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Exploratory Study on Latvian Secondary School Teachers' Understanding of the Concept of Scientific Literacy

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ABSTRACT

Teachers' scientific knowledge and understanding of science are prominent in determining how teaching scientific literacy will be integrated in the curriculum. However, in previous literature in-service teachers' understanding of scientific literacy has not been studied sufficiently. This qualitative study aims to close this gap and explore how Latvian secondary school teachers (N = 23) understand the concept of scientific literacy. In our study, we distinguished three dimensions of scientific literacy: procedural, affective, and conceptual. Our results indicate that teachers associate scientific literacy mainly with the aspects related to procedural dimension: having knowledge about conducting a scientific study, applying scientific methods, and having an understanding about scientific concepts and processes. Teachers do not perceive themselves as highly scientifically literate for a variety of reasons. For the teachers interviewed, features of scientific literacy overlap with media and information literacy and critical thinking. We conclude that the teachers' understanding only partly covers the depth and breadth of the concept of scientific literacy, and differs depending on teachers' previous education and school subject thought. The importance of teachers' (further) education in developing their understanding of the concept of scientific literacy is discussed.

Keywords: scientific literacy, media literacy, critical thinking, scientifically literate person, secondary school teachers

Introduction

Schools undoubtedly are among the main developers of appreciation of science in society and the main providers of science literacy during one's school years (Solomon, Scott & Duveen, 1996). However, since the emergence of the scientific literacy concept in late 1950s, the teaching of science at schools and the varied notions of scientific literacy have been an object of heated discussions for researchers and policy makers. Educational goals or constructs, as said by Wilson (1986, p. 27), often "take on a life of their own … before we know, literally, what we are talking about." Wilson (1986) has proposed that, before we uncritically accept (or reject) any educational goal, first we should attempt to answer the question of meaning, i.e., what is meant by the construct or educational goal? While on a macro level, the meaning of scientific literacy can change depending on the context such as the constraints of the curriculum or institution (Miller, 1998; Laugksch, 2000), on a micro level, it solely depends on teachers' scientific knowledge, their own understanding of science, as well as their ability to assess students' conception of science (Schwartz & Lederman, 2002). Surprisingly, in this long-standing discussion, the voices of educators and in-service teachers and analysis of their interpretations of what it means to be scientifically literate and how such an educational goal can be achieved are understudied (e.g., Choi et al., 2011). Hence, in the present study, our aim is to examine teachers' own interpretations of the concept of scientific literacy. The premise of this study is that by understanding teachers' conceptualizations, it is possible to propose a vision on teacher education and further education and to design new curriculum and professional development frameworks.

In the present study, we also problematize the immoderate focus on science as belonging to natural ("hard") subjects that does not equally include social sciences and humanities (Charlton, 2006). This creates a risk of these disciplines being marginalized in the debate about school science. Moreover, the long-standing split between sub-cultures of humanistic/social and "hard" sciences (Snow, 1990) has never truly been removed from the discussions about scientific literacy in schools. Besides that, we add this specific layer of analysis to our study because **in the Latvian context**, it is intriguing to discuss teachers' interpretations of scientific literacy from the school subject perspective due to the current changes in the educational paradigm. Since the late 1990s, in Latvian school system the pressure on educators has been mainly to increase the number of students who pursue education and careers in STEM (science, technology, engineering, and mathematics) fields (Kiselova & Gravite, 2017; Karaseva, 2017), thus marking a clear line between the STEM subjects and the rest of the disciplines taught. However, the current school reform, labeled as "School 2030", is grounded in competence-oriented and interdisciplinary teaching framework that prepares students to creatively master the various economic, political, social and cultural challenges in a rapidly changing world (Birzina, Pigozne & Cedere, 2021). Such an approach calls for curricula implementation that is based on the principles of inter- or trans-disciplinarity and the development of students' inquiry skills that breaks the long-standing boundaries between school subjects (Goodson & Mangan, 1995).

Conceptualizations of scientific literacy

There is no single agreed definition of the term "scientific literacy." Rather, a number of conceptualizations exist that stress the varying elements of content knowledge, attitudes, and skills (for extensive reviews see DeBoer, 2000; Laugksch, 2000; Roberts, 2007), leading actually to a conclusion that the concept has become "ill-defined and diffuse" (Laugksch, 2000, as cited in Dillon, 2009, p. 201). Reportedly first used in 1952, the term "scientific literacy," states, in a very condensed manner, that being scientifically literate means "being educated and possessing knowledge in and about science" (Norris & Phillips, 2016, p. 947). Norris and Phillips (2003) note that the term is often used to refer to the following aspects: understanding the nature of science and its relationships with socio-cultural issues, understanding of science and its applicability, appreciation of and comfort with science, including its wonder and curiosity, distinguishing what is and what is not science, ability to use scientific knowledge in everyday life, appreciation of science, its benefits, and understanding the risks of science, ability to think critically about science, and deal with scientific expertise. In an attempt to consolidate the rather scattered aspects of scientific literacy, Miller (1983) proposed a three-dimensional conceptualization consisting of

a) an understanding of the norms and methods of science;
b) an understanding of key scientific terms and concepts; and
c) an awareness and understanding of the impact of science and technology on society.

Similarly, Kemp (2004) has suggested a three-dimensional model of scientific literacy that entails the following:

a) procedural dimension (learning about science, using science in everyday life, applying science for social purposes, being able to decode and encode scientific communication, think scientifically, engage in inquiry, and use the tools of science);
b) affective dimension (having appreciation for science, interest in science, inclination to stay up to date with science development and science related social problems, having objective and open mind, and having self-confidence to use science); and
c) the conceptual dimension (knowledge of science history, science concepts, science vocabulary, principles of science, and limitations of science, as well as the understanding of the interrelations between science, society, and technology, and the understanding of science as a social activity).

Based on an extensive literature review, Chadwick (2018) proposed that scientific literacy can be defined as consisting of various individual and societal aspects. She argued that various combinations of competencies and skills of science, knowledge of the content of science, knowledge of nature of science, and knowledge of scientific processes (all being individual aspects of scientific literacy) impact our interactions with society. For example, knowledge of the nature of science and understanding about the scientific process supports the development of sympathetic and critical attitude towards science (a societal aspect of scientific literacy); while knowledge of scientific content together with competencies and skills of science enables us to actively participate in scientific society (Chadwick, 2018). A scientifically literate individual also can have a sympathetic and critical view of science that benefits them in their daily lives (AAAS, 1989; DeBoer, 2000). For example, they can carry out basic critical evaluation and participate in a discussion about reports of science in the media (DeBoer, 2000).

Advancing the idea of scientific literacy as a multi-dimensional concept, Choi et al. (2011) have outlined a scientific literacy definition for the 21st century. It consists of five dimensions:

a) scientific contents;
b) mental habits—communication, systematic thinking, information management, and the use of evidence;
c) character and values to act responsibly;
d) science epistemology and the relations of science with society;
e) metacognition and self-direction.

For them, scientifically literate individuals are global citizens who "are active agents who take responsibility to resolve global issues with moral and social compassion and ecological worldview" (Choi et al., 2011, p. 682).

In academic literature, quite prominent also are the conceptualizations of scientific literacy as a continuum. Among the most well-known such frameworks are those developed by Shamos (1995) and Bybee (1997). As proposed by Shamos, a continuum consists of the degrees of "sophistication as well as the chronological development of the science-oriented mind" (Shamos, 1995, p. 87). For him, the first degree, "cultural scientific literacy," is the simplest, and in Shamos' view, it represents the level of scientific literacy possessed by most educated adults who know science-related terms and their definitions, and thus are able to "recognize many of the science-based terms (the jargon) used by the media, which is generally their only exposure to science" (Shamos, 1995, p. 88). The second form, "functional scientific literacy," entails some level of command of a scientific vocabulary—a "science lexicon" (p. 88)—but it also means that the individual is able to discuss, read, and write using science terms in a nontechnical but meaningful context. A functionally scientifically literate individual would thus not only be able to read and comprehend a science-based newspaper article, but would also be able to communicate the content of the article to somebody else. The third form and level of scientific literacy, "true scientific literacy," according to Shamos (ibid.), is the most difficult to attain, because in addition to the previous forms, also involves, knowledge about the scientific enterprise, science epistemology, and analytical and deductive reasoning skills.

Conceptualizations of scientific literacy as a continuum has led to questioning of whether deep sophisticated knowledge about science is necessary for/is attainable to everyone (for "pro" arguments of such a proposition see Shamos (1995); for a critique of it, see, e.g., Fensham, 2002). As a response, two main views on teaching science at schools (called Vision I and Vision II) have emerged, namely the "focus-on-sciences-and-scientists" (Vision I) and the "focus-on-situations" approaches (Vision II) (Roberts, 2007). Vision I is linked to Shamos' (1995) proposed dimension of "true scientific literacy" that is claimed by him not to be necessary for or attainable by everyone. In the school context, Aikenhead (2006) has described it as learning or teaching science with an aim to prepare future scientists. It emphasizes science as a discipline that demands procedural and propositional knowledge (Liu, 2013), and its subsequent application in a lab-based environment (Bybee, 1997; 2016).

Vision II (and its extension into Vision III—see, e.g., Roth & Barton, 2004, Santos, 2009) on the contrary, draws on a socio-cultural perspective of teaching and learning science, and, as noted by Aikenhead (2006), recognizes that science is not isolated content, but involves rich cultural connotations (values, attitudes, power relations), where both the products and processes of science are embedded in social situations that we face as citizens. Valladares (2021) describes science teaching at schools as a slowly progressing journey from teaching that is focused on the memorization of scientific concepts and laws (Vision I), toward a scientific teaching focused on the study of science risks and impacts on society and, more recently, on the role of science as a tool for social change (Vision II). Hence, often the ways of promoting scientific literacy at schools have been criticized for placing too much focus on a mere body of concepts or indisputable facts (Leden, Hansson & Redfors, 2017), shaped by the image of laboratory science (Roth & Lee, 2002). It is said that while striving to achieve the educational goals related to scientific literacy, schools are missing the sociocultural context of science and insufficiently covering the epistemology of science (Lederman, 2007; Lederman, Lederman & Antik, 2013). It is also said that the competing Visions I and II manifest themselves in current evaluative designs and strategies for teaching and learning. For example, while PISA evaluations are characterized by contextualizing the survey items making it clearly linked to Vision II, at the same time, TIMSS assessments, through its textbook questions without context, reflect the spirit of Vision I (Bybee, 2016; Liu, 2013).

Vision II also tries to tackle the long-standing problem of "two cultures" coined by C. P. Snow in his famous Rede Lecture at Cambridge University in 1959 (Snow, 1990), in which he highlights the sharp division between humanities, social sciences, and natural sciences caused by the narrowing of the notion of "science" to only include natural sciences and using the term "scientist" to only refer to a person who works in or studies an area of natural science.

The **Table 1** provides an overview of the various conceptualizations on scientific literacy summarized above. In this summary, we indicate that most of the previous proposals distinguish mainly among three dimensions of scientific literacy: knowledge (cognitive dimension), skills (procedural dimension), and attitudes (affective dimension).

Table 1. Overview of the various conceptualizations of scientific literacy in previous literature

Author	Knowledge	Skills	Attitudes
Miller, 1983	an understanding of the norms and methods of science (i.e., the nature of science); an understanding of key scientific terms and concepts (i.e., science content knowledge);		an awareness and understanding of the impact of science and technology on society
National Academy, 1996	content of science; context of science	science process	scientific attitude
Gräber et al., 2001	Subject competence; Epistemological competence	Learning competence; Social competence; Procedural competence; Communicative competence	Ethical competence
Norris & Phillips, 2003	Understanding the nature of science and its relationships with socio-cultural issues; understanding of science and its applicability ability to think critically about science and deal with scientific expertise	Ability to use scientific knowledge in everyday life	Appreciation of and comfort with science, including its wonder and curiosity, distinguishing what is and what is not science; appreciation of science, its benefits, and understanding the risks of science
Kemp, 2004	*Conceptual* (e.g. science concepts; science vocabulary; broad principles of science etc.)	*Procedural* (e.g. use science everyday life; apply science for social purposes; think scientifically; reason and argues; judge the validity of claims; solve problems; integrate knowledge; engage inquiry; use some of the tools of science etc.)	appreciation for science; interest in science; objective, open mind and skepticism; ethical values; self-confidence to use science

Table 1. Continued

Author	Knowledge	Skills	Attitudes
Chadwick, 2018	Knowledge of nature of science; knowledge of scientific content; knowledge of scientific processes	Competences and skills of science	
PISA, 2018	Scientific understanding: an individual's understanding of scientific concepts, phenomena and processes	Science inquiry skills: their ability to apply this knowledge to new and, at times, non-scientific situations	

Parallels with media and information literacy and critical thinking

The various conceptualizations of scientific literacy entail understanding of science communication or abilities to evaluate trusted sources of scientific information, hence tapping the domains that are typically attributed to media literacy (Rosenthal, 2020). The same can be said about critical thinking. Such a trend has intensified itself due to the growing amounts of science related disinformation, especially during the current COVID-19 pandemic, and the need to grasp the complex role that the digital media play in informing audiences about science-related issues and the cognitive challenges that we experience as media audiences (Singh & Banga, 2022). For the purposes of this study, we conceptualize scientific literacy, media literacy, information literacy, and critical thinking as related but still distinct concepts, and propose that it is fruitful to explore the relationships between them.

The popular descriptions of media literacy refer to the abilities to access, analyze, evaluate and create messages in a wide variety of media modes and formats, and recognize the role and influence of media in society (Aufderheide & Firestone, 1993; Livingstone, 2004). It is generally believed that there are links between scientific literacy, how individuals generally use media, and people's media consumption habits. For example, proficiency in media consumption positively correlates with scientific literacy (e.g., see Takahashi & Tandoc, 2016). Information literacy is often defined as the ability to search for, select, critically evaluate, and use information for solving problems in various contexts (Bawden, 2001).

As for critical thinking, it refers to disciplined and structured intellectual process in which an individual engages when he or she conceptualizes, applies, analyzes, and/or assesses information obtained from different sources. An individual exercises his or her critical thinking by considering the various alternatives when judging (Ennis, 1987; Hatcher & Spencer, 2000). Previous studies indicate that skills to critically evaluate the accuracy of scientific information online are related to practices of information consumption and sharing (Vosoughi, Roy & Aral, 2018; for a review see Madathil et al., 2015).

The aim of the present study and research questions

To date, few studies have focused on in-service teachers' understanding of the concept of scientific literacy (Choi et al., 2011). Moreover, there is a dearth of studies on the views on scientific literacy of different subject teachers. Hence, in the present study, we explore how Latvian secondary school teachers understand the concept of scientific literacy.

In our study, we aim to capture the views of teachers of STEM, humanities, and social sciences. We examine teachers' understanding from three different angles. First, the "meaning" of scientific literacy is clarified by asking our study participants "How do you describe scientific literacy?", second, we identify what are the participants' views on the "elements" of the concept of scientific literacy by asking "What characterizes a scientifically literate (or illiterate) person?", and third, we apply the lens of reflectivity (Roth & Barton, 2004) by asking how scientifically literate the study participants feel and why.

Method

Participants. Participants were recruited by using purposive sampling. Participation in this study was voluntary. Twenty-three individual interviews were conducted among 25–67 year old secondary school teachers (seven men, 16 women; length of service at the school from one to forty-four years). Teachers represented the following subjects: nine STEM teachers (Mathematics, Biology, Chemistry, Physics, Geography, ICT), seven social sciences teachers (Economics, Psychology, Political science), five humanities teachers (Latvian language, English as foreign language), one sports and one design teacher. When quoted, study participants were identified by code number, area of teaching subject (STEM, SS – social sciences, HS – humanities, other) and age (for example, A1, HS, 28).

Data collection. Semi-structured interviews (40–60 min) were used as a data collection method. Interview questions were formulated in such a way that it would be possible to find out teachers' understanding of science literacy, as well as to examine the following topics: science literacy, scientific literacy, characteristics of a scientifically literate person. Participants were informed about the confidentiality of the information collected.

Data analysis. Inductive thematic analysis was used. First, repeated examinations of each interview took place. Then, the search and definition of topics and sub-topics was performed. As a result of the thematic analysis, we defined, for example, the following themes: scientific literacy (knowledge, skills, attitudes), scientifically (ill)literate person (see Table 2 for topics, sub-topics and examples).

Table 2. Topics, sub-topics, and examples

Topic	Sub-topic	Example
Scientific literacy	Knowledge	"I understand that it is knowledge, understanding of different scientific concepts, processes that are necessary for everyday life." (A2, STEM, 39)
	Skills	"I think that scientific literacy could be related to the methods of scientific research, its design." (A1, HS, 28)
	Attitudes	"Scientific literacy is when we trust scientific discoveries." (A11, other, 44)
Information literacy		"Literacy is the way they (students) know how to find information." (A18, HS, SS, 37)
Critical thinking		"I think it is the ability to deal with facts, to argue your point. Critical thinking – either I accept the facts as true or false." (A13, SS, 46)
Scientifically literate person	Others	"A scientifically literate person goes about his daily life in a way that is accepted or scientifically proven throughout the world." (A10, STEM, 67)
	Self	I feel more scientifically literate than the average member of the public because I have written scientific papers, and I know what to do if you have to gather a lot of information. (A16, SS, 37)

Results

1. The teachers' views on the concept of scientific literacy

Following the structural distinction that we established in reviewing the theoretical conceptualizations of scientific literacy, we coded the results on teachers' views on the concept of scientific literacy by looking at three dimensions: conceptual dimension (knowledge), procedural dimension (skills), and affective dimension (attitudes).

On the conceptual dimension, most of the teachers who participated in our study mainly emphasized that scientific literacy means understanding the general concepts of science, understanding what a scientific theory is, and knowing different scientific terms (science vocabulary). Several teachers also noted that scientific literacy is achieved by developing abilities to think in the ways scientists think. Notion of scientific literacy was explained by comparing them to media and information literacy and critical thinking, for example, in the words of one of our study participants:

> *The way I understand it [scientific literacy], well, let's say, I read some text about what is happening in the world, I immediately think: "The way it was presented, is it the opinion of one person? Or is it based on some research?" I think of the human ability to think critically, understanding of which sources is scientific literature, but which is a gossip page.* (A3, STEM, 48)

Our study participants also mentioned that scientific literacy means making decisions, based on scientific information. However, one teacher insisted that a "general scientific" literacy does not exist, for her scientific literacy meant deep knowledge in a specific discipline (A9, HS, 49).

On the procedural dimension, several teachers noted that science is a process, hence also scientific literacy can be associated with its procedural properties: application of various research methods, being able to measure, make conclusions, and compare your findings with the previous literature. During the interviews, the skills for collecting data were emphasized. One of our study participants said that "scientific literacy is related to scientific research methods, their creation, study designs" (A1, HS, 28). When asked to explain more in detail which research methods teachers have in mind, most of them referred to scientific observations that are typical in natural sciences. As one teacher explained, scientific literacy manifests through

> *some issue that people are deeply interested in. In biology and such fields people can experiment in a laboratory, they experiment with it [the issue] in a lab environment. (...) Then it is proved, described. This cannot be done without research.* (A12, SS, 53).

On the affective dimension, we coded only two items and found two types of trust in our data: trust in scientists and trust in scientific discoveries. Both types of trust were associated with features that overlap with some elements of media and information literacy, such as being able to critically evaluate information sources. As one of the teachers interviewed said:

> *I haven't heard such a term [scientific literacy], but I think what it might mean is trusting scientists who have dedicated their time to researching a problem, not trusting your neighbor posting on Facebook some rubbish.* (A16, SS, 37)

An interview participant who was speaking about the affective dimension of scientific literacy emphasized the role of science communication that, in his opinion, could be improved in order to increase the public's trust in scientific discoveries and raise the overall level of scientific literacy in the society. He said that *scientific literacy is when we trust scientific discoveries when we read about them in the media. Scientific literacy is that we know how to check resources, facts, it is similar to media literacy. (…) As nowadays everything we know comes mainly from the media, including scientific discoveries, therefore in general, scientists should communicate more with society, then scientific literacy will also be greater.* (A11, other, 44)

2. The teachers' views on what characterizes a scientifically literate person.

When coding our data related to the second research question "What characterizes a scientifically literate (or illiterate) person?", we initially applied the same three-dimensional coding scheme focusing on the conceptual, procedural, and affective dimensions of scientific literacy, however, after reviewing all codes, we created a fourth—occupational—dimension.

On the cognitive dimension, the views on what characterizes a scientifically literate/illiterate person overlapped with the descriptions that teachers used when explaining their understanding of the concept of scientific literacy. For our study participants, a scientifically literate person was knowledgeable about scientific theories, about scientific processes, and is able to discuss issues related to science. Most of the teachers insisted that a truly scientifically literate person has deep expert knowledge in only one or, in rare occasions, in several fields. One the teachers explained:

A scientifically literate person is one who understands and has delved into one field of science, who can explain like an expert. From my point of view, if I know, if I have studied history, then I can explain something about it, but if don't have clarity, then I can't explain anything. (A7, HS, 51)

For this interviewee, "clarity" meant knowledge of the general paradigms dominant in the specific discipline. Formal studies finalized with a degree in one specific discipline was the key to ensure that the dominant paradigms are learned. She said: "If I hadn't studied [the field], I could misunderstand things or understand them not in the right way."

On the cognitive dimension, we also found that data codes overlap with the notions of media literacy and critical thinking: several of the study participants equated scientific literacy with information and media literacy. In the words of one of our study participants: "Most likely, a scientifically literate person will be a smart person, an informed person, a person who consumes information carefully, and who has skills of logical thinking and critical thinking." (A9, HS, 49). On cognitive dimension our participants also emphasized the need to develop a habit of constantly improving one's knowledge about science-related matters.

When describing a scientifically illiterate person, teachers most often said that such a person does not know scientific terminology (in the words of one teacher, "does not speak the language of science"), and has limited understanding about science. Parallels were drawn with information illiteracy and potential consequences associated with the lack of this skill, for example, by saying that such a erson is an easy target for manipulation.

On the procedural dimension, the abilities to use technologies, different equipment for engaging in scientific activity, knowing and applying the principles of academic ethics, and, more generally, demonstrating evidence-based behavior in everyday life were mentioned as the characteristics of a scientifically literate person. In this dimension, we noticed overlaps with information literacy, when the study participants compared scientific literacy with doing research by using various information sources before making decisions.

Scientific illiteracy on the procedural dimension, according to our study participants, manifests itself through arguing against science, refusing to act according to scientists' advice, engaging in discussions on science topics without understanding them, and again, overlapping with information literacy, not evaluating information, and not doing proper information analysis before shaping one's opinion.

On the affective dimension of a scientifically literate person, participants noted that such a person trusts science, appreciates science and its discoveries, is enthusiastic and supportive toward science, is motivated to study, learn about science, and is self-motivated to increase one's level of knowledge about science. On the contrary, a scientifically illiterate person was characterized as distrusting scientists, believing in pseudoscience, and, as several of our study participants emphasized, not having interest in the world, and being indifferent to the important issues and challenges that we face as societies. It was discussed in the context of the School 2030 reform, and posed as a challenge that teachers face. One teacher explained:

> *If a student has the will and desire to understand science, then they also are scientifically literate. You can immediately feel that a student wants to do something, discover something, and check how things work.* (A20, STEM, 54)

We established a fourth layer of analysis, the **occupational dimension**, to highlight the participants' views where the professional engagement in science as the core criterion for being a scientifically literate person was expressed. Several of our interviewees pictured such a person, in the words of one of the participants: "He/she is a scientist – creative, passionate, open minded and with a broad horizon." (A19, STEM, 46). The views on an illiterate person justified the creation of this fourth—occupational—dimension, because several teachers noted that a scientifically illiterate person is the one who is not professionally involved in science.

3. The teachers' views on their own levels of scientific literacy

When asked about their own self-perceived levels of scientific literacy, teachers were quite modest and in most cases—critical towards themselves. When asked to assess their scientific literacy on the scale from 1 to 10 (where 1 is "very low" and10 is "very high"), only three teachers said that they are able to assess their scientific literacy in numerical terms. The answers that they gave were "between 4 and 5", "7" and "between 7 and 8", indicating that they do not evaluate their scientific literacy as being high. Instead of assessing their scientific literacy with a number, several teachers provided reasoning about what makes them feel scientifically literate. One quite often used explanation was that they feel to some extent scientifically literate because of their **knowledge** in specific fields – the school subject that they are teaching or a discipline that they personally are interested in (e.g., medicine, biology) due to some health issues or some other reasons. Several teachers responded that they feel to some extent scientifically literate because they have **interest** in the subject that they teach at school and an urge to update knowledge and follow the developments in this one specific science field. For others, the indicator that they are scientifically literate was **skills** in carrying out scientific studies, supervising student research.

Explanations for self-perceived scientific illiteracy. Several reasons can be identified why the teachers assessed their own scientific literacy as being rather moderate and actually quite low. In a number of interviews, links between scientific literacy and information literacy can be identified: these were manifested through, first, self-perceived inability to find, read and understand scientific articles, and second, self-perceived insufficient information processing habits:- the lack of skills to evaluate the credibility of information source and find trusted sources. One teacher explained: "I am moderately scientifically literate, my problem is that I tend to trust people and information uncritically" (A1, HS, 28).

In one instance, the self-perceived low levels of scientific literacy were related to the lack of computer handling skills ("I 'cannot do' ICT"), and in one instance were related to lack of foreign language skills that was the main obstacle why the teacher cannot read scientific studies in their original language of publishing.

We coded two items under the **occupational dimension**: one teacher said that she cannot assess her scientific literacy because "only scientists are scientifically literate, and I am not a scientist." Another teacher explained that "scientific literacy is not for everybody," indicating later during the interview that the presence of scientific literacy is related to one's occupation as a scientist (A23, STEM, 44).

Discussion and Conclusions

In this study, we aimed to explore how Latvian secondary school teachers understand the concept of scientific literacy. We examined teachers' understanding from three different angles. First, the "meaning" of scientific literacy was clarified by asking our study participants "How do you describe scientific literacy?," second, we identified what are the participants' views on the "elements" of the concept of scientific literacy by asking "What characterizes a scientifically literate (or illiterate) person?," and third, we applied the lens of reflectivity (Roth & Barton, 2004) by asking how scientifically literate the study participants feel and why. In this section we will discuss, first, the main findings from the study, and second, provide recommendations for the educators of teachers and teachers' (further) education to develop teachers' understanding of the concept of scientific literacy.

The thematic analysis of the interviews allowed us to assess the link between the expectations placed on teachers and their perceptions of scientific literacy, i.e., teachers are not expected to educate students based on the latest scientific findings. One of the main themes that emerged from the analysis of the results is that most teachers don't see their work as related to science and consequently teachers do not think that they have a role in introducing students to scientific discoveries and establishing links between the school science and students' daily life. Most of our study participants said that they follow the prescribed curriculum and use ready-made teaching materials and textbooks that do not tell how to use science to explain everyday phenomena. It indicates the dominance of Vision I (Roberts, 2007) approach where the school science means "lab science", while the current educational reform in Latvia "School 2030" requires the opposite by postulating that every student should be scientifically literate, understand the process and challenges of science in order to be able to build one's own opinions based on facts (Skola 2030, n.d.). We conclude by arguing that there seems to be a gap between the core ideas of the new curriculum and the fact that teachers who are now implementing it have difficulty in seeing the links between their subjects taught and science, and understanding that science is an interdisciplinary effort, and is heavily theory-laden (Choi et al., 2011). Paradoxically, teachers teach science-based knowledge and scientific discoveries, but their perceptions lack this link between the subject and science, i.e., they do not see themselves as promoters of science.

Another important finding was the realization that teachers align scientific literacy with deep knowledge in one field or discipline. It became most evident when teachers were speaking about their own levels of scientific literacy and compared this with disciplinary knowledge in the subjects that they teach. In their utterances, teachers highlighted that one universal scientific literacy and general understanding of the nature of science does not exist, but it is tied to the expertise in a specific discipline. Moreover, teachers' understanding about scientific literacy referred mainly to the procedural dimension or one's abilities to carry out a scientific study, collect and analyze data, etc. Much less attention was paid to the epistemology of science as well as the conceptual dimension, especially the social aspects, relations between science and society. In previous literature, it is documented as a disciplinary literacy that is developed by teachers as representatives of different academic disciplines and used to produce and construct knowledge within one specific disciplinary community (e.g., Zygouris-Coe, 2015; Rainey et al., 2017). As a conclusion, we agree with previous literature that there are risks with such an approach, as warned by Holbrook (2010). He notes that scientific literacy must by all means be developed in a meaningful social context—the real world outside the walls of the school, where the everyday challenges require interdisciplinary thinking and solutions that do not derive from one specific discipline. If there is too much emphasis on preserving the subject boundaries and focusing on the disciplinary content without links to a larger picture, the true purpose of teaching scientific literacy becomes hidden (Lederman, Lederman & Antik, 2013).

During the data analysis, it became obvious that scientific literacy is not integrated into the professional identity of teachers. Many of them did not assess their own scientific literacy as being high, and generally proposed that scientific literacy is possessed by those people who can be called as scientists because of their occupation and workplace—an academic institution or a scientific institute. For teachers it is much easier to identify themselves as being information literate, data literate, and media literate than science literate. These former literacies were familiar to teachers and these encompass skills that many teachers reported as being trained to use in their daily work. Our conclusion here is that this finding once again highlights the gap between everyday school life and science: teachers are familiar with the basic facts of science they trust science and use its results, but are not always aware that the knowledge of scientific methods and the understanding of the nature and process of science is necessary for everyone, not just scientists. Here again we established parallels with the Vision I on scientific literacy (Shamos, 1995). It is something to consider in the light of the recent educational reform School 2030 that is drawn on cross-disciplinarity.

Speaking about teacher (further) education, in the context of School 2030 and also within the post-pandemic context, we suggest adding additional emphasis on two issues. First, the broadness of the concept of scientific literacy is not covered sufficiently in teacher training programs. Our analysis shows that teachers are mostly directed toward learning the procedural aspects of scientific literacy, while the conceptual and affective domains lay untouched. Also, the conceptual clarity must be established, distinguishing between various literacies—scientific literacy, media literacy, information literacy, and other literacies, of course, also indicating the overlaps between these similar but still distinct concepts. And second, teacher educators should pay more attention to the cross-curricularity aspects of scientific literacy development of student teachers and also in-service teachers. Our results indicate that the subject boundaries influence the teachers' views on the concept of science and inevitably also their teaching of science. It would be preferable also for helping students to establish a coherence between different school subjects (McClune, Alexander & Jarman, 2012) which a highly appreciated path to take for implementing the Vison II approach in teaching science in schools (Valladares, 2021). Here we can refer to recent studies conducted in Latvia that highlight the necessary changes for teacher educators and teacher education curriculum in Latvia (Pipere et al., 2022; Odina, Mikelsone & Grigule, 2021), e.g., to include in all subject teaching more topics related to scientific literacy such as research ethics, presentation of scientific results, and others (Davidova & Zariņa, 2021; Jurgena, Cēdere & Keviša, 2015).

Our suggestion for future studies is related to the teachers' views on the structure of the concept of scientific literacy. In teachers' views, it was overlapping with various other literacies, especially media literacy and information literacy. Critical thinking was seen by our study participants as a fundamental aspect of scientific literacy, too. Of course, previous literature outlines that information literacy and critical thinking are necessary for the development of scientific literacy (e.g., Rosenthal, 2020; Takahashi & Tandoc, 2016), but they are not the same concept. Our small sample and qualitative approach allowed us to catch a glimpse here on the given problem, but our findings indicate that there is a need to study this further and capture the teachers' perceptions of science and scientific literacy knowing that the ways how teachers integrate scientific literacy promotion in their teaching solely depends on their scientific knowledge and their own understanding of science (Schwartz & Lederman, 2002).

Limitations of the study are related to the small size of our sample and the qualitative approach that does not let us generalize our findings.

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