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Student teachers' syntheses of knowledge on biodiversity loss from relevant, irrelevant and fake sources

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ABSTRACT

Scientific literacy is becoming increasingly important for teachers in the current knowledge landscape, where fake information is gaining ground. However, little is known about how fake content becomes part of ordinary knowledge in science education. This study investigated how Finnish student teachers recognised fake content on the topic of biodiversity loss in an online learning environment and how they used it. Seventy-one first-semester primary student teachers at a Finnish university were given the task of writing a synthesis using online sources and evaluating those sources. The learning environment included relevant, irrelevant and fake texts. The analysis used quantification, content analysis and discourse analysis. The findings showed that nearly half of the participants used fake content in their synthesis, while they also succeeded in synthesising relevant texts. We focused on the use of fake content and identified three discourses referring to it: (1) fake as fact, (2) fake as second opinion and (3) fake as suspicious. The study's implications regard improving curriculum development and programme design in teacher education.

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Biodiversity; scientific literacy; teacher education

Introduction

Today, the boundaries of relevant, irrelevant and false information become increasingly blurred (e.g. Lombardi & Sinatra, 2013; Sinatra & Hofer, 2021). Although sustainability topics are examined thoroughly and research-based knowledge is available, misinformation and disinformation on them also appear at an increasing rate. Misinformation refers to the inadvertent online sharing of false information, whereas disinformation means the deliberate creation and sharing of information known to be false (Bakir & McStay, 2018). Part of the latter is fake news, which involves the deliberate presentation of typically false or misleading claims as news (Gelfert, 2018). They are circulated via user-generated content and propagandists (Bakir & McStay, 2018) and systematically manipulate the audience's cognitive processes (Gelfert, 2018).

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With the rise of fake news and technology's growing role in society, scientific literacy is increasingly needed from active citizens and future professionals in any field (Lederman et al., 2024). Scientific literacy is a combination of commitment to science (Norris & Phillips, 2003), scientific content knowledge (Roberts, 2007) and multiple-source reading skills (Britt et al., 2014). An important task for science education is teaching scientific literacy, and in that effort, the role of teachers is vital (Lederman et al., 2024; Osborne & Allchin, 2024). Therefore, teachers themselves need scientific literacy. They should be especially competent in recognising valid knowledge and synthesising it from several sources to be prepared for their lessons and to support their pupils' scientific literacy.

In our study, student teachers practised scientific literacy in an online learning environment, including relevant, irrelevant and fake text sources on biodiversity loss. We examined how student teachers recognised fake content and how they referred to it in their written syntheses. Biodiversity loss is one of the most urgent sustainability issues because of its global advancement (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2019). Biodiversity refers to the variability of life at the levels of genes, species and ecosystems (Audrin, 2023; UN, 1992). Biodiversity loss has far-reaching consequences for humans, including greater food insecurity, increased ecosystem vulnerability and damaged connections between humans and nature that cause severe risk and threats to our livelihoods, health and security as well as to the economy (Dasgupta, 2021; Gass et al., 2021; IPBES, 2019). The world's biodiversity declines because of land- and sea-use changes, unsustainable use of wild species, human-induced climate change, pollution and invasive alien species (Dasgupta, 2021; Gass et al., 2021; IPBES, 2019). Thus, the World Economic Forum (2024) has classified biodiversity loss and ecosystem collapse as among humankind's most severe risks over the next decade.

However, similarly to, for example, climate change, biodiversity loss is a phenomenon that has arisen denialist opinions and the spread of mis- and disinformation (Saunders et al., 2025). Biodiversity loss denialists argue that scientific assessments like the IPBES Global Assessment exaggerate the scale of extinction (Turnhout & Purvis, 2020). They portray biodiversity loss claims as politically motivated or influenced by special-interest groups and downplay the consequences of biodiversity loss, suggesting that economic growth will solve environmental problems rather than contribute to them (Turnhout & Purvis, 2020). Therefore, along with rigorous scientific studies, combating biodiversity loss denialism requires science communication and science education (Lindemann-Matthies et al., 2009; Saunders et al., 2025).

By studying student teachers' scientific literacy in the context of biodiversity loss, we contributed to this aim. We especially aimed to find out whether student teachers recognised fake sources on biodiversity loss and how they used them and viewed them because there has not been a special focus on the use of fake content in the previous research on scientific literacy.

Teacher education's role in sustainability and biodiversity loss

Nowadays, sustainability issues, such as biodiversity loss, are essential to science education. On the other hand, education is a key strategy in supporting the necessary behavioural changes that can address severe environmental problems and trends affecting local and global communities (Reid et al., 2021; UN, 2024). Fighting against biodiversity loss

especially requires the development of teacher education because teachers educate several generations during their careers, and the basis of the level of teachers' knowledge and skills lies in teacher education (Heikkilä, 2022). Mis- and disinformation on scientific issues are nowadays recognised as major global threats to democracy, evidence-based policy, sustainable development, public health and social cohesion (Saunders et al., 2025), to which teachers contribute by fostering future citizens and decision-makers (Koskela & Kärkkäinen, 2021). How future teachers themselves are equipped with scientific literacy depends on teacher education.

Scientific content and scientific literacy are not only taught by science teachers in upper-secondary and higher levels of education, where the curricula consist of several subjects, such as biology or chemistry. Instead, the early acquisition of science literacy starts in early childhood, and individual differences in the level of scientific literacy can be noticed, even in early childhood (Kähler et al., 2020). Alongside the home environment, kindergartens offer learning opportunities, materials, activities and support for young children (Kähler et al., 2020). The development of scientific literacy continues in primary school, as the role of formal education increases in children's lives and even more specific learning outcomes concerning science are set. For example, in the Finnish national core curriculum for the first six grades, biology, geography, physics, chemistry and health education are integrated into a subject called environmental studies, which includes the perspective on sustainability (Finnish National Agency for Education, 2024).

Science education, environmental education, teacher education and education in general can all equip learners for scientific literacy. A primary justification for teaching science to all young people is to develop students to become 'critical consumers' of science (Osborne & Allchin, 2024). However, science education in school seems not to be sufficient to develop intellectual independence, but science education must develop the capabilities to become a 'competent outsider' capable of making judgements not of the science itself, but of whether the source is credible (Osborne & Allchin, 2024). Similarly, environmental education based on critical thinking and close to science enables learners to identify fake information and ideologies that wilfully separate economic policies from ecological realities and boundary conditions (Reid et al., 2021). Responsible and sustainable science-related decisions are required every day regarding, for example, our nutrition, health and transportation (Bråten et al., 2011; Kaakinen et al., 2025). Thus, supporting student teachers to prepare their pupils to become critical consumers of science (Osborne & Allchin, 2024) and fostering emancipatory and transformative agency towards sustainability (Koskela & Kärkkäinen, 2021) are important goals for teacher education. Moreover, on average, the nations and social classes with the highest educational levels have the highest rates of per capita consumption and, relatedly, the largest ecological footprints (Reid et al., 2021), which should highlight these goals in countries such as Finland.

This study is located in primary teacher education, which in Finland is a five-year, master's-level university programme in a multidisciplinary university. The professional basis for the programme is teaching in grades 1–6 in a comprehensive school. Student teachers major in educational science, which comprises courses in educational science, teaching practice in the teacher training school of the university, courses on research skills and a bachelor's thesis (University of Turku, 2024). In the programme, they also

study the respective school subject didactics, take minor subjects and, finally, complete their empirical master's theses. By conducting their own research, they learn research skills that should also bring about scientific literacy. In addition, a statement in the curriculum refers to that direction: 'The point of departure of the programme is science-based, active interaction of teaching and educational and multidisciplinary research' (University of Turku, 2024). The structures of the primary teacher education programmes in universities throughout Finland are basically similar. The context of Finnish primary teacher education is interesting for this study because it has been at the master's level for several decades and, due to its strong foundation in the multidisciplinary university, have potential to equip teachers with scientific literacy. For the sake of comparison, in many countries, primary teachers do not study master's level degrees. However, a master's level programme does not necessarily indicate the level of scientific literacy.

Although the role of teacher education has been recognised as supporting sustainability, concrete means of developing teacher education have been scarce and exact means regarding biodiversity loss even scarcer. For example, Wolff et al. (2022) examined Finland's teacher education policy and found that it has not yet fully acknowledged sustainability issues and teachers' transformative agency in addressing them but emphasises other aims. They concluded that it is mainly up to individual teacher educators and the leaders of their faculties to decide how to bring about changes towards sustainability (Wolff et al., 2022). These findings reflect global policy tendencies, as several political events have shown a high level of disregard for 'the truth' in environmental and sustainability issues (Stratford & Wals, 2020). Stratford and Wals (2020) argued that, for example, climate deniers have misused scepticism about climate science to falsely claim that there are two 'sides' to the climate debate. As the educational system is inherently political (AlDahdouh, 2021), it often defines what kind of content is emphasised in teacher education curricula. In teacher education programmes, teachers' scientific literacy is increasingly needed in discerning false claims from valid knowledge and synthesising coherent knowledge from multiple online sources to be prepared for their work in educating future citizens who can act against biodiversity loss.

Student teachers' scientific literacy in an online learning environment

Today, science denial is a wide phenomenon, and the proliferation of fake content on the internet significantly burdens online readers (Sinatra & Hofer, 2021). Anybody should be able to critically evaluate what and how they know and explicitly appraise the quality and validity of their judgements (Lombardi & Sinatra, 2013). This is not easy because fake news websites typically mimic the 'look and feel' of mainstream sources to garner credibility (Gelfert, 2018). Thus, separating reliable from unreliable information and relevant from irrelevant information is becoming increasingly difficult (Lombardi & Sinatra, 2013) and, therefore, requires practice.

In this study, we focused on scientific literacy. The concept has several definitions that reflect the aspects that are understood as the most central (Osborne, 2023). One productive way of viewing it is that it comprises a commitment to science (Norris & Phillips, 2003), scientific content knowledge (Roberts, 2007) and multiple-source reading skills (Britt et al., 2014). Multiple-source reading skills entail the idea that selecting and using multiple sources of information requires skills beyond single-text reading and

comprehension (Britt et al., 2014). It involves several core processes: understanding of the task, assessment of one's information needs, selection, processing and integration of the information in the texts, construction of a task product (in this case, the synthesis) and assessment of the quality of the product (Rouet & Britt, 2011). Thus, to manage multiple-source reading, individual readers must implicitly formulate precise reading goals and regularly assess their current state of knowledge based on those goals (Rouet et al., 2017). Then, they must find relevant ideas from each source and recognise connections between different texts (Perfetti et al., 1999), which is not easy, as texts can either complement or contradict each other (Britt & Rouet, 2012). Coherently synthesising different texts requires understanding the concepts, relationships, such as cause-and-effect, and perspectives that they contain (Britt & Rouet, 2012). These processes are important for both student teachers and their future pupils.

Integrating information from different sources into a written product has proven to be challenging, even in the highest educational grades (Britt & Aglinskias, 2002; Mateos & Solé, 2009). For example, in Mateos and Solé's study (2009), students from four different educational levels could not form links between different sources or write a synthesis. Instead, the students summarised each source and presented their summaries in sequence. According to Bråten et al. (2011), this failure to integrate information from multiple sources can lead to an understanding that is heavily influenced by unreliable sources or does not sufficiently consider different perspectives.

Previous studies have indicated that argument evaluation and critical, flexible thinking dispositions are important for accurately evaluating the credibility of online texts (Svedholm-Häkkinen et al., 2025). Also, reading comprehension skills and prior topic knowledge serve as resources in justifying the credibility of multiple online texts (Kiili et al., 2024). However, in addition to skilful credibility evaluation, today one needs to construct scientifically valid conceptual knowledge from multiple sources. A key to scientific knowledge is the development of conceptual knowledge because well-organised knowledge facilitates the deep thinking and reasoning needed to evaluate evidence (Lombardi et al., 2024). Many socio-scientific phenomena on sustainability, such as biodiversity loss, climate change, exploding population growth, declining availability of fresh water, growing ocean dead zones or continued forest losses, have a basis in natural sciences, which does not consist of arguments of different quality but cumulated research-based knowledge.

Therefore, interestingly, although student teachers may have high media literacy, their pseudoscientific beliefs can also be high, as in a Turkish study by Kızılcık (2024). This is because the media spreads both scientific and pseudoscientific concepts (Kızılcık, 2024). However, in scientific literacy, recognising fake information is, in a manner, a presumption because commitment to science (Norris & Phillips, 2003) and scientific content knowledge (Roberts, 2007) require valid, research-based information and acknowledge only information that supports the current scientific view on the topic at hand.

Research design and methods

Research question

Given the importance of scientific literacy for student teachers and for researchers' mapping out the key challenges in their learning to further support them, our research

questions are as follows: 1. *How do student teachers recognise fake content on biodiversity loss in an online learning environment?* 2. *How do they refer to it in their written syntheses?* Answering those questions contributes to the larger aim of supporting student teachers' scientific literacy and understanding of a global, complex socio-scientific phenomenon of biodiversity loss.

Participants and data collection

We conducted a two-part study with first-semester primary student teachers at a Finnish university in 2023. The participants were just beginning their studies and the study was conducted during an orientation course to university studies. The ages of the participants varied between 18 and 48; however, most of them were in their early twenties. Of the participants, 88% were female and 12% male. The age and gender distribution represent typical ones among primary student teachers in Finland. In the first part (written syntheses), 65 student teachers participated (response rate 89%), and in the second part (text source evaluations), 71 student teachers participated (response rate 97%). The participants overlapped, and the reason for the different response rates is that not all the participants returned the written synthesis. We asked the student teachers to participate in a task in an online learning environment designed to be a controlled system for practising scientific literacy. We informed them beforehand that their participation in the study would not affect their grades. The learning environment covers the entire multiple-source reading process and collects all student actions, such as written syntheses and text evaluations (Erdmann et al., 2022). Every core process, such as reading the task, reading and evaluating a text and writing the synthesis, has its own view. The learning environment is flexible and allows students to move freely between these views. Consequently, the student may move back and forth between the core processes several times (Erdmann et al., 2022). The participants were required to use only the text sources in the learning environment for the task. Since the participants worked remotely, the use of external sources such as Google could not be entirely controlled. However, as the task was voluntary and did not affect their grades, the participants presumably worked inside the learning environment.

The individual task was to write, in 200–350 words, a synthesis of source texts that were available to the participants in the closed learning environment. These syntheses served as the first research data for this study. The specific task instructions were as follows: 'You are working on biodiversity loss with your pupils. Prepare your lesson by explaining, based on scientific knowledge, what biodiversity loss means. Discuss its causes and implications from as many perspectives as possible'. In addition, the student teachers had to evaluate the reliability of the source texts. They rated the texts on a scale of emojis representing grades 1–5 of reliability and were asked to write their arguments. These evaluations served as the second research data for this study.

Each of the 10 texts was 300–400 words long and had a title, names of an imaginary author or organisation, the date and a real reference list. However, four of the texts were relevant, four were irrelevant in terms of the task and two were fake, pseudoscientific texts. The relevant texts were based on scientific knowledge and they included different perspectives, which were additive to each other in the spirit of multiple-source reading (Rouet & Britt, 2011). They were shortened from texts received directly

from the author of the texts (biodiversity researcher). The irrelevant and fake texts were based on internet sources. The authentic references used were marked at the end of each text.

The four relevant texts provided basic information on what biodiversity loss is, presented its causes and consequences and provided different perspectives on it, such as the increased risk of pandemics, environmental migration, general inequality and problems with food security and freshwater. In some of the texts, perspectives were also presented at a general level, mentioning climate change, the economy, health and general security. The irrelevant texts included a political blog post written in emotive language, a survey report concerning nature, an advertisement for a science event and an announcement of a climate change panel. However, the content of the source was crucial, whether it was scientific, related to biodiversity loss or based on previous research-based knowledge on the topic.

This was especially essential for the two fake sources, which mimicked scientific texts. Source 1 (see [Table 2](#)) focuses on climate change. It was claimed to be a research report by NASA headquarters, translated by a Finnish author. The text argued that global warming is not mainly caused by humans but is part of natural cyclicity and that warm air is more beneficial to humans than cold air. Source 2 (see [Table 2](#)) had an imaginary author who claimed to be an associate professor at an environmental studies research centre. The author argued that the loss of species was completely natural and that human activities on the planet were also natural. Thus, nature would revive from extinction, and it would probably be even more beneficial for humankind if there were fewer species on the planet.

Ethical compliance

This study complied with the ethical principles of research with human participants and the ethical review in the human sciences in Finland, published by the Finnish National Board on Research Integrity (TENK, 2023). According to these guidelines, a formal ethical review statement from a human sciences ethics committee was not required for this study. The participants submitted their written consent for the research. Participant identification codes were used for anonymity.

Data analysis

The following table presents the phases and methods of the analysis and the insights gained from them, leading to further steps in the analysis ([Table 1](#)).

We began the analysis of the synthesis data with conventional content analysis (Hsieh & Shannon, 2005), concentrating on the coherence of the used sources, and thereby, consistency of the content in the syntheses (Analysis phase 1). In conventional content

Table 1. Methods and insights of the analysis phases.

Phase	Method	Insight
1	Content analysis to syntheses, concentrating on the coherence of the used sources	Heavy use of fake content
2	Quantification and content analysis of participants' evaluations of fake sources	Striking differences in participants' evaluations
3	Discourse analysis of the parts of syntheses including fake content	Different ways to refer to fake content

Table 2. Percentages of the participants' evaluations (scales 1–5).

	1	2	3	4	5
Source 1 (N = 71)	15 21.1%	21 29.6%	18 25.3%	14 19.7%	3 4.2%
Source 2 (N = 71)	11 15.5%	28 39.4%	16 22.5%	14 19.7%	2 2.8%
Total (N = 142)	26 18.3%	49 34.5%	34 23.9%	28 19.7%	5 3.5%

analysis, coding categories are derived directly from the text data (Hsieh & Shannon, 2005). We read the syntheses thoroughly several times to gain a grasp of the level of their quality in terms of the task that highlighted using multiple sources and explaining biodiversity and its causes and implications from many perspectives. During this phase, we discovered that much of the fake content was used, and we decided to focus on that in this study. We discovered that the heavy use of fake content made syntheses incoherent and inconsistent, whereas there were also syntheses where accurate content from several relevant sources had been integrated as a coherent whole in terms of multiple-source reading.

The source evaluation data (Analysis phase 2) were first read several times and analysed by conventional content analysis (Hsieh & Shannon, 2005). We organised the data by including only the evaluations of fake texts. We used quantification to view how the evaluations differed on the scale and between each fake source. We also used content analysis to view how the participants justified their verbal evaluations. We organised the justifications according to each scale number representing emojis and thereby wrote a description of how the participants evaluated each number (see Table 2). We also chose examples of each number (see Table 2). The analysis phase 2 was led by the second author of this article, and the first and second authors negotiated several times together about the analysis process.

Then, we went back to analyse the syntheses data and picked those that included fake content. We focused our discourse analysis on how fake content was referred to in the syntheses and how fake content created meaning in the syntheses (Analysis phase 3). Discourse analysis is a broad methodology for studying language in use, and it is simultaneously an analysis of language and of practices in society (Gee & Handford, 2012). It is founded upon the idea that through speaking and writing in the world, we make the world meaningful in certain ways and not in others, and we shape, produce and reproduce the world through language in use (Gee & Handford, 2012). Its origins are in social science and philosophical frameworks by postmodern theorists such as Michel Foucault (1926–1984), but nowadays it is also used in small-scale educational research in more applied ways, also called textual analysis (Atkins & Wallace, 2012).

The term 'discourse' simply signifies an expression of a point of view that is taken for granted and not questioned (Atkins & Wallace, 2012). It is not formulated as a clear argument but by less obvious means, which can be revealed through textual analysis. Discourses are created by careful choices of emotive words or a careful selection of facts, which leaves out those that do not fit the point of view (Atkins & Wallace, 2012). Discourses are interconnected with the cultural expectations that the speaker or writer negotiates. The 'evidence of expectation' can be revealed in repetitions, hedges, negatives, contrastives, evaluative language and evaluative verbs (Hyvärinen, 2008; Tannen, 1993).

Through this thorough analysis of the language, we recognised that fake content was referred to in three distinctive discourses. In the analysis, we used colours to highlight those parts of the data. We also attempted to use quantification at this point, but it turned out that a single participant could use more than one of these discourses and thus decided to portray them as general patterns of referring. Finally, although we did not search for discourses in the evaluation data, we were able to use a similar linguistic approach to their analysis. The analysis phase 3 was led by the first author of this article, and the first and second authors negotiated several times together about the analysis process.

Findings

First, based on the evaluation data, we illustrate how the participants recognised fake sources. Second, we present discourses found in the synthesis data of how the participants referred to fake content and also show examples of the evaluation data to portray a picture of how participants recognised fake sources. Many participants (30 out of 65) used fake content in their syntheses. Most of those who did not use fake content could explain what biodiversity loss means and describe at least some of its causes and implications, and from many perspectives, according to the task. This had, in the spirit of multisource reading skills (Britt et al., 2014), required that they use several of the relevant sources and not the fake and irrelevant sources. However, because fake sources were used so often in this study, we concentrated on this.

How student teachers recognised fake content

The evaluations of the text sources varied between the participants. There were no significant differences in how the participants evaluated the two fake sources. However, it was interesting that the participants either recognised both sources as fake or, at least, were suspicious of their reliability or believed both. Thus, participants who believed one of the fake sources but suspected the other one were rare. The following table presents the percentages of participants evaluating each scale number.

The following table presents a description of the significance of the participants' evaluations on each scale number and different examples of participants' verbal justifications for their evaluations. There were differences between participants' justifications for scale numbers 1, 2 and 3, whereby their examples are presented in respective columns. Those participants who gave either 4 or 5 justified their answers in a very similar way; this is presented in a joint column (Table 3).

How student teachers referred to fake content

Although fake content was used in 30 out of 65 syntheses, interestingly, some of those who had used fake sources were able to also provide relevant information on the topic. However, these syntheses were mostly incoherent, as they included both scientific and fake content. In addition, the student teachers seemed to be able to refer to fake news but not accept its claims; therefore, in the next discourses, we focused on the ways in which fake content was used.

Table 3. Examples of verbal justifications for the evaluations.

Scale number	5–4	3	2	1
Description of the evaluation	The participant's justification indicates confidence in the reliability of the source.	The participant notices both reliable and unreliable elements in the source. The justification indicates uncertainty about whether the source is reliable or not.	The participant notices mainly unreliable elements in the source and inconsistencies with other sources. This justification indicates a slight uncertainty of reliability.	The participant's justification indicates confidence in the unreliability of the source.
Short examples of justifications by several participants	'reliable' 'very reliable' 'well presented' 'a good approach'	'on the other hand, ...' 'however, ...' 'it is not necessarily based on ...' 'a little different approach' 'the claims are quite well justified but ...'	'no factual data' 'in contradiction with other sources' 'opinions' 'no actual justifications' 'partly right' 'confusing'	'unreliable' 'suspicious' 'false information' 'fake information'
Examples of justifications by one participant	The source is very reliable because its text type is purely a research report, and all the references are mentioned accurately'. (6)	The source caused confusion. It's a research report, whereby it should be highly reliable. However, the results are significantly different from studies that usually deal with climate change, which raises my doubts. So, I cannot say if the source is reliable or not, because a deviant research result doesn't automatically mean that it's wrong. Additionally, concerning biodiversity loss, the report is not very useful'. (54)	The source is useful in a way because it gives a different view of the topic. However, it deals with global warming and not biodiversity loss. It's difficult to find the source reliable, as it doesn't match my conceptions and knowledge that I've learned. The references could be broader'. (27)	'A strange opinion text that practically refers to a similar opinion, vicious cycle, no factual basis'. (62)

Fake as fact

In this discourse, fake content was presented as part of the synthesis in a declaratory manner, without criticism or hesitation. In addition, fake content was held equally important as relevant content. Thus, ordinary expressions concerning argumentation, such as 'on the other hand' or 'however', were scarce. However, only in a few cases was there only fake and irrelevant content, because generally the participants had found one or more relevant texts and could synthesise them. Thus, fake content usually appeared in the middle of the synthesis without a proper connection to relevant content and made the synthesis very incoherent in its entirety. In some cases, terms were mixed so that relevant content on biodiversity loss could be presented logically, whereas fake content was connected to a term such as 'species loss' and thereby presented separately. There were also cases where, first, relevant content from several texts was synthesised comprehensively, but in the end, the participant included fake content and ended up with a false conclusion in a factual style: 'Results from several vast studies show that climate change is connected to natural cyclicity' (4).

The following example shows a similar argumentation chain:

Historically, 99.9% of the species that have lived around the globe have become extinct. Thus, the extinction and development of species can, from that point of view, be thought of as part of the natural life cycle. (65)

The first sentence represents a declarative style. Referring to a historical review is meant to strengthen the argument. In the second sentence, the adverb ‘thus’ integrates fake content as a conclusion to the previous statement in the synthesis. As there were very few participants who mainly used fake content, in this example, ‘from that point of view’ is also used to demonstrate that this content is not the whole truth, but another way to think about the topic. Interestingly, this participant had synthesised several relevant texts in an appropriate way, and the problem seems to be that the participant integrated everything, relevant, irrelevant and fake content, as facts.

The evaluation data show that the participant succeeded halfway in recognising fake content. The participant gave the first text a 1 rating and commented:

The article contradicts other sources and my previous knowledge. Of course, it’s possible that my previous readings are propaganda, but still, I wouldn’t use that text as a source. The article has only one author and I don’t know about his background. The research results to which the author refers do not have adequate references.

Here, the participant lists several arguments against the reliability of the text.

However, the participant rated the other fake text as 4. Interestingly, the participant did not recognise this text as fake, although both fake texts were quite similar in style. The participant commented as follows: ‘The article only has one reference and writer. However, it can be used as a counterview’. Finally, the comments indicate that the participant has thought about the reliability of the texts carefully, but still has not really acknowledged the possibility of fake content. In the latter comment, the expressions ‘however’ and ‘can be utilised’ refer to a positive attitude towards the text.

Fake as a second opinion

In the discourse on fake as a second opinion, fake content seemed to be used as another perspective on the topic alongside relevant ones. In this discourse, linguistic means, such as ‘however, some people or researchers say’, ‘however, some researchers say’, ‘on the other hand’ or ‘there are also other opinions, according to which’, were commonly used. Participants using this discourse usually found one or more relevant texts, and they mostly used them in their syntheses. However, at some point, fake content was presented as if it brought more views to the topic. Finally, the fake content did not make the synthesis more multifaceted but blurred the idea of the topic and the conceptual understanding of the phenomenon. This is also the case in the following example, in which the participant first discussed the topic in an appropriate way but then turned to fake texts:

Studies according to which climate warming has slowed down give another perspective on the topic. According to research, for example, warming after the 1940s was notably slower than in the middle of the 1800s. There have also been theories arguing that extinction of specific species and invasion of alien species are part of the natural life cycle. (42)

In the example, the expression ‘give another perspective’ is used. Giving is a positive verb that refers to possibilities, and ‘another perspective’ directly refers to a second

opinion. In the second sentence, the value of fake content is strengthened by referring to 'research'. The adjective 'notably' further fortifies the meaning. In the third sentence, there is another reference to 'theories'. Repetition of the word 'also' gives the impression that these sources offer something additional to the main ones.

Looking at how the participant evaluated the fake texts reveals that the participant did not recognise the texts as fake. The participant rated both fake texts as 4 and commented as follows:

It's a research report, so you can assume it's reliable. Just for once, kind of a little less negative data about climate change. The publisher appears reliable. An interesting perspective that slightly differs from the mainstream and that I have also read sometimes before.

Both comments indicate that only the claim that a text is research or based on research has made the participant count on it. The participant relies on superficial factors such as the title of a research report and a publisher name, which refers to science. These factors are important to notice, but one cannot evaluate the text holistically without a critical reading of its actual content. In addition, interestingly, the comments use evaluative and emotive language, indicating a certain kind of attitude towards the topic and influencing the participants' evaluations.

Fake as suspicious

In this discourse, fake content was used and presented, but the participant took some distance from it. The argumentation usually followed a specific pattern: After synthesising relevant texts appropriately, fake content was brought in by students distancing themselves from it by somewhat similar linguistic means as in the previous discourse, for example, 'on the other hand' and 'some people say'. However, the main difference is that, thereafter, fake content is passed by going back to relevant texts in linguistic means, such as 'however', 'but' or 'although'. Therefore, fake content does not become a second opinion but something suspicious. In addition, in this discourse, fake content was usually presented quite briefly, and it did not gain as much ground from relevant content as in the previous discourses.

There were also different kinds of examples of this discourse, where fake content was included and held as a fact, but at the same time, the participant openly wondered how such distinguished professionals and researchers can argue like that, as the perspective is contrary to the general one. In these cases, there is some criticality, but it does not extend to suspecting the origin of the text. In the following example, the first pattern is visible:

It has also been presented that biodiversity loss is not a threat that should be prevented. Some researchers believe in the recovery alleged to follow from mass extinction. Extinctions are referred to as evolution's mechanism of revival and a matter that would first and foremost be beneficial to us. The source suggests that surviving in a world with fewer species would be easier. However, this kind of hypothesis is undoubtedly very challenging, and one must view it with caution. (57)

In this example, multiple linguistic means are used to indicate distance from the content: 'it has also been presented', 'some researchers believe', 'is alleged', 'the source presents' and the usage of the conditional instead of the present. In the end, open criticality is presented with several hedges: 'however', 'undoubtedly', 'very challenging' and 'one must view it with caution'.

Looking at this participant's evaluations strengthens the view that they have held fake texts as suspicious. The participant rated one text as 1 and commented, 'The text includes false information'. This is a clear indicator that the participant recognised the text as fake. The participant rated the other fake text as 2 and commented, 'The text only has one reference'. Here, fake content has not been recognised, although some alarm bells rang. This text is the one that the participant used in the synthesis.

Discussion

This study examined how student teachers recognised fake content on biodiversity loss when working in an online learning environment and how they referred to it. The study used the perspective of scientific literacy (Lederman et al., 2024; Osborne, 2023), highlighting skills in multiple-source reading (Britt et al., 2014; Britt & Rouet, 2012) in an online learning environment. The urgent topic of biodiversity loss related to sustainability, which has been argued to have been emphasised more as a principle than on the practical level in teacher education, lacks concrete means (Reid et al., 2021; Wolff et al., 2022).

The findings convey a significant message for teacher educators as well as for the broader domains of programme development and curriculum design within teacher education. The results showed that while the student teachers could recognise and synthesise relevant texts, they also used fake texts in their synthesis. Fake content was used a lot, as nearly half of the participants (30) used it. It was also quite poorly recognised as an unreliable source, as approximately one-fifth of the participants rated the two fake sources as 3, and another one-fifth rated them 4 in reliability (scales 1–5). In addition, some (3.5%) rated the fake sources as 5, finding them very reliable. A similar trend has been visible in other studies. For example, in a study by Kulju et al. (2024), student teachers were mostly able to identify more credible texts from less credible ones, but reasoning was more difficult.

The findings of our study indicate a need for teaching all features of scientific literacy. Included in multiple-source reading, source criticism is influenced by text quality and content, messenger's characteristics, and the reader's characteristics such as prior knowledge, beliefs and source memory (Bouali & Kolinsky, 2023). Source criticism, also known as sourcing (Barzilai et al., 2015; Bouali & Kolinsky, 2023), source assessment or source evaluation (Lie et al., 2025), can thus be seen as an important feature of scientific literacy. In their review article on scientific literacy, Lombardi et al. (2024) state that seeking and understanding scientific knowledge relates to differentiating and evaluating scientific evidence and explanations and then making reasoned relational and causal connections. As the example in the discourse of fake as second opinion showed, true understanding is not possible without careful reading of the text and striving for conceptual understanding of the content. Conceptual knowledge is generative, meaning that it allows the student to draw inferences, make predictions, and think and reason with that conceptual knowledge (Lombardi et al., 2024). It allows the student to access deeper than the surface-level factors such as the name of the author or publisher (Lombardi et al., 2024).

The discourses found in this study reveal different degrees of lack of conceptual understanding, which, in turn, can be carried to classrooms when the student teachers begin their work. The three discourses, (1) fake as fact, (2) fake as second opinion and (3) fake as suspicious, indicate that fake content is not easy to spot, and when it is synthesised

within a research-based context, it becomes even more difficult to track its origins. This finding has severe consequences for how sustainability issues are taught in classrooms. Although revealing patterns of this mixing provides new knowledge, similar shortcomings were observed by Marttunen and Kiili (2022), in which university students were able to find different perspectives in the provided source texts, but they had challenges in coherently combining the texts and structuring their own writing.

Based on our findings, the discourse of fake as fact is the easiest one to discern from other texts, but, simultaneously, the most worrying discourse among student teachers. If student teachers really believe in fake information, they are not ready to teach young pupils. Their scientific content knowledge (Roberts, 2007), multiple-source reading skills (Britt et al., 2014), including source criticism (Lie et al., 2025), and probably their commitment to science (Norris & Phillips, 2003) are at an inadequate level to be able to understand the content in a conceptual level (Lombardi et al., 2024). However, they had just started on the programme and had 5 years to gain sufficient knowledge and skills to be able to work and develop as teachers. It has been known for a long time that evaluation of sources is critical to successful learning from Internet-based inquiry and can be improved through instruction (Wiley et al., 2009).

The discourse of fake as a second opinion shows the dangers of including everything one has read, a lack of criticism and an inability to acknowledge that there might be information that is purposely false. This discourse is also a reminder of Stratford and Wals (2020) argument about climate deniers' way of falsifying a claim by saying that there are two 'sides' to the climate debate. In this discourse, references to research were common, although the reliability of this 'research' remained unnoticed. As such, it is beneficial that research-based knowledge is appreciated. However, using 'research' as an argument is also typical of fake information, and scientific literacy in today's knowledge environment requires much more than valuing research. This is because fake news mimics fact-based news (Gelfert, 2018). The discourse of fake as a second opinion evokes sourcing practices found by Barzilai et al. (2015), where some of their participants did not explicitly engage in sourcing while reading, whereas others formed detailed source representations, source-content links, and source-source links. In today's post-truth culture, the discourse of fake as a second opinion may be easy to enact without using specific sourcing practices or representations.

In the discourse of fake as suspicious, some distance was taken. Fake content was included, discussed and given an opportunity, but finally, it was rejected and cast off. This discourse shows that using fake information is not automatically a sign of false information, but sometimes it might be seen as worth discussing, probably because it is so visible in society. Thus, researchers tracking higher education students' and other people's understanding must be careful not to draw overly simple conclusions about using fake information. However, this discourse shows how online reading is permeated by decisions of relevance and recognition. There is seldom only purely scientific knowledge available, as the media provides both scientific and pseudoscientific information (Kızılcık, 2024).

The findings of this study are in line with those of previous studies (e.g. Britt & Aglinskias, 2002) in which reading multiple sources proved challenging. The findings also confirm the difficulty experienced by student teachers in producing a synthesis (e.g. Mateos & Solé, 2009) and evaluating the reliability of the sources (Kulju et al., 2024).

By emphasising the student teachers' recognising and using fake information, the study brings about new knowledge of scientific literacy and opens new avenues for more specialised applications of this concept. The study could capture ways in which fake information became part of student teachers' knowledge and blurred with relevant knowledge when they planned their lessons. These kinds of mechanisms may have far-reaching consequences for science education and its basis in valid knowledge and research.

Methodologically, the mixture of content analysis, quantification and discourse analysis was useful in portraying a multifaceted picture of recognising and referring to fake content. In particular, discourse analysis proved useful in digging deeply into how fake content becomes part of student teachers' understanding of the phenomenon. A limitation of this study is that we could not follow how the participants' scientific literacy developed during their study years when they studied, especially research skills as part of their degree in educational science and didactics in related science subjects. Moreover, we analysed a product in the current test situation that was affected by the participants' motivation to perform the task.

An ethical issue concerns giving irrelevant and fake sources to the participants during the task. We simulated studying using the Internet and did not specifically reveal to the participants that all the source texts in the online learning environment were not relevant to the task. However, they were told that the task was about scientific literacy, and evaluating the reliability of the texts on a scale and writing justifications for their ratings guided them to think that not all texts were equally reliable. After the task, the student teachers were informed of the sources to ensure that they finally had valid knowledge. By conducting the study in a closed learning environment instead of internet-enabled, the student teachers were able to practise scientific literacy in a controlled system, where their performance could be supervised and assessed. If the study had been conducted by letting the participants freely choose sources on the internet, they would probably have been more critical.

Longitudinal studies examining whether some development in student teachers' scientific literacy will happen should be conducted in the future. Further research could take the perspective of student teachers' science capital (e.g. DeWitt et al., 2016; Kaakinen et al., 2025). Including a survey on student teachers' science capital, that is, what and how they think about science and what kinds of networks and facilities they possess to foster science in their lives (e.g. DeWitt et al., 2016; Kaakinen et al., 2025) could provide a multifaceted view of student teachers' science aspirations and backgrounds, which further affect science education when they begin their working lives. Further research should also discover other topics, such as climate change, natural resources or specific biodiversity issues like the 'wolf-issue' in the Nordic countries by using the same design. Thereby, it can be seen if and how the findings relate to the specific topic.

Conclusion

Our findings indicate student teachers' difficulties in discerning fake content from scientific content, although it was assumed that our participants would have some scientific literacy based on their education in upper-secondary school and elsewhere to succeed in the task. However, the participants were at the beginning of their studies, and they

will have five years to develop their scientific literacy during the programme. Some of the participants managed well in the task by both clearly recognising the fake sources and writing a coherent synthesis, indicating that the task was not impossible for the student teachers. Considering the fake sources, it is also noteworthy that the warning bells may not be ringing when the task is given by university teachers. However, a general assumption among our participants was not to suspect the reliability of the sources – a skill definitively needed in today’s knowledge landscape regarding various environmental issues (Reid et al., 2021). This indicates a need to further develop online learning environments where student teachers can practice multiple-source reading, source criticism and enhance their conceptual understanding (Lombardi et al., 2024). Previous research has indicated that these skills do not develop without practising (Kiili et al., 2020), they can be improved by collaborative inquiry (Barzilai & Chinn, 2025).

A study of Lie et al. (2025) revealed that although teachers find source criticism to be important, many do not facilitate for activities directed at developing source criticism skills. One of the reasons was a lack of professional guidelines on how to do it in practice. Also, this study supports student teachers’ provision of supportive task environments, explicit and complete representation of document sources and guidelines on what to read and how to read it to fully understand intertextual, complex contents (Britt & Rouet, 2012). In line with previous literature (Bråten et al., 2011; Lederman et al., 2024; Osborne & Allchin, 2024), student teachers need practice, especially in recognising the validity of sources by adequate scientific content knowledge, true commitment to science and synthesising relevant sources from multiple texts.

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