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Students' Strategies When Dealing with Science-Based Information in Social Media—A Group Discussion Study

Nadja Belova *, Moritz Krause and Christopher Siemens

Department of Biology and Chemistry, University of Bremen, 28359 Bremen, Germany
* Correspondence: n.belova@uni-bremen.de

Abstract: As the world becomes increasingly complex, students must learn how to critically evaluate media messages and facts. Young people often obtain information from social media. Due to the ease with which information can be spread through such media, science misinformation is more prevalent. Learning how to critically evaluate information is expected to develop students' abilities to critically evaluate science and media content. Group discussions were conducted with 33 secondary school students in northern Germany to examine (1) their experiences with social media in the (science) classroom, (2) their strategies for dealing with science-based information in the media, and (3) their perception of the role of social media in the science classroom. Qualitative coding revealed that students frequently use social media for information purposes, both in school and privately, and perceive social media as relevant to science education. In social media, they are successful at applying general media literacy and IT strategies, but struggle with science-related strategies. This study suggests that more opportunities should be provided for students to critique science information, and a greater focus should be placed on educating students about evaluation skills and scientific reasoning.

Keywords: social media; media literacy; group discussion

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1. Introduction and Background

Science education aims to prepare students to become scientifically literate citizens [1]. Although the definition of scientific literacy has been the subject of debate for many years [1–3], nearly all available definitions acknowledge that the social dimension is an integral part of the concept. An individual who is scientifically literate should be able to make everyday decisions based on science [4]. In today's society, media plays an important role and shapes such decisions—from smaller ones such as purchasing a particular product to participating in politics. The post-truth world [5] is becoming increasingly complex as multidimensional questions rarely have simple solutions. The media landscape reflects this trend, since people are able to spread information through social networks such as Instagram, TikTok, or Facebook, and their numbers are increasing worldwide [6]. There is a scientific background to much of the information in such media, but it does not necessarily have to be disseminated by experts, which fundamentally changes how we communicate about and reflect on scientific content [7]. Furthermore, chemistry-related information is especially and often depicted negatively, and is referred to as "chemophobia" [8]—although there is a slow shift towards a more positive picture. Several school subjects now cover media aspects, especially in the humanities and social sciences [9]; however, these aspects are still very sparse in science education, and are mostly limited to traditional media such as newspapers [7,10]. This does not adequately reflect the media reality of young people, most of whom use social media. The ease with which anyone can create and share content on platforms such as Instagram, Facebook, or TikTok (removing the previously existing media gatekeepers) can lead to misinformation spreading quickly [5,11] and, in extreme cases, lead to social divisions, as is currently occurring in the debates around the COVID-19 pandemic [12]. In addition to such misinformation [11], both private and commercial users of social media use a range of strategies to make science-based content in general, and chemistry-based content in particular, appear more serious and credible [13]. These include, for example, deliberately emotive assertions (both positive and negative), insinuation of harm (e.g., regarding chemistry itself or "the chemical industry"), manipulated illustrations (e.g., graphs), linguistic exaggerations ("best effectiveness"), vague linguistic devices ("helps with", "a feeling of..." etc.), correlation which is presented as causality or the creation of a feeling of simple, and satisfactory answers (see e.g., [7,8,13–15]). UNESCO [16] calls the concept underlying the reflection of media "media and information literacy". It is divided into three dimensions (information literacy, media literacy, and digital literacy), each with related competences (e.g., "critically evaluate media content in light of media functions" or "make ethical use of information", p. 9). "Scientific media education" [10] or "science media literacy" [7] can in turn be viewed as a fusion of scientific literacy and media literacy in school science. Several research areas related to scientific media education have been identified by [10], emphasizing the importance of skills related to SME for all citizens in modern societies. For classroom interventions, promoting such skills to be as effective as possible, a baseline assessment of students' abilities to assess scientific information in social media must be established. How do they do this? What are the signs of critical awareness (or epistemic vigilance) they demonstrate [17]? What are the recognized media manipulation strategies? Are they already familiar with them in the context of schools? This is where our study seeks to bridge the gap. Throughout grades 9–13, we conducted twelve group discussions with students. Students were asked about social media use and school experiences. Additionally, we showed them three Instagram posts with scientific backgrounds for evaluation. Our goal was to see what manipulation strategies they recognize and, in turn, what strategies they themselves use to assess the information in the posts.

2. Theoretical Framework

A large part of society is confronted with digital media daily. Within the last decade, social networks in particular have gained in popularity. In total, 94% of German young people between the ages of 12 and 19 own a smartphone, and according to a survey, Instagram is the second most important app for them (after WhatsApp)—58% of the teenagers surveyed use the app every day [18]. As a source of information, social media offers huge opportunities for democratic participation on the one hand, but also great challenges in the educational realm, since understanding the use (and misuse) of scientific information is an essential competence for critical citizens and therefore for participation in society [19]. Furthermore, addressing current and controversial issues discussed in mass media increases learners' sense of relevance [20]. However, young people often misuse information in social media without critical thinking, despite being considered "digital natives" [21]. Students struggle with a variety of aspects associated with online information gathering, including searching for and evaluating it [22–24]. Young people actually trust misinformation as much as they trust accurate news when it comes to web-based media [25]. It is for this reason that appropriate materials and instructional interventions are repeatedly needed together with more thorough research, especially in science education [26]. So far, a limited amount of research has been conducted on social media or other internet resources in the science classroom. A study by Reid and Norris [10] outlined certain areas of scientific media education research for the future, including the design of standardized assessments for media literacy, something that has not yet been done for science education. Social media was not explicitly discussed in their paper, but they pointed out the importance of teaching students how to evaluate online science representations to avoid misinformation. In the context of science education research, social media has mostly been regarded as a communication tool [27,28] so far, and interventions for promoting knowledge in science on modern media types slowly began to develop a few years ago as part of the research agenda of science education researchers. A study by [13] examined how the media manipulates young people in the context of sustainable development using different types of manipulation techniques; the techniques (e.g., creating an urgency) were presented explicitly to secondary school students in a short lecture, and a post-test revealed that the majority of students were able to "identify and decode" them (p. 102). A critical reading intervention used by [11] utilized a pre- and post-test design: students were given two persuasive scientific articles and a critical reading guide for the treatment group only. Students from the treatment group demonstrated increased epistemic vigilance in the pre- and post-tests, although the effect sizes were small. A six-week intervention on sourcing was designed by [29]. Using science-based texts on climate change and nuclear power in their study design, they observed greater sensitivity to careful source selection in the treatment group; this effect lasted for more than five weeks. Similar effects have also been observed in research on adults (mainly from domains such as psychology) [30]—which is also called "inoculation" [31] against misinformation. As an example, Roozenbeek and van der Linden [32] developed an online game for recognizing misinformation and developing corresponding dissemination strategies. It requires players to actively apply certain strategies (such as polarization or emotionalization). It was found that the game significantly reduced the perceived reliability of tweets that used several common strategies of online misinformation.

Although it is not the main focus of this paper, the perspective of teachers should not be neglected in this context, as they ensure that innovations are actually embedded in classrooms [33]. Little research is available on teachers' attitudes towards the use of social media in science education. In a review that was published over ten years ago [34], it was found that teachers tend to use traditional, print-based media such as newspapers in science lessons. We confirmed this in a recent small interview study [35]. In general, the teachers interviewed were rather reluctant to use them. The reasons for this are manifold and range from a weak self-concept due to their own non-use to a failure to recognize the potential for teaching and learning. Other recent studies, such as [36], focus more on the use of social media as a communication tool between teachers and learners and parents.

Students' engagement with science-based information on social media is a relatively new field of research. A few other studies of this kind have been done in the scientific context so far. Recently, Tseng [22] conducted a similar study, on which our investigation is partly based. Using an online article on vaccination as instructional material, she conducted Think Alouds and retrospective interviews with 14 high school students. Students who were most critical of the claims based their evaluations on their knowledge of appropriate scientific reasoning and literacy skills. Those who accepted the claims relied on novice-level content knowledge or flawed scientific reasoning. After being explicitly asked to critique the article during the interview phase, some students who initially accepted the claims became critical in retrospect. Based on the results of this investigation, there is a need for more opportunities for students to critique science information, and more curricular emphasis should be placed on it. Students' levels of evaluation competence varied greatly. According to a recent small-scale study from Germany [37], which showed comparable tendencies, learners have very different levels of competence in dealing with social media posts and use their expertise differently. The purpose of our study is now to provide further answers to the following research questions: Which strategies do adolescents use when dealing with science-based claims in social media, namely Instagram? To which extent do they recognize specific manipulation techniques which can also be related to science? Based on the previously conducted studies described above, we also anticipate that students will have difficulties with this, particularly in the science-related area.

3. Materials and Methods

Group discussions were conducted in a total of six public schools in urban areas in the federal state of Bremen, Germany, with a total of 33 students. Table 1 shows an overview of the sample. One of the discussions was attended by a single student. The schools in which discussions 1, 2, 3, 11, and 12 were held are located in neighborhoods with an above-average socioeconomic status of the population, whereas the remaining schools tend to be located in areas with a low socioeconomic status of the population, which is characterized by a high degree of heterogeneity. The schools were selected to aim for a sample that is as heterogeneous as possible. Each of the schools was located in a different district, so that the entire area of Bremen was covered. The study was conducted from year 9 onwards, as young people from around 15 years of age spend significantly more time on social media than younger ones [18]. Within the schools, teachers who taught the relevant classes were asked to distribute information letters about the study in their classes, whereupon students volunteered to participate in it.

Table 1. Overview of the sample and the cornerstones of the discussions.

Number of Group Discussion	Grade	Age Range (Years)	Number of Students	Duration (min.)
1	12	17–18	4	50
2	10	15–16	3	43
3	10	15–16	3	37
4	10	15–16	1	23
5	9	14–15	3	24
6	9	14–15	2	28
7	10	15–16	2	26
8	11	16–17	4	49
9	9	14–15	3	34
10	9	14–15	2	28
11	12	17–18	3	69
12	13	18–19	3	42

The interview guide encompasses questions about the students' social media habits as well as their experiences using social media in the (science) classroom. It also delves into any potential ideas for how to include social media in science teaching as well as a general perception of respective initiatives. Each section is designated by a guiding question, which is then further divided into sub-questions. These sub-questions in each section make the interview guide flexible and adaptable to specific interview situations. Additionally, illustrative material was prepared for the students [38–40]. As an integral part of the discussion, they were asked for spontaneous comments on three Instagram posts with science-based contexts. Instagram content was chosen because the posts offer a certain depth of content due to the image-text combination and because Instagram is a popular social network among young people in this age group. In the introduction (see above), we enumerated some manipulation strategies used in social media to enhance credibility. We specifically chose Instagram posts that used as many of these strategies as possible at the same time. In addition, we also wanted to distinguish between sponsored and non-sponsored content to see to what extent students recognize advertising. For the ads, we chose one that was not immediately recognizable as such and looked more like an infographic. This gave us a total of three posts (two ads, one meme; science background from three different domains, using as many strategies as possible). A detailed description of the selected posts can be found in Table 2. The overall structure of the interview guide is presented in Table 3. The guide was created by the authors and pre-tested in one pilot interview. Due to the novelty of the topic, the study can be characterized as a "discovery study" [41].

The group discussions were conducted by the first as well as the third author via Zoom. The group discussions lasted between 24 and 69 min and were first audio-taped and then transcribed. The interviews were carried out in German. The analysis was conducted following the principles of Qualitative Content Analysis (QCA, [39]). QCA is a cyclical, multi-step procedure for analyzing qualitative data. It is a theory-based method for systematically processing such data. First, based on the interview guide, initial deductive categories (also called a priori categories [42]) were formed and applied to the data. The remaining data sections were then openly coded; afterwards, the codes were regrouped in a cyclical process into more general inductive categories. Thus, the interview guide provided selection criteria for the coding process and category formation. This process led to the following core categories: use of social media (platforms/purposes), experiences with social media in the school context/in the science classroom, general strategies used to assess the credibility of social media content, explicit strategies used to assess the chosen Instagram posts, ideas for social media implementation in the science classroom, and general perception of the role of social media in the science classroom. Each core category was divided into several sub-categories. After the initial rating was completed, a second rater applied the grid of categories to the data. Inter-rater agreement was calculated using Cohen's kappa [43]. The agreement was very high, $\kappa = 0.95$.

Table 2. Overview of the structure of the interview guide.

Section Number	Guiding Idea	Question(s)
1	Personal use of social media	Which social networks do you use? For which purposes do you use these social networks?
2	Experiences with the use of social media in the school context /the science classroom.	Describe situations (in the classroom in general and specifically in science classes) in which social media was used for learning purposes.
3	Credibility of posts on social media	Describe how you determine the credibility of posts on social media.
4	Identifying own strategies for evaluating posts	Evaluate these Instagram posts. Describe everything that goes through your mind.
5	Ideas on using social media in the science classroom	Formulate ideas about possible scenarios to use social media in science classrooms.
6	Assessing the potential use of social media in science education.	Take a stand on the following statement: "In chemistry classes, you should critically engage with science posts on social media more often."

Table 3. Descriptions of the Instagram posts used as instructional material.

Instagram-Post	Description
Advertisement for a nutritional supplement disguised as an information graphic	• Posting of a private person, who however is managing director of a company for food supplements • Clear, simple design of the posting, which looks scientific • Claims: Important for bones, more energy and better mood, hormones and hair growth, anti-inflammatory, effect on skin • Label on the package: O3-D3-K2 • Reference to "real feedback" • In text: Description of the product as an essential supplement
Advertisement for a Vitamin C serum for the skin	• Posting of a company • Simple design with large inscription: "40+ clinical studies don't lie" • Inscription on product: High potency, triple antioxidant treatment, with 15% L-Ascorbic Acid, 1% Alpha Tocopherol and 0,5% Ferulic Acid

	• Bottle of the product looks like a laboratory device • Hashtag: #scientificallyproven fact • In text: "If your Vitamin C serum isn't backed by clinical proof, you may not get the result you want"
Meme on the supposed dangers of pesticides	• Posting of a private person • Two pictures showing workers spraying pesticides on a field • Inscription: "Monsanto workers promise it's safe to eat—wears gas mask and bio hazard suits" • In text: "For years Monsanto has claimed that Glyphosate is SAFE. If it's so safe why the hazmat suits when spraying Roundup? Because it's anything but SAFE!"

4. Results

In the following, we will present the main results within the core categories.

4.1. Students' Use of Social Media

All of the students surveyed use social media. Instagram is the most popular network (which goes in line with [18]), closely followed by YouTube. Other frequently mentioned networks are Snapchat and TikTok. Twitter was mentioned only by five students. Here, almost all of the students use social media for entertainment in their free time. For example, they follow the content of celebrities or scroll aimlessly through the timeline and let themselves be entertained. However, the networks are also used just as frequently to search for information, both for private and for school purposes. In the private sphere, they mainly inform themselves about current events and topics that are of explicit interest. Here, three students explicitly mentioned science content that they search for or get stuck on in social media. In the school context, students mainly use it to learn about topics that were not fully understood in class, for example, via YouTube videos. In addition, media such as Snapchat in particular are used to communicate with peers—this was mentioned as frequently as searching for school-related information. Only four students use social media for self-expression, such as posting photos of themselves.

4.2. Experiences with Social Media in the School Context

Regarding the use of social media in school, most students have little experience and highlight that the networks hardly play a role in the classroom: "We are sometimes allowed to google things, but otherwise we don't really use such things" (W1S2). Two students even mentioned that social media had not played any role at all for them in the school context so far. About a quarter of the students reported fairly frequent experiences with social media in a variety of subjects: "So in English, definitely, we talked a lot about fake news and social media and scandals that weren't true or something like that Pizzagate thing. Or in politics, of course, we also talked a lot about that. And yes, actually in many subjects" (G2S1). In such responses, however, science subjects were not explicitly mentioned in any case. Interestingly, students from five of the six schools described a project on cyberbullying in which social media was a topic. However, this was a one-time event. It was also noticeable that students from schools in structurally weak districts were less likely to report experiences with social media in the classroom than those from economically strong districts. In summary, it can be stated that social media do not play a major role in the everyday school life of the respondents. This is consistent with the research findings which show that teachers (especially in the natural sciences) are very reluctant to use modern media [34].

4.3. General Strategies Used to Assess the Credibilty of Social Media Content

Before showing students specific examples of Instagram posts, we asked them about their strategies for handling information on social media—how do they go about assessing the credibility of it? The most common strategy was to see who is running the profile. If this is a well-known and trustworthy person or organization, the students also find the content credible—half of the sample mentioned this as a main strategy. The students named several major German news portals as examples of credible profiles. As an example of a less credible source, many students cited profiles of brands that were more interested in selling a product rather than informing the public. Ten respondents would research other sources about the content before forming an opinion. When asked how they would then assess their credibility, five students said that they pay attention to whether the information is reported in the same way in several sources ("I think the comparison is important, i.e., whether it is reported in the same way on Youtube as in an article, that would then be easy to find out how plausible it is" (V2S2)). Seven respondents would explicitly do research on the authors of the channel. Likewise, seven students would look to see if the content on social media was backed up with sources, but then again, they would tend not to check the credibility of these. Interestingly, eight students would rely on their knowledge or assessments to evaluate information: "I would say that common sense also plays a role for me. Well, you can recognize what might be a lie simply from your own experience" (S2S3). However, similar studies have already shown that this is often not achieved or is inadequate [22]. Other aspects such as the verification of the channel (by a "blue tick"), the number of subscribers and likes, the visual appearance of the content, or the quality of the language were rarely mentioned.

4.4. Explicit Strategies to Assess the Chosen Instagram Posts

At this point, we will first discuss the general perception of the three selected posts (see Table 2). In the case of the first post (nutritional supplements), most students initially noticed the appealing design, which led to about one third not immediately recognizing this post as an advertisement (see [44]), and in some cases even describing it as an infographic—something we anticipated when choosing the post (see above). These learners rated the product as positive and useful. Even when students recognized that the post is an advertisement, they acknowledged the professional layout: "The illustration […] reminds me a lot of an infographic and that's why you can't see at first glance that it's advertising" (V1S1). It is interesting to note here that few students previously identified the quality of the graphics as a factor in credibility, yet it plays a major role here. Three students even thought that the product was a medicine. A central focus of the discussion were the technical terms used. For the most part, learners recognized that these served certain functions: "First of all, it says something about O3-D3-K2, which at first looks as if it were something scientific, for which one is too stupid as a normal person. I think the more complicated something like that is at first glance, the more likely you think that there is some truth to it. [...]" (V1S2). In addition, the claims attributing a positive effect to the product were addressed. Here, respondents highlighted that there was exclusively positive information and ergo, it is not balanced reporting, which reduces credibility.

The second post was assessed similarly, although here it became clearer to the learners that this was not an advertisement, because the post contained, for example, a direct link to the online store, which most learners immediately recognized as such. In [22], such "website features" (p. 256) also played a major role in students' assessment. Here, the more prominent technical terms played an even more central role than in the first example: "Various chemicals are listed, but I don't know them, I don't know what they do for me, I just know that they sound scientific […]" (V2S1). In addition, many respondents mentioned the 40 studies on which the product relies: "I also find the whole thing with these studies strange, there is no reference at all to what these studies said or what the studies were about, or how they found the product in the end, if they existed at all […]" (V1S2). A basic skepticism about possible study designs or implementations could also be observed in [22], where she characterizes those students who argue this way as advanced in their reflective abilities.

The third post aimed to construct a supposed logic as well as to trigger the feeling of a threat from a chemical, namely glyposate. In fact, the younger respondents felt threatened by the meme: "I would ask myself why they wear masks if they think it is so safe" (W1S2) or "When you see it like that, you get a strange feeling" (W2S2). Interestingly, some students from the younger cohort stated that they would not explicitly investigate further after the negative feeling the meme gave them: "Somehow I am confused then, but I am too lazy to delve further into it" (W2S1). It was not until students in Year 10 and above generally realized, though often only after a few minutes, that the meme required a more nuanced approach (in the sense of "the dose makes the poison"): "The people who are spraying around with glyphosate are standing in this glyphosate mist, so to speak. So when they spray, it is really everywhere, but when you really have it in the product, I think there is actually only a fraction of the glyphosate only in the product, so the image is perhaps a bit exaggerated. But in the first moment it seems to the one who sees it rather first so, oh my God, what is that […]" (V1S1).

Generally, for all three posts, the tendency was observed that the younger students from year 9 assessed them more positively and uncritically than the other older participants. As an example, a statement by a student on the first post (dietary supplements) should be cited here: "It says, for example, more energy and better mood, important for the bones, so I think to myself now that these are perhaps tablets. And that this is good for the skin, for hormones and hair growth, that strengthens things in the body and makes things better perhaps" (W1S1). A study by Büssing, Hamm and Fiebelkorn [37] also found large differences in the evaluation of social media posts, also related to age (although the sample there was very small).

To gain a more nuanced picture of what kinds of strategies students use when rating posts, we adopted the categories suggested by Tseng [22] (except for one, which did not appear in our data). A description of these categories can be found in Table 4. These are relatively broadly defined categories in terms of content, but each has a clear focus. We focused on whether each strategy was used correctly or incorrectly. What is obvious at first glance from the number of codes in Table 4 is that the students have problems with the scientific strategies in particular—this also goes in line with [22]. Especially in the area of those strategies that had to do with science content knowledge, there were more incorrect or inaccurate statements than correct ones. For example, many students classified the information used in the posts incorrectly ("This is a food supplement that has particularly good vitamins" (G1S3)) or dismissed them completely as unbelievable ("All these chemical substances, that's all total nonsense" (G1S4)). In addition, some students showed incorrect expertise when commenting on the posts themselves: "I think that glyphosate somehow [...] has a bad effect on groundwater" (H1S3). Learners also showed incorrect ideas in the area of scientific reasoning. Here, 10 of the total of 31 incorrect statements referred to the statement about the 40 studies in the second post—the learners were unsure about their role and significance: "And if you define your product by the fact that it has gone through 40 clinical studies, you should be worried. If it took 40 clinical trials to confirm it's not harmful, maybe I'd worry about that, too." (G2S3). In addition, the idea was widespread that one could always write all kinds of promises of effectiveness on a product, which is de facto false since there are legal regulations for this.

Table 4. Categories related to the strategies applied by the students to evaluate Instagram posts.

Category (Adapted from [22])	Coding Criteria	Strategies from Post	Number of Codes
Science content knowledge	References to scientific concepts/content knowledge	Use of scientific explanations to make the products or claims appear more credible (e.g., health, dangers of pesticides)	Applied correctly: 18 Applied incorrectly: 27
Knowledge of scientific reasoning	References to statements that may affect conclusions, context of information, generalizability of scientific information, control groups, logical scientific conclusions, timeliness of research, and uncertainty of science	References to studies, effect of products derived from studies, pseudo-scientific conclusions ("If it's so safe why the hazmat suits when spraying Roundup")	Applied correctly: 40 Applied incorrectly: 31
Knowledge of literacy	References to biased or emotional language, persuasive language, framing or connotations, logical arguments, grammar, clarity of writing, vague or ambiguous terms	Persuasive language, emotional language ("you may not get the result you want"), pseudo-logical arguments, vague terms ("effect on skin")	Applied correctly: 58 Applied incorrectly: 13
Media literacy	References to genres of new and traditional media, special interests of media, features of media (i.e., imagery)	Different designs of images (look of an infographic, very simplistic design, meme), choice of social media posts as a widespread media type	Applied correctly: 58 Applied incorrectly: 12
Information technology literacy	Reference to domain names, URLs, types of websites, hyperlinks, "sharing" functions	Choice of hashtags, names of profiles (brand vs. personal profile)	Applied correctly: 25 Applied incorrectly: 0

As you can see from the data in Table 4, students were more successful in applying general media literacy and IT literacy-related strategies. For instance, in the context of media literacy, most of the students highlighted the power of images: "The way he [author of first post on supplements] has designed this, this post, is really smart. It's appealing, it's minimalistic, which is why you can read a certain credibility out of it" (G1S1). In addition, the learners showed themselves competent in describing general mechanisms of social media, for example in relation to influencer marketing: "These fitness influencers, they have a great influence on their followers, they are paid to say certain things. And then they are also told how to do it and they are sent the pictures to upload" (G1S4). There was a fundamental skepticism with regard to information on social media and it was emphasized that one should always check the respective source or profile carefully. The category "knowledge of literacy" mostly referred to the role of language. The students were able to recognize persuasive or vague linguistic strategies: "And it's all very inaccurate. […] It says, "Effect on the skin", so great. But what kind of effect exactly? Where?" (G2S3). The IT category is characterized by the fact that the students always correctly identified the corresponding strategies. This involved aspects such as the verification of accounts ("blue tick"), certain functions of Instagram (e.g., the possibility to swipe between different pictures in the same posts), or links. It is therefore clear that learners are well-acquainted with the technical aspects and can classify them well.

4.5. Ideas for Social Media Implementation in the Science Classroom and General Perception of Their Role

The students formulated some ideas on how they thought social media could be addressed in science classes. For example, a total of five respondents suggested that amounts in social media could be used to enter into a topic or also to conclude one. Another five students suggested that one should deal critically with contents of social media posts in class: "Well, I think it is good to show posts and then judge whether that could be true or not" (G1S1). Five other students suggested that products presented on social media could be tested to verify the claims experimentally.

In the end, students were asked to comment on the statement that social media should play a greater role in science class. Overall, more agreeing than disagreeing statements were coded. Positive aspects associated with it were new perspectives in the classroom, relevance of the topic due to the greater spread of misinformation, and greater relevance to everyday life which almost one third of the students pointed out: "In general, school is very outdated in many places and science is often just super dull […] and I think through something like that you simply establish a connection to everyday life" (V1S3). It was noticeable that students from socioeconomically weak areas expressed themselves exclusively positively about the implementation of social media, although they hardly ever experienced it before in practice (see Section 4.2). Rejecting statements referred, for example, to the fact that it would be inauthentic for many teachers who are not so familiar with social media themselves. In addition, two older students said that for them such things had no place in chemistry lessons, but rather belonged in other subjects (such as German lessons): "Well, I don't necessarily need it in chemistry lessons. So it's good to use an example to show that it also concerns scientific aspects, but I think something like that somehow belongs more in a subject like German. […]" (H1S2). Such tendencies could also be observed in previous studies on advertising in higher grades [20]. Apparently, some of the older students seem to hold to an overarching, clinical image of science, which often does not include (or even allow) societal aspects.

5. Discussion

In light of the transformation of the media landscape, it is now incredibly important to critically question messages from the media. This should play a role in all subjects at school, because young people have difficulties in adequately assessing science-based information [22,23]—a claim that also could be strengthened in our group discussion study. Similar to previously conducted studies [22,37], students showed quite different levels of reflection on science-based claims in the media, while generally being skeptical regarding information on social media. Here, we had indications that younger students have greater difficulties with assessment, or that young people make a big leap in this regard roughly between 9th and 10th grade (i.e., between about 14 and 15 years of age, at the very end of the "reflective stage" [45]). Younger students initially rated the posts shown as generally more positive and credible than older students, and only applied some strategies when explicitly asked and not immediately, as did the older students. However, this finding should only be seen as an initial starting point for further investigation, as the sample considered was limited. In the future, however, a comparative study between larger groups of younger and older students could be designed. In addition, although some of the learners recognized the weaknesses in the postings and were skeptical, they still felt threatened by the information (for example, about pesticides). Emotions play a very large role in judgment [46]—we believe what we want to believe. How to break through such mechanisms is a key question for future research. In general, as a first answer to one of our research questions, it could be shown that students do not fully recognize manipulation strategies and are easily blinded by certain aspects, especially when they tend to emotionalize.

For data evaluation, we used, among others, the categories proposed by [22]. She provided a functional way to generate on overview of the types of strategies students use when dealing with science-based information in social media. Here, we used these categories to quantify how often corresponding strategies were correctly or incorrectly identified or applied. Although students are very well-versed in the technical aspects of social media, they have problems with the science-based aspects. They sometimes find it difficult to apply their knowledge to the media contexts or to correctly classify the role of scientific aspects (e.g., references to studies, use of technical terms). This provides a first answer to our second research question and is exactly in line with Tseng's findings, which show that learners are unable to make adequate use of the content knowledge they have acquired at school to "appropriately reason" (p. 262) their conclusions on media messages. This is where the most central implication of our study comes from: we must give students opportunities to apply their knowledge to current, controversial, and complex media issues in science subjects as well and distinguish between credible and not so credible information [47]. More specific instruction on how to evaluate scientific arguments (from a textual/literacy perspective) may be needed, with more opportunities to do so [48]. Corresponding interventions can already be found in the literature [13,29] and have been described in Section 2 of this paper, but they are still rare. They would also need to focus more specifically on social media.

Apart from the strategies, we were able to show, among other things, that students would like to see social media contexts implemented appropriately in science lessons and that they rate them positively. This tendency was particularly strong in the structurally weak areas—special attention should be paid to this. However, such aspects can only find a way into schools if they are appropriately supported by teachers. Corresponding teacher education programs are needed if we want to integrate both learning with and about traditional and new media types in the classroom, thereby ensuring that teachers can keep pace with a highly visual, text-shy, and media-savvy younger generation [49]. This, along with suggestions for time-efficient "best-practice" interventions, could thus mitigate the problematic issues described in Section 2 and lead to an increase in teachers' self-concept.

Our study has several limitations. As already mentioned, we only interviewed a fairly small sample, and it is possible that students may have been influenced by each other in what they said due to the format of a group discussion. In addition, the instructional material was limited to the three selected postings. Here, other contents could have led to slightly different results. In addition, we only gave the students less reliable postings. In further studies, it will be interesting to see to what extent young people can distinguish reliable from unreliable information and how they go about it. Of course, the respondents were in an "artificial" situation. They knew that this was a scientific study and therefore were certainly more skeptical than they would be if they were simply scrolling through their social media feed in their free time. Nevertheless, we were able to identify certain problem areas and thus pathways for further research. In general, this limitation of the authenticity of the study design is very often discussed in papers on the effect of (social) media content. For example, in a study on influencer marketing, Balaban, Mucundorfeanu and Mureșan [44] sent the instructional material directly to the participants via Instagram direct message and had them answer an online questionnaire afterwards. Although this increased the authenticity, such an approach would not have been possible due to the strict data protection guidelines in Germany. In their conclusions, they again discuss the advantages of an approach like the one we chose—all subjects see the same instructional material at the same time and also for the same length of time. In addition, students volunteered for the study. This led (also according to the respective teachers) to the fact that rather the good, motivated, and committed students participated. This "positive selection" distorts the results and leads to the cautious conclusion that the problems highlighted may be even more pronounced in other cohorts.

Due to these limitations, further research is needed to provide more evidence. Measurement of the effects of social media in science classes is particularly important. Specifically, this involves evaluating student learning outcomes and attitudes. Upon conducting more detailed research, we anticipate that social media will reveal itself as an important teaching and learning approach. Ultimately, critical scientific media literacy will be promoted in learners, and more new, innovative, and exciting pedagogies will be developed.

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