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Primary school student teachers' scientific literacy on biodiversity loss: The use and evaluation of source texts

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ABSTRACT

Finding reliable information is increasingly difficult as false information spreads on the Internet, necessitating scientific literacy for both students and teachers. This study examines the source texts used by 71 first-year primary school student teachers when presented with ten different texts in an electronic learning environment and how they evaluated those sources. The participants were tasked with summarizing texts on biodiversity loss and assessing their reliability and usefulness. Of the ten texts, four were relevant, four irrelevant, and two contained false information. The analysis indicated that whilst all student teachers utilized at least one relevant source, irrelevant texts and false texts were also incorporated. Evaluations revealed uncertainty regarding the reliability and usefulness of the sources, emphasizing the need to consider multiple factors rather than only isolated aspects in the source texts. The study concludes with suggestions for enhancing scientific literacy in teacher education programs.

Keywords: scientific literacy, biodiversity loss, teachers, primary teachers, teacher education

INTRODUCTION

Everyone increasingly needs the ability to understand and apply science even in everyday situations (Osborne & Allchin, 2024; Sinatra & Hofer, 2021). Almost daily, both children and adults are required to make decisions that are sustainable for themselves and others, concerning, for example, nutrition, health or travel. Consequently, active citizenship today—which schools aim to promote—requires scientific literacy (Lederman et al. 2024; Osborne, 2023). As future primary teachers will teach several generations during their careers, their own scientific literacy has a significant impact on the future of society. For future primary teachers to support the development of their pupils' scientific literacy, they must develop it themselves (Mikkilä-Erdmann et al., 2024).

We examine the scientific literacy of Finnish primary school teacher students at the start of their studies by investigating the types of texts they choose to use when presented with texts that are both relevant and irrelevant to the task, as well as those containing false information, and how they assess the reliability and usefulness of these texts. In Finland, primary school teachers teach pupils aged 7 to 12 in grade 1-grade 6 and are responsible for teaching a wide range of subjects. The students' task was to prepare for a lesson by finding out what 'biodiversity loss' means and reflecting on it from different perspectives. By scientific literacy, we mean a combination of knowledge, skills and attitudes relating to science (Osborne, 2023; Vidbäck et al., 2023).

Biodiversity loss was chosen as the topic for the task because it is a global threat to sustainability (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2019), and universities and schools in general play a key role in promoting sustainable development and education for sustainability. Biodiversity loss refers to the decline in natural diversity at the levels of genes, species and ecosystems (United Nations [UN], 1992). The causes of biodiversity loss include greater food insecurity, increased ecosystem vulnerability and damaged connections between humans and nature that cause severe threats to our livelihoods, health, security and economy (Dasgupta, 2021; IPBES, 2019). World Economic Forum (2024) has classified biodiversity loss as one of the most significant risks to humanity in the coming decades. For example, pollinators and their critical role in the pollination of both wild and cultivated plants require educational initiatives because their role in the production of essential resources such as food and biofuels is largely unknown by most people (Morais et al., 2024).

Previous research has found that student teachers have a positive attitude towards science in general (Heikkilä et al.,

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2025). However, they face challenges in synthesizing scientific information from multiple sources into a coherent summary (Heikkilä et al., 2024), which highlights the need to develop scientific literacy. Furthermore, it is known that critical reading skills, including evaluation of content, sources and evidence, do not develop on their own, but require practice (Kiili et al., 2020). It is possible to develop these skills through practice: For example, in a study by Hämäläinen et al. (2023), an online reading intervention carried out with upper secondary school students had an impact on their ability to identify, evaluate and utilize the characteristics of sources in search queries, reliability assessments and written work. The students who benefited most from the intervention were those with the weakest critical reading skills (Hämäläinen et al. 2023). Furthermore, it has been found that the ability to evaluate arguments and flexible thinking are important for assessing the reliability of texts found on the Internet (Svedholm-Häkkinen et al., 2025) and reading comprehension skills and prior knowledge of the subject matter are helpful when justifying the reliability of such texts (Kiili et al., 2024).

Previous research on multiple-source reading and writing has focused on critical literacy (e.g., Hämäläinen 2023; Kiili et al., 2020), which is important today. Critical literacy contributes to scientific literacy, but scientific literacy comprises a broader range of knowledge, especially conceptual knowledge, skills and attitudes. In particular, scientific literacy is needed to understand scientific phenomena, as today's problems are so complex. Misinformation regarding scientific phenomena poses a significant threat to, among other things, democracy, evidence-based practices and sustainable development (Saunders et al., 2025), because informed civic participation and evidence-based decision-making depend on access to trustworthy knowledge (Lewandowsky et al., 2023). Developing scientific literacy is, in fact, a process of becoming a social actor, in which scientific concepts and practices are utilized to solve various local, regional and global challenges (Lombardi et al., 2025). In the context of scientific literacy, the skillful searching for, evaluation and use of source texts help to build conceptual understanding from the concrete to the more abstract, to see connections and to organize concepts in relation to one another (Lombardi et al., 2025). In this study, we focus on how student teachers utilize source texts. The results of our study provide insights into what it is in individual source texts that appeals to student teachers to such an extent that they choose to use that particular source or assess it as reliable or useful, and, conversely, why this is not the case for other texts. The results of the study can be utilized in the development of teacher education and, more broadly, in society to support scientific literacy on environmental issues.

SCIENTIFIC LITERACY AND STUDENT TEACHERS

The Importance of Scientific Literacy in Society

The boundaries between relevant, irrelevant and outright false information are becoming increasingly blurred in our society, and it can be difficult to identify reliable information (Lombardi & Sinatra, 2013; Sinatra & Hofer, 2021). Our knowledge landscape is undergoing radical change, as fake news, trolling and emotionally loaded stories are supplanting factual and research-based knowledge (Hauke, 2019; Mäkelä et al., 2021). The reasons for these changes have been sought in technological developments, the nature of social media and algorithms and a culture that values rapid reaction at the expense of depth, and in which stories and emotive arguments are harnessed to serve economic goals (Hauke, 2019; Mäkelä et al., 2021).

Although research-based knowledge is available in greater quantities and more easily than ever before, misinformation and disinformation concerning environmental phenomena are also being disseminated at an ever-increasing rate. Biodiversity loss is a phenomenon that has arisen denialist opinions and the spread of mis- and disinformation (Saunders et al., 2025).

Misinformation refers to the unintentional sharing of false information online, whereas disinformation refers to the deliberate production and dissemination of false information (Bakir & McStay, 2017). The latter category also includes fake news, in which false or misleading claims are deliberately presented as news (Gelfert, 2018). These are circulated through user-generated content and by propagandists (Bakir & McStay, 2017) and systematically seek to manipulate the cognitive processes of their readers (Gelfert, 2018). There is also discussion on pseudoscience, i.e., the artificial imitation of science without any scientific processes whatsoever (Kızılcık, 2024). For this reason, when seeking scientific information, one cannot simply rely on the status or organization of the author of a text found online, nor is trusting 'science' alone sufficient. Operating in today's knowledge landscape therefore requires versatile scientific literacy.

The Concept of Scientific Literacy

Scientific literacy can be seen as comprising interrelated knowledge, skills and attitudes (Osborne, 2023; Vidbäck et al., 2023). The readers must already possess some scientific content knowledge on the subject – prior knowledge (Roberts, 2007). To evaluate and understand multiple sources they must understand the general vocabulary contained in the texts, as well as scientific concepts and their definitions (Britt et al., 2014). Knowledge of how scientific information is evaluated is also required (Vidbäck et al., 2023). For this reason, for example, teacher education programs emphasize the importance of research skills (Heikkilä, 2022). It is also necessary to understand the nature of knowledge and the uncertainty that is always inherent in it, as knowledge is always, in one way or another, created by people (Murtonen & Salmento, 2019). Furthermore, one must be aware of the operating principles of the current knowledge landscape, such as the fact that Internet searches offer numerous results, including useless and unreliable ones (Vidbäck et al., 2023).

Secondly, skills in multi-source reading and writing are required (Britt et al., 2014). In today's online environment, information is sought from a variety of sources, meaning that simply internalizing a single text is no longer sufficient (Britt et al., 2014). Readers must be able to understand the task, assess their own information needs, evaluate content, sources and evidence, select reliable and useful sources, process the

information contained in the sources and combine it into a coherent whole, which they should then be able to examine critically (Rouet & Britt, 2011). Consequently, in multi-source reading, the reader should be constantly aware of their own reading goals and intentions (Rouet et al., 2017). One should be able to identify the main points of the information sources and establish connections between them (Perfetti et al., 1999). This is not easy, as different sources may complement one another but may also sometimes contradict each other (Britt & Rouet, 2012). Corroborating and consistently combining sources therefore requires the reader to understand the concepts, the relationships between them, the cause-and-effect relationships of phenomena, and the different perspectives contained within the texts (Britt & Rouet, 2012).

Thirdly, attitudes also play an important role in scientific literacy. A commitment to science is required (Norris & Phillips, 2003). This can be understood as an interest in and appreciation of science, as well as confidence in one's own abilities (Vidbäck et al., 2023). If science is not considered important from the outset, even the most basic scientific knowledge and skills will not promote the goals of utilizing reliable information, nor will these knowledge and skills develop. Attitudes extend beyond science to reading, as they influence the way a reader progresses through the reading process (Britt & Rouet, 2020). Thus, literacy in general forms the basis of scientific literacy. Attitudes also influence the way in which readers seek information and assess its suitability in line with their own engagement and information needs (Britt et al., 2014).

The Importance of Scientific Literacy in Primary Teacher's Work

Primary teachers are instrumental in promoting scientific literacy in terms of knowledge, skills and attitudes (Lederman et al., 2024; Osborne & Allchin, 2024). They play a key role in shaping what pupils – and thus future citizens – understand about science, how they relate to it, and to what extent they embrace science and participate in its processes (Heikkilä et al. 2025). Primary teachers lay the foundations for the development of important basic skills and attitudes as they teach the decision-makers and influencers of the future to promote sustainable development (Koskela & Kärkkäinen, 2021).

Teachers' own scientific literacy should be studied and supported during their teacher education. The development of scientific literacy is one of the key objectives of basic education (Lavonen, 2021), and its components are also included in the current national core curriculum for basic education (National Board of Education, 2014). However, teachers have been found to face challenges in supporting pupils' scientific literacy. In an interview study by Vidbäck et al. (2023), teachers perceived the following as challenges: firstly, the limitations of their own expertise – they found the science subject challenging even for themselves, and furthermore, they lacked interest in it, which caused uncertainty regarding their own competence (Vidbäck et al., 2023). On the other hand, challenges arose from the Internet as a learning environment – teachers felt that practicing the use of the Internet was important but considered it appropriate that the number of sources could be limited (Vidbäck et al., 2023).

Teachers need scientific literacy to support their pupils' scientific literacy in classroom interactions, but also to plan their teaching. When planning lessons, they must be able to assess the reliability of information sources encountered in the online environment. This is not an easy task, as misinformation can sometimes find its way into scientific knowledge, for example through the media, when journalists edit information (Kızılcık, 2024). Social media presents another challenge, as readers must be even more critical when evaluating the reliability of information there. However, it is now commonplace to seek tips and ideas for teaching from online sources. For this reason, it is important to support the scientific literacy of teachers, and particularly student teachers, in a variety of contexts.

When assessing scientific literacy, one revealing task type is summarizing multiple sources, as this has proven to be a challenging task even at the highest levels of education (Britt & Aglinskas, 2002; Mateos & Solé, 2009) and also in the Finnish context (Kiili et al., 2020). In Finland, student teachers must pass a two-stage selection process to be admitted to this popular program. Although primary school teacher students are no longer so-called top students (Vilppu et al., 2022), they nevertheless possess the prerequisites for scientific literacy and its development, and gradually also for supporting pupils' scientific literacy. Throughout their five-year university education leading to a master's degree, they acquire expertise in scientific content knowledge and pedagogical content knowledge—that is, how scientific phenomena are taught—as well as, for example, interaction skills and emotional skills, which are also needed to support pupils' scientific literacy. Indeed, teachers themselves are lifelong learners as they continuously evaluate what content to include in their teaching and how to combine it in meaningful ways.

MATERIALS AND METHODS

Research Question, Data, and Analysis

Our research questions are as follows:

1. Which source texts do student teachers use in their summaries when they are provided with sources that are relevant and irrelevant to the task, as well as sources containing false information?
2. How do they assess the reliability and usefulness of these source texts?

The research data were collected from first-year students in a primary school teacher education program at a Finnish university at the very start of their studies. Participation in the study was voluntary, did not form part of their coursework and did not affect the students' grades. The study was conducted in accordance with the Guidelines for Good Scientific Practice published by the Finnish Advisory Board on Research Integrity (TENK, 2023). 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. Students were asked to provide written consent to

participate in the study after reading the research information sheet and privacy notice. The data were pseudonymized with codes 'SO' and a number immediately after collection.

The data were collected in an e-learning environment for scientific literacy (Erdmann et al. 2026). A total of 71 primary school students teachers took part in the task. The participants' task was, first, to familiarize themselves with the source texts provided and based on these, to write a 200-350-word summary (data 1). The task was: "You are discussing biodiversity loss with your teaching group. Prepare for the lesson by explaining, based on research-based knowledge, what biodiversity loss means. Consider biodiversity loss from different perspectives." In this context, 'perspectives' referred to research-based arguments found in sources containing factual knowledge. Participants were asked to make use of four reliable source texts and to use text codes (e.g., T1, T2) as references.

Secondly, participants were asked to evaluate all source texts numerically and verbally according to how reliable and, on the other hand, useful they considered them to be (data 2). In the online environment, emojis were used, which were converted to a scale of 1-5, where 1 meant very unreliable, 2 fairly unreliable, 3 neither reliable nor unreliable, 4 fairly reliable and 5 very reliable; the same scale was used for usefulness.

Six participants did not return the summary, and of the 65 participants who returned it, six had not indicated the sources they had used. Consequently, when answering research question 1, we reviewed 59 summaries. When answering research question 2, we used the numerical and verbal evaluations of all 71 participants. The digital environment was flexible and allowed participants to move freely between views and tasks (Erdmann et al., 2026). According to the task instructions, the estimated time to complete the task was 90 minutes, but there was no time limit. Participants completed the task individually. The task assignment and instructions were designed so that the task could only be completed within this closed electronic learning environment simulating an Internet environment. Technical restrictions within the system ensured that, for example, the copy-paste function was not available from the open Internet environment.

The digital environment included different types of source texts: firstly, texts on biodiversity loss written by researchers and based on scientific evidence that were relevant to the task; secondly, irrelevant texts such as an advertisement for a science event; and thirdly, fake texts that had been translated and adapted from fake news websites on the Internet. The source texts were 300-400 words in length. Each text had a headline, and the author was listed as a fictional person or organization, along with the publication date and genuine sources. The texts were drafted in such a way that it was not possible to form a comprehensive understanding of the subject matter based on a single relevant text. After the task, the student teachers were informed of the validity of the source texts to ensure that they finally had valid knowledge of the phenomenon.

Data were analyzed in Finnish. The titles of the source texts and illustrative examples from the participants' verbal assessments were translated into English. The texts were initially translated into English using DeepL (DeepL SE), after which the translations were reviewed and manually revised by the researchers to ensure conceptual and contextual equivalence. **Table 1** describes the source texts found in the online environment.

Analysis

We began the analysis by calculating how many source texts of each type of each participant had used in their summary (data 1). We did this based on the source citations provided by the participants. Furthermore, to obtain the most accurate picture possible of source use, we applied qualitative judgement when coding the data. References to source texts were counted only when the text was used as a source of information in the summary. For example, when a participant mentioned the fake text only to point out that it contained disinformation, this was not recorded as use of that source. We then tabulated the use of sources by both student and source text to examine the use of sources from a variety of angles.

Next, we moved on to examining the numerical and verbal assessments provided by the participants regarding the reliability and usefulness of the sources (dm the numerical assessments. We then turned our attention to the verbal justifications for their ratings written by the students. The justifications were analysed using data-driven content analysis (Hsieh & Shannon, 2005).

The analysis began with a close reading of the justifications several times, which provided an overall picture. The content of the justifications was then classified into four categories: features indicating the reliability of the source, features indicating the unreliability of the source, features indicating the usefulness of the source, and features indicating the uselessness of the source. The analysis of the data was then continued within each category by grouping together similar features (Hsieh & Shannon, 2005). Thus, the subcategories of features indicating reliability and unreliability were formed as follows:

(1) features describing source factors (e.g., author, publisher, text type),

(2) features relating to the content of the text (e.g., scientific basis, presentation of arguments) and

(3) references to prior knowledge (e.g., knowledge taught at school).

A further feature indicating reliability that emerged was

(4) comparison with other sources used in the task.

The sub-categories of features indicating usefulness and lack of usefulness were

(1) reliability,

(2) the source's relevance to the assignment,

(3) other relevance of the source (e.g., personal interest in the topic),

(4) comprehensiveness of content (e.g., limited/sufficient perspective) and

(5) comprehensibility.

The analysis was not based on pre-defined theoretical categories, but the researchers' prior understanding of the

Table 1. The source texts: their character (relevance to the task) and number, title, author/source, text type and key content

Character (no.)	Title	Author/source	Text type	Main content
Fake text (0)	The climate is changing as part of a natural cycle	NASA headquarters, Texas, USA. How Earth is not changing (by Steven Reynolds/AFC, trans. Kaarlo W. A. Kannisto	Pseudoscientific text	- Climate change is linked to natural cycles - Nature's ability to adapt to warming is good - Cold air is considerably more challenging for humans than heat
Relevant (1)	Insect decline threatens food production	Science magazine	Popular science text	- The decline in insect populations is part of the decline in biodiversity - Food production relies on insects that pollinate plants - Insects are also important as food for other organisms, as predators, herbivores, scavengers and nutrient recyclers
Relevant (2)	It is possible to halt the decline of nature	Ville Niinistö, MEP (former Minister for the Environment and Member of Parliament) and Prof. Ilari Sääksjärvi, University of Turku Biodiversity Unit	A newspaper article based on scientific evidence	- Biodiversity loss has significant consequences for the economy, security, health and quality of life - Pandemics are an example of these consequences - The causes of biodiversity loss are population growth and the overconsumption of natural resources
Irrelevant (3)	Intergovernmental Panel on Climate Change compiles scientific data on the Earth's climate	Kansalaisinfo.fi (Citizen Info)	Announcement	- The task of the Climate Panel, as required by the Climate Act, is to promote interaction between science and politics on climate issues - The panel makes recommendations on decision-making regarding climate issues
Relevant (4)	Biodiversity loss as a global challenge	Prof. Ilari Sääksjärvi and Dr. Kari Kaunisto, University Researcher; Kari Kaunisto, Biodiversity Unit, University of Turku	General science text	- Biodiversity loss manifests itself at the level of species, their genetic diversity and ecosystems - A healthy environment is a human rights issue - Biodiversity loss causes environmental displacement
Irrelevant (5)	How to solve biodiversity loss?	Science events	Advertisement	- Around one million animal and plant species are facing extinction in the coming decades - In the 'Solving the Loss of Nature' series, leading experts discuss biodiversity
Irrelevant (6)	Biodiversity loss is one of the greatest threats to our natural world	Nature and Environment Centre	Survey report	- Awareness of the state of nature has grown, and the perception of biodiversity loss as a threat has increased - The Barometer surveyed respondents' views on various nature-related issues
Relevant (7)	Deforestation of the Amazon rainforest and its impacts	University blog	A blog post based on scientific evidence	- The Amazon rainforest is home to as much as a quarter of the world's species - The region's vegetation and soil form a vast carbon sink, the preservation of which is crucial for slowing down climate change
Irrelevant (8)	Biodiversity loss is a reality in Finland too	Luonnonvoimaa blog	Blog post	- Environmental movements and organisations are working to halt the loss of nature, for example through political decision-making - Not enough is being done to safeguard the biodiversity of Finland's forests
Fake text (9)	What is species loss?	Dr. Aron Lehtiniemi, Research Centre for Environmental Science	Pseudo-scientific text	- Species extinction is entirely natural, as is human activity on Earth - Mass extinctions are always followed by recovery - Both the planet and humanity are likely to fare better in a world with fewer species

topic and the theory of multi-source reading (Britt & Rouet, 2012) partly guided the formation of categories.

RESULTS

Use of Source Texts in the Summary

Participants used different types of source texts in their summaries to varying degrees (**Table 2**). All participants utilized at least one relevant source, and 47.5% of them used three relevant sources. Most students used one irrelevant source, whilst 22.0% of them did not use any irrelevant texts in their summaries. None of the students used both sources containing false information, but in 22.0% of the summaries, one of the false texts was used. However, almost 80% of the students did not cite the fake sources at all (**Table 2**).

The analysis of the individual texts also revealed variation in how the texts were utilized: **Table 3** shows that the least frequently used text was the fake text "The climate is changing as part of a natural cycle", which was used by four participants. The most frequently used text, "Biodiversity loss as a global challenge", was a relevant text and was used by 52 students. On this basis, it can be concluded that the participants were on the right track regarding the reliability and usefulness of the

Table 2. Use of different types of source texts in the participants' summaries (n = 59)

N	Summaries with relevant sources		Summaries with irrelevant sources		Summaries with fake sources	
	n	Percentage (%)	n	Percentage (%)	n	Percentage (%)
0	0	0	13	22.0	46	78.0
1	18	30.5	21	35.6	13	22.0
2	12	20.3	12	20.3	0	0.0
3	28	47.5	13	22.0	-	-
4	1	1.7	0	0.0	-	-

Note. N: Number of source texts of each type used in the summary

Table 3. Number of participants who used each text in their summary, and the scores given to the texts for reliability and usefulness

Character (no.)	Participants who used the text in their summary (n = 59)		Average score given by participants: reliability	Average score given by participants: usefulness
	Frequency (f)	Percentage (%)		
Fake text (0)	4	6.8	3.0	2.6
Relevant (1)	31	52.5	3.9	3.6
Relevant (2)	33	55.9	4.1	3.9
Irrelevant (3)	20	33.9	3.8	3.0
Relevant (4)	52	88.1	4.4	4.3
Irrelevant (5)	10	16.9	3.4	2.4
Irrelevant (6)	26	44.1	3.7	3.3
Relevant (7)	14	23.7	3.0	3.2
Irrelevant (8)	28	47.5	3.0	3.4
Fake text (9)	9	15.3	2.6	2.8

texts. On the other hand, the relevant text "Deforestation of the Amazon rainforest and its impacts" was used by only 14 participants, which is significantly fewer than the three irrelevant texts. For example, as many as 28 participants used the blog post "Biodiversity loss is a reality in Finland too", and 26 participants used the survey report "Biodiversity loss is one of the greatest threats to our natural environment". Although the fake texts were used least frequently in the summaries, they were not entirely excluded. For example, the text "What is species loss?" was used by 9 participants (**Table 3**).

Numerical Assessment of the Reliability and Usefulness of the Source Texts

The scores given by participants for the reliability and usefulness of the texts reveal some hesitation regarding the texts. Firstly, the participants did not use the entire 1-5 scale. The least reliable text received an average score of 2.6, whilst the most reliable text received 4.4. The trend is correct, as the text rated as least reliable was a fake text and the text rated as most reliable was relevant. However, few participants rated the texts as completely unreliable or completely reliable. The situation is similar in terms of usefulness: the text rated as the least useful, with an average of 2.4, was "How to solve biodiversity loss?", which was a short advertisement for a science event. The most useful text, "Biodiversity loss as a global challenge", received an average score of 4.3 points. **Table 3** shows the number of participants who used the texts in their summaries, as well as the average scores given by participants regarding the reliability and usefulness of the texts.

Table 3 shows that the use of the texts and their evaluation in terms of both reliability and usefulness are broadly consistent with one another. The most frequently used text, 'Biodiversity loss as a global challenge', was also rated both as the most reliable, with an average of 4.4, and as the most useful, with an average of 4.3. Similarly, the least-used of the relevant texts, "Deforestation of the Amazon Rainforest and its Impacts", was rated as significantly less reliable (mean 3.0) and less useful (mean 3.2) than the most-used relevant text.

Of the irrelevant texts, the advertisement "The Intergovernmental Panel on Climate Change compiles scientific data on the Earth's climate" was rated as the most reliable. It is worth noting that it received an average score of 3.8, which is significantly higher than the relevant Amazon text. However, in terms of usefulness, the text ranked in the middle, with an average score of 3.0. On the other hand, this is only two decimal places lower than the Amazon text. Of the irrelevant texts, the blog post by environmental organizations, "Biodiversity loss is a reality in Finland too", was considered the least reliable. It received an average score of 3.0 for reliability, i.e., average. Interestingly, however, it was the most frequently used text among the irrelevant ones.

Of the fake texts, the highest scores were awarded to "The climate is changing as part of a natural cycle", which pretended to be a NASA research report: the average score for reliability was 3.0 and for usefulness 2.6. The reliability of this text was thus assessed as the same level with both the relevant Amazon text and the irrelevant environmental organization blog post. The other fake text, "What is species loss?", was also rated as surprisingly reliable with a score of 2.6 and useful with a score of 2.8. Next, we will examine how the participants justified their ratings in their own words.

Verbal Assessment of the Reliability and Usefulness of the Source Texts

In their verbal justifications, participants referred to many different factors. In their reliability assessments, they first highlighted source factors (e.g., author, publisher, text type). For example, the reliability of relevant text no. 2 was justified: "Reliability is enhanced by the fact that the author is an expert in the field, there are many sources and they are listed at the end, and the content is scientifically proven and well-founded"

(ST11). On the other hand, irrelevant texts and fake texts were also justified by referring to source factors, such as fake text no. 9: "it is reliable because Aron Lehtiniemi from the Environmental Science Research Centre wrote the text" (ST53).

Secondly, in their arguments regarding the reliability of the text, the participants referred to the text's content (for example, identifying mis- or disinformation). For example, regarding the authentic Amazon text no. 7, ST63 stated: "A truthful text." And regarding the fake text no. 9: "This text, based on a news story, downplays the effects of biodiversity loss and the wave of extinctions, as well as the role of humans in bringing them about. I would also go so far as to claim that it contains disinformation" (ST24).

Furthermore, in their assessments, the participants drew on their prior knowledge, corroborated content across the texts at hand, and examined the matter from the perspective of the task at hand, as is appropriate in multi-source reading. For example, the reliability of relevant text no. 2 was assessed: "The authors, date and job titles were mentioned, and the reference list was also good. The text was also fact-based and contained statistical data that I have heard before in the same context." (ST17): "The article also used several sources, and many other articles in the assignment contain similar information" (ST45).

Some participants appeared to focus their assessments solely on individual source aspects, for example by judging a blog post to be completely unreliable based solely on the text type, as in the case of the key Amazon text no. 7: "It's a blog, so people's own opinions influence and come through in the text" (ST18). Participants might also judge a text to be reliable based on the author's title or because of the statistics or numerous source references it contained. For example, the non-relevant Climate Panel text no. 3 was assessed as reliable: "Because it's the Citizens' Information website, so it has to be reliable" (ST53).

Some participants made a deeper interpretation beyond individual source details. For example, when assessing the reliability of a blog post, they also considered their own prior knowledge of the text's publisher and author. Consequently, the participant's knowledge of the publisher's and author's expertise in the topic in question enhanced the source's reliability. Those who examined statistical or other data and source references more closely also paid attention to the quality of the evidence, for example, whether the information provided was consistent with research-based knowledge. For example, the irrelevant blog post no. 8 by an environmental organization was assessed: "The text is also not reliable, as some of the content is based on the author's opinions rather than statistics or research. Nor is the text objective. Furthermore, the sources are not accurate" (ST11).

The reliability assessment appears, at least in part, to be linked to the usefulness assessment in terms of verbal justifications; that is, if a participant deemed the source text to be completely unreliable, they did not consider it useful for the task either. Other factors also emerged in the assessments of usefulness. For some, the comprehensiveness of the text's content appeared to be a key factor, and consequently they might have chosen not to use a source text that highlighted a single perspective, such as the decline in insect populations: "The text is not useful for this task because it deals only with the decline in insect populations, not the decline in nature in general" (ST50).

In addition to content-related issues, factors such as the text's readability and comprehensibility also came to the fore. A participant might have chosen not to use a text, for example, because they felt it was heavy going and contained a lot of figures: "At first glance, the text has a lot of numbers and figures, so it can be a bit hard to read, which is why I didn't use it myself" (ST7). It is interesting to note that participants did not always assess the text's usefulness in relation to the task itself, despite being explicitly asked to do so, but instead justified its usefulness, for example, on the grounds that the topic interested them. **Table 4** summarizes the participants' reasons for the reliability and usefulness of the source texts.

Table 4 shows in many instances that the same factors were cited by participants as grounds for both reliability and unreliability: for example, the fact that the text was published in a newspaper or that the text is based on scientific research, as fake news specifically present false information as researched facts or news. For example, regarding fake text no. 0, one participant stated: "The text is written in a research-based style, the sources are cited, and it is fairly recent" (ST4), whilst another participant said: "A newspaper article brimming with climate denialism and disinformation. We have a relatively large amount of scientific evidence globally regarding species decline, so the claim: 'Corals, trees, birds, mammals and insects are adapting extremely well' can quite simply be dismissed as nonsense" (ST24).

It is worth noting that, although numerical scales were not used very frequently, the participants' verbal assessments differed significantly from one another regarding both relevant and irrelevant texts, as well as fake texts. The usefulness of the irrelevant science event advertisement text no. 5 was assessed, on the one hand: "A clever text with good points" (ST63) and, on the other hand: "You couldn't really get any information out of the text, so it's pretty useless. The text felt more like an advertisement" (ST50). In their verbal assessments, the participants did not hold back on strong expressions. A particular text might be described as "really reliable" or "really unreliable", and strong views were expressed, for example: "'University blog' and incredibly poor referencing – suspicious!" (ST72) or: "A Green Party MP promoting their own agenda under the guise of an informational text" (ST58).

Furthermore, in the verbal evaluations, attention is drawn to how participants perceive the concept of 'perspective' mentioned in the task description. The usefulness of the irrelevant survey barometer text no. 6 was assessed on the one hand: "The text is quite useful, as it deals with the loss of nature and reports on citizens' views. It helps to understand the loss of nature from different perspectives" (ST11) and, on the other hand: "The text is mainly a report on a study that has been carried out, but what people think about the loss of nature does not help to explain what it is" (ST44). The task required the causes and consequences of biodiversity loss to be analyzed from different perspectives, such as health or the economy. In the latter example, the participant adheres to the task, whereas in the former example, the views of the public

Table 4. Summary of participants' justifications for their assessments of reliability and usefulness

Reasons indicating reliability	Indicating unreliability	Indicating usefulness	Indicating lack of usefulness
Source:	**Source:**	**Reliability:**	**Reliability:**
-publisher	-questionable or unknown place of publication	-reliability of the source	-unreliability of the source
-well-known / expert authors	-publisher	**Relevance to the task:**	**Relevance to the task:**
-text type	-author unknown or author's political background/ agenda	-Relevance to the topic	-not related to the topic
-date stated, topicality	-text type	Other relevance:	Other relevance:
- appropriate citations and a bibliography	-old source	-interesting to me	-cannot be used in teaching
Text content:	-incomplete references	-provides links	**Text content:**
- accuracy: statistics, figures	-not peer-reviewed	-can be used in teaching	-limited or one-sided content
-objectivity	-populist tone	**Text content:**	-no reasons are given or concepts used
Evidence:	**Text content:**	-new perspective,	**Comprehensibility:**
-based on research information	-based on a one-sided or single person's perspective	-use of concepts,	-difficult to read
-arguments are well-founded	-claims are contradictory	-cause-and-effect relationships	-difficult to understand
-limitations highlighted	-misinformation and disinformation	-facts and practical examples	
Corroboration:	**Evidence:**	**Comprehensibility:**	
-similar information in other sources	-claims are unsubstantiated	-clarity, conciseness	
Prior knowledge:	-based on unknown, dubious or limited sources	-comprehensive content	
-information already familiar to oneself	**Surface factors:**		
	-spelling mistakes		
	-short text		
	Prior knowledge:		
	-claims do not support what has been taught at school/researched information		

are accepted as a valid perspective. Furthermore, the fake texts were sometimes mistakenly regarded as the so-called 'other side' of the phenomenon:

The loss of nature is often discussed as a very negative thing, which it is. This text highlights the other side of biodiversity loss: species extinction, which is actually a positive thing. In my opinion, this is a useful text precisely because it takes a different perspective on species extinction. Many people often assume it is a negative thing, so this article shows that this is not always the case (ST20).

DISCUSSIONS AND CONCLUSIONS

In our study, we investigated which source texts student teachers used when they were provided with ten different texts on biodiversity loss in an online learning environment to help them prepare for teaching, and how they evaluated these source texts both numerically and verbally. The study is timely in today's information society, where many environmental issues such as biodiversity loss (Saunders et al. 2025; Stratford & Wals, 2020) are often the subject of deliberately disseminated misinformation, which can become increasingly intertwined with reliable information over time (Kızılcık, 2024). Better ways are needed to support people's scientific literacy (Lederman et al., 2024; Osborne & Allchin, 2024), and schools play a significant role in this work, as they reach almost the entire age group.

For schools to support pupils' scientific literacy, primary teachers themselves must possess it and have the capacity to develop it in terms of scientific knowledge, multi-source reading skills and attitudes towards science (Lombardi et al., 2025; Vidbäck et al., 2023). Viewed through the lens of scientific literacy, our findings suggest that student teachers' engagement with multiple sources involves the interplay of scientific knowledge, information evaluation skills, and attitudes toward scientific information. Rather than representing separate dimensions, these elements appeared to support one another when participants evaluated, selected, and used information for a teaching-related task.

In our research design, we provided student teachers with texts that were both relevant and irrelevant to the task, as well as texts containing false information. According to our findings, the student teachers identified relevant sources well, and each of them used at least one of these in their summaries. The majority also used irrelevant sources, whilst texts containing false information were utilized less frequently. The three most popular texts for summaries were relevant, and the least frequently used were those containing false information, although they were still included in some summaries. In this respect, the results regarding the use of source texts are in line with the study by Heikkilä et al. (2024), which found that student teachers were indeed able to define a phenomenon and identify its causes and consequences, but some of them included absolutely everything in their summaries: relevant and irrelevant information as well as false information, resulting in an inconsistent and incorrect final product. Similar shortcomings were observed in the study by Marttunen and Kiili (2022), in which university students were able to identify different perspectives in the source texts provided, but they faced challenges in coherently synthesizing the texts and structuring their own writing.

The primary teacher students' assessments of the reliability and usefulness of the source texts provided an interesting perspective on the use of the texts. Three relevant texts were rated as the most reliable, but the reliability ratings for the irrelevant texts were nevertheless close to these ratings. One of the fake texts was rated as reliable as the least-used relevant text. The relevant texts received the highest scores for usefulness, whilst the scores for the fake texts and the irrelevant advertising text were clearly lower than the others. Overall, however, it can be concluded that evaluating

source texts was not an easy task for the student teachers but revealed uncertainty regarding how to approach different types of texts. These results reflect our knowledge landscape, where sources may contradict one another (Britt & Rouet, 2012) and yet one should identify the main points of the sources and establish connections between them (Perfetti et al., 1999). Similar results were also observed in the study by Kulju et al. (2024), in which teacher students were largely able to distinguish more reliable texts from less reliable ones, but found it more difficult to justify their choices.

In addition to numerical ratings, participants provided verbal assessments of the reliability and usefulness of the source texts. According to their explanations, the assessment of reliability drew on source factors, but also aspects related to the text's content and evidence, such as argumentation and the highlighting of limitations, as well as other features of scientific texts, such as accuracy and statistical data. In addition, comparisons were made with prior knowledge and content was corroborated across other source texts. Participants who compared the text's content with their prior knowledge based on researched information, such as what they had learnt at school, were also able to identify fake sources. In contrast, those who focused on source factors were more likely to believe fake sources, possibly because evaluating source characteristics is easier with limited prior knowledge (Barzilai et al., 2020). This illustrates the importance of prior knowledge as part of scientific literacy (Roberts, 2007) and how knowledge and skills are interlinked (Vidbäck et al., 2023). This also demonstrates how an assessment based on individual source characteristics, such as the publisher, can lead to a completely incorrect interpretation of a source's reliability. These results offer suggestions for developing the content of teacher education programs, both in educational science and in the didactics of various subjects: When assessing the reliability of information sources, it is often not enough to consider only individual source factors; instead, multiple factors must be evaluated, and the content and the evidence must also be examined. On the other hand, prior knowledge can sometimes be a poor starting point if previous information is incorrect or other sources are false, as people are prone to notice information that aligns with their own preconceptions and disregard other views (Chinn & Brewer, 1993; Stadtler & Bromme, 2014).

In our research findings, the assessment of the usefulness of source texts appeared to go hand in hand with reliability, which is logical, as an unreliable source is less likely to be perceived as useful. Furthermore, reliability was assessed from the perspective of the task at hand. However, some perspectives were contradictory: accuracy and statistics were seen as indicators of reliability, but on the other hand, a text that was dense with figures, for example, was associated with being unhelpful, meaning that the text might be considered reliable by the participants but not useful. If a text contained only one perspective, such as the 'insect decline' text, it was considered useless for the task at hand. Such a perception is worrying in the light of the need to raise awareness of the diversity and role of pollinators (Morais et al., 2024) and contradicts the principles of multi-source reading. As an implication for teacher education, we therefore suggest that the use of multiple sources should be taught from this perspective as well.

Another worrying feature that emerged in the usefulness assessments was the tendency of some participants to evaluate the usefulness of source texts based on their own interests rather than the requirements of the task. Many texts that were irrelevant to the task, or even fake texts, were seen as offering a different perspective and new aspects of the phenomenon, and the specific task description seemed to have been forgotten during the task, even though it was available during the whole task. In multi-source reading, the reader should be constantly aware of their own reading goals and intentions (Rouet et al., 2017). In teacher education, students should therefore be supported in focusing on the topic and sticking to it when dealing with academic content, as in multi-source reading, the task is to be able to understand in order to assess one's own information needs, select suitable information sources and combine them into a coherent whole (Rouet & Britt, 2011). Student teachers often remind their pupils of the importance of the task, but staying on task is essential for scientific literacy at all ages.

Taken together, the findings can be interpreted as reflecting different dimensions of scientific literacy. Participants generally demonstrated the skills needed to identify relevant knowledge and evaluate sources, but these skills were not always applied consistently. Differences in source use and evaluation appeared to be connected not only to participants' knowledge but also to attitudes towards knowledge, such as openness to alternative perspectives, confidence in one's own judgement, and commitment to staying focused on the purpose of the task. Scientific literacy therefore emerged not merely as the ability to distinguish reliable information from unreliable information, but as the capacity to use knowledge and skills in a reflective and goal-directed manner.

A limitation of our study is that attitudes receive less attention, even though they are part of scientific literacy. However, we refer to a recent study showing that first-year primary teacher students have science-positive attitudes and possess so-called 'science capital'—that is, science-related self-efficacy, identity and networks—and have received science-related encouragement and support (Heikkilä et al., 2025). Our study complements previous research in this regard by focusing on concrete skills that could be practiced and explored in an e-learning environment. Some findings in our study also suggest that attitudes may have influenced participants' engagement with source texts, particularly in situations where personal interests, confidence in prior knowledge, or willingness to scrutinize information appeared to shape source selection and evaluation.

The work of a primary teacher is a responsible and demanding intellectual role that requires mastering a wide range of subject matter and keeping up to date across multiple disciplines. The aim is to nurture pupils into active citizens who can work to ensure, amongst other things, the sustainability of the planet (Stratford & Wals, 2020). In teacher education, it is not enough to teach students to absorb information from a single source at a time, as the current information environment requires the ability to read from multiple sources (Britt et al., 2014). Therefore, student

teachers must be supported in identifying relevant and irrelevant information, as well as mis- and disinformation, and in evaluating the reliability and usefulness of sources in a multifaceted and varied manner, considering the source authors, content, evidence, multi-sourced nature and their prior knowledge. Furthermore, their ability to understand and stay on track with the task at hand must be strengthened. These development measures can be implemented within the framework of current curricula and structures, as they cut across both educational science – which is a major subject in many primary teacher education programs – and the didactics of various subjects, and are also evident in teacher practice in the student teachers' future careers.

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