Teaching geomedia literacy in school geography: Teachers' perspectives on students' interpretive and productive skills

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Abstract

Maps, diagrams, images, and visualisations are central to how geographical knowledge is learned and communicated in school. Drawing on 20 interviews with Finnish lower and upper secondary geography teachers, this article analyses geomedia literacy as disciplinary literacy through an abductive, theory-informed thematic analysis. Teachers described geomedia as the everyday representational language of geography, but also identified students' difficulties in moving from observation to explanation. The findings show that geomedia literacy requires explicit modelling, guided interpretation, evidence-based justification, and scaffolded production tasks that treat geographical representations as tools for reasoning.

Keywords

Geomedia literacy; Geography education; Disciplinary literacy; Spatial literacy; Geographical reasoning

1 Introduction

Geographical knowledge is rarely encountered as prose alone. Geography has long been described as a strongly visual discipline in which knowledge is made through maps, images, diagrams, field observations, and other representational practices (Driver 2003). These visual and spatial representations organise spatial relations, make patterns visible, foreground scale, and invite comparisons between places, regions, and processes (National Research Council 2006; Gersmehl 2008). For students, learning geography therefore involves learning to read and produce representations that carry specifically geographical meanings.

Attention to geomedia in geography education has often centred on digital maps, GIS, geospatial technologies, and changing media environments (Felgenhauer and Quade 2012; Gryl and Jekel 2018; Hynynen et al. 2022). This technological emphasis is important, but it does not by itself explain how students learn to make geographical meaning from representations. Research on map-reading and geospatial literacy shows that students' ability to use such representations cannot be assumed simply because maps and digital spatial applications are familiar or widely available (Ooms et al. 2016; Moorman and Crichton 2018). . Finnish matriculation examination research similarly suggests that students may be able to name conventional map elements while struggling to justify what those elements allow them to infer, especially when scale, colour, symbols, and coordinates invite over-interpretation (Lehtoranta et al. 2026). A narrow focus on tools can therefore obscure a more fundamental educational question: what interpretive and productive competences do students need in order to use geographical representations for reasoning? A map, a climate diagram, a population pyramid, or a satellite image becomes educationally meaningful only when students can identify what it represents, select relevant information, compare it with other evidence, and formulate geographical explanations from it (National Research Council 2006; Lee and Bednarz 2012; Lammi et al. 2026).

Finnish curricula use geomedia as an umbrella concept for maps, GIS, diagrams, statistics, images, videos, and other spatially or regionally connected forms of information (Muukkonen et al. 2022; Hynynen et al. 2022). Previous Finnish research has shown that teachers recognise the importance of geomedia, although the term can remain broad or ambiguous in classroom practice (Hynynen et al. 2022; Pellikka et al. 2024). To clarify what such competence may involve for young people, the GeoTAITO model conceptualises geomedia skills as cumulative competences involving acquisition, interpretation, production, visualisation, analysis, and critical evaluation (Lammi et al. 2026). The model is useful for the present study because it shifts attention from naming geomedia towards specifying the competences involved in working with it. Building on this discussion, the present article shifts attention from the presence of geomedia in teaching to the literacy practices through which students learn to interpret and produce geographical representations.

Taken together, this literature shows that geomedia is increasingly recognised in geography education, but it also leaves an important pedagogical question insufficiently developed. Existing research has clarified the breadth of the concept, described students’ geomedia and map-reading skills, and examined teachers’ views on geomedia and digital GIS-related teaching (Ooms et al. 2016; Moorman and Crichton 2018; Hynynen et al. 2022; Muukkonen et al. 2022; Pellikka et al. 2024; Lehtoranta et al. 2026; Lammi et al. 2026; Muukkonen and

Aarnio 2026b). Less is known about how teachers describe the everyday instructional work through which students are helped to read, interpret, evaluate, and produce geomedia as part of geographical reasoning. This gap is important because geomedia literacy is not only a matter of access to maps, images, or digital tools; it concerns how students learn to use representations as evidence in geography.

In Finland, compulsory basic education covers Grades 1–9, usually for pupils aged 7–16. Geography is integrated into environmental studies in Grades 1–6 and taught as a separate subject from Grade 7 onwards, where the curriculum emphasises spatial thinking, human–environment relations, and geographical representations (Finnish National Agency for Education 2014). After basic education, students continue either to general upper secondary education or vocational education. In general upper secondary school, geography includes one compulsory module and three elective modules, across which students use geomedia, geospatial information, maps, diagrams, images, and other representations to interpret, analyse, and communicate geographical information (Finnish National Agency for Education 2019). General upper secondary education culminates in the national Matriculation Examination, which is generally taken at the end of upper secondary school and assesses how students have assimilated the knowledge and skills required by the curriculum (Matriculation Examination Board 2026). Finnish secondary geography therefore provides a relevant context for examining how geomedia literacy is understood and taught.

Research on GIS and digital geomedia teaching shows that students' opportunities to work with geographical representations are shaped by classroom conditions, tool usability, pedagogical organisation, and classroom routines (Curtis 2019; Muukkonen and Aarnio 2026a, 2026b). These conditions form an important background for the present study, but the analysis focuses on how teachers describe students' capacities to interpret, evaluate, produce, and reason with geographical representations. GIS tools, classroom technologies, and digital infrastructures are considered only when they directly affect the interpretation, production, or pedagogical support of geomedia literacy. The study therefore focuses on the classroom work through which teachers make geomedia literacy teachable: how students are guided to interpret, justify, connect, and produce geographical representations.

Three research questions guide the article: (1) How do geography teachers describe geomedia as part of the everyday language of school geography? (2) What challenges do teachers identify in students' interpretation and production of maps, diagrams, images, and other forms of geomedia? (3) What pedagogical practices do teachers use to support students' movement from guided interpretation towards more independent production and geographical reasoning with geomedia?

2 Geomedia literacy as disciplinary literacy in geography

The theoretical foundation of the study brings together three partly overlapping discussions in geography education. The first concerns geomedia education and geomedia competence: how students acquire, interpret, produce, visualise, analyse, and critically evaluate geographical information in multiple representational forms (Muukkonen et al. 2022; Hynynen et al. 2022, 2023; Lammi et al. 2026). The second concerns spatial thinking and map-reading, where representations are understood as tools for reasoning about location, scale, distribution, movement, and spatial relationships (National Research Council 2006; Lee and Bednarz 2012; Ooms et al. 2016; Bednarz and Lee 2019). The third concerns disciplinary literacy, which emphasises that school subjects have distinctive ways of reading, representing, arguing, and explaining (Moje 2008; Shanahan and Shanahan 2008). Bringing these discussions together makes it possible to define geomedia literacy not as general media use or technical map handling, but as a disciplinary literacy of geography.

Visual literacy provides one point of departure, but in geography it is inseparable from spatial literacy. Students need to recognise what kind of representation they are encountering, identify its elements, and interpret how meaning is constructed through symbols, colour, orientation, scale, classification, and layout. Spatial thinking has been defined as a constructive combination of spatial concepts, tools of representation, and reasoning processes (National Research Council 2006). Empirical research on young people's map-reading skills indicates that even basic topographic map tasks may become difficult when they require contour interpretation, symbol knowledge, navigation, measurement, or several subtasks in combination (Ooms et al. 2016). A student reading a map or diagram must therefore decode signs and understand spatial relationships: where phenomena occur, how places differ, how patterns extend across areas, how scale alters interpretation, and how processes connect places over time (Lee and Bednarz 2012; Bednarz and Lee 2019).

Geography, like other school subjects, has characteristic ways of reading, representing, arguing, and explaining (Moje 2008; Shanahan and Shanahan 2008). Its texts include maps, landscape images, statistical graphs, remote sensing images, field observations, and hybrid combinations of these. Students must learn how such texts are produced, what they can and cannot show, and how they can be used as evidence in geographical reasoning (Gersmehl 2008; National Research Council 2006). Critical cartography adds that maps should be read as authored and selective representations rather than neutral mirrors of the world (Briwa and Wetherholt 2020). From the perspective of critical geomedia literacy, students also need to distinguish between claims that are evidenced by the representation and claims that exceed what the map can support (Lehtoranta et al. 2026).

For this article, geomedia literacy refers to interrelated capacities: recognising geomedia, reading and interpreting geomedia, comparing and connecting representations, evaluating representational quality, producing geomedia, and using geomedia for geographical reasoning. This conceptualisation is informed by discussions of geomedia education and geomedia competence (Muukkonen et al. 2022; Hynynen et al. 2022, 2023; Lammi et al. 2026), and by spatial thinking research linking spatial concepts, representations, and reasoning (National Research Council 2006; Lee and Bednarz 2012). These dimensions are analytical rather than sequential. In classroom practice, they often overlap. For example, producing a thematic map may require students to interpret data, classify phenomena, make visual choices, and consider how another reader will understand the representation.

Multimodal representation is central to this framework. Multimodality research emphasises that meaning is made across multiple semiotic modes rather than through language alone (Kress 2010; Jewitt 2014). Geography teaching regularly asks students to move between visual, numerical, verbal, and spatial forms of information. A climate diagram, a photograph of a landscape, and a map of vegetation zones may each present different aspects of the same geographical phenomenon. Geomedia literacy therefore includes the capacity to connect representations, recognise what each foregrounds, and use their combined evidence to construct geographical explanations.

This need to interpret representations across modes is especially visible in digital and image-based geomedia, where apparently familiar visual materials may still require specialised ways of seeing.. In their study of Grade 5 and 6 students using Google Earth, Moorman and Crichton (2018) showed that students' interpretation depended on image-reading elements such as tone, shape, size, shadow, association, pattern, and texture, as well as on understanding nadir view, scale changes, orientation, dimensional transformation, and the technological construction of satellite imagery. Apparently intuitive digital representations may therefore require explicit teaching before students can use them meaningfully, especially when tool use, interpretation, and geographical reasoning need to be coordinated in classroom practice (Moorman and Crichton 2018; Muukkonen and Aarnio 2026b).

The framework used in this study therefore treats geomedia literacy as a set of interrelated representational practices. Students need to recognise geomedia, understand its conventions, interpret evidence, connect representations, evaluate what a representation can support, produce their own geomedia, and use these practices for geographical reasoning. These dimensions draw on research on geomedia competence, spatial thinking, disciplinary literacy, multimodality, and scaffolding in teaching (National Research Council 2006; Moje 2008; Shanahan and Shanahan 2008; Kress 2010; Jewitt 2014; Hynynen et al. 2023; Lammi et al. 2026; van de Pol et al. 2010). The study uses these dimensions as sensitising concepts rather than as a fixed developmental sequence, allowing the analysis to examine how teachers describe the practical classroom work through which geomedia literacy becomes teachable.

3 Materials and methods

The empirical material consists of 20 semi-structured thematic interviews with Finnish geography teachers working in lower secondary school, general upper secondary school, or across both levels. The participants were qualified geography teachers with teaching experience ranging between 2–30 years. Of the teachers, four worked mainly in lower secondary education, 14 in general upper secondary education, and two across both levels. The participants were recruited by identifying qualified in-service geography subject teachers through school websites and contacting them by email. The first invitation round targeted teachers working in the Helsinki metropolitan area, because the original aim was to conduct as many interviews as possible at the teachers' schools. Owing to a low response rate, reminder emails were sent and the second invitation round was extended to teachers both within and outside the Helsinki metropolitan area. In total, more than 120 invitations were sent, and the final sample consisted of 20 teachers who agreed and were able to participate. Twelve participants had geography as their first teaching subject, while seven had biology and one had another subject as their first teaching subject, meaning that geography was their second teaching subject in these cases. The interviews formed part of a broader study on visuality, geomedia, GIS education, classroom technologies, student devices, information searching, and teachers' pedagogical practices.

The interviews were conducted in Finnish in May and June 2022 and lasted approximately 15–40 minutes. Eight interviews were conducted at the teachers' schools, and 12 were conducted online using Microsoft Teams. The original aim was to conduct as many interviews as possible in teachers' own school environments, but online interviews were used when distance, scheduling constraints, or the spring 2022 teachers' strike made face-to-face interviews impractical. The interviews were audio-recorded with participants' consent and transcribed manually.

The interviews formed part of a broader CRITICAL project dataset on geography teachers' visual, digital, and pedagogical practices. The present article analyses only the parts of the interviews that concerned geomedia literacy. The relevant data consisted of passages in which teachers described how students read, interpreted, evaluated, produced, or received pedagogical support in working with geographical representations. These passages concerned, for example, maps, diagrams, tables, photographs, satellite and aerial images, landscape images, infographics, videos, map elements, regional comparison, data interpretation, and students' visual or multimodal products.

Although the interviews were collected within a broader project, the present article is designed as a standalone analysis of one research object: teachers' accounts of students' geomedia literacy in geography education. Material on classroom spaces, equipment, student devices, login routines, software availability, or general information searching was included only when teachers explicitly connected it to students' interpretation, production, evaluation, or reasoning with geomedia. This boundary was necessary because the wider interview material also addressed classroom technology, student devices, and GIS teaching beyond the scope of the present article.The interview guide covered background questions about the school and the teacher, followed by questions on classroom equipment, teaching tools, visual materials, teacher-produced drawings, ready-made visual materials, and multimodal communication in geography teaching. For the present article, the most relevant questions were those asking teachers what kinds of visual materials they used in geography teaching, where these materials came from, whether and how they modified them, in what situations they used ready-made or teacher-drawn representations, and how multimodal communication was realised in their teaching. Follow-up questions invited teachers to give concrete examples of classroom situations involving geomedia, visual materials, maps, diagrams, images, digital maps, and students' own representational work. The teachers were not asked to complete tasks or evaluate a fixed set of instructional materials. Instead, the study was based on semi-structured interviews in which teachers described the visual materials, tools, tasks, and classroom situations that they themselves considered relevant to geography teaching.

The data were analysed using an abductive, theory-informed thematic analysis. Thematic analysis supports flexible but systematic identification of patterned meaning across qualitative data (Braun and Clarke 2006, 2021), while abductive analysis emphasises movement between empirical observations and theoretical concepts rather than a purely inductive or deductive procedure (Timmermans and Tavory 2012; Thompson 2022).

Sensitising concepts from geomedia literacy, visual literacy, spatial literacy, multimodal representation, disciplinary literacy in geography, and pedagogical scaffolding guided the analysis, but coding remained open to teachers' own classroom terms. The analysis proceeded in two main stages, followed by a validation reading. First, the full transcribed dataset was read to identify passages relevant to geomedia literacy and to describe them in terms close to teachers' classroom accounts. Second, these descriptive observations were interpreted in relation to the sensitising concepts and organised through the theory-informed dimensions in Table 1. Finally, the full dataset was read again to check that the interpretations were represented across interviews, that contradictory or qualifying accounts had not been overlooked, and that the findings remained aligned with the abductive, theory-informed framework. This abductive interpretation informed the reporting and discussion of the findings, as well as the conceptual synthesis presented in Figure 1.

` The dimensions in Table 1 were selected because they connect the theoretical literature on geomedia competence, spatial thinking, disciplinary literacy, multimodality, and scaffolding to the research questions of the study (National Research Council 2006; Moje 2008; Shanahan and Shanahan 2008; Kress 2010; Jewitt 2014; Hynynen et al. 2023; Lammi et al. 2026; van de Pol et al. 2010). The first and seventh dimensions address how teachers understand geomedia as a concept and as part of ordinary geography teaching. The second and third dimensions address students' interpretive challenges and their movement towards geographical reasoning. The fourth dimension focuses on students' production of geomedia, while the fifth and sixth dimensions capture the pedagogical and multimodal work through which teachers support students' use of representations. Together, the framework made it possible to analyse geomedia literacy as a classroom practice rather than as a list of tools or media types.

Table 1. Theory-informed coding framework for analysing teachers' accounts of geomedia literacy.

Theory-informed dimension	**Analytical lens**	**Analytical focus in this study**	**Examples of included interview segments**	**Initial descriptive codes**
Geomedia as the language of school geography	Geography as a visual and representational discipline; geomedia as place-related information across maps, images, diagrams, texts, and digital applications.[a]	How teachers describe geomedia and visual representations as integral to geography teaching rather than as optional teaching aids.	Talk about maps, images, diagrams, satellite images, landscape photographs, and visualisations as everyday materials in geography lessons.	visuality as core; geography cannot be taught without maps; geomedia as self-evident; geomedia as an umbrella term.
Students' interpretive challenges	Map-reading, geospatial literacy, and critical geomedia literacy research on symbol knowledge, scale, contour interpretation, satellite-image interpretation, and evidence-based map reading.[b]	How teachers describe students' difficulties in identifying what maps, diagrams, images, or data visualisations show and what can reasonably be inferred from them.	Segments about map symbols, legends, scale, contours, diagrams, population pyramids, climate diagrams, satellite images, and students' difficulty seeing relevant information.	difficulty reading contours; weak diagram interpretation; seeing but not interpreting; difficulty identifying relevant features; over-reading representations.
Higher-order interpretation and geographical reasoning	Spatial thinking and disciplinary literacy as the use of subject-specific representations for comparison, inference, explanation, and reasoning.[c]	How teachers describe movement from recognising or describing representation features towards comparison, causal explanation, and geographical argumentation.	Talk about comparing regions, explaining spatial patterns, connecting climate and population data, interpreting distributions, or making conclusions from multiple representations.	from description to explanation; regional comparison; causal reasoning; connecting evidence; explaining distributions.

Production of geomedia	Geomedia competence and geomedia literacy as including production, visualisation, analysis, and communication of geographical information.[d]	How teachers describe students' production of maps, diagrams, infographics, presentations, and other visual or multimodal geographical products.	Segments about drawing climate diagrams, producing thematic maps, making infographics, creating presentations, or choosing how to visualise geographical data.	diagram production; thematic map production; production as selection; classification; visualisation choices; technical production versus reasoning.
Pedagogical scaffolding of geomedia literacy	Teachers' pedagogical accounts were interpreted through scaffolding as contingent support, fading, and transfer of responsibility, together with guided interpretation and movement towards more independent student reasoning.[e]	How teachers make representational interpretation visible through modelling, questioning, shared interpretation, examples, and structured tasks.	Segments about teacher demonstration, step-by-step guidance, interpretive questions, comparison of examples, classroom discussion, and feedback on student products.	teacher modelling; guided questions; shared interpretation; step-by-step support; using errors as learning opportunities.
Multimodal and representational thinking	Multimodality research emphasising meaning-making across visual, verbal, numerical, and spatial modes; geography education research on connecting representations for spatial reasoning.[f]	How teachers describe students' use of multiple representations together and the need to connect visual, numerical, textual, and spatial information.	Talk about combining maps, diagrams, photographs, statistics, videos, texts, or observations to understand a geographical phenomenon.	connecting representations; multimodal explanation; image–map comparison; diagram–map integration; visual and numerical evidence.
Conceptual ambiguity of geomedia	Finnish and international discussions showing that geomedia is a broad and still contested concept in educational contexts.[g]	How teachers understand, use, avoid, or problematise the concept of geomedia in relation to students' representational skills.	Segments in which teachers define geomedia, describe it as vague or artificial, treat it as an umbrella term, or separate the term from everyday	vague curriculum concept; geomedia as everything; concept not used with students; useful umbrella term; practice without terminology.

			teaching practices.	

Note. [a] Driver 2003; Felgenhauer and Quade 2012; Muukkonen et al. 2022; Hynynen et al. 2022. [b] Ooms et al. 2016; Moorman and Crichton 2018; Lehtoranta et al. 2026. [c] National Research Council 2006; Lee and Bednarz 2012; Moje 2008; Shanahan and Shanahan 2008. [d] National Research Council 2006; Hynynen et al. 2023; Lammi et al. 2026. [e] van de Pol et al. 2010; Briwa and Wetherholt 2020. [f] National Research Council 2006; Kress 2010; Jewitt 2014. [g] Felgenhauer and Quade 2012; Hynynen et al. 2022; Muukkonen et al. 2022; Pellikka et al. 2024.

Several steps were used to strengthen the trustworthiness of the analysis, understood as transparency in the analytical process and coherence between data, interpretation, and reporting (Nowell et al. 2017). The coding framework was derived from established literature and is made explicit in Table 1. The full dataset was read twice, with the second reading used to test the coverage and fit of the interpretations across interviews. The analysis also attended to qualifying accounts, such as teachers who used geomedia extensively without using the term explicitly, or who described student production as valuable only when it was connected to interpretation. Illustrative quotations were selected to represent recurring patterns rather than exceptional cases.

4 Findings

4.1 Geomedia as the everyday language of school geography

Teachers described geomedia as the ordinary representational medium of geography teaching. Maps, photographs, diagrams, landscape images, satellite images, animations, and map services were not occasional additions to lessons; they made geographical phenomena visible and discussable. Teachers expressed this most clearly when they described visuality as inseparable from the subject itself:

> *"Visuality is the be-all and end-all of teaching. In geography, bringing it into the lesson is extremely easy."* (Teacher 4)

Visual materials were valued because they allowed students to see spatial relations, temporal change, and the form of geographical processes rather than only read about them. One teacher described this everyday function of visual material:

> *"The subject is one where visual material is necessary. I use photographs, maps, animations, GIFs, and map services a great deal, because they make it possible to show how a particular phenomenon changes."* (Teacher 6)

The constant use of visual materials also created conceptual tension. Teachers used geomedia continuously, but they did not always name it, define it, or present it to students as a distinct object of learning. Some treated the term as a broad curriculum-level umbrella, while others saw it as an artificial label for longstanding geography practices. One teacher captured this tension:

> *"I do not particularly like the term geomedia, because it means so much that it almost stops meaning anything. Geography cannot really be taught without geomedia."* (Teacher 8)

Geomedia literacy may therefore remain pedagogically implicit even when representational work is central to lessons.

4.2 Students' difficulties in seeing geographical meaning

Teachers also described a gap between looking at a representation and seeing geographical meaning in it. They did not present students' difficulties only as technical problems of reading map symbols, contours, scale, or diagram axes. These conventions mattered, but they formed part of a broader difficulty: students often needed support in identifying what was geographically relevant and how a visible detail could become part of an explanation. In some cases, this began with basic cartographic conventions that teachers expected students to have encountered earlier:

> *"Not everyone knows what the brown lines on a map mean. In upper secondary school, map interpretation has to begin from the very basics."* (Teacher 2)

Similar difficulties appeared in teachers' accounts of diagram interpretation. Climate diagrams, population pyramids, pie charts, bar charts, and line graphs were familiar school materials, yet students often needed explicit teaching in how to extract patterns, compare cases, and connect visual information to geographical concepts. Teachers contrasted the abundance of visual material with students' limited ability to use it analytically:

> *"The world is full of visual material, but students do not necessarily see much in it. That is why I teach the interpretation of diagrams from the very beginning."* (Teacher 16)

Teachers also described situations in which students did not recognise that the representation itself contained the evidence needed for an answer. This was particularly visible in map-based tasks, where interpretation required careful attention to the map rather than recall from elsewhere:

> *"There was even an exam task where they interpreted a map, and for some it was difficult to understand that the answers were on the map, if only you knew how to look."* (Teacher 5)

Familiarity with maps or diagrams was therefore not enough. Basic conventions were necessary, but they did not by themselves lead to interpretation, comparison, or explanation. Research on map-reading skills supports this point, showing that difficulties may persist when tasks require symbol knowledge, contour reading, navigation, measurement, or several subtasks at once (Ooms et al. 2016). Finnish matriculation examination research points in the same direction: students can identify map elements yet over-infer unsupported meanings from colours, symbols, scale bars, or coordinate systems (Lehtoranta et al. 2026). The teachers' accounts suggest that students need repeated practice in asking evidence-based questions of visual material: Where is this located? What pattern is visible? What exactly supports this claim? What is missing or simplified?

4.3 Scaffolding geomedia interpretation

Teachers made interpretation teachable through scaffolding. They did not expect students to move independently from a map, diagram, or image to a geographical explanation. Instead, they modelled how to approach a representation, directed attention to relevant features, and gradually shifted responsibility to students. In map work, this could mean demonstrating key functions and then asking students to apply the procedure independently:

> *"I usually show a few basic functions together, but I do not show that this is how task one is done. I describe where the legend information can be found and which symbols or tools they need to know, and then students try it themselves."* (Teacher 2)

The amount of scaffolding varied with the task and students' prior experience. Unfamiliar digital map tools often required precise procedural guidance so that technical uncertainty did not displace attention from the geographical task. One teacher described this deliberately explicit instruction:

> *"In class, I show them that we go to this site and click here, and then we do it like this. There are also instructions on the handout. Some students get through*

> *it very easily, while others immediately start asking what they are supposed to do and what the website was. So the instructions are really a very explicit step-by-step version."* (Teacher 9)

Scaffolding also continued after students had produced something. Teachers used students' maps and diagrams to discuss whether visual choices supported interpretation. One teacher described how a flawed classification became an opportunity to discuss readability and meaning:

> *"When we made maps about migration gains and losses, some students had set the class limits so that minus one hundred and plus one hundred were in the same category. Then we discussed that this does not make sense, and that the map cannot be read in a meaningful way."* (Teacher 8)

Across these accounts, scaffolding meant more than providing technical instructions. Teachers slowed down observation, directed attention, compared alternatives, and made interpretation visible. This finding is consistent with critical cartography teaching, which recommends moving from instructor explanation to guided case analysis and collaborative map interpretation (Briwa and Wetherholt 2020), and with GIS-related teaching research showing that guided pacing can prevent procedural uncertainty from displacing geographical meaning (Muukkonen and Aarnio 2026b).

4.4 From interpreting to producing and reasoning with geomedia

Student production was another important part of geomedia literacy. Teachers described maps, diagrams, infographics, presentations, videos, and other visual products as demanding forms of geography learning rather than as purely technical exercises. Production required students to select information, classify data, make visual choices, generalise from detail, and communicate spatial or regional relationships. Some teachers described a progression from diagram work towards more demanding map production:

> *"Students produce tables and diagrams all the time in courses 1–3. Their own maps come later, in the geomedia course."* (Teacher 14)

In project work, production meant transforming source material into a representation for others to read. Students had to find data, choose visual forms, and produce maps or diagrams rather than simply copy ready-made material. One teacher described this requirement in regional study tasks:

> *"In the regional study, they produce these things themselves: a map, tables, and graphs made from tables. I have said that they may use some ready-made material, but at least one map has to be produced by themselves."* (Teacher 10)

Producing geomedia changed the nature of students' reasoning. A thematic map or infographic required decisions about purpose, categories, omissions, and how the reader would be guided towards a geographical interpretation. Production could therefore strengthen geographical reasoning when it was framed as more than visual presentation.

Teachers distinguished between technical production and geographical value. The key issue was not whether students could make a visual product, but whether they understood why a particular representation was used and what it helped the reader to see. One teacher separated the mechanics of diagram-making from the interpretive work that matters in geography:

> *"Making a diagram is like learning to use a pencil. What is valuable for geography is that they can interpret it."* (Teacher 16)

Production therefore required scaffolding and feedback. Without guidance, products could remain decorative or procedural; with support, they became opportunities to practise locating, comparing, classifying, explaining, and evaluating representational choices. Some teachers reviewed student products from the perspective of communicative clarity:

> *"When something has been produced, whether written or visual, we look at it through someone else's eyes: can the reader understand what the point was?"* (Teacher 8)

Production supported geomedia literacy when it was treated as reasoning rather than as a final presentation. This interpretation aligns with GIS-related digital pedagogy research showing that demanding production and analysis require time, curricular positioning, student readiness, and pedagogical support (Muukkonen and Aarnio 2026b). Across the findings, teachers repeatedly connected students' interpretive difficulties with the support needed to make geomedia meaningful in geography teaching. Table 2 synthesises these connections across the theory-informed dimensions used in the analysis; it does not introduce a separate coding framework.

Table 2. Synthesis of findings across the theory-informed dimensions of geomedia literacy.

Theory-informed dimension translated into findings	**Classroom problem made visible**	**Teaching response described by teachers**	**Implication for geography teaching**
Geomedia as the language of school geography	Students may encounter maps, diagrams, images, and digital spatial media as separate lesson materials rather than as the	Teachers used visual and spatial materials continuously, often without foregrounding the term geomedia.	Make explicit that geography is learned through representations, not only illustrated by them.

	representational language of geography.		
Students' interpretive challenges	Students may see a map, diagram, or image without recognising what is geographically relevant, even when the evidence is visible.	Teachers revisited basic conventions and guided attention to location, pattern, scale, classification, and evidence.	Treat interpretation as a teachable practice rather than as an assumed prior skill.
Higher-order interpretation and geographical reasoning	Students often identified single features, values, or visual details but needed support in comparison, explanation, causal reasoning, and evaluating what a representation can support.	Teachers used questions that asked what a pattern shows, why it matters, how it differs between places, and what evidence supports the claim.	Ask students to justify interpretations and explain the geographical significance of visible patterns.
Production of geomedia	Student-produced maps and diagrams showed how students classified, simplified, selected, and communicated geographical information.	Teachers reviewed student products for category choices, legends, titles, readability, and communicative clarity.	Use production tasks to assess and develop geographical reasoning, not only technical competence.
Pedagogical scaffolding of geomedia literacy	Technical uncertainty or unfamiliar tools could prevent students from attending to geographical meaning.	Teachers modelled procedures, provided step-by-step support, circulated during tasks, used examples, and gradually transferred responsibility to students.	Plan a progression from guided work towards independent representational reasoning.
Multimodal and representational thinking	A single representation rarely carried the whole explanation of a geographical phenomenon.	Teachers moved between maps, diagrams, photographs, statistics, text, videos, and digital spatial media during explanation, tasks, and discussion.	Design tasks that require students to connect evidence across representations and state what each representation contributes.
Conceptual ambiguity of geomedia	Geomedia may remain vague even when it is constantly used, and teachers may not share a common classroom language for it.	Teachers either avoided the term, used it broadly, or explained it through examples of maps, diagrams, images, videos, and spatial data.	Clarify what geomedia literacy means beyond the presence of visual or digital materials.

5 Discussion

The findings address a central concern in geography education: how students learn to work with the representations through which geographical knowledge is made. The abductive, theory-informed analysis brought the dimensions in Table 1 into dialogue with teachers' classroom descriptions and showed geomedia literacy as interrelated practices of recognition, interpretation, connection, production, and geographical reasoning. Figure 1 presents this argument as a conceptual synthesis rather than as a fixed developmental sequence. The emphasis therefore shifts from access to maps, digital platforms, or visual materials towards the teaching of representational reasoning. The findings should be read as cross-level patterns in Finnish secondary school geography rather than as evidence of systematic differences between lower and upper secondary teaching.

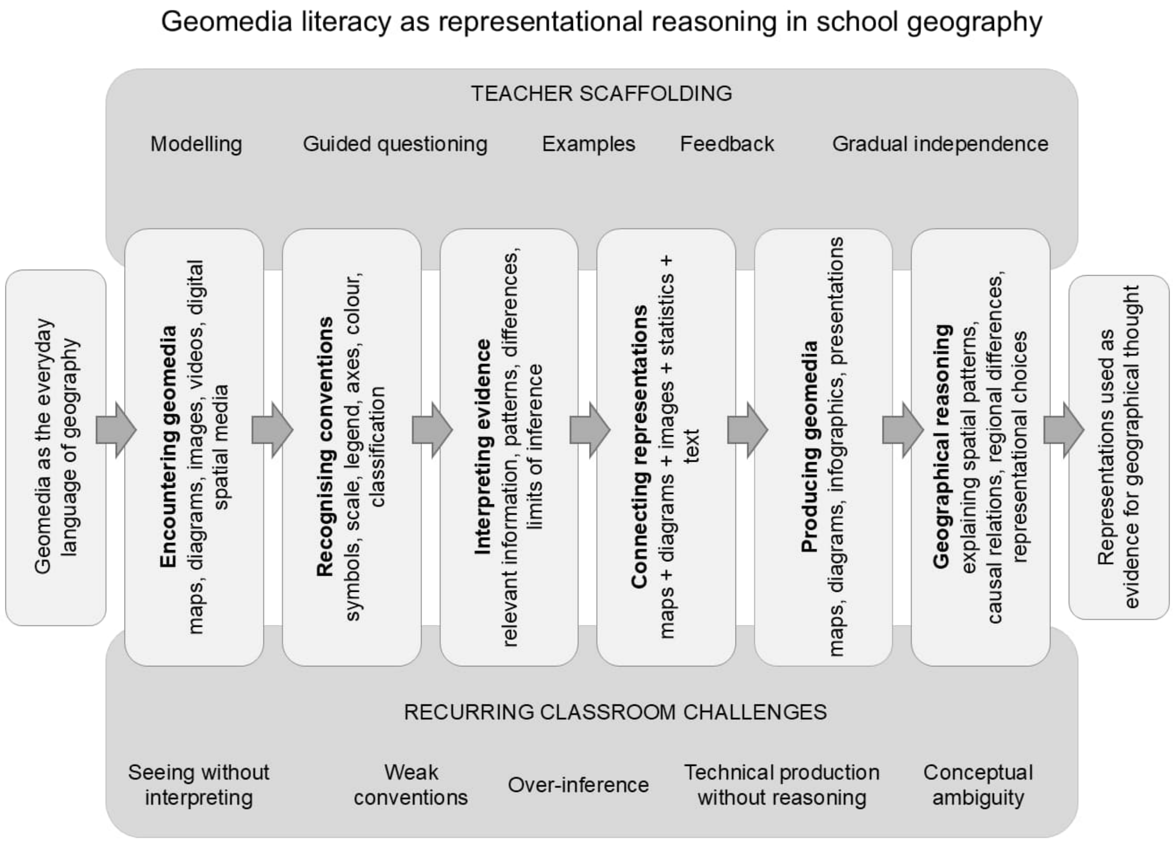

Figure 1. Geomedia literacy as representational reasoning in school geography.

Alt text: Figure 1 presents a conceptual model of geomedia literacy as representational reasoning in school geography. The model presents geomedia literacy as a set of interrelated practices that connect encountering geomedia, recognising conventions, interpreting evidence, connecting representations, producing geomedia, and geographical reasoning. Teacher scaffolding spans the process and includes modelling, guided questioning, examples, feedback, and gradual independence. A lower band identifies recurring classroom challenges, including seeing without interpreting, weak conventions, unsupported interpretations, technical production without reasoning, and conceptual ambiguity. The final aim is the use of geographical representations as evidence for geographical thought.

The findings support understanding geomedia literacy as disciplinary literacy in geography. Disciplinary literacy research stresses that subject learning involves specialised ways of reading, writing, representing, and reasoning (Moje 2008; Shanahan and Shanahan 2008). In geography, these practices include recognising location, scale, spatial patterns, regional differences, processes, and causal relations in visual and spatial materials (Driver 2003;

National Research Council 2006; Gersmehl 2008). They also include understanding how maps and other representations are constructed, what they foreground or omit, and whose perspectives they may privilege (Briwa and Wetherholt 2020). The teacher interviews show that these ways of seeing require modelling, guided interpretation, and opportunities for students to articulate their reasoning.

Students' interpretive challenges show where this teaching is needed. Map-reading, virtual-globe, and examination studies have reported difficulties with symbol knowledge, contour and scale interpretation, orientation, nadir view, dimensional translation, technological knowledge, and unsupported interpretations (Ooms et al. 2016; Moorman and Crichton 2018; Lehtoranta et al. 2026). The interviews add a classroom perspective: students often need help slowing down observation, selecting relevant features, and explaining why a visible pattern matters geographically. Representational interpretation should therefore be taught as a routine practice rather than assumed as a prerequisite skill.

Production extends this work because it makes students' representational reasoning visible. Creating a map, diagram, or infographic requires students to classify information, decide what to foreground, simplify complexity, and make spatial relations legible. In the teacher accounts, production tasks were most valuable when they were linked to interpretation, evaluation, and reasoning rather than treated as decoration or technical completion. Student products could also reveal misunderstandings through inappropriate class intervals, missing legends, unclear titles, or unsupported visual claims.

Scaffolding and multimodality explain why geomedia literacy needs explicit teaching. The teacher accounts suggest four classroom principles: make representational reading visible, require evidence-based interpretation, frame production as reasoning, and ask students to connect maps, diagrams, photographs, statistics, texts, and digital spatial media. Basic conventions such as scale, legends, symbols, axes, and classification should also be revisited across grade levels because they cannot be assumed to transfer automatically from earlier schooling.

Conceptual ambiguity remains a curriculum and teacher education issue. Finnish discussions have noted that geomedia is central to geography education but needs clearer conceptual and pedagogical definition (Muukkonen et al. 2022; Hynynen et al. 2022; Lammi et al. 2026). Teachers' concerns about students' critical geomedia literacy and uneven digital competence point to the same need (Pellikka et al. 2024), as does student examination research on evidence-based map interpretation and representational limits (Lehtoranta et al. 2026). Curricula, teacher education, and teaching materials should therefore specify not only what geomedia is, but what forms of reading, interpretation, production, and evaluation students are expected to learn.

The article therefore foregrounds the literacy demands embedded in ordinary geography teaching. Classroom infrastructure, devices, software, and lesson organisation shape what teachers can ask students to do with spatial information (Muukkonen and Aarnio 2026a, 2026b), but the central pedagogical task is to make geography's representational practices teachable: reading, interpreting, connecting, producing, evaluating, and reasoning with geomedia as evidence for geographical thought.

6 Conclusion

Across Finnish lower and upper secondary school geography, the abductive, theory-informed analysis suggests that geomedia literacy is a central condition for learning geography. Teachers described maps, diagrams, images, and other representations as the everyday language of the subject, but they also showed that students do not automatically learn to read them geographically. Students needed support in recognising relevant evidence, interpreting patterns, connecting representations, and explaining why visible features matter. Geomedia literacy should therefore be taught explicitly as a disciplinary literacy of geography.

Producing geomedia can support this development when it is carefully scaffolded. Creating a map, diagram, infographic, or presentation requires decisions about selection, classification, simplification, visualisation, and explanation. These decisions are disciplinary, not merely technical. The findings therefore point to a practical teaching principle: students need sustained support to move from seeing representations to interpreting, explaining, and producing them as evidence for geographical thought. In this sense, geomedia literacy is not an additional component of geography teaching, but one of the ways in which geography becomes visual, evidential, and explanatory.

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Disclosure statement

The authors report there are no competing interests to declare.

Declaration of generative AI use

During the preparation of this work, the authors used Microsoft Copilot iteratively to support English-language editing, idiomatic expression, and the translation of interview quotations from Finnish into English. The tool was used through repeated author-led prompting to ensure meaning of the text and terminology. After using the tool, the author reviewed, edited, and approved all wording and take full responsibility for the content of the published article.

Biographical note

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Human ethics and consent to participate

This study was conducted in accordance with the Finnish National Board on Research Integrity (TENK) Guidelines for Ethical Principles of Research with Human Participants and Ethical Review in the Human Sciences and the Guidelines for Research Integrity (HTK 2023). Ethical review by a Human Sciences Ethics Committee was not required because the study consisted of voluntary semi-structured interviews with competent adult participants and did not involve intervention in participants' physical integrity, exposure to exceptionally strong stimuli, risk of long-term mental harm, security risk, or other research settings requiring prior ethical review under the Finnish national guidelines. All participants were informed about the purpose of the study, the voluntary nature of participation, the recording and processing of interview data, and their rights as research participants. Informed consent was obtained from all participants prior to the interviews. The interview recordings and transcripts were handled without direct identifiers, and participants are referred to by teacher identifiers in the article. Quotations used in the article were translated from Finnish into English with attention to preserving the meaning and tone of the original speech.

References

Anunti H, Vuopala E, Rusanen JJ. 2018. Lukiolaisten kokemuksia geomedian käytöstä tutkivassa oppimisessa [Upper secondary students' experiences of using geomedia in inquiry-based learning]. Terra. 130(1):17–32.

Bednarz SW, Lee J. 2019. What improves spatial thinking? Evidence from the Spatial Thinking Abilities Test. Int Res Geogr Environ Educ. 28(4):262–280.

Braun V, Clarke V. 2006. Using thematic analysis in psychology. Qual Res Psychol. 3(2):77–101. https://doi.org/10.1191/1478088706qp063oa

Braun V, Clarke V. 2021. Thematic analysis: a practical guide. SAGE.

Briwa R, Wetherholt W. 2020. Teaching critical cartography in the introductory geography classroom. Geogr Teach. 17(4):162–168. https://doi.org/10.1080/19338341.2020.1828135

Driver F. 2003. On geography as a visual discipline. Antipode. 35(2):227–231. https://doi.org/10.1111/1467-8330.00319

Felgenhauer T, Quade D. 2012. Society and geomedia: some reflections from a social theory perspective. In: Jekel T, Car A, Strobl J, Griesebner G, editors. GI_Forum 2012: geovizualisation, society and learning. Herbert Wichmann Verlag & VDE Verlag. p 74–82.

Finnish National Agency for Education. 2014. National core curriculum for basic education 2014. Finnish National Agency for Education.

Finnish National Agency for Education. 2019. National core curriculum for general upper secondary education 2019. Finnish National Agency for Education.

Gersmehl P. 2008. Teaching geography. 2nd ed. Guilford Press.

Gryl I, Jekel T. 2018. Spatially informed citizenship education as an approach for global understanding. In: Demirci A, de Miguel González R, Bednarz S, editors. Geography education for global understanding: international perspectives on geographical education. Springer. p 43–56. https://doi.org/10.1007/978-3-319-77216-5_4

Hilander M. 2017. Havaintoja geomedian tulkinnoista [Observations on interpretations of geomedia]. Terra. 129(4):223–229.

Hilander M. 2022. Visuaaliset kuvastot maantieteelliseen ajatteluun virittäjinä [Visual imagery as a stimulus for geographical thinking]. Terra. 134(3):194–197.

Hynynen L, Jylhä M, Lammi P, Nylén T, Muukkonen P. 2023. Geomediakyvykkyys, geomedialukutaito ja niiden kehittyminen [Geomedia capability, geomedia literacy, and their development]. Terra. 135:92–98.

Hynynen L, Nylén T, Hirvensalo V, Lammi P, Muukkonen P. 2022. Maantieteen opettajien näkemyksiä geomediasta ja geomediaopetuksesta [Geography teachers' views on geomedia and geomedia education]. Terra. 134(4):241–252. https://doi.org/10.30677/terra.120326

Jewitt C, editor. 2014. The Routledge handbook of multimodal analysis. 2nd ed. Routledge.

Kress G. 2010. Multimodality: a social semiotic approach to contemporary communication. Routledge.

Lammi P, Hirvensalo VJ, Nylén T, Hynynen LS, Pellikka A, Muukkonen P. 2026. GeoTAITO-malli: Nuorten geomediataidot ja osaamisen tasot [The GeoTAITO model: adolescents' geomedia skills and proficiency levels]. Ainedidaktiikka. 10(2):81–112. https://doi.org/10.23988/800ejp61

Lehtoranta A, Muukkonen P, Mäntylä T. 2026. How do general upper secondary school students interpret map information? Geomedia literacy and visual map elements in Finland's geography Matriculation Examination [preprint]. EarthArXiv. https://doi.org/10.31223/X54783

Lee J, Bednarz R. 2012. Components of spatial thinking: evidence from a spatial thinking ability test. J Geogr. 111(1):15–26. https://doi.org/10.1080/00221341.2011.583262

Matriculation Examination Board. 2026. Matriculation Examination. Matriculation Examination Board. https://www.ylioppilastutkinto.fi/en/matriculation-examination

Moje EB. 2008. Foregrounding the disciplines in secondary literacy teaching and learning: a call for change. J Adolesc Adult Lit. 52(2):96–107. https://doi.org/10.1598/JAAL.52.2.1

Moorman LA, Crichton S. 2018. Learner requirements and geospatial literacy challenges for making meaning with Google Earth. Int J Geospat Environ Res. 5(3):Article 5.

Muukkonen P, Hynynen L, Jäntti L, Lammi P. 2022. Geomedia on keskeinen osa maantieteen opetusta, mutta miksi ja mitä se on? [Geomedia is a central part of geography education, but why and what is it?]. Terra. 134(3):191–193.

Muukkonen P, Aarnio R. 2026a. Geography classrooms as learning spaces for GIS: teaching space arrangements, display tools, and student devices. Geogr Teach. https://doi.org/10.1080/19338341.2026.2688097

Muukkonen P, Aarnio R. 2026b. Pedagogical integration of digital GIS tools in secondary education: teachers' uses, classroom organisation, and constraints [preprint]. EarthArXiv. https://doi.org/10.31223/X50J4F

National Research Council. 2006. Learning to think spatially: GIS as a support system in the K–12 curriculum. National Academies Press. https://doi.org/10.17226/11019

Nowell LS, Norris JM, White DE, Moules NJ. 2017. Thematic analysis: striving to meet the trustworthiness criteria. Int J Qual Methods. 16(1):1–13. https://doi.org/10.1177/1609406917733847

Thompson J. 2022. A guide to abductive thematic analysis. Qual Rep. 27(5):1410–1421. https://doi.org/10.46743/2160-3715/2022.5340

Timmermans S, Tavory I. 2012. Theory construction in qualitative research: from grounded theory to abductive analysis. Sociol Theory. 30(3):167–186. https://doi.org/10.1177/0735275112457914

Ooms K, De Maeyer P, Dupont L, Van Der Veken N, Van de Weghe N, Verplaetse S. 2016. Education in cartography: what is the status of young people's map-reading skills? Cartogr Geogr Inf Sci. 43(2):134–153. https://doi.org/10.1080/15230406.2015.1021713

Pellikka A, Nylén T, Hirvensalo V, Hynynen L, Lutovac S, Muukkonen P. 2024. Understanding teachers' perceptions of geomedia: concerns about students' critical literacy. Teach Teach Educ. 144:104607. https://doi.org/10.1016/j.tate.2024.104607

van de Pol J, Volman M, Beishuizen J. 2010. Scaffolding in teacher–student interaction: a decade of research. Educ Psychol Rev. 22(3):271–296. https://doi.org/10.1007/s10648-010-9127-6

Shanahan T, Shanahan C. 2008. Teaching disciplinary literacy to adolescents: rethinking content-area literacy. Harv Educ Rev. 78(1):40–59. https://doi.org/10.17763/haer.78.1.v62444321p602101