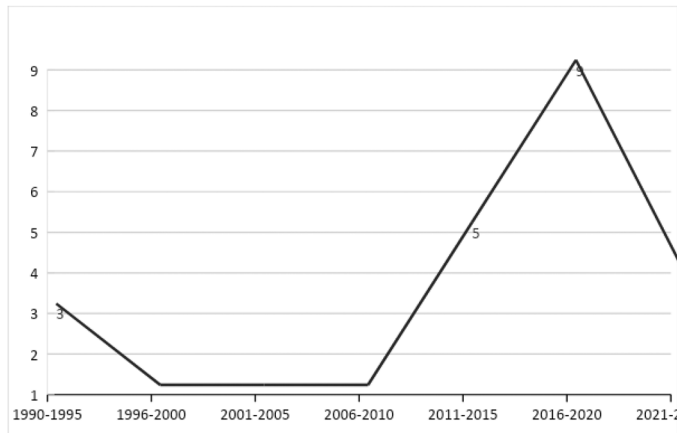


Figure 2. Trend of article publication 1990–2022.

Table 4. Selected journal articles' areas of research.

Discipline	# of articles
Social Sciences – Education	13
Environmental Science	12
Psychology	2
Urban Studies	1
Additional disciplines (multiple assignments): Social Sciences – Geography; Arts & Humanities; Energy; Engineering; Business, Management & Accounting	1 article each

Table 5. Study populations in the empirical studies.

Population	# of studies	Studies
Children (primary school)	1	14
Middle & vocational school students	2	2, 21
University students (environmental programs)	3	4, 13, 15
University students (other programs of study)	4	13, 15, 19, 20
Pre-service science teachers	1	16
In-service science teachers	2	5, 12
Employees	1	19
Mixed adults and adolescents	2	8, 9
General adult population	1	20

Note: Studies 13 and 15 compared students from environmental programmes with those of other programs of study.

Table 6. Perspectives reflected in the selected articles.

Perspective	Number of articles	Articles
Empirical		
Students/learners	10	2, 4, 8, 9, 13, 14, 15, 19, 20, 21
Teachers	3	5, 12, 16
Theoretical		
Students/learners	6	1, 7, 10, 11, 17, 18
Research	2	3, 6

1. Bounded rationality

When it comes to navigating complex topics, a central aspect of cognitive bias is the individual use of so-called mental heuristics or predetermined patterns of actions to evaluate a situation, take a decision or understand the implications of one's behaviour (Kahneman 2011; Korteling et al. 2023). Mental heuristics are used because human

Table 7. Terms used to describe educational practice.

Term	Number of articles	Articles
Environmental Education	13	1, 2, 3, 4, 5, 8, 10, 11, 12, 13, 14, 15, 16
Climate Change Education	5	9, 11, 12, 15, 21
Education for Sustainable Development	2	7, 16
Environmental and Sustainability Education	2	18, 19
Science Education	1	7
Ecological Education	1	9
Sustainability Education	1	15
Urban Design Education	1	17
Not applicable	1	20

cognitive capacity is limited. Although most of the time it is useful to rely on these heuristics, instead of randomly extracting information from the environment (since the heuristics may be described as a mental map that has evolved based on people's experiences, Bardwell 1991), sometimes its application may be flawed. Such a flawed application of one's mental heuristics is called 'bounded rationality'. It refers to the use of mental heuristics owing to cognitive limitations, which make it difficult to solve (quantifiable) problems, and to process and absorb information quickly (Beck 2014). According to the literature we analysed, bounded rationality is also highly relevant to understanding flawed judgment and decision-making related to sustainability-related challenges.

Several cognitive biases that were identified in our review may be subsumed under the term 'bounded rationality'. One of these biases is the availability heuristic (Hovardas and Korfiatis 2012; Sinatra, Kienhues, and Hofer 2014; Zaval and Cornwell 2017; Carmi and Alkaber 2019), 'a mental strategy in which people judge probability, frequency or extremity based on the ease with which and the amount of information that can be brought to mind' (Baumeister and Vohs 2007, 92). In their conceptual paper, Sinatra et al. (2014) state that people who pursue directed goals with their reasoning (i.e., when motivated to reach a particular conclusion) are more likely to rely on availability heuristics, because 'individuals are not motivated to take the time and effort to be reflective and actively assess the viability of nonpreferred conclusions' (Sinatra et al. 2014, p.130). In line with that statement, Zaval and Cornwell (2017) reviewed literature that showed that 'people's beliefs about climate change were malleable and could easily be influenced by salient features of the decision environment' (p. 478).

Carmi and Alkaber's empirical studies (2019), and Hovardas and Korfiatis's (2012) corroborate the foregoing perspectives. Carmi and Alkaber (2019) found that students in environmental studies are less susceptible to temporal- and spatial-availability heuristics when assessing environmental risks, when compared to students in other programmes. However, they do not differ from their peers in their weighting of perceived certainty and negative emotions as predictors of risk assessment. This means that students in environmental studies still rely on their emotions to assess the severity of a risk. This phenomenon is also referred to as the 'affect heuristic' (Kahneman 2011) and is a type of availability heuristic.

Hovardas and Korfiatis (2012) report availability heuristics as a possible explanation of the false-consensus effect (i.e. the phenomenon of people overestimating the extent to which others are like them). In their study, they asked students to indicate their intention to engage in pro-environmental behaviour and to estimate their classmates' willingness to engage in the same behaviour. After an intervention in which students were exposed to heterogeneous opinions, the authors observed more accurate consensus estimates than before that intervention. They argue that when confronted with others' opinions, students rely less on what is available to them than they do without that interaction.

Table 8. Biases addressed in the sample.

Category/bias	Definition
Bounded rationality	People resort to (judgmental) heuristics, owing to cognitive limitations that make it difficult to solve quantifiable problems and to process and absorb information quickly. (Beck 2014)
Availability heuristic	'A mental strategy in which people judge probability, frequency or extremity based on the ease with which and the amount of information that can be brought to mind'. (Baumeister and Vohs 2007, 92)
Present bias	People's tendency to choose a smaller present reward in a trade-off situation, rather than to wait for a larger future reward. (Wang and Sloan 2018)
Averaging bias	People's tendency to predict the impact of a product based on the average of its components, rather than its sum ($A + B < A$). (Ateş 2020)
Confirmation bias	Refers to the human tendency to search for, interpret and remember information in such a way that it confirms one's belief or values. (Nickerson 1998)
Selective exposure	The tendency for people to avoid information that challenges their existing beliefs and values. (Hess & Maki, 2019)
Attitude polarisation	The tendency for people confronted with ambiguous evidence to interpret it according to existing attitudes, thus reinforcing these attitudes, despite contrary evidence. (Lord et al. 1979)
Belief perseverance	'The tendency to cling to one's initial belief even after receiving new information that contradicts or disconfirms the basis of that belief'. (Baumeister and Vohs 2007)
Biased assimilation	The tendency to interpret new evidence in a way that fits pre-existing assumptions. (Lord et al. 1979)
Self-enhancement	A motive that '[...] refers to people's desire to enhance the positivity or decrease the negativity of the self-concept'. (Sedikides and Strube 1995, 1330)
(Fundamental) attribution bias	Systematic errors made when people evaluate and explain their own behaviour in comparison to those of others (Heider 1958). In particular, the over-emphasis on dispositional explanations for others' behaviour, while under-emphasising situational cues and the reverse pattern for oneself. (Ross 1977)
In-group favouritism	People's tendency to favour others who belong to the same group as themselves. (Aronson et al. 2010)
Egocentric bias	The tendency to rely too heavily on one's own perspective and/or have a higher opinion of oneself than is justified. (Schacter et al. 2010)
Rationalisation	Refers to a process in which people give rational reasons for their behaviour while hiding other 'unreasonable reasons'. (Fischer et al. 2013, 18)
Ambiguity aversion	The tendency to favour the known over the unknown, closely related to the need for closure, the desire for a firm answer to a question. (Kruglanski and Webster 1996)
Illusion of understanding	The tendency for people to overestimate the degree or depth of their understanding of a matter (Kahneman 2011)
Groupthink	Occurs when members of a group are so intent on achieving unanimity on a decision that they fail to critically evaluate the potential flaws in their decision or seriously consider alternative courses of action. (Janis 1971)

Another manifestation of bounded rationality reported in the literature is the present bias, that is, the tendency to choose a smaller reward in the present in a trade-off situation, rather than to wait for a larger future reward (Wang and Sloan 2018). The present bias represents a heuristic that underlies the phenomenon of delayed gratification, addressed by Charry and Parguel (2019). Delayed gratification refers to the phenomenon of sacrificing an immediate and smaller reward in favour of a larger reward in the future (Mischel et al. 1989). In their original study, Mischel et al. (1989) found that children preferred to have one marshmallow now, than several in the near future. When referring to this study, Charry and Parguel (2019) argue that the benefits of 'saving the planet' are much more delayed and abstract than 'more marshmallows', so delaying gratification in favour of the climate and environment is extremely challenging.

One last bias mentioned in the literature, which may be attributed to bounded rationality, is the averaging bias (Ateş 2020). This refers to people's tendency to predict the impact of a product based on the average of its components rather than their sum ($A + B < A$). Ateş (2020) reports this bias among pre-service science teachers who were asked to evaluate the carbon footprint of various meals. Participants estimated the carbon footprint of a standard menu plus sustainable topping as being lower than the standard

menu alone, which is referred to as the negative footprint illusion. This suggests that consumers do not add up the impact of individual elements, but that carbon footprint estimates are based on heuristic impressions of an overall dish, namely, the average of the footprint of the various elements. Ateş (2020) argues that furthermore, the averaging bias may lead to the misconception that unsustainable behaviour may be outweighed by previous sustainable behaviour.

2. Confirmation Bias

The largest number of articles in our body of literature (19 of 21 papers) refers to various manifestations of confirmation bias. Confirmation bias refers to the human tendency to search for, interpret and remember information in a way that fulfils or confirms one's beliefs or values (Nickerson 1998).

One prominent kind of confirmation bias is selecting information that conforms to one's preconceptions by avoiding any information that is inconsistent with one's original opinion. This bias is referred to as selective exposure (Hess & Maki, 2019). Hess and Maki (2019) found this bias among college students identifying with conservative political opinions, who were less represented in courses that addressed environmental questions than were students with less conservative opinions. Hovardas and Korfiatis (2012) suggest that selective exposure is a reason for availability bias in consensus estimates (as discussed above), as people's beliefs are not only more available in their own reasoning, but also through their homogenous environment.

According to Smith (2017), confirmation bias is relevant to ESE, because the nature of a discourse (whether it is conducted through deliberation or dispute) determines whether its goal is to win or reach a consensus. Since climate change discourse is characterised by polarisation, the culture of dispute and the associated goal of winning opens the door to confirmation bias, that is, a focus on confirming one's own view, rather than considering others'. Frank also describes this polarising mechanism (2021). He holds that attitudinal polarisation presents a risk to educational practices, if learners' affective-motivational processes are not considered when they are exposed to sustainability-related topics. In this case, they may lead to motivated reasoning processes that support existing (un-) sustainable belief systems. Long, Henderson and Meuwissen (2022), and Welsch (2022) corroborate this perspective: according to Welsch (2022), conservative learners often engage in motivated reasoning that maintains their existing worldviews by minimising cognitive dissonance when they learn about climate change.

Kunkle and Monroe (2018) suggest that the same cultural values that shape differences in worldviews and divide public opinion about anthropogenic climate change also influence whether and how science educators support education on this topic. This, they argue, occurs because of confirmation bias in the sense that more conservative teachers may feel confirmed in their worldviews (i.e., that the science of climate change is flawed and polarised) when confronted with material that is inconsistent with their viewpoint in a disputative environment (Kunkle and Monroe 2018).

Closely related to attitude polarisation is belief perseverance, the tendency to adhere to initial beliefs, even in light of contradictory evidence (Baumeister and Vohs 2007). Hess and Maki (2019) found that for conservative students, even participation in environmental courses did not necessarily lead to more accepting attitudes to the reality of anthropogenic climate change.

Finally, assimilation bias, which is the tendency to interpret new findings to fit pre-existing assumptions (Lord et al. 1979), represents the last type of confirmation bias described in the selected sample of literature. Cincera (2013) and Bardwell (1991) emphasise that in light of new information that does not fit pre-existing models, people have the choice of accommodating the information and developing a new model, or rejecting it, and

interpreting it in a way that they can assimilate into their existing models. If the latter happens, that is biased assimilation. Robertson (1994) and Wals (1992) provide a different perspective on this mechanism, however. These are two of the three oldest articles in our sample, and they interpret this type of assimilation not as flawed, but as a natural and necessary process of learning.

3. Self-Enhancement

Self-enhancement is a motive based on a human's desire to maintain a positive self-concept (Sedikides and Strube 1995). Several biases reported in the literature have their roots in this desire.

The first bias related to self-enhancement was the (fundamental) attribution bias. This refers to the tendency to rely on dispositional explanations for others' behaviour, even when situational factors are known to be significant (Heider 1958). The attribution bias may lead to the fundamental attribution error (FAE), whereby people tend to overemphasise the importance of dispositional or internal factors when explaining others' behaviour, while underemphasising situational or external factors (Ross 1977). Hansmann and Steimer (2017) found FAE when people talked about the littering behaviour of themselves and others, they attributed external explanations to their own littering (e.g. insufficient infrastructure) and internal reasons for littering by other people (e.g. laziness).

Smith (2017) identifies FAE as a particular challenge for climate change educators, because 'when [one attributes] words and behaviour to a person's disposition rather than the situation they are in, their words and behaviour are easier to ignore or reject' (p. 163). This is because across party lines, behaviour and ideas that contradict one's own are more easily categorised as the ideas of a 'madman' or liar. This special case of FAE is the result of a phenomenon called in-group favouritism, which is people's tendency to favour members of their in-group over members of an out-group (Aronson, Wilson, and Akert 2010). Here, patterns such as FAE that otherwise occur at the individual level are transferred to the group level (i.e. in- and out-groups). Sinatra et al. (2014) also identify in-group favouritism in science education, and emphasise that people pay closer attention to arguments and opinions that are typical of their in-group, leading to biased information processing. Building on this perspective, Long, Henderson, and Meuwissen (2022) provide evidence that tertiary education and learner exposure to scientific knowledge is not sufficient to counteract this tendency. On the contrary, they state that 'individuals with greater science literacy and numeracy use these skills to adjust their cognitions to their group identity' (p. 386).

Another self-enhancing bias is the so-called egocentric bias, which refers to the tendency to rely too heavily on one's own perspective and/or have an inflated opinion of oneself (Schacter et al. 2010). Hovardas and Korfiatis (2012) describe this bias in their study about the false consensus effect in pro-environmental behaviour when they argue that people use their own behaviour as an anchor when judging others.

Finally, several articles refer to rationalisation as another self-enhancing bias that is relevant to ESE. Rationalisation refers to the process in which people give rational reasons for their behaviour while hiding other 'unreasonable reasons' (Fischer et al. 2013). Rationalisation (here, as a strategy to reduce cognitive dissonance) was reported by Cincera (2013), who interviewed science teachers who were undergoing environmental education training. According to Cincera's (2013) article, without adequate support from the course managers, teachers who realised that they were not teaching environmental education properly at their schools fell back on rationalisation. In these cases, they gave reasons such as a lack of support from their colleagues and the school administration but gave no reasons that originated in themselves (such as lack of knowledge or lack

of skills) (Cincera 2013). Similarly, Frank (2021) describes people's rationalisation processes when they are confronted with their unsustainable behaviour, and resulting unpleasant emotions, such as shame or guilt. He argues that 'if [an] individual feels unable to change or is motivated to continue with their behaviour, it is likely that they will try to dissolve the unpleasant emotional state by repressing, neutralising or rationalising information related to the impact of one's actions' (Frank 2021, 6). Finally, Hansmann and Steimer (2015) emphasise that rationalising unsustainable behaviour (i.e. littering) may neutralise norm violations, and lead to the stabilisation of that behaviour over time. In an empirical study, Frank et al. (2022) hypothesised that mindfulness meditation might mitigate bias related to one's consumer behavior but found evidence that people who participated in a mindfulness-based intervention would rationalise their consumer behaviour no less than non-practitioners would.

4. Ambiguity Aversion

The tendency to prefer the known to the unknown is referred to as ambiguity aversion, a concept closely related to the need for closure, the desire for a definite answer to a question (Kruglanski and Webster 1996).

It seems probable that this need is fundamentally threatened by sustainability-related problems, because of their inherently complex and ambiguous nature. Sinatra et al. (2014) state that topics such as climate change are so complex that people overestimate the depth of their understanding, which is referred to as the illusion of understanding (Kahneman 2011). As a result, people can more easily develop an unambiguous position that provides grounds for unreasonably extreme stances.

Ambiguity aversion may also be observed at a collective level in the form of groupthink. Groupthink occurs when members of a group are so intent on achieving consensus on a decision that they fail to critically evaluate the potential flaws in their decision or to seriously consider alternative courses of action (Janis 1971). Nitsch (2014) argues that groupthink in sustainability education and research is rooted in a reductionist paradigm that aims to simplify highly complex and ambiguous questions, and thus fails to answer them adequately. In his conceptual article, he argues that the traditional research community cannot stand the uncertainty of a co-existence paradigm, and therefore clings to a reductionist one.

3.5. How are ESE and cognitive bias related in the literature?

This section aims to give an overview of how the concept of cognitive bias is discussed in ESE. Our findings reveal three perspectives that are used to approach cognitive bias, namely: (1) education to mitigate bias associated with sustainability-related matters, (2) bias as a barrier to ESE and (3) bias at the research-paradigm level. Next, each perspective is given a dedicated subsection.

1. Education to mitigate bias associated with sustainability-related matters

This first perspective focuses on education as a means to mitigate cognitive bias associated with sustainability-related matters (e.g. bias leading to (un)sustainable behavior or attitude). Biases in this category were the false consensus effect and associated availability heuristic, averaging bias, egocentric bias, confirmation bias, and the fundamental attribution error and rationalisation (Hovardas and Korfiatis 2012; Hansmann and Steimer 2015, 2017; Kunkle and Monroe 2018; Ateş 2020; Fritsche 2020; Frank et al. 2022). Importantly, in this category, cognitive biases are relevant outside of the educational context, although the role of ESE is regarded as reducing them, for example, by communicating information about these biases and making people aware of them

(Hansmann and Steimer 2015; Kunkle and Monroe 2018; Ateş 2020), and/or to creating an environment in which they are being counteracted and prevented (Hovardas and Korfiatis 2012; Hansmann and Steimer 2017; Kunkle and Monroe 2018; Welsch 2022). Suggestions made by authors who emphasise education to mitigate bias include teaching skills for developing risk literacy (i.e. critical and systems thinking, interpreting probabilities and proficiency when comparing risks) (Carmi and Alkahrer 2019), creating awareness of common reasoning errors (Ateş 2020), critical questioning (Hansmann and Steimer 2015), intrapersonal competence (Frank 2021), face-to-face campaigns (Hansmann and Steimer 2015 2017), collaborative learning environments that shift the focus from oneself to the others (Hovardas and Korfiatis 2012), or innovative learning activities (e.g. mindfulness) and pedagogies (Fritsche 2020; Frank et al. 2022; Welsch 2022).

2. Bias as a barrier to ESE

The second perspective that is used to approach cognitive bias related to ESE considers how cognitive bias hinders sustainability-related learning. According to this perspective, bias occurs when people explicitly and consciously address sustainability-related questions in educational contexts. The literature reviewed here suggests that cognitive bias hinders education when people try to resolve and make sense of the complexity and uncertainty that characterise sustainability-related problems (e.g. Sinatra et al. 2014). According to this perspective, being exposed to sustainability-related evidence and its underlying complexity may prompt motivated reasoning, which may lead to the illusion of understanding (Sinatra et al. 2014), or confirmation bias, expressed through selective exposure bias, belief perseverance (Hess and Maki 2019) and biased assimilation (Bardwell 1991; Sinatra et al. 2014). Consequently, barely exposing learners to sustainability-related evidence may lead to attitude, and hence group, polarisation, instead of enabling learners to contribute to the vision of sustainability (Sinatra et al. 2014; Smith 2017; Frank 2021; Long, Henderson and Meuwissen 2022; Welsch 2022). The discourse on climate change, in particular, is a highly polarised topic that is fertile ground for confirmation bias based on group favouritism (Smith 2017; Long, Henderson and Meuwissen 2022). Therefore, Long, Henderson and Meuwissen (2022) point out that 'individuals with greater science literacy and numeracy use these skills to adjust their cognitions to their group identity. The finding that better education may amplify rather than attenuate the ideology and morality dependence of decision-relevant climate change cognitions sheds doubt on the proposition that better education unambiguously furthers the prospects for climate change mitigation' (p. 386). Kunkle and Monroe (2018) point out that cognitive bias may also present challenges to education when educators themselves show such bias. They argue that 'educators who believe they have formed their opinions on the best available evidence are not likely to be motivated to seek new information that may remedy their unintentionally biased assessment' (p. 19).

Strategies for addressing bias in ESE share the fact that they shift the focus from theoretical knowledge acquisition to other forms of learning and learning outcomes. For example, Frank (2021) suggests developing intrapersonal skills that enable learners to deal with unpleasant emotions that may arise when they are confronted with unsustainability, to reduce their influence on cognitive processes, such as sense- and decision-making. Similarly, Bardwell (1991) suggests storytelling in the form of success stories, to help people see the possibilities rather than the threats associated with environmental problems. Kunkle and Monroe (2018) stress the importance of using teaching material to make educators aware of their bias resulting from their political worldview, and of providing workshops in which teachers interact in deliberative dialogue with their peers. This is complemented by Smith's (2017) call to abandon the culture of dispute in

educational settings, in favour of a deliberative culture that emphasises commonality and consensus, to reduce bias based on group affiliation.

3. Bias at the research paradigm level

Some researchers suggest that bias may affect the research or educational paradigm that is being applied as a whole. In the literature discussed here, this perspective was mainly taken by Nitsch (2014). According to this author, current research and education is dominated by a reductionist paradigm, leading to an incomplete and biased perception and understanding of sustainability-related problems as well as their potential solutions. He argues in favour of a paradigm that allows various perspectives and opinions to mitigate groupthink, and that promotes inter- and transdisciplinary research and education. He emphasises that such a shift from a reductionist to a co-existence paradigm is needed, to meet the demands of teaching and learning about sustainability in higher education. Robertson (1994) and Wals (1992) provide an alternative view on cognitive bias in ESE in general. Robertson (1994) describes bias (i.e., assimilation) not as a flaw, but as a normal part of an individual learning process. He argues for a social constructivist approach to environmental education, and especially to environmental education research. In fact, Wals' qualitative 1992 study is the only empirical study in the sample that follows this approach. He argues that uncovering students' misconceptions is essential, not to correct them, but to know 'where to start'. He even states that misconception may not be an appropriate term, given that 'it refers to an alternative interpretation of a phenomenon that is valid in light of the students' own experiences' (p.53). Nevertheless, as do other scholars, he points out that students need space to explore and collaborate with their peers, to arrive at new conclusions without being overwhelmed by the burden of complexity that sustainability presents.

4. Discussion

This study set out to contribute to a better understanding of how cognitive bias is currently addressed in ESE scholarship and practice. When compared to other fields, and even to the broader sustainability discourse (e.g. Engler et al. 2019; Azzopardi 2021; Korteling et al. 2023), it can be stated that cognitive bias does not yet play a prominent role in ESE scholarship and practice. Especially if the quantitative trend of publications related to this topic is compared with the broader development of ESE publications (Figure 3), it becomes evident that cognitive bias remains under-researched in the field of sustainability-related education. Since 1992, only 11 articles have empirically addressed cognitive bias related to ESE, which illustrates that there is a need for more research on this topic. This said, the literature we selected covered a variety of cognitive biases, which mirrored the increasing diversification of cognitive bias, more broadly.

Given the literature presented in this study, cognitive bias may, arguably, be an important tendency for understanding certain challenges of ESE research and practice. The analysis indicates that cognitive bias is relevant to ESE at three different levels, namely ESE to mitigate cognitive bias, cognitive bias as a barrier to ESE and bias at the research-paradigm level.

In terms of mitigating bias through ESE, the suggestions provided in the literature go from simply providing information about bias (e.g. Hansmann and Steimer 2015; Kunkle and Monroe 2018), to more explicit learning activities and educational approaches to reducing bias (e.g. Fritsche 2020; Frank et al. 2022; Welsch 2022), to defining specific skills for learners and educators, and help to avoid and mitigate bias related to (un-)sustainability (e.g. Carmi and Alkaher 2019; Frank 2021). These findings provide preliminary insights into how to address bias in educational settings, and what learning outcomes may inform the design of learning activities that revolve around cognitive bias. It is worth mentioning again that only a few of the articles discussed here empirically consider the effectiveness of specific learning approaches for mitigating bias or the relevance of specific skills needed to address cognitive bias. Thus, there is a need for more empirical research

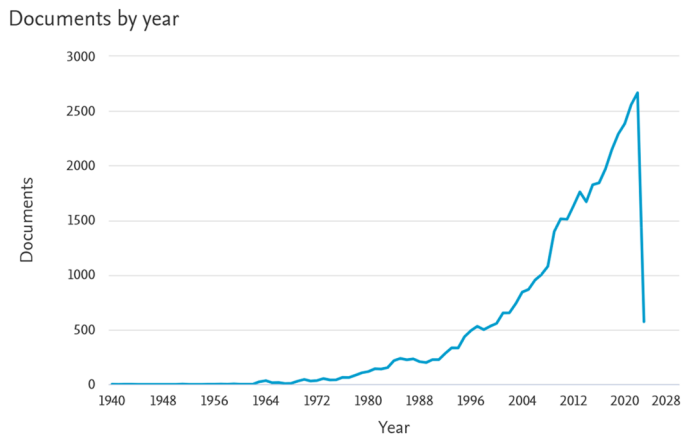


Figure 3. Trend of publications in ESE.

that examines the potential of specific learning activities for addressing cognitive bias, and the corresponding skills that enable learners to become aware of, and overcome, bias.

With regard to bias as a barrier to ESE, the literature identifies at least three types of barriers that cognitive bias may present. First, from a constructivist learning perspective, biased reasoning may be some sort of innate feature of learners, and hence be a natural part of learning (e.g. Wals 1992). However, for ESE purposes, this tendency still presents a significant challenge, as societal transformation towards a sustainable future depends – at least to a certain extent – on individuals accepting the scientific evidence that reveals the unsustainability of current behavior, and subsequently being willing to act in line with principles of sustainability. Second, ESE practices may prompt cognitive bias, for example, by exposing learners to the overwhelming threat and complexity related to sustainability-related problems. This barrier is of critical importance for designing ESE programmes and activities, for, if sustainability-related learning leads learners to biased reasoning, it risks undermining its core educational purpose of enabling individuals to find solutions to the pressing problems society faces (e.g. Sinatra et al. 2014; Frank 2021; Long, Hendersson and Meuwissen 2022). Third, the educators' own cognitive biases present a relevant barrier to education, insofar as these biases may directly affect their educational practices and ability to mitigate bias among learners (Ateş 2020; Cincera 2013). These findings are relevant for ESE scholarship and practice, insofar as they allow educators to differentiate among various types of barriers, and more selectively implement strategies that aim to avoid biased reasoning in ESE. However, among the few studies selected for this review, only a minority ($n=3$) actually focus on the educators' role with regard to cognitive bias. To summarise, our findings suggest that educational practices may prompt cognitive bias among learners, thereby undermining the key educational purposes of ESE. We recommend dedicating more research to this tendency, to develop a better understanding of how it may be avoided.

Finally, bias at the research-paradigm level fundamentally questions the way sustainability-related challenges are addressed by ESE practices, but also the way one thinks about cognitive bias in this context. It seems that this perspective involves two almost opposing implications. As Nitsch (2014), in particular, argues, sustainability-related research and education should be more strongly oriented towards inter- and transdisciplinary learning and collaboration, thereby integrating various forms of worldview and knowledge. Indeed, this is consistent with more recent suggestions put forward by ESE scholars who argue for problem-based, inter- and transdisciplinary learning, especially in higher education (Lozano et al. 2017; Reimers 2021). At the same time, some have argued that these forms of learning may further increase the subject's complexity, and tend to prompt cognitive bias, which becomes a barrier to ESE-related learning (Mälkki

2010; Ojala 2016; Frank 2021). Speaking of biased reasoning implies that there is another, less biased, and therefore a more unbiased way of reasoning. From a constructivist learning perspective, such a judgment of reasoning is hard to justify, especially if the normative basis of educational practice emphasizes learner autonomy and self-determination in a democratic society.

A consideration of bias at the research-paradigm level creates an opportunity for a broader discussion of the theoretical, methodological and empirical approaches that influence the field of ESE, and the role of cognitive bias as an analytical concept. The ambition behind this paper is to better understand how the concept of cognitive bias may be leveraged to illuminate the nuances of the sprawling field of ESE research. The concept of cognitive bias, which comes from psychology, also includes a specific (and growing) subset of affiliated concepts. As was emphasised in this paper's methods and analysis, this leads to a specific way of approaching the field of ESE research and the bodies of knowledge that it encompasses. Arguably, other concepts may be understood in light of cognitive bias, to deepen the understanding of the field of ESE. Concepts such as 'critical thinking' (Reffhaug et al. 2024) 'action competence' (Mogensen and Schnack 2010), 'pluralism' (Öhman 2006) and 'participation' (Breiting et al. 2015) shed light on the importance of engaging critically and rationally with questions of sustainability and the challenges that they present. Linking ideas of cognitive bias to positions such as these could deepen our insight into the multitude of ways that knowledge, actions, values, emotions and so on are entangled in ESE practices.

To summarise, the findings of this study indicate that a potential area of tension emerges when attempts are made to integrate the concept of cognitive bias into ESE. On the one hand, ESE must convey a certain amount of content knowledge to enable individuals to act for a more sustainable future, and mitigating bias may be an important aspect of this type of learning. On the other hand, perception of a learner's reasoning as biased may evolve from a bias in the paradigm itself, which, in turn, avoids critical reflection on, and improvement of, the existing body of knowledge, and of the associated educational practices that convey this knowledge. At the same time, more integral (e.g. inter- and transdisciplinary) ways of learning risk further increasing complexity and (emotionally) overwhelming learners. Reconciling this area of tension would then be an important task for ESE scholarship and practice. If the ability to deal with the complexity of sustainability-related challenges and the resulting emotional distress is considered a key outcome of ESE, this task comprises a stronger focus on learning activities focusing on the affective-motivational dimensions of learners (Frank 2021; Ojala et al. 2021; Grund et al. 2023).

5. Limitations

Several limitations characterise the findings of our literature review.

First, the keywords used to find literature that addressed cognitive bias were derived from a single article (Pronin et al. 2002). Even though this article is often cited, and refers to leading scholars in the field, it does not cover all the biases that have been identified in the literature (cf. for example, the Wikipedia list of cognitive biases). Including an extended list of biases would probably have yielded a larger number of articles.

Second, educational traditions close to ESE, such as Citizenship Education, were not explicitly captured by the search string. Other traditions may also contribute to the purposes of ESE without referring to this term (e.g. Urban Design Education, science education). Again, including such terms in the search string may have led to a larger number of studies that were eligible for this review.

Third, a more comprehensive understanding of cognitive bias and its relevance to ESE might be obtained by considering how such bias is addressed in a broader educational context. Although the purpose of this review was to examine the connection between cognitive bias and ESE, this field could probably learn from similar studies conducted for other educational fields in which cognitive bias concerns teaching and learning activities.

Fourth, the findings of this review may be limited by the fact that it focused on cognitive bias as a coping strategy manifested in relation to ESE. The resulting search string and eligibility

criteria may have excluded research that explored the prevention of cognitive bias in the first place, for example, by explicitly addressing the emotional challenges that eventually prompt cognitive bias. For instance, Ojala's (2016) study of how to address climate-change anxiety in the classroom was not included in this review, because it did not explicitly address cognitive bias, yet addressed the avoidance of bias by looking at the underlying emotional processes.

Fifth, the applied conceptualisation of cognitive bias has its theoretical roots in the field of psychology (Kahneman 2011). Although it is intensely discussed, critiqued and debated in this field, this is not necessarily the case with ESE-related research traditions. Although this may also be opportunity to leverage the concept of cognitive bias, to better understand ESE practices and challenges, it also calls for further work on given specificities of the concept of cognitive bias, and how it relates to existing concepts and positions in ESE research.

6. Conclusion

Cognitive bias can present an important obstacle to sustainability-related knowledge generation and decision-making. ESE may play an important role in addressing cognitive bias. However, there is no systematic overview of cognitive biases and their role in ESE. Our article contributed to closing this gap.

We conducted a scoping review that used peer-reviewed, scientific literature that addressed cognitive bias in ESE. In SCOPUS, Web of Science and ERIC, we found 21 articles (13 empirical, 8 theoretical) published between 1992 and 2022, which matched our search criteria. These studies came from various educational traditions (e.g. Education for Sustainable Development, Climate Change Education), covered a range of educational institutions and settings (from primary schools, to universities, to adult education), and focused mainly on the manifestation of bias among learners (in contrast to educators, for example). Furthermore, the studies analysed in this review focused on various forms of cognitive bias. We could identify four clusters of cognitive bias that were addressed in the literature, namely bounded rationality, confirmation bias, self-enhancement and ambiguity aversion. Finally, we distinguished three perspectives from which cognitive bias is discussed in the literature, namely education to mitigate bias associated with sustainability-related matters bias as a barrier to ESE and bias at the research-paradigm level. We discussed a potential area of tension that emerges from these relations for ESE practice.

Overall, our review revealed that cognitive bias and its relevance to ESE remains an under-researched and fragmented topic of ESE scholarship. Given the importance of cognitive bias with regard to sustainability-related learning and decision-making, we hold that the field would benefit from more research on the connection between cognitive bias and ESE at all educational levels. However, future studies should be clear about the kind of bias they aim to address, and should be explicit about the perspective from which they look at cognitive bias.

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Appendix A

Systematic literature search

Web of Science: TS = ("cognitive bias" OR "percept* bias" OR "information-processing bias" OR "attention bias" OR "confirmation bias" OR "reactance" OR "attribution* bias" OR "fundamental attribution bias" OR "false consensus effect" OR "cognitive dissonance") AND (TS = ("education" AND ("sustainab*" OR "environmental" OR "climate change"))

Scopus: TITLE-ABS-KEY ("cognitive bias" OR "percept* bias" OR "information-processing bias" OR "attention bias" OR "confirmation bias" OR "reactance" OR "attribution* bias" OR "fundamental attribution error" OR "false consensus effect" OR "cognitive dissonance") AND (TITLE-ABS-KEY ("education" AND ("sustainab*" OR "environmental" OR "climate change"))

ERIC: (abstract:"education for sustainable development" OR abstract:"sustainability education" OR abstract:"environmental education" OR abstract:"environmental and sustainability education" OR abstract:"education for sustainability" OR abstract:"climate change education" OR descriptor:"environmental education") AND (abstract:"cognitive bias" OR abstract:"information processing bias" OR abstract:"attention bias" OR abstract:"confirmation bias" OR abstract:"reactance" OR abstract:"fundamental attribution error" OR abstract:"perception bias" OR abstract:"false consensus effect" OR abstract:"perception bias" OR abstract:"attribution* bias" OR descriptor:"Schemata (Cognition)")

Excluded terms

self-serving bias, ego-defensive bias, planning fallacy, false polarization, hostile media effect, overconfidence bias, lay epistemology, third person effect, naive realism, better than average effect, unwillingness to trade, reactive devaluation, psychological rationalization, dissonance reduction, representativeness bias, availability bias, assimilation bias, psychological bias, motivational bias, loss aversion, halo effect.