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RESEARCH ARTICLE

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Students' credibility criteria for evaluating scientific information: The case of climate change on social media

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Abstract

The rise of social media platforms and the subsequent lack of traditional gatekeeping mechanisms contribute to the multiplied spread of scientific misinformation. Particularly in these new media spaces, there is a rising need for science education in fostering a science media literacy that enables students to evaluate the credibility of scientific information. A key determinant of a successful credibility evaluation is the effectiveness of the criteria students apply in this process. However, research suggests that existing credibility criteria are often not integrated into students' actual social media evaluation behavior. This hints to a lack of transferability of the existing criteria. As a consequence, knowledge about how learners evaluate credibility in social media is a first step in closing this gap. In the present study, we report results from six focus groups with 21 10th-grade students (M = 15 years, 57% female, 38% male, 5% nonbinary) about their usage of different credibility criteria in the case of social media posts about climate change. The data were analyzed through qualitative content analysis and as a first step assigned to established credibility dimensions of content (what?) and source-related criteria (who?). Additionally, given the complexity of social media, we also added a composition-based category (how?). In a

second analysis step, we adapted our subcategories to the recently proposed credibility heuristic by Osborne and Pimentel. The findings suggest that students generally take criteria from all three heuristic credibility dimensions into account and combine different criteria when evaluating the credibility of scientific information in social media. Based on the application of the credibility criteria to the heuristic, implications for the development of teaching materials for fostering science media literacy are discussed.

KEYWORDS

credibility, science media literacy, scientific information, social media, students' conceptions

1 | INTRODUCTION

Especially young people are increasingly using social media as a source of science-related information such as climate change (Greenhow et al., 2015). While students can become informed about science topics on these platforms, they may also be confronted with entertaining, commercial, and pseudo-scientific content (Dolan et al., 2019; Höttecke & Allchin, 2020; Mavrodieva et al., 2019). The different types of content were once clearer to distinguish but are harder to differentiate in the digital environment (Alexander & Tate, 1999), as sponsorships and commercials could be hidden in the form of a friend's post. Amidst this abundance and mixture of content in the fast-moving social media environment, it is not easy for young people to discern scientifically credible information (Höttecke & Allchin, 2020).

This is especially problematic in the face of a growing body of misinformation that is spreading on social media (Osborne & Pimentel, 2023). Conspiracy theorists have been around for a long time (Gardner, 1998), but the accessibility of social media and its lack of traditional gatekeeping, for example, an editorial board, make it possible for anyone to effortlessly spread misinformation (Höttecke & Allchin, 2020). These conditions underline the need for science media literacy that enables students to effectively evaluate the credibility of scientific information. However, one of the main challenges in the development of effective credibility procedures on social media is: Users cannot review all information in-depth because time is limited in this fast-living environment (Metzger & Flanagin, 2013) and because students do not have sufficient expertise to evaluate content (Höttecke & Allchin, 2020). While this challenges education in many ways (Chinn et al., 2021), concentrating on fostering credibility evaluation may be one way to adapt to the insecurities of online spaces (Metzger et al., 2010).

Science education needs to adapt to this challenge as students need to be prepared with effective strategies to evaluate the credibility of scientific information on social media to make informed choices (Osborne & Pimentel, 2023). Osborne and Pimentel (2022) proposed a promising heuristic for how non-experts may evaluate the credibility of scientific information. However, this heuristic has scarcely been applied to real situations. Thus, a specific analysis of the heuristic in the context of scientific information in a selected media environment may help to better understand its merits and shortcomings for further development. Furthermore, the heuristic is based on theoretical implications and may not align with users' actual usage behavior, since research suggests online behavior to be a lot more diverse and less systematic (Metzger et al., 2010). Thus, identifying the criteria that students include in their credibility evaluation on social media is an important first step in developing effective theoretical explanations. It can also build a basis for more authentic student-centered and therefore more effective

science-educational concepts (Chinn et al., 2021). In this study, we specifically focus on social media as one specific digital environment due to its central role in students' information behavior (Bashir et al., 2021).

Therefore, we investigate (1) the criteria students include in their credibility evaluation process for scientific information on social media and (2) apply these to the heuristic by Osborne and Pimentel (2022). Before further explaining the methodological framework, we explicate the case of climate change on social media and explain the credibility evaluation of science content in such new media environments.

2 | THEORETICAL BACKGROUND

2.1 | Information dissemination and credibility evaluation on social media

Social media platforms are a common source for news, including science-related topics such as sustainability and climate change (Pearce et al., 2020). Today, it is more likely for young people to consume information on social media platforms like TikTok than on conventional media (Pew Research Center, 2021). The term social media sums up a heterogenous group of affordable and accessible internet-based mobile platforms on which users can create a profile to represent themselves and communicate with others (Baram-Tsabari & Schejter, 2019; Carr & Hayes, 2015; McIntyre, 2018). Social media are characterized by their interactivity and participatory features, which facilitate a quick dissimilation of a large amount of output.

On the one hand, this participatory character encourages the public to share their opinions and try to engage with scientific topics like climate change (Mavrodieva et al., 2019). This holds immense potential since it not only raises awareness but also mobilizes activism and affects public perceptions about scientific topics (Anderson, 2017; Büssing et al., 2019; Mavrodieva et al., 2019). On the other hand, the participatory characteristic exists due to a lack of traditional gatekeeping. This results in mainly unfiltered content and the possibility of easily spreading misinformation on these platforms (Höttecke & Allchin, 2020). One consequence is that nonscientific positions from climate change deniers are disproportionally often found on social media (Allgaier, 2019). In this context, the term "post-truth" society has been used to demonstrate how misinformation flood new media and opinions often prevail over evidence (Chinn et al., 2021; McIntyre, 2018).

Due to the coexistence of credible and non-credible information and the exponential growth of the body of accessible knowledge (Bornmann et al., 2021), the consumer of information is required to do more selection work than before, while the capacities to process that information remain unchanged (Osborne & Pimentel, 2023). When processing information on social media, users are influenced by the focus on visual elements (Mavrodieva et al., 2019). The high level of multimediality of social media adds a persuasive dimension that differentiates it from other digital information platforms such as online newspapers, which are mainly text-based (Mavrodieva et al., 2019).

Additionally, the fast-moving environment might force users to make immediate credibility decisions, which might explain why students apply different heuristics on the platform itself and rarely switch to other websites, for example, Google, to check the credibility of information (Wineburg et al., 2022). Referring to Haidt (2001), intuition plays a large role in decision-making and is also the basis for information evaluation. When examining credibility criteria on social media, it is therefore important to also investigate the initial, rather intuitive criteria students consider since they might have an underestimated influence in fast-moving credibility evaluation processes.

Credibility evaluation processes on social media are also influenced by the function social media fulfills for the user. Other than news pages, the main function of which is to enhance knowledge, social media platforms can fulfill functions such as entertainment and relaxation, social interaction, or financial renumeration (Ko et al., 2005). The specific need users want to fulfill through social media usage can influence their vigilance in evaluating the credibility of information (Gierth & Bromme, 2020). For example, when users use social media for entertainment and relaxation, they might be less vigilant in evaluating the credibility of science-related information. Therefore, it is

important to include students' individual needs in social media usage. Additionally, if and how students are confronted with scientific content on social media strongly depends on their interest in and access to the topic. This is due to social media algorithms functioning on user personalization, meaning content is presented based on the user's preferences and contacts (Alvarado & Waern, 2018).

Due to the described circumstances and characteristics, procedures to evaluate information in social media environments might also be specific to the environment. Since research and theoretical approaches regarding credibility evaluation on social media are limited, in the following section we include literature on general media credibility evaluation.

2.2 | Credibility evaluation approaches in science education

2.2.1 | Heuristics for evaluating scientific information

According to Osborne and Pimentel (2023), the novel challenge for science education becomes educating "competent outsiders" who primarily evaluate the source of the information through the application of heuristics. Generally, heuristics are efficient cognitive processes that save effort by ignoring details or certain parts of the information (Gigerenzer & Gaissmaier, 2011). They can be conscious or unconscious (Gigerenzer & Gaissmaier, 2011). Metzger et al. (2010) state that in online environments users often make use of heuristics when making credibility decisions (Metzger & Flanagin, 2013; Metzger et al., 2010). In the context of credibility decisions in media environments, Osborne's and Pimentel's (2023) heuristic includes the conscious application of the following three evaluation filters: (1) Is the source of the information credible? (2) Does the source have the expertise to vouch for the claim? (3) Is there a consensus among the relevant scientific experts? (see Figure 1).

The filters are meant to be applied chronologically and all of them have to be affirmatively answered to classify the source as credible. Subpoints to determine the answer for filter 1 are the absence of conflicts of interest, the acknowledgment of the source, and an unbiased analysis of the topic. Subpoints for filter 2 consist of the source's track record, reputation among peers, credentials and institutional context, and relevant professional experience. For filter 3, the consensus should be inquired through the explanations, the nature of the evidence, and the degree of certainty. In case there is no consensus among relevant experts, the "competent outsider" should probe the uncertainty with the four follow-up questions displayed in Figure 1.

In the context of our research, there are three uncertainties regarding the heuristic: First, since this heuristic is designed for evaluating scientific information sources in the media in general, it is unexplored if it can be applied to the social media environment. Second, the heuristic is based on theoretical implications and might not align with users' actual usage behavior. Filter 3 for example is concerned with examining the scientific consensus among relevant experts. Even though this is an important credibility concept, it is hard to explore for outsiders and an implication of this filter would require a lot of time and disrupt the usual social media usage immensely, not being congruent with actual user behavior. This, to some degree opposed the concept of a heuristic approach. Lastly, for an application of the heuristic, it might lack concreteness concerning the concepts, for example, how should students proceed in social media when examining if a source holds relevant expertise or if there is consensus? This is additionally obstructed since the terminology of filter 1 (source credibility), and filter 2 (source expertise) could be misleading. The credibility of a source usually includes its expertise, but in the heuristic by Osborne and Pimentel (2022) these are separate filters.

A more specific and evidence-based approach for credibility evaluation online is suggested by Metzger et al. (2010). Their approach is based on focus group data, which found that participants mainly made use of the following six cognitive heuristics: reputation, endorsement, consistency, self-confirmation, expectancy violation, and persuasive intent. The reputation heuristic included name recognition and familiarity with the source. The endorsement heuristic suggests that people are more likely to believe information if others do as well. When

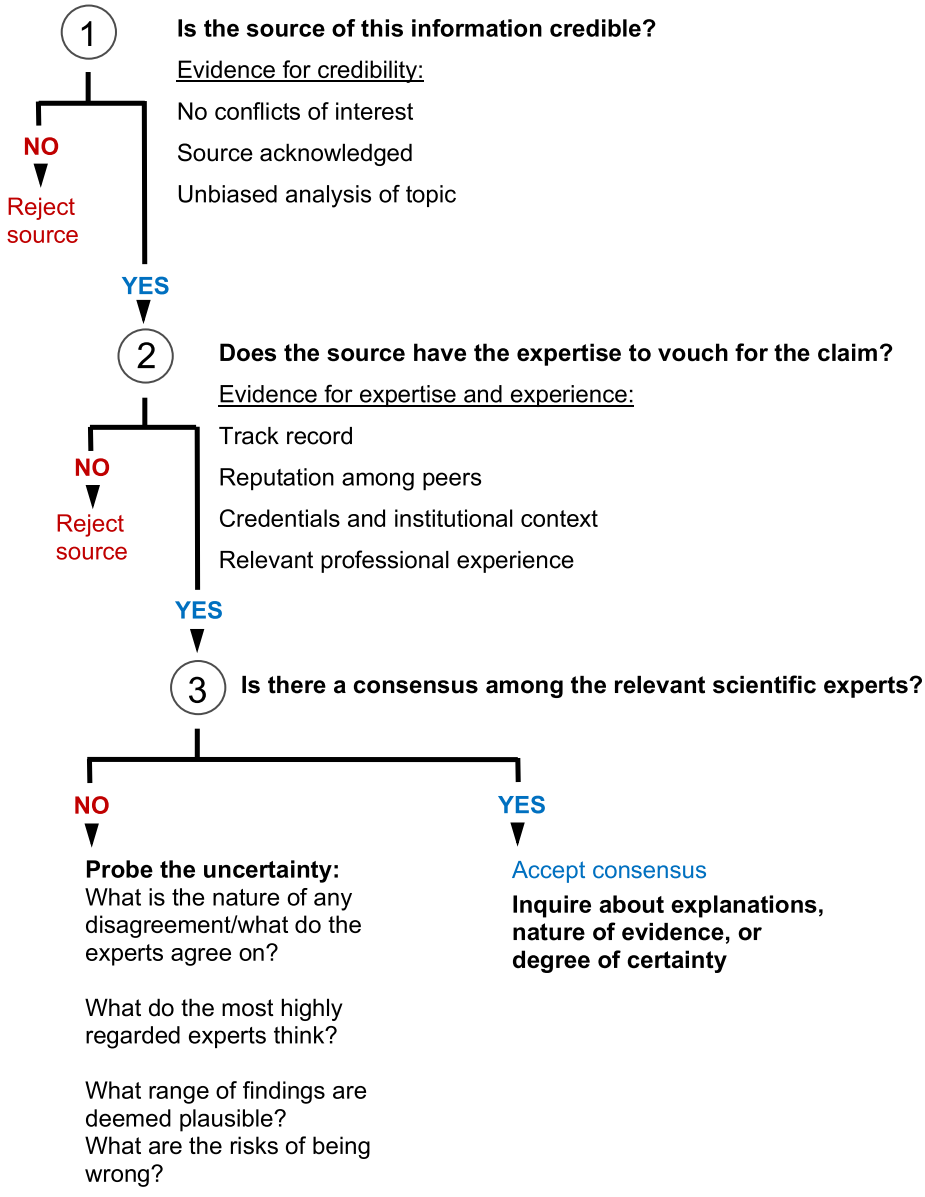

FIGURE 1 Heuristic to evaluate scientific information based on Osborne and Pimentel (2022, p. 247).

looking at consistency, people examined if the information was consistent with different sources. The self-confirmation heuristic included people perceiving information as credible when it confirmed preexisting beliefs and less credible when it countered existing beliefs. Expectancy violation includes a website being perceived as less credible if it does not meet the users' expectations, for example, the presence of typographical errors or a poor homepage design. Lastly, the persuasive intent heuristic is applied when people believe biased information is not credible, for example, commercial content. Metzger et al. (2010) also found that the heuristics are not mutually exclusive because many decision-making situations require multiple and combined heuristics.

Although Metzger et al.'s study was conducted with users to investigate the credibility evaluation of online information, it did not focus on the context of social media or the specific perspective of students. It is still an open task how and if the heuristics can be transferred to specific contexts such as the credibility evaluation of scientific information on social media platforms for student audiences. Nevertheless, these heuristics provide criteria that constitute a core of credibility evaluation.

2.2.2 | Criteria of credibility evaluation: Who is informing about what?

For the present study, we make use of three superior categories to understand and structure relevant criteria in credibility evaluation. In credibility research in science education, approaches are commonly divided into the categories of content (what is the information?) (e.g., McComas et al., 1998) and source-related criteria (who is giving the information?) (e.g., Allchin, 2022). Due to the multimedia and fast-moving nature of social media, we propose composition-related criteria (how is the information conveyed?) as another important perspective for understanding the evaluation of scientific information (see Figure 2).

A common approach to evaluating the credibility of scientific information is to focus on content-related criteria. These approaches often include content knowledge or epistemic criteria. The epistemic criteria are derived from the epistemic nature of science (McComas et al., 1998) that emphasize scientific practices, such as analyzing and interpreting data and evidence-based arguing. Teaching about these criteria in science education offers valuable insight into the practices of science. However, concerning credibility evaluation, the focus on content-related criteria would build on the premise that a person can evaluate the credibility of information by themselves. However, an increasing amount of evidence illustrates the dependence on the expertise of others since a person cannot provide expert content knowledge in all areas (Allchin, 2022; Gierth & Bromme, 2020; Osborne & Pimentel, 2023). Thus, in the context of credibility evaluation, a sole focus on content-related criteria is insufficient in social media.

Consequently, source-related criteria have been proposed as an additional approach to evaluating the credibility of scientific information. Examples are the already described heuristic by Osborne and Pimentel (2022), including the source's expertise and credibility, and Allchin's four ways to assess the trustworthiness of scientific claims in news media (expertise, transparency, conflict of interest, honesty, and deceptive strategies) (Allchin, 2022). According to Gierth and Bromme (2020), people more thoroughly examine the information claims and are more probably able to detect inconsistencies when they expect a non-credible source. Thus, relying on the source when evaluating information can only be an effective epistemic strategy if people have cognitive mechanisms to identify non-credible sources and therefore become more attentive (Gierth & Bromme, 2020). Since social media platforms

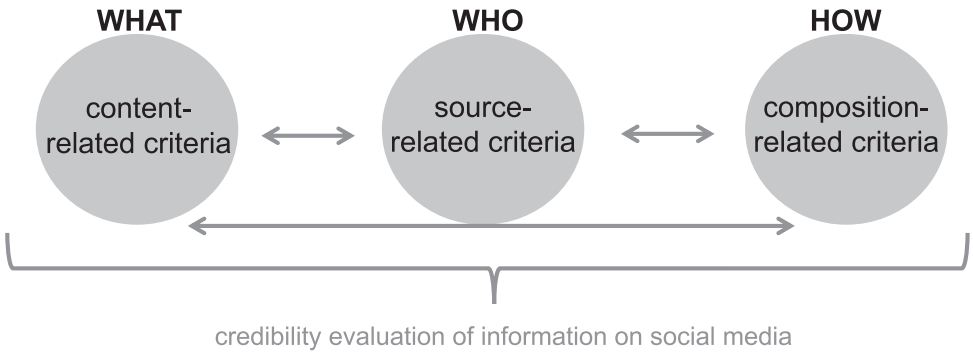

FIGURE 2 Theoretical assumptions on the credibility evaluation process of information on social media.

are designed around user profiles, and there is no direct content knowledge required for source-related credibility evaluation, these criteria might play a crucial part in credibility evaluation procedures on social media.

A more holistic approach by Bromme and Kienhues (2014) suggests a combination of content- and source-related approaches when evaluating trust in scientific knowledge. The approach includes a plausibility judgment that is content-related and a trust judgment that is source-related. Plausibility judgments are made based on factors such as comprehensibility of the information, coherence, previous content knowledge and beliefs, and value systems. On the other hand, trust judgments are made according to criteria such as integrity and benevolence and expertise, and responsibility (Bromme & Kienhues, 2014). These two manners of judgment influence each other in that information is perceived as more plausible if stemming from a trustworthy source and vice versa (Thomm & Bromme, 2016).

2.2.3 | Credibility in social media: Adding the how

In addition to content and source information, how information is visually conveyed is a crucial determinant for users to identify non-credible sources. Although many types of information exist in the media (e.g., text, video, audio), credibility literature has primarily focused on textual information (Metzger & Flanagin, 2013). On multimedia-focused platforms, such as social media, visual elements must be present since it is the vehicle that conveys the information. Fogg (2003) found that consumers of online information mainly consider the visual design elements of websites in their credibility assessment rather than content or source information. They argue that this is due to users rarely spending a long time on any given site, they likely develop fast strategies to detect credible information. Kim et al. (2021) had similar findings, stating that students make use of simplistic strategies involving superficial physical cues. In addition, a focus group study with 109 participants found that people often do not have the cognitive capacity in medial information-rich environments to systematically evaluate information (Metzger et al., 2010); they make use of strategies that minimize cognitive effort and time by applying a diversity of heuristics to evaluate the credibility of information (Metzger & Flanagin, 2013). The effectiveness of the credibility process is a central aspect of science education since it can hinder or empower a nonexpert audience to make informed science-related decisions (Allchin, 2022; Baram-Tsabari & Schejter, 2019).

Even when one focuses on source-related criteria such as expertise, visual compositional choices have an unavoidable influence on how this expertise is perceived; an example is Allchin, (2012) four ways to evaluate trustworthiness. One of these ways is the author's deceptive strategies, which include factors such as (1) style, aimed to evoke trust and (2) disguise, the falsified appearance of expertise, and (3) exploiting social emotions (Allchin, 2012). Thus, how the information is transmitted plays a crucial role in deceiving the user, for example, exploiting emotions through emotive images or the professional appearance of a post or website. In the context of climate change, Coen et al. (2021) found that news comment readers construct expertise on climate change relying on the authors implicitly presenting themselves as experts (e.g., language use, images, post-design) and the construction of one's argument as factual (e.g., application of diagrams). The user's unawareness of the persuasive influence of visual choices on perceived expertise is actively exploited. A study by Wineburg and McGrew (2019) shows that students struggle to avoid such deception. Therefore, it is important to consider information conveyance, next to the content and the source, as a third main area of credibility evaluation; despite this, how information is transmitted is a mostly neglected area, especially concerning social media and climate change research (Pearce et al., 2020).

It is helpful to get a deeper insight into which of the previously mentioned criteria students consider when they evaluate the credibility of information in social media. Research shows that even though students are aware of recommended information evaluation criteria and approaches (Kim & Sin, 2011) and the unreliability of social media information, they often forego diligent application of those strategies (Kim et al., 2014; Leeder, 2019), which may suggest their inability to apply this knowledge to actual usage and conditions on social media platforms. It also underscores the urgency for researchers and science educators to be more vigilant toward how students use and evaluate information on social media (Höttecke & Allchin, 2020). The overall lack of in-depth understanding of

students' evaluation criteria on social media underscores the urgency of examining their credibility evaluation behavior as a basis to specify, improve and extend the existing heuristics such as Osborne's and Pimentel's (2022). The findings hold the potential to foster an application-oriented science media literacy that enable students to properly evaluate and use scientific social media information.

2.3 | Research questions

To develop learner-centered educational concepts about social media and climate change, the following research questions are proposed:

Research question 1: Which criteria (who, what, how) do students include in their credibility evaluation of information on climate change on social media?

Research question 2: How do these criteria contribute to the heuristic's (Osborne & Pimentel, 2022) usability for climate change-related social media contexts and student users?

3 | METHODS

3.1 | Research design

Within this paper, we present results from a focus-group study in which we investigated the process of students' credibility evaluation using social media posts about climate change. For this momentary status of the research field, our aim was to enable an in-depth examination of students' perspective on how they evaluate credibility of scientific information on social media posts. It was our aim to collect a wide selection of specific criteria and gain an understanding of how students proceed when evaluating credibility. Griffioen et al. (2020) state that the user experiences need to be included in social media research for informative and ecologically valid findings. For this purpose, focus groups are a highly suitable method since they cover specific topic, are aiming to uncover a range of experiences and perspectives, want to foster a non-threatening group environment, and want to stimulate discussions between participants rather than with the moderator (Hennink & Leavy, 2014). We understand our study as a basis for future more experimental designs.

Overall, we conducted six focus group interviews with 21 students from the end of January until the end of March 2022. Before the interviews, students and their legal guardians provided written consent to participate in the study, including consent to video and audio record the focus group sessions and process the data. All students participated in their free time and were able to withdraw consent at any time. As we also anonymized all interviews, data collection was in line with the Declaration of Helsinki and the Guidelines of the American Psychological Association.

All focus group interviews were conducted remotely via videoconferencing software due to the ongoing pandemic. The interviews were transcribed upon completion of each meeting via MAXQDA20. The interviews lasted between 1 and 1.5 h and additional qualitative data was collected, which are not a part of this paper.

3.2 | Participants

The 21 participants attended varying school forms (10% grammar school, 33% comprehensive school, 57% secondary school) in different areas in Germany (14% from a metropolis [500,000 to 1.5 million inhabitants], 52% from a medium-sized town [between 200,000 and 500,000 inhabitants], 33% from a rural area [below 50,000

inhabitants]). All students were between the ages of 14 and 16 (M = 15 years; 57% female, 38% male, 5% nonbinary). We chose this age group because the German science standards include the effects of anthropogenic interventions on the ecosystem on the level of grades 9/10 (Kultusministerkonferenz, 2020). This increases the probability that participants had at least a basic level of understanding and awareness of climate change through school education. Additionally, this group is known to use social media extensively (Vogels et al., 2022).

Concerning the evaluation of scientific evidence and determination of credibility at middle school level, there are some aspects included in German science standards. Generally, the science standards for the age group aim at students developing arguments in more complex decision-making situations and explain their decision on the basis of the weighting of arguments (Neumann et al., 2010). More specifically, the students should be able to evaluate various sources when researching scientific information. Thereby, they should be able to distinguish between relevant and irrelevant information and between scientific explanations and everyday explanations (e.g., Niedersächsisches Kultusministerium, 2015).

Furthermore, we purposefully aimed for a diverse sample to consider that students relate to the topic of climate change in various ways and uncover different perspectives on content. Since McLafferty (2004) states that homogeneous groups appear to be more fruitful than heterogenous ones, three groups consisted of climate activist students (see Table 1, focus groups 4–6), and three more groups consisted of non-climate activist students (see Table 1, focus groups 1–3). First, we contacted Fridays for Future (FFF) groups Germany-wide via e-mail to reach young activist students. The e-mail addresses were listed on the official German FFF website. To acquire non-activist participants, we visited a school, where interested students could leave their contact information and mark whether they had ever participated in a climate protest. Since McLafferty (2004) states that focus groups made up of strangers require more moderator intervention, the non-activist students as well as the activist students, built groups of 3–5 people by themselves and chose one contact person to communicate with us.

Although we approached the activist and non-activist students in different ways, all groups were given the same information about the study beforehand. We communicated the frame conditions, including a 20 € incentive for completion of the interview.

Since students had differing social media usage and knowledge of climate change, we collected the names of all social media platforms that the students used and highlighted the platforms that were mentioned by every member of the group (Table 1). Based on Ko et al.'s (2005) scheme for user needs in social media usage, we asked students why they use social media. We also asked all students if they see and/or post content about climate change on social media; these three criteria generated diverse answers. At the end of the interview, we asked the students what they had learned about evaluating credibility on social media in school (see Table 1). Three out of six groups said that they had not talked about evaluating credibility on social media in school. Two groups said that they had several lessons on the detection of fake news and one group had several lessons on the influence of social media content and fake news on democracy. This was not necessarily in science class, but in any subject.

It was our goal to have a heterogenous sample including students that relate to the topic of social media and climate change in different ways since this will also be the case in most classrooms.

3.3 | Interview manual and material

The semistructured interview manual was based on the first research question (RQ1) and was divided into three phases (see Supporting Information S1: Table 4). In a warm-up phase, we asked the students four introductory questions to gain information about each student's social media usage (apps and functions) and the climate change content they encounter and post on their social media (see Table 1). When necessary, we made use of probing questions to extract more in-depth responses from participants. The students sequentially answered questions and could add thoughts on the answers of others.

TABLE 1 Students' background information.

	FG1 (*n* = 5)	FG2 (*n* = 3)	FG3 (*n* = 3)	FG4 (*n* = 3)	FG5 (*n* = 4)	FG6 (*n* = 3)
Social media apps used	**Snapchat** Instagram TikTok	**Instagram** TikTok Snapchat	**TikTok** Instagram Snapchat YouTube	**Instagram** Youtube (Twitter)	**Instagram** **Telegram** Youtube	**Instagram** Twitter Snapchat Pinterest
Functions of social media (Ko et al., 2005)	Entertainment and relaxation Social interaction	Entertainment and relaxation Social interaction	Entertainment and relaxation	Entertainment and relaxation Knowledge enhancement	Knowledge enhancement Social interaction	Entertainment and relaxation Social interaction Knowledge enhancement
Do you see content about climate change on social media?	Few (2) None (3)	Yes (1) Few (1) None (1)	None	Few	Yes	Most of the time
Do you post content about climate change on social media?	No (5)	No (3)	No (3)	Yes (2) No (1)	Yes (2) Few (1) No (1)	Yes (1) Few (1) No (1)
What have you talked about evaluating credibility on social media in school?	Origin, spread, and detection of fake news on social media (about three lessons)	-	-	-	Detection of fake news and verifying sources on social media (about four lessons)	Social media and algorithms as a threat to democracy and information research of multiple independent sites/ sources (about four lessons)

Note: The social media apps written in bold in column one are apps that the participants of the group mentioned to use the most.

Abbreviation: FG, focus group.

The warm-up phase was followed by two phases (phase 1 and phase 2) of confrontation with the topic of credibility evaluation. The two phases included different methodological procedures as this can lead to a deeper understanding of the subject. In phase 1, we asked students what they pay attention to when they review information about climate change on social media for its credibility. This was supposed to prompt them to discuss features of credibility including components in their credibility decision-making. In phase 2, we successively showed three prepared social media posts about climate change (see Figure 3) to students and asked them what they pay attention to in the specific posts when evaluating credibility. In phase 2, we wanted to receive expanded information about the credibility criteria in a more application-related setting. Here, the students did not have to answer one after the other in a specific order but could spontaneously share their thoughts. Phase 2 aimed at surfacing subconscious thought processes and previously unmentioned criteria. For this purpose, our criteria for the creation of the posts were: (i) to vary the posts in terms of the credibility of content, source, and design, (ii) to have no more than three posts due to cognitive overload, and (iii) to base the stimuli on real posts to demonstrate authentic examples.

On this basis, we discussed main characteristics of the posts and decided on the following input to the students:

A) Create one post against the scientific consensus, that appears credible, but lacks credible content.
B) One post in line with scientific consensus, that appears credible, but lacks credible content.
C) One post in line with scientific consensus and that includes credible content, but does not appear credible.

To gain complexity, we decided to create two posts that are in line with the scientific consensus and have credibility deficit in different areas. Even though the posts were based on real examples, we designed them particularly for study to avoid copyright infringement.

We conducted one test focus group interview with the final interview manual and final posts to see if there are any problems concerning the understanding or presentation of the material or the questions of the manual. Since there were no problems, the test focus group interview was included in the general analysis of the data.

3.4 | Data analysis

Before the analysis, we anonymized the names of participants using pseudonyms, which are also used in this paper. To answer research question 1, we analyzed the credibility criteria students mentioned when asked about credibility criteria on social media (phase 1) and their reactions to the three stimuli (phase 2). To examine the initial decision-making process, we also included the credibility criteria students initially mentioned at the beginning of the shown stimuli in phase 2.

3.4.1 | Initial statements

To gain a more complex insight into students' social media evaluation behavior during fast-living scrolling processes (RQ1), we additionally looked at the initial criteria students consider. To reduce deliberation, we only analyzed the very first statement for each presented post in phase 2. We understand this as an initial reaction to the post. The criteria mentioned in the first response were also assigned to one of the main categories who, what, and how. We created a coding system for analysis of the overall criteria in phases 1 and 2.

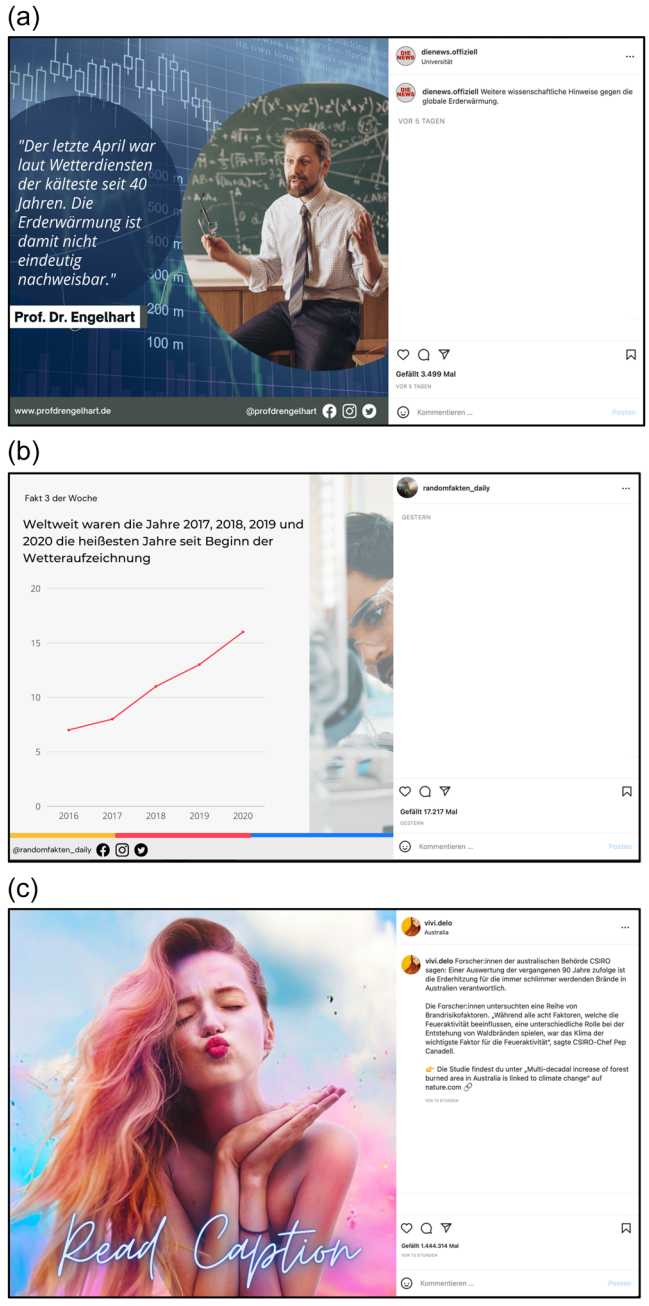

FIGURE 3 Focus group stimuli used in phase 2. The stimuli are oriented on real Instagram posts and written in German. They vary in credibility (e.g., concerning scientific consensus, source acknowledgment, diagram label, expertise of source, post-design, number of likes). Translation of textual elements for each stimulus: Stimulus (a): image left: Last April was the coldest in 40 years, according to weather services. Global warming is thus not clearly proven; caption right: More scientific evidence against global warming. Stimulus (b): image left: Fact 3 of the week; globally, 2017, 2018, 2019, and 2020 were the hottest years since weather records began. Stimulus (c): caption right: Researchers from the Australian agency CSIRO say: According to an evaluation of the past 90 years, global warming is responsible for the increasingly severe fires in Australia. The researchers are examining a range of fire risk factors. "While all eight factors that influence fire activity play different roles in causing wildfires, climate has been the most important factor in fire activity," said CSIRO chief Pep Canadell. For the study, see "Multi-decadal increase of forest burned area in Australia is linked to climate change" on nature.com.

3.4.2 | Coding system

As a first step, the focus group interviews were analyzed by qualitative content analysis, according to Rädiker and Kuckartz (2019), using a deductive coding system. As described in the theoretical background, we created the categories of who, what, and how based on theoretical approaches and empirical evidence on credibility evaluation. We used these categories as a first step to structure the complex qualitative data. Additionally, we found the distinct main categories helpful to specifically gain information about the unexplored role of composition-related criteria and for the derivation of specific educational implications. The definitions of the codes and general coding instructions were documented within a coding manual (Rädiker & Kuckartz, 2019). The deductive coding system was then used on the focus groups with the aid of the coding manual, including coding rules oriented on Rädiker and Kuckartz (2019).

To identify and reduce problems and subjectivity concerning these deductive main categories and their definition during the process of coding, the coding system was independently double coded by two researchers (Rädiker & Kuckartz, 2019). Therefore, two interview transcripts were coded that differed in length and content to ensure that the coding system is suitable for various interview outcomes. Rädiker and Kuckartz (2019) call this the principle of contrast. Since the Cohen's κ coefficient in the first round was not satisfactory, the researchers discussed differences in their coding decisions and further clarified and specified the coding manual or the coding system. After a second double coding, we determined the Cohen's κ coefficient $\kappa = 0.95$ for transcript 1 and $\kappa = 0.89$ for transcript 2. The tables that we used to determine κ are included in the Supporting Information S1: Tables 1 and 2.

The coding system was then inductively extended. The inductive extension ensured that we were able to include criteria that might not fit any main category and that we remain focused on the real data. We also inductively added the main category opinion of others as utterances about the inclusion of external opinion did not distinctively fit into any of the other categories and seemed to play a role in the students' evaluation process. We added specific features the students mentioned as inductive subcodes of the four main categories in a phase of open coding (Rädiker & Kuckartz, 2019). To identify and reduce further problems concerning the categories and their definition, the codes were discussed by a group of transdisciplinary scientists on the basis of two focus group codings, again following the principle of contrast (Rädiker & Kuckartz, 2019).

Our research interest focused on the code intersections of both focus groups rather than differences. We believe the intersection of criteria from the activist and the non-activist focus groups suggests key aspects and builds the base level of knowledge that can be expected in the classroom. Therefore, we eventually excluded the categories that were mentioned by only one group of students: activist or non-activist.

The students' quotes were translated by a scientist who is a native German speaker with a C2-level in English. To ensure a corresponding translation, the English quotes were additionally presented to a native English speaker, and their meanings were discussed and adjusted accordingly.

3.4.3 | Application to Osborne's and Pimentel's heuristic

To explore how the criteria described above can be applied to the heuristic by Osborne and Pimentel (2022) as a part of the second research question, we first listed the three filters of the heuristic, including their subpoints (see Figure 1). For filter 1, we joined the subpoints “unbiased analysis” and “no conflict of interest.” This is because the definition of conflict of interest includes a lack of bias (Davis et al., 2001). For filter 2, we joined the subpoints “credentials and institutional context” and “relevant professional experience” since credentials include relevant professional experience. Additionally, we added the subpoint “track record” to “credentials and institutional context” since they both refer to the source's professional background information and therefore the practical

appliance of these aspects appeared to be very similar. For filter 3, we only included the subpoints on how to inquire about the consensus (Figure 1, filter 3: yes) since we focused on platform-related criteria. The points of inquiry in case there is no consensus require complex research that went beyond our research question and therefore did not match our research design (Figure 1, filter 3: no). The final arrangement of the subpoint can be found in Table 4. Subsequently, we assigned the students' credibility criteria from Table 3 to one or more of the filters of the heuristic. Those criteria could also be a specification or example of the filters for the social media and climate change context of scientific information.

4 | RESULTS

4.1 | Students' initial statements

Students generally included all three deductively created credibility dimensions in their initial evaluations (see Table 2). Within these dimensions, the credibility how was the most dominant dimension in the students' initial utterances. It also became apparent that the students do not always include a single criterion in their initial credibility evaluation. Rather, they applied a set of criteria that stemmed from different credibility dimensions (see Table 2), which the following quote demonstrates:

> "It looks scientific to me because it's from a professor and because it falsifies something we thought was true for many years. […] In the background are many numbers and calculations. I think that shows that they worked on the topic a lot or that the post has a high standard, because you don't see that just anywhere." (FG2, 67)

Sebastian included the academic title of the person speaking (who), the evaluation of the content (what), and the composition-related post elements (how) in his initial credibility evaluation. It also became apparent that for stimulus C, the students mainly included criteria from the composition-related dimension (see Table 2). This differs in stimuli 1 and 2, where the applied criteria were distributed among all dimensions (see Table 2).

Further information about the students' initial statements can be found in the supplemental material (Supporting Information S1: Table 3). The inductively added dimension opinion of others was not included in the students' initial statements.

TABLE 2 Overview over initial credibility criteria for each stimulus and focus group in phase 2.

	Stimulus A			Stimulus B			Stimulus C		
	What	Who	How	What	Who	How	What	Who	How
FG1		X				2X			X
FG2	X	X	X	X	X	X			2X
FG3	X	X			2X	2X			2X
FG4	X	3X	X		X				3X
FG5	X	X	X	X		X	X		2X
FG6			X	X				X	

Note: A cross indicates a student initially applied one criterion from this dimension. A number in front of a cross indicates the amount of different criteria the student used from the dimension.

Abbreviation: FG, focus group.

4.2 | Students' credibility criteria

4.2.1 | Content-related criteria (what)

As the results of 5.1.1 suggest, we found criteria for all three credibility dimensions throughout the focus group interviews. Content-related credibility criteria were context, coherence, and the inclusion of facts (Table 3). Concerning context, they expressed that information in posts should be explained with further details or background information, for eaxmple, putting numbers into context and illuminating all aspects of a topic. Concerning content coherence, the students mentioned that they specifically look for illogical conclusions and sensible labels on diagrams. It seemed that for some students, content knowledge about climate change helped to detect incoherence, as the following quote demonstrates:

> "Everyone who is a little involved in that topic knows that weather and climate are not the same thing. So, the utterance doesn't make sense." (FG 5, 100)

Coherence was exclusively mentioned concerning the displayed posts (see Table 3). However, students often mentioned the term facts, when talking about the credibility of a post. When we asked the students what they meant by this term, they often gave vague, sometimes speculative definitions like the following:

> "[It is a fact] because it was scientifically proven. There is probably research about it, where someone researched the data." (FG 2, 98)

Another utterance seemed to be more about how the information is displayed language-wise than the content itself:

> "[…] I think it's credible that the post is a fact and not a thesis." (FG 2, 98)

This statement also suggests the student perceives a factual delivery of information as more credible than a thesis.

4.2.2 | Source-related criteria (who)

For the category who, we found that students pay attention to the following credibility criteria: scientific account, academic title, further content, content consistent account name, verified account, no self-advertisement, and familiarity. Of all the credibility criteria mentioned for the dimension who, we found that academic title and no self-advertisement were exclusively mentioned as a credibility criterion in phase 2 (Table 3). For those two criteria, we also found that some students took opposite approaches to the same information in the stimuli to come to different credibility decisions. Whereas most students mentioned that the "Prof. Dr." in the post creates a professional impression, other students point out that it is relevant if the expert received the title in the field of climatology, which is not indicated (see Table 3, academic title). Concerning self-advertisement, one student mentions that the links to other accounts in stimuli A are "weird," "unnecessary," and only made use of by entertainment posts. Another student refers to the same information in stimuli A as helpful since one can find out who the posting person is (see Table 3, no self-advertisement).

Concerning the criterion familiarity, some students mentioned that familiarity itself does not suffice and there must be trust in the familiar account, as the following quote exemplifies:

TABLE 3 Mentioned criteria for what, who, how, and opinion of others in phase 1 and 2.

Category	Mentioned in phase 1 and/or 2	Description	Anchor quote(s)
What			
Context	1, 2	Information is put into context through detailed explanation and/or multiple perspectives	"I would say you can tell if something is credible through the explanation. For example if a post is about CO_2-emmissions and they explain how it works and when CO_2 is emitted und how much is emitted." (FG 2, 76)
Coherence	2	Source contains coherent conclusions or plausible diagram labels	"I wrote down that the quote is not credible, because I know pretty sure that it is not right to conclude that global warming does or does not exist due to one somehow colder April. I wouldn't look at the post again and I also wouldn't look at the professor again. The quote would be enough for me to say: 'Okay, that is not credible.'" (FG 4, 99)
Facts	1, 2	Students used the word facts to describe credible information	"[When thinking about credible posts on social media] I think about fact posts. Posts […] from publicly available media channels, where facts are posted." (FG 1, 111)
Who			
Scientific account	1, 2	Information from accounts perceived as scientific	"If the post comes from a serious institute, it is not questioned much or if I see something from a more or less known scientist." (FG 5, 72)
Academic title	2	Information from people with academic title	"It makes a professional impression because it says 'professor doctor' below [the quote]." (FG 4, 246) "[…] This 'professor doctor' stands out, which I also find very amusing, because there is never written next to it for what actually. I can be professor and doctor in different things and I find that still relatively relevant, because if he has a history doctorate, that doesn't have anything to do with climatology." (FG 4, 135)
Further content	1, 2	Other content from the account	"When I read something […] I look: Okay, who wrote this? How trustworthy is this human? What else did he write? And if he

TABLE 3 (Continued)

Category	Mentioned in phase 1 and/or 2	Description	Anchor quote(s)
			wrote things where I thought: 'Oh, no!', then I won't read it. I don't feel like it then." (FG 6, 34)
Content consistent account name	1, 2	Name of account perceived as serious and/or with connection to the content	"I depend on the content and the name. For example, if [an account] has a normal name like 'Foreignermemes212' it's different from an account that's named 'Environment.de.'" (FG 5, 77)
Verified account	1, 2	Accounts perceived as official, often with blue check mark	"It definitely depends on the blue check mark, if I trust someone. That's the first thing I look at." (FG 6, 65)
No self-advertisement	2	Sharing the information intents financial profit or self-marketing	"I find it weird when public accounts put 'follow me here' and 'I have another account here' everywhere. I find it unnecessary. […] In my opinion, only entertainment posts make use of that." (FG 4, 135)
			"I think it's good that the professor's social media accounts are linked again below, so you can find out who the man is in the first place." (FG 5, 98)
Familiarity	1, 2	Level of familiarity with the account	"You would question the credibility more on pages that you didn't know before." (FG 2, 33)
How			
Coherent composition of elements	2	The elements included in information source complement each other	"For me this isn't a credible post. Especially because it's not professional […], specifically because of the image. The image is in the foreground and if the post is about a forest fire or about the climate crisis, there shouldn't be a woman with a kissing face, except she's hanging in a burning forest, then maybe. There has to be some kind of relation to what's standing next to it […]." (FG 5, 116)
Authentic footage	2	Pictures included in information source appear authentic	"I think it looks very untrustworthy because that is a typical stock picture." (FG 6, 94)

(Continues)

TABLE 3 (Continued)

Category	Mentioned in phase 1 and/or 2	Description	Anchor quote(s)
Number of likes	2	Number of likes perceived as high	"I also noticed that there are a lot more likes [than on the post before]. So, this could be a more professional page." (FG 1, 257)
			"[…] Over a million likes in 13 h. Respect! (laughs) That's where I think to myself: Okay, maybe they is botting involved. That's buying likes. It just seems untrustworthy to me." (FG 5, 117)
Possibility for further reading	1, 2	Information source including option to read more about topic	"There is an added link to the page […]. [That's credible], because they give us the chance to check." (FG 2, 105)
Source indication	1, 2	Source is indicated	"There are no sources. These are random facts, but prove your facts! It's not really credible like this." (FG 5, 108)
Integration of studies	1, 2	Direct reference to an empirical study	"I think it's always good if […] studies appear in the post. So that you have the source indication in the form of a study in the posts. That's a sign of competence for me." (FG 5, 91)
Visualized data	2	Information source includes visualized data, for example, a diagram	"I think it's credible, because you can see statistics right away." (FG 1, 257)
			"[…] I don't understand this kind of math in the background. It doesn't make any sense at all. I haven't been able to find out exactly which formulas these are, but these are triangles and as far as I know, that's usually not relevant in climatology." (FG 4, 135)
Opinion of others			
Comments	1, 2	Checking the comment section, researching online	"I read the comments to check the credibility. I look at what other users say. If they don't have the same opinion, then I'll google." (FG 2, 14)

> "With pages that I have a personal connection with or a trusting relation, I do not check the source, but on other posts, there needs to be sources." (FG 5, 88)

The quote also suggests that a trusting familiarity with the account decreases the need for other credibility criteria, such as an indication of sources. This concept was found in several utterances, and unfamiliarity increased students' need for other credibility criteria (see Table 3, familiarity). This suggests that from students' perspectives, familiarity is a superior criterion influencing the need for other credibility criteria. Generally, familiarity was explicitly mentioned in reference to institutions that also hold credibility outside social media, such as magazines or research centers.

4.2.3 | Composition-related criteria (how)

For the category how, we found that students pay attention to the following credibility criteria: coherent composition of elements, authentic footage, visualized data, integration of studies, number of likes, possibility for further reading, and source indication. The students exclusively referred to the first four of the six criteria in phase 2 (see Table 3).

A coherent composition of elements was a dominant criterion mentioned by the students exclusively in phase 2. This involved different compositional elements in a post revolving around the same topic and therefore making sense as a whole. Some students specifically evaluated the level of professionalism based on the composition of the post elements (see Table 3, coherent composition of elements).

Even though the criteria visualized data, integration of studies, possibility for further reading, and source indication include content-related aspects, we assigned them to the composition-related dimension. This is because most students were observed to superficially check for the existence of these elements rather than their quality (see Table 3, visualized data). For example, most students referred to the existence of links for further reading or sources included in a post as important because it signalized an opportunity to check the posts credibility on a content level (see Table 3, possibility for further reading); however, only a few mentioned performing this action. Rather, most students seemed to only look for the option to check the information, which increased their perception of credibility. Even though source indication was a dominant criterion in the students' utterances, some students seemed to struggle to differentiate a source from a link for further information or even self-advertisement, as the following dialogue between two students demonstrates:

> Laura: "In my opinion, this post is not scientifically proven because usually there is always a source." Sarina: "Huh? I just said there is a source indicated." Laura: "BUT WHERE? There is only a website indicated and no source." Sarina: "Yes, there is. You can do some further reading. It's a source. It's his website and that's where it [the information] probably comes from. And that's the source then."

Another dominant credibility criterion mentioned by a majority of students was the number of likes. Since students had differing opinions concerning the role of likes in credibility evaluations, we consider number of likes to be a controversial criterion. On the one hand, students mentioned a high number of likes as a sign of credibility (see Table 3, number of likes). On the other hand, students still perceived the amount likes but did not view it as a sign of credibility, as the following quote demonstrates:

> "Judging by the number of likes is absolutely stupid in my opinion because she [the posting person] could also be very popular and little kids may like it because they like her. But those kids don't even read the text that is down there." (FG 2, 109)

Similarly, we found that students interpret visualized data in opposing manners concerning credibility. On stimuli A one student mentioned that the post appears credible, because they initially see statistics. In contrast, another student elaborated that the math in the background does not make sense, since they have no connection to climatology (see Table 3, visualized data).

4.2.4 | Opinion of others

In the credibility dimension opinion of others, some students mentioned they include the comments beneath a post when deciding on its credibility. These students mentioned they mostly examine if there is consensus on the topic in the comments (see Table 3). Two students mentioned that if there was no obvious comment consensus, they leave the platform to complete a Google research (see Table 3).

4.3 | Application to the heuristic

To explore research question 2, we examined how the three filters from the heuristic by Osborne and Pimentel (2022) could be assigned to the students' credibility criteria. We generally assigned criteria from all credibility dimensions of what, who, and how to filter 1 (see Table 4). For no conflicts of interest and an unbiased analysis of topic, we assigned the credibility criteria context, no self-advertisement, account name, and verified account. We included context because students often included multiple perspectives in their elaboration of context (see Table 3). We understood the integration of multiple perspectives on a topic as an indicator of a lack of bias. We included content consistent account name because the name of the account might offer information about a possible conflict of interest when posting about climate change (e.g., @lufthansa). We finally included verified account because students reasoned that a verified account is more credible since it was checked by the social media platform. For source acknowledged, we assigned the credibility criterion source indication.

We generally assigned criteria from the credibility dimensions who, how, and opinion of others to filter 2 (see Table 4). For track record, credentials, and institutional context we exclusively assigned criteria from the credibility dimension who, namely the following: further content, scientific account, academic title, and content consistent account name. We included content consistent account name because if the account name includes the overall topic of the information (e.g., @climatechange_info), students believe the account specializes in content on this specific topic (see Table 3). For reputation among peers we assigned the criteria number of likes and comments.

We generally assigned criteria from the credibility dimensions what, how, and opinion of others to filter 3 (see Table 4). For explanations we assigned the content-related criteria context and coherence, and the composition-related criterion coherent composition of elements (see Table 4). We included coherent composition of elements since visual elements also carry information, therefore their composition is a part of the explanation. For nature of evidence, we assigned the composition-related criteria integration of studies and visualized data. These criteria do not offer much information about the actual nature of the evidence, except that it is empirical; the criteria indicate whether empirical evidence is present.

Therefore, these criteria are more superficial than the criterion of filter 3. For degree of certainty, we assigned the criteria facts and comments. Comments do not, or only rarely, offer information about the degree of certainty among relevant experts. Since students described that they gain a sense of certainty and consensus through the comments, we assigned this criterion with restrictions to filter 3.

Finally, we were not able to assign the criteria authentic footage, possibility for further reading, and familiarity to a filter of the heuristic. Since the criterion possibility for further reading specifically focused on the chance to gain further information and not on the act of reading the information, we could not assign it to any filter. Familiarity was not assigned since it is a superior criterion that increases or decreases the need for other credibility

TABLE 4 Application of students' credibility criteria to filters of heuristic by Osborne and Pimentel (2022).

	What	Who	How	Opinion of others
Filter 1: source credibility				
No conflicts of interest (including unbiased analysis of topic)	Context	No self-advertisement Content consistent account name Verified account		
Source acknowledged			Source indication	
Filter 2: source expertise				
Track record, credentials, (including relevant professional experience) & institutional context		Further content Scientific account Academic title Content-consistent account name		
Reputation among peers			Number of likes	Comments
Filter 3: consensus among experts				
Explanations	Context Coherence		Coherent composition of elements	
Nature of evidence			Integration of studies Visualized data	
Degree of certainty	Facts			Comments

criteria, as described before. Overall, the students seemed to evaluate the credibility more superficially (see Table 4, nature of evidence) than the heuristic suggests.

5 | DISCUSSION

5.1 | Credibility dimensions

5.1.1 | What, who, and how as a structuring frame

In the initial as well as in the overall credibility evaluation of scientific posts about climate change, students included various criteria and often combined criteria from different credibility dimensions. All three credibility dimensions were included and helped to structure the data. These results suggest that students make initial credibility evaluations not based on only one dimension but a complex, holistic composition of several criteria, mostly from different dimensions. The results suggest that credibility evaluation is a process that decreases the probability of misinformation and increases the probability of credible information. To detect misinformation, none of the

credibility criteria are sufficient by themselves, but the combination of different criteria from different dimensions increases the probability of information being credible.

This is contrary to several contemporary theoretical approaches, such as Allchin's "Who Speaks for Science" approach (2022) and Osborne's and Pimentel's heuristic (2022), that focus on the source-related dimension. However, the results are in line with Metzger et al.'s (2010) findings about how people make use of several heuristics and combine various aspects of different heuristics when evaluating the credibility of online information. Our results suggest this procedure can also be found in the social media environment behavior of students.

The specific criteria applied might be partly based on the specific stimulus because students might have mainly applied composition-related criteria to stimulus C (phase 2) since it solely included an image in the prominent area of the post and had scientific textual information only in the caption below. This suggests that students apply different credibility criteria within a social media platform depending on the composition of the post. This underscores a diversity in credibility evaluation within a specific environment and might also be transferable to other media, such as news pages or Google results.

The process of combining different criteria into the initial credibility evaluation might be applied because on fast-moving platforms there is no time to apply an in-depth analysis. Therefore, students might combine different quickly applied criteria that work together for effectiveness reasons. A single quickly applied criterion would not suffice, but the combination of several criteria means each criterion is not required to be completely reliable regarding the probability of information credibility. This is in line with the research of Metzger, suggesting that users do not systematically analyze online information and combine several criteria (Metzger & Flanagin, 2013; Metzger et al., 2010). In science education, the dimensions what, who, and how can also function as a comprehensible frame helping students to loosely structure their credibility criteria. This can be a basis for students to reflect upon their criteria as it offers a clear structure without forcing non-applicable procedures on them.

Within each credibility dimension, we found various criteria, some of which are included in the literature, and some that are new, particularly in the context of social media. The results also suggest that the students might have a varying level of awareness concerning the credibility criteria they apply, with the tendency to be more unaware of the composition-related dimension. One possible explanation for this is that the science standards do not include the composition-related dimension, but rather focus on the content- and the source-related dimension (Niedersächsisches Kultusministerium, 2015).

5.1.2 | The role of facts in the what

In the content-related dimension (what), students included coherence and context in their credibility evaluation. The coherence criterion can also be found in Bromme's and Kienhues' (2014) plausibility judgment, where coherence is portrayed as an important principle when processing information. It states that textual information that is, logically compatible can be processed more deeply and remembered more easily (Bromme & Kienhues, 2014). However, the students mentioned coherence exclusively in phase 2. This could be due to them not being aware of including coherence in their credibility decision, which explains why they did not mention it in phase 1. It could also be possible that the lack of coherence was more dominant in the stimuli posts than the students were used to, which explains why it was a more dominant factor in phase 2 and might be less relevant in the real environment.

Even though the term facts was rather dominant in the students' evaluation of credibility, the concept of facts or their determination is not a part in German science standards (Niedersächsisches Kultusministerium, 2015). Despite using the term facts in the focus groups, the meaning of the word might not be clear to most of the students. It seemed the students used the term facts as knowledge that cannot be questioned, information they believe is true, or information that is conveyed as being true and therefore perceived as credible. Labeling

information a factual might be helpful for students in the process of evaluating credibility. It also might be a helpful basis for understanding the concept of scientific consensus. However, according to Osborne and Pimentel (2023) students' need for authoritative answers to scientific questions is due to the approach on consensus in formal education, often neglecting the uncertainty of science-in-the-making. This is problematic in the face of our findings that even though students used the word facts to refer to content, it seemed through the students' utterances that their perception of information was highly influenced by how the information is conveyed, for example, on a language level. This is in line with Coen et al.'s (2021) findings on news comment readers who construct expertise on climate change relying on construction of one's argument as factual. This suggests that how the information is delivered can subconsciously influence other dimensions, which underscores the power of composition-related decisions on credibility evaluation of information. Such a superficial and quick judgment of information as factual might be dangerous in the context of intentional misinformation. If students misjudge misinformation as factual, it might be harder to change their mind due to the rigid concept of facts. This might hint to a lack of understanding of the tentativeness of scientific information. Therefore, the occurrence of tentativeness and uncertainty as a central part of the nature of science and its credible character needs to be addressed in science education and the context of social media.

5.1.3 | Specifying the understanding of who

Concerning the source-related dimension (who), we found that students check that there is no self-advertisement included in the information. This is related to Metzger and Flanagin (2013) persuasive intent heuristic, which includes the impression of a bias and is especially prompted through commercial content. In this heuristic, commercial content is a strong negative credibility criterion, especially when not obvious, as it leaves the user feeling manipulated and therefore activates defense mechanisms (Metzger & Flanagin, 2013). This could also be the case for students in social media environments where advertisement and especially self-advertisement regularly occur but are often untransparent.

When evaluating scientific information on social media, the students mentioned their familiarity with the source as a credibility criterion. Several students explained that they are more skeptical of unknown sources and, in contrast, are looking for fewer credibility criteria when they are familiar with the source. It seems the criterion of familiarity is a superior criterion that inhibits or reinforces the application of other credibility criteria. This is similar to Metzger et al.'s (2010) reputation heuristic, which involves the reputation or the name recognition of an online source and is described as a "cue allowing information seekers to avoid more effortful processing of online sources and information" (p. 214).

If students trust the source, for example, if the source has proven to be credible in the past, this can be an effective criterion. However, including familiarity with a source in the credibility evaluation can be problematic. Research on persuasion shows that familiar sources are perceived as more credible than unknown sources, independent of the content (O'Keefe, 2015). Students need to be aware of the difference between trusting familiarity and mere familiarity with a source. In the classroom, this could be implemented through inoculation.

5.1.4 | Understanding the how of credibility evaluation in social media

In the final composition-based dimension (how), students did not only pay attention to coherence with regard to content but also the overall composition of the post. Therefore, students do not only check for coherence within a text but also between different visual elements and, combining the content- and composition-related dimensions, between the content of the text and the chosen visual elements. The coherence criteria that is also a part of Bromme's and Kienhues' (2014) plausibility judgment can therefore be transferred to composition-related criteria.

Generally, an overall impression of the information on social media as coherent seems to have a central role in the credibility evaluation.

Since most students superficially checked for the presence of these elements rather than their quality, the following criteria were assigned to the composition-related dimension: visualized data, integration of studies, possibility for further reading, and source indication. These results suggest that the students used these credibility criteria, which have a content relation, and adjusted them to composition-related criteria through a more superficial application. This might be a general process of credibility evaluation on social media that is, ongoing due to efficiency. This is compatible with research showing that people focus on verification strategies that require the least effort (Metzger, 2007). Criteria requiring the least effort are on more superficial cues such as visual design elements (Fogg, 2003; Kim et al., 2021; Metzger, 2007). It is argued that due to the fast-moving online environment, users "likely develop quick strategies for assessing credibility" (Metzger & Flanagin, 2013, p. 213) to minimize time and cognitive load (Metzger & Flanagin, 2013). The described manner in which students apply the criteria visualized data, integration of studies, possibility for further reading, and source indication might be one of those strategies. Initially, this might seem like these strategies lead to a false credibility evaluation. However, some early research on internet usage shows that these superficial criteria can help users to effectively cope with a large amount of information they are confronted with daily and may often lead to accurate decisions (Gigerenzer & Todd, 1999).

It became obvious that the indication of sources is a dominant credibility criterion for the students. This might be due to its presence in educational contexts since source indication is a traditional credibility criterion. However, it also became apparent that some students struggled to distinguish between sources and regular hyperlinks, for example, for further reading. This could suggest that students struggle to translate the concept of source indication onto the complex social media environment. This struggle could be sparked through the superficial examination of the existence of a source indication. For example, without opening a link it is sometimes impossible to distinguish a source indication from other information. Metzger and Flanagin (2013) state that online source information is more complex since it can be unavailable, masked, entirely missing, or provided but difficult to interpret, for example, when information is taken from one site and applied to another. This suggests that the development of credibility evaluation criteria requiring less effort and time can lead to new challenges arising from more superficial examination, such as this source detection problem.

Several criteria in the composition-related dimension, such as number of likes, were only mentioned in phase 2. This suggests students are less aware of including these criteria in their credibility decision-making. This could be especially dangerous for scientific information since a lack of awareness would make students more vulnerable to deceptive strategies, which often build on composition-related criteria (Allchin, 2012; Coen et al., 2021).

Despite the obvious importance of composition-related criteria in students' credibility evaluation of information on social media and how they can be used for deception, composition-related elements are mostly neglected in educational social media research, including approaches with a heuristic claim, such as Osborne and Pimentel (2022). As a consequence, the composition-related dimension is also not included in the German science standards (Niedersächsisches Kultusministerium, 2015).

This lack of consideration of real user behaviors and more authentic and therefore more complex (Chinn et al., 2021) social media environments might be a reason why research shows that students rarely apply recommended information evaluation approaches (Kim et al., 2014; Leeder, 2019). Since the composition-related dimension plays a role in the credibility evaluation of scientific information in social media, similar to the content- and source-related dimensions, it needs to be included in holistic approaches. Not including the composition-related dimension in science education leaves the students with an incomplete toolbox because they are not aware of the entirety of influential criteria and therefore still vulnerable to deceptive content due to superficial miscues. The lack of connection of credibility evaluation approaches to students' real holistic experience on social media platforms increases its negative influences. In the science classroom, students' awareness of these criteria could be strengthened through the psychological theory of inoculation (McGuire, 1961). The theory is designed to strengthen peoples' resistance to persuasion attempts, for example, misinformation (Lewandowsky & van der

Linden, 2021), by (i) raising awareness of possible threats and (ii) exposing people to those threatening strategies (Banas & Rains, 2010).

5.2 | Usability of the information heuristic for science education

As a part of our second research question, we investigated the application of the credibility criteria to the decision-based heuristic for evaluating science information (Osborne & Pimentel, 2022). While the subpoints of the heuristic were unspecific, the credibility criteria facilitated filling the categories with more specific content. Nevertheless, we suggest a further extension of the heuristic for the context of scientific information on social media. This extension is based on the following points of discussion.

Our findings suggest that the subpoints of the three filters are usually defined through several of the students' credibility criteria. This aligns with our finding from RQ1, showing there is usually a combination of criteria that give information about the credibility of information or in this case about a subpoint of the credibility evaluation. We also found that even though the heuristic is focused on the source-related dimension, we were able to apply criteria from all three dimensions to the heuristic. This could be because students gain information about a specific dimension also by including criteria from other dimensions, such as composition-related criteria to evaluate a source's expertise. This is in line with our findings from RQ1, where we found that especially composition-related dimensions influence students' perception of the other dimensions, for example, their perception of facts.

It became apparent that the students examine some of the subpoints from the heuristic more diversely and holistically in that they either use a high number of criteria and/or criteria from different dimensions that tell them about the subpoint. These subpoints are (a) no conflicts of interest, (b) track record and credentials, (c) reputation among peers, and (d) explanations. For no conflicts of interest, for example, the students included context (content-related dimension) as well as the occurrence of self-advertisements, a verified account, and a content-consistent name (source-related dimension). Even though, these criteria by themselves are quickly applied and less in-depth than the heuristic anticipated, combined they hold the potential to detect conflict of interest if all are applied by one student.

However, it also became apparent that some subpoints were included less diversely in the students' credibility criteria. This was the case for the subpoint source acknowledged, where we solely assigned the composition-related criteria source indication. This criterion, however, only includes checking for the presence of a source and does not examine if all sources are acknowledged or if sources are real. This suggests that the students paid less attention to this subpoint. This might be due to the circumstance that examining each source required too much effort as this can be especially complex in online environments (Metzger & Flanagin, 2013). Therefore, this hints at an area in which students are more vulnerable to misinformation since they are relying on only one criterion that has little reliability by itself.

Other subpoints in which the students appear to be more vulnerable to misinformation are nature of evidence and degree of certainty, both subpoints from filter 3. For nature of evidence, we assigned the students credibility criteria integration of studies and visualized data, both stemming from the composition-related dimension. This again suggests a much more superficial examination of the criterion than the heuristic anticipates since the nature of the evidence is not examined but checked if there is some evidence. For degree of certainty, we assigned the criteria facts and comments. As described in Section 6.1, facts is an unreliable deceptive criterion the students included. Checking the comments for a degree of certainty about a topic can help to get a first impression but does not suffice for a reliable evaluation. Since there are rarely relevant experts in the comments giving their opinion and the existence of echo chambers, the comments are not a single reliable criterion to seek external validation. Additionally, there is the possibility to buy bots that comment on information to impart a specific perspective. Reliance on comments can also be found in Metzger et al.'s (2010) endorsement heuristic, which includes the opinions of others. They conclude that although including the opinions of others can aid credibility evaluation, it is

potentially problematic in its reliance on group opinion as it is subject to crowd behavior and may falsely equate popularity with credibility (Metzger et al., 2010). Thus, the combination of the two criteria facts and comments leaves the students vulnerable to wrong conclusions. This could be because examining the nature of the evidence, the degree of certainty, and sources acknowledged would require the students to leave the platform, which according to Wineburg et al. (2022) they usually do not do since this requires too much effort and time (Metzger & Flanagin, 2013). The scope of generalizability of these findings and the extent to which students are vulnerable for misinformation due to superficial filter application of the heuristic needs to be the subject of further research.

5.3 | Reflecting social media as a specific media environment in science education

Some credibility criteria from different credibility dimensions students mentioned throughout the interview were specific to social media. These criteria were number of likes, comments, verified account, and account name. This list is not exhausted and rather hints at the existence of a set of influential credibility criteria that are unique to social media. Unlike Metzger and Flanagin (2013), who state that in some cases criteria such as the source function differently in online environments, we argue that additionally, there are new criteria that are arising through the usage of social media. These specific criteria can influence the perception of all credibility dimensions, for example, a high number of likes causing the content to appear more credible.

Since these criteria impact students' credibility perception, they should be included in holistic approaches to credibility evaluation on social media. Students need to critically reflect on the criteria and their informative value so that they can use them as helpful tools in credibility judgments. A verified account for example holds the informative value that the account was checked by the platform and the person was found to be real. However, it does not declare the person to be a credible source of information. Therefore, students could benefit from knowledge specific to social media, including mechanisms that influence these specific credibility criteria, such as algorithmic functions. However, in science standards and science education, social-media-specific criteria are often neglected, and to our knowledge, social-media-specific approaches to credibility evaluation of information do not yet exist. This underscores the need for a social-media-specific educational framework, which includes technical knowledge about the influence of algorithms and advertisement on their credibility perception, for example, algorithmic function can influence the number of likes. This is also relevant for other online environments, such as search engines, where the order of search results is influenced by algorithms and commercial interests.

6 | CONCLUSION

6.1 | Limitations

Since the stimuli were Instagram posts, phase 2 of the interviews was specifically concerning the social media platform Instagram, other than the more general question in phase 1. This was because we wanted to create a more specific environment in phase 2 (Chinn et al., 2021). Since every student indicated using Instagram and it was the most dominantly used application in general (see Table 1), every student was able to relate to the platform.

A limitation of the research design is that it is unsure if the criteria the students mentioned in the reflective setting of the study are the same criteria they actually apply when using social media in their everyday life. For this momentary status of the research field, our aim was an to enable an in-depth examination of students' perspective on how they evaluate credibility of scientific information. It was our aim to collect specific criteria and gain an understanding of how students proceed when evaluating credibility. The transferability of our results on the students' everyday usage needs to be tested in more authentic environments in future studies.

Because we asked students to share how they would evaluate credibility, the setting of the research design might be less authentic than their real usage, where they decide by themselves which posts, if any, they evaluate on credibility. Therefore, some students mentioned they might not have checked the credibility of the stimuli posts. Research shows that users do not check all posts for credibility (Metzger & Flanagin, 2013). Here, the function of social media in students' lives might play a role, for example, if a student mainly uses social media for entertainment and relaxation, they might be less vigilant towards the credibility of posts. In addition, students mentioned that they were more likely to check the credibility of topics of interest. Hereby, students could be threatened to follow their cognitive biases, meaning they subconsciously look for information in line with their prior beliefs (Davis & Lewandowsky, 2022). Besides a better understanding of how these biases may affect credibility evaluations, other triggers that make students apply credibility criteria still need to be researched. Nevertheless, the credibility criteria students apply, even for posts that they would normally not examine for credibility, give information on what they pay attention to and value.

Another methodological limitation is that some social media criteria might go beyond the post itself and might therefore be less included or not at all included since the students were shown only the post and could not freely move around a platform to explore. For example, the integration of the amount of followers on an account might have been mentioned less since they were not present in the stimuli. Therefore, our results might be more focused on rather effortless platform-based scrolling criteria, which are probably applied more regularly.

Lastly, a limitation might be that specific elements of the stimuli from phase 2 influenced the students in a way that some criteria are overrepresented in the data. Since the students included these elements in their credibility evaluation, they are relevant criteria. The occurrence of the specific criteria in the real social media environment needs to be analyzed on a quantitative basis.

6.2 | Implications and outlook

The study showed the importance of including visual social media representations in the science classroom. In a more application-based environment, students include the composition-related dimension to evaluate scientific information on social media just as much as the content- and source-related dimensions. Future science education should therefore adjust to the fast-moving and multimedia circumstances on social media. Otherwise, the theoretical frameworks presented to students do not have a chance to be helpful to them because they are detached from usage.

Even though developing an understanding of the epistemic basis of science is still important for students' in-depth evaluation of scientific information, it is just as important for them to have tools that adjust to the social media environment and equip them with an awareness for efficient and therefore applicable evaluation procedures.

To make sure the criteria are connected to students' actual behaviors, it appears helpful to begin with the students' procedure when evaluating information for credibility on social media, which ensures the content of the lesson is student-centered and usage-based, making it more helpful and specific to students. This can also help students to become aware of the criteria they now use to evaluate scientific credibility on social media. Afterward, students question each of the criteria on reliability and eventually adjust their criteria after a phase of inoculation about deceptive strategies and possible dangers.

The found criteria are not exhausted. Further research is needed to gain a deeper understanding of the subject. Quantitative studies are necessary to gain more reliable information on students' credibility criteria for their evaluation of scientific information. Additionally, it is important to gain a deeper understanding of students' knowledge about social-media-specific criteria and their complexity. Therefore, students' awareness of social-media-specific communication mechanisms, such as algorithms and bots, might be promising for a better understanding of students' holistic view on credibility evaluation.

Understanding which criteria students use to evaluate the credibility of scientific information on social media and how they make use of them can help science educators and researchers to design interventions that increase students' scientific media literacy and thus help them to avoid deception, manipulation, and persuasion by misinformation in the social media environment. This is critical because students increasingly gain information from social media to guide their decisions.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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