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How Do General Upper Secondary School Students Interpret Map Information? Geomedia Literacy and Visual Map Elements in Finland's Geography Matriculation Examination

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How Do General Upper Secondary School Students Interpret Map Information? Geomedia Literacy and Visual Map Elements in Finland's Geography Matriculation Examination

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Abstract: This study examines general upper secondary school students' geomedia literacy in a high-stakes assessment context by analysing 272 essay answers to a map-related question in Finland's nationwide geography Matriculation Examination (spring 2020). The task ("Visual elements of a good map") asked students to identify at least five map elements and justify what each element conveys using a provided source map. Using qualitative content analysis combined with simple frequency counts, we coded (1) which visual elements were named and (2) how students justified their purpose, grouping justifications into four recurring categories: delivering information, helping interpretation, working tools for analysing information, and enhancing map quality. The article contributes to geography education and map-reading research by showing how students' apparently competent naming of cartographic conventions can coexist with weak evidence-based reasoning and over-inference. Most students treated map elements primarily as information deliverers and interpretation aids, while fewer described them as tools for measurement, comparison, or inference. Although many answers demonstrated basic competence in naming key elements (e.g., legend, scale bar, symbols, colours, coordinates), recurring misconceptions emerged, especially over-interpreting attributes not supported by the map (e.g., inferring population or vegetation zones) and misunderstanding scale bar use. The findings suggest that geography education and geographical literacy research should pay closer attention to how students justify claims from maps, recognise limits of inference, and practise scale and symbology in both static and digital mapping contexts.

Keywords: Geography; Geomedia; Literacy; Maps; Cartography; Secondary education; Misconceptions

Highlights:

- Students mostly treated map elements as information deliverers and interpretation aids
- Misconceptions often involved over-inference and misunderstanding the scale bar
- Findings support teaching critical geomedia literacy via evidence-based map reading

1. Introduction

1.1 Geomedia and maps

In contemporary society, rapid information flows across platforms heighten the need for multiliteracy and geomedia-related competencies in education. Geomedia refers to geographic information communicated through maps, diagrams, texts, and digital applications, combining traditional cartographic representations with modern geospatial technologies to support understanding of spatial relationships and phenomena (Felgenhauer and Quade, 2012; Gryl and Jekel, 2018). Its growing educational relevance is reflected in the Finnish National Core Curriculum for basic and general upper secondary education (Finnish National Agency for Education, 2014; 2019), which emphasises students' ability to acquire, analyse, and critically evaluate geographic data in a geospatially interconnected world.

In what is often described as an information society, news and data circulate rapidly across platforms, and much of this information is linked to place. Everyday technologies increasingly rely on location and geospatial data, for example in smartphone mapping, public transport route planning, and localised weather services (Strobl, 2014). Shared images and messages can also include location metadata. Against this backdrop, scholars have argued that contemporary societies are becoming "geomedialised", and that participation in everyday civic life increasingly requires geomedia literacy (Jekel et al., 2014).

Definitions of geomedia range from narrow perspectives that emphasise digital geographic information systems and geoinformation to broader interpretations that include maps, images, texts, and other media referring to place (Lapenta, 2011; Felgenhauer and Quade, 2012; Vogler and Henning, 2014; Gryl and Jekel, 2018; Muukkonen et al., 2022). As the concept evolves with changing technologies, users are not only consumers of geospatial information but may also contribute to its production through everyday sharing and location-enabled services, sometimes without being fully aware that they are producing geomedia data (Fisher, 2014; Fast and Abend, 2022; Hynynen et al., 2023). At the same time, location-sharing and related privacy judgements are becoming part of everyday digital practice (Wang and Lin, 2017; Wisniewski et al., 2020; Muukkonen et al., [forthcoming]). Media, in turn, shapes how people understand places and events, reinforcing the need for critical geomedia literacy in education (Finn and Palis, 2015; Muukkonen, 2026).

In this paper, we use the term *critical geomedia literacy* to foreground the idea that reading spatial information is not only a technical skill, but also an interpretive and evaluative practice. Related terms appear in earlier literature, including *map-reading literacy* (or map skills) and *geospatial literacy*, which are often used to describe the abilities required to interpret cartographic representations and geospatial technologies. For example, work on critical cartography emphasises that maps are authored cultural texts and may carry bias or latent meanings, which readers need to recognise and question (Briwa and Wetherholt, 2020; Monmonier, 2019). Research on geospatial literacy similarly highlights that making meaning from digital geospatial representations requires not only navigation and interpretation skills, but also critical thinking about what is shown, how it is produced, and what can reasonably be inferred (Moorman and Crichton, 2018).

Traditional printed and digital maps are fundamental parts of geomedia. Research on map-reading skills stresses that proficiency is more than knowing map conventions: it includes strategies and cognitive processes for interpreting representations in context (Arthurs et al., 2023). Research on geospatial literacy further highlights that meaning-making with widely available digital geospatial texts (e.g., virtual globes) requires a combination of knowledge, skills, and dispositions, including an understanding of the underlying technology and its constraints (Moorman and Crichton, 2018). Building on these perspectives, *critical geomedia literacy* in this study refers to the ability to interpret and evaluate place-linked information across multimodal representations (e.g., maps, diagrams, images, and texts), to justify interpretations with evidence visible in the representation, and to recognise both the limits of inference and the possibility of bias, simplification, or manipulation in how geographic information is produced and visualised (Briwa and Wetherholt, 2020; Muukkonen, 2023).

1.2. Geography in the Finnish school system

The Finnish school system is typically described in three stages. Early childhood education and care are optional and include day care and pre-primary education. Compulsory basic education (Grades 1–9; ages 7–16) provides a broad foundation; geography is taught within Environmental Studies in Grades 1–6 and as a separate subject from Grade 7 onwards, emphasising spatial thinking and human–environment relations (Finnish National Agency for Education, 2014). After basic education, students enter upper secondary education (general or vocational); around half of each age cohort attends general upper secondary school, and roughly 30,000 students start general upper secondary education each year (Statistics Finland, 2025). In general upper secondary school, geography includes one compulsory module and three elective modules in the National Core Curriculum (Finnish National Agency for Education, 2019).

Geography bridges the natural and social sciences and helps students connect physical landscapes, environmental change, and societal processes (Finnish National Agency for Education, 2019). In basic education, it is often taught interdisciplinarily, linking with subjects such as biology, history, and civics. The curriculum also emphasises students' everyday and local living environments as important starting points for geographical learning, so map use is not limited to distant or abstract regions but is connected to places familiar to students. In general upper secondary education, the curriculum expands towards geomedia, cartography, and global challenges, supporting students' ability to interpret and evaluate environmental and societal phenomena. In line with the Finnish National Core Curriculum, geography contributes to multiliteracy, critical thinking, and spatial awareness (Finnish National Agency for Education, 2019). Students work with diverse forms of geomedia, such as maps, infographics, and geospatial technologies, to analyse, interpret, and communicate geographic information. Finland has also had school-oriented geospatial learning environments, such as PaikkaOppi, which was developed to support GIS studies and spatial thinking in upper secondary schools (Riihelä and Mäki, 2015).

General upper secondary education culminates in the Matriculation Examination, a national standardised assessment used to evaluate readiness for higher education. The Matriculation Examination is held twice annually, in spring and autumn (Matriculation Examination Board, 2024). At each exam session, approximately 2,000–2,500 students sit the geography examination. Geography is an elective subject and requires students to apply knowledge when interpreting maps, analysing spatial data, and evaluating geographic phenomena. Exam tasks frequently draw on geomedia literacy by asking students to critically read and integrate visual and textual information. Many tasks require essay answers. The exam consists of three sections: the first section contains compulsory questions for all candidates (totalling 20 points), the second section contains 20-point tasks from which candidates choose a required number of questions, and the third section contains 30-point tasks. Candidates answer two of four tasks in the third section. Thus, the maximum score in the geography exam is 120 points.

1.3. Research objectives

Although geomedia is emphasised in the Finnish National Core Curriculum, less is known about how students demonstrate *critical geomedia literacy* in high-stakes assessment situations. This study therefore examines how general upper secondary school students interpret and justify key visual elements of a good map when responding to a matriculation examination essay task (Task 5, spring 2020). The novelty of the study lies in shifting attention from whether students can name map elements to how they justify what those elements allow them to know, infer, or not infer. By focusing on what students name, how they explain what map elements are for, and where their reasoning exceeds what the source map can support, we aim to identify both strengths and recurring challenges that are relevant to developing critical geomedia literacy in geography education and to broader geographical research on map interpretation.

Accordingly, the study addresses the following research questions:

1. Which visual map elements do students mention when answering the task?

2. How do students explain what these map elements are for (i.e., as information deliverers, interpretation aids, working tools, or quality markers)?

3. What recurring misconceptions or over-inferences appear in students' justifications, and what do these reveal about challenges in critical geomedia literacy?

2. Materials and Methods

A total of 2,276 general upper secondary school students participated nationwide in the spring 2020 Finnish geography Matriculation Examination (Matriculation Examination Board, 2026). The Matriculation Examination Board granted research permission and provided the complete set of submitted geography exam answers for Task 5, "Visual elements of a good map" (maximum 20 points). From this full dataset, a stratified random sample of 272 essay responses was drawn from the score distribution (0–25%, 26–50%, 51–75%, 76–100% of the maximum 20 points) (see Lehtoranta, 2024). The sample size was chosen to include enough answers from all performance levels for qualitative content analysis while keeping the dataset feasible for detailed element-by-element coding. Task 5, located in the exam's second section (candidates answer selected tasks in the section, each worth 20 points), asked students to name at least five visual elements of a good map and justify what each conveys using a provided source map (see Figure 1). Because geography was among the first subjects included in the electronic Matriculation Examination (introduced in 2016), all essay answers were produced digitally during the exam session. Students sitting the spring 2020 examination had followed the 2015 National Core Curriculum (Finnish National Agency for Education, 2015), as the 2019 curriculum had not yet been implemented when they began their studies.

The Matriculation Examination Board (2020) specified that in Task 5 each correctly identified visual element can earn up to four points: 1 point for precise naming, 2 points for explaining how the element supports interpretation, and 1 point for describing what the element conveys in the source map. The overall structure and linguistic maturity of the answer can earn an additional 0–2 points.

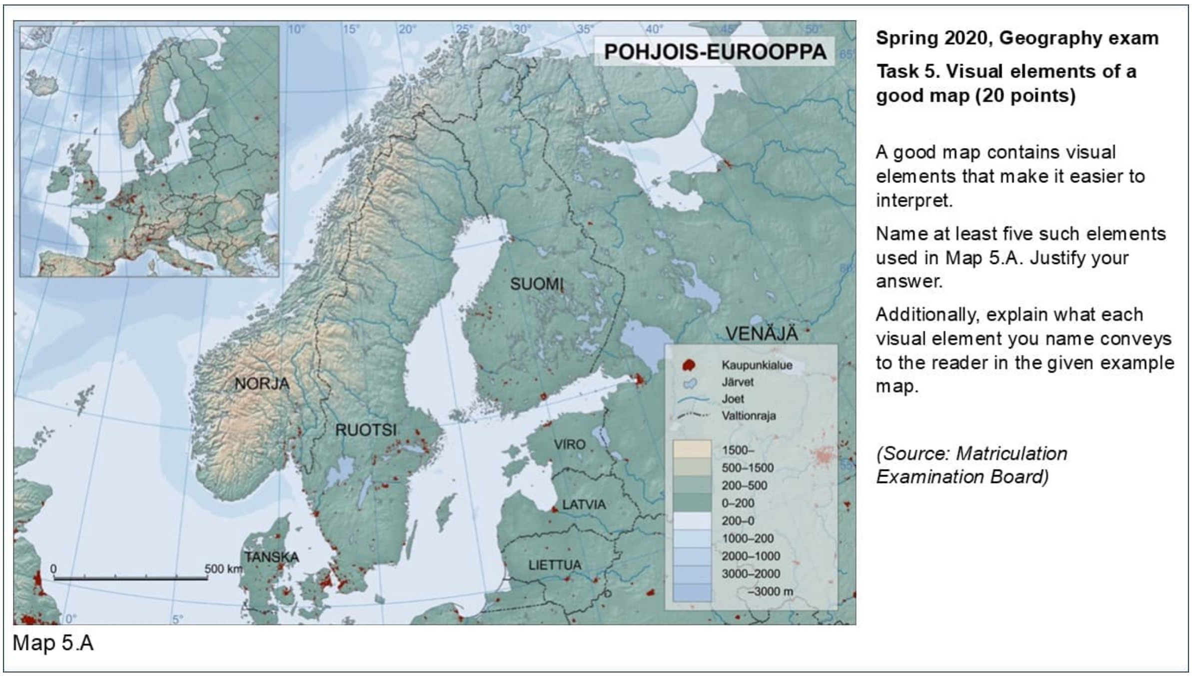

Figure 1. Task 5 and its source map 5.A from the spring 2020 geography Matriculation Examination. The map shows Northern Europe (see the Finnish title "Pohjois-Eurooppa"). The original examination task was available in both Finnish and Swedish because the geography Matriculation Examination is bilingual. Source: Finnish Matriculation Examination Board. The map is published with permission granted by the Matriculation Examination Board, as it is classified as an official work produced by a public authority.

Alt Text: Physical map of Northern Europe focusing on Finland, Sweden, and Norway, with elevation shown using shaded colour gradients. The map includes labeled countries, major lakes and rivers, cities, national borders, a legend, scale bar, latitude–longitude grid, and an inset map showing the region's location within Europe. On the right side of the image, English-language geography exam text refers to this map in a question about visual elements of a good map.

The study combines qualitative content analysis with simple frequency counts to describe patterns in students' geomedia reading. We used two analytic lenses, combining data-driven coding with theory-guided coding. In the theory-guided phase, each essay answer was coded for (1) which map elements were named. This coding followed the official description of the characteristics of a good answer published after each examination session by the Matriculation Examination Board, and the list of key elements of a good map provided by Muukkonen et al. (2021). These materials were used as an external criterion for identifying the map elements expected in the task and for distinguishing valid statements from misconceptions. A statement was coded as a misconception only when it attributed to a map element information or functionality that was not supported by the source map, the legend, or standard cartographic interpretation in this context; merely mentioning an additional or uncommon map element was not treated as a misconception. The coded elements included the scale bar, legend, coordinate system, place names, symbolism (symbols and colours), and the index map; in addition, border lines were treated separately due to their frequent mention and variable quality of description.

In the data-driven phase, the essay answers were coded for (2) how students justified what each map element is for. These justifications were then grouped into four recurring purpose categories: (a) delivers information, (b) helps interpretation, (c) working tool for analysing information, and (d) enhances map quality (see Table 1).

Figure 2. Research process and analytical workflow.

Step	Analytical purpose	Output
1. Dataset and sampling	Complete set of Task 5 answers was stratified by score level.	272 essay answers representing different performance levels.
2. Theory-guided element coding	Named map elements were identified using the official scoring guidance and map-element literature.	Frequency of mentioned map elements.

3. Data-driven purpose coding	Students' justifications were grouped according to what each element was said to do.	Four purpose categories reported in Table 1.
4. Misconception coding	Statements exceeding what the source map supported were identified.	Recurring over-inferences and misconceptions.
5. Interpretation	Findings were interpreted through critical geomedia literacy and map-reading research.	Implications for geography education and future research.

When reporting results, direct quotations from the essay answers cannot be published due to data-sharing restrictions set by the Matriculation Examination Board. Findings are therefore reported using aggregated counts and concise descriptive summaries, and any illustrative examples are reconstructed from recurring formulations.

Microsoft Copilot was used to support English-language editing and to improve idiomatic expression in the manuscript. In addition, the reconstructed model answers were first drafted in Finnish and then translated into English with the assistance of Microsoft Copilot for the purposes of this article. All analytical decisions and final wording were checked and approved by the authors.

3. Results

3.1. Students' explanations of map-element purposes

In the matriculation examination essay answers about the elements of a good map, every response in the sample (n=272) included at least one description of a map element. Some answers were list-like, simply naming elements without detailed justification. Across the essay answers, students typically explained the purpose of map elements in four recurring ways (see Table 1). First, many treated elements as information deliverers that directly "show" or "tell" something to the reader. This wording often positioned the reader as a relatively passive recipient of information, although some answers described how readers "see" or "understand" information from the map. Second, students framed elements as interpretation aids that make reading the map easier, clearer, or quicker. These explanations were often comparative (e.g., without the element the map would be harder or more confusing to interpret), and they foregrounded the reader's active work in making sense of the map. Third, some explanations described elements as working tools for doing something with the map, such as measuring, comparing, locating, or making deductions. In these cases, answers emphasised that the element enables an action (and sometimes that map reading would be impossible without it). Finally, a small set of answers treated elements as quality markers that make a map look better or seem more credible, without describing how the element helps the reader interpret this specific map.

Taken together, the results show a clear distinction between naming competence and evidential reasoning. Students were generally able to identify conventional map elements, but their explanations varied in how actively they treated these elements as tools for interpretation. The most analytically important pattern was that misconceptions clustered around elements that invite inference, especially colour, symbols, scale, and coordinates, rather than around elements that mainly provide contextual labels, such as place names or the map title. Thus, the descriptive frequencies in Table 1 should be read not only as evidence of what students recognised, but also as an indication of where critical geomedia literacy becomes most demanding.

Table 1. Shares of how students explained the purpose of map elements (n=272). The counts reflect coded mentions and explained purposes of map elements. A single essay answer could contribute to multiple purpose categories within the same map element.

Map element	Number of students who mentioned the map element	Explained purpose of map elements			
		Delivers information	Helps interpretation	Working tool for analyzing information	Enhance quality of map
Map symbols and colour choices	247 (91%)	201 (74%)	117 (43%)	89 (33%)	12 (4%)
Scale bar	228 (84%)	155 (57%)	71 (26%)	117 (43%)	10 (4%)
Coordinate system	178 (65%)	71 (26%)	60 (22%)	108 (40%)	5 (2%)
Index map	153 (56%)	97 (36%)	96 (35%)	37 (14%)	1 (<1%)
Legend	151 (56%)	112 (41%)	65 (24%)	48 (18%)	7 (3%)
Place names	149 (55%)	86 (32%)	87 (32%)	8 (3%)	6 (2%)
Border lines	124 (46%)	74 (27%)	69 (25%)	12 (4%)	4 (1%)

Map title	96 (35%)	87 (32%)	27 (10%)	6 (2%)	4 (1%)
Other (e.g., framing, projection)	19 (7%)	5 (2%)	19 (7%)	1 (<1%)	3 (1%)

The element-level findings are reported descriptively because the data-sharing restrictions prevent the publication of direct quotations from student answers. The reconstructed examples are therefore used to illustrate recurring reasoning patterns rather than isolated individual responses.

The following subsections (3.2–3.9) examine in more detail the most important visual elements of a good map and how students referred to them when answering the examination task. Other elements mentioned in the essay answers were infrequent and varied (e.g., projection, aspect ratio, data limits, emphasis techniques, source information). Due to their low frequency, it was not possible to classify them as a distinct category of map elements in a meaningful way. Instead, they are best understood as broader design choices that can influence map reading but did not occur often enough here for systematic analysis.

3.2. Map symbols and colour choices

With the term map symbols we refer to conventional cartographic signs used to depict and distinguish features (e.g., point, line, and area symbols as features). We treat colours and colour choices separately, because the students mostly separated these two elements in their answers and they reasoned those separately. Analysis showed that students predominantly understood map symbols as conveying location information or general object information, such as where urban areas, rivers, and lakes are situated on the map. Map symbols were also seen as aiding feature identification or enabling simple comparisons (e.g., inferring where rivers flow). Attribute information, such as population magnitude, was rarely mentioned and mainly appeared through over-interpretation that is not supported by the map (see Figure 1).

> Reconstructed examples of how map symbols **deliver information**: *“[Map symbols] show where features such as rivers are located.”; “[Map symbols] depict the shapes and sizes of urban areas.”; “[Map symbols] provide additional information about the mapped area.”;*

> Reconstructed examples of how map symbols **help interpretation**: *"From the [map symbols], it is easy to see where a feature is located."; "[Map symbols] help to observe the locations of features."; "[Map symbols] help to grasp the mapped area.";*
>
> Reconstructed examples of map symbols as **working tool for analysing information**: *"Based on the [map symbols], one can infer where rivers flow."; "Using the [map symbols], one can examine the shapes of water bodies."; "From the [map symbols], one can compare the number of lakes regionally.";*
>
> Reconstructed examples of how map symbols **enhance quality of map**: *"[Map symbols] add clarity."; "[Map symbols] are essential in a map.";*

Misconceptions were limited but included confusion about the red markings for urban areas. Some students mistakenly interpreted these symbols as indicating population size, which is not possible without additional variables or attributes. Moreover, symbol size and population are not directly correlated.

> Reconstructed example of **misconception**: *"The red symbols indicate how large the population is.";*

Students most often described the map's colour choices and colouring as conveying attribute information about elevations and sea depths, that is, values presented in the legend. Colours were also understood to communicate location information by indicating where particularly high or low areas occur and by depicting terrain more generally. Interpretive explanations were common for both attribute and location information: students noted that colour helps them grasp differences in elevation and makes it easier to notice the locations of features such as mountain ranges. More broadly, colour was seen as supporting overall map interpretation by improving clarity and helping distinguish areas from one another. Colour was also described as a working tool for interpretation, because the elevation- and depth-related colour descriptors enable readers to make inferences and comparisons based on attribute information. A few answers mentioned colour as helpful for practical tasks such as route and travel planning, and some framed colour as enhancing map quality by creating a natural look and making the map more pleasant to view.

> Reconstructed examples of how colour choices **deliver information**: *"[Colour choices] indicate elevation and sea depth."; "(Colouring] shows height and depth."; "From the [colouring], you can see elevation differences."; "The [colouring] shows where it is high and where it is deep."; "From the [colouring], you can distinguish mountainous areas."; "The [colouring] gives a better picture of the terrain."; "From the [colouring], land and water areas are easy to distinguish.";*

> Reconstructed examples of how colour choices **help interpretation**: *"[Colouring] helps to grasp height above sea level."; "From the [colouring], elevations are easy to distinguish."; "From the [colouring], it is easy to notice where the terrain is high."; "The [colouring] helps to find water bodies and seas."; "The [colouring] makes the map easier to interpret."; "With the [colouring], areas are clearly distinguishable from one another.";*

> Reconstructed examples of how colour choices act as a **working tool for analysing information**: *"With the [colouring], you can interpret landforms."; "From the [colouring], you can observe where deep areas are concentrated."; "Thanks to the [colouring], you can see where mountain areas are located."; "The [colouring] is useful for route planning."; "Using the [colouring], you can distinguish land from water.";*

> Reconstructed examples of how colour choices **enhance map quality**: *"The [colouring] gives the map a natural feel."; "Thanks to the [colouring], the map is clear and pleasant to look at.";*

Compared with symbolism, misconceptions about attribute information were slightly more frequent for colour: some students interpreted the elevation colour scheme as indicating vegetation zones. While vegetation can be mapped using colour in some contexts, it cannot be inferred unambiguously from this map's colouring without an explicit legend for vegetation zones; elevation alone does not determine vegetation, which is also shaped by factors such as ocean currents and geothermal activity.

> Reconstructed example of **misconception** (colour choices): *"From the [colour choices], you can infer the vegetation zone.";*

3.3. Legend

Students frequently mentioned the legend (56%; see Table 1) and most often framed it as delivering information (41%). Many answers also described the legend as helping interpretation (24%) and, less often, as a working tool for analysing information (18%), whereas only a small share linked it to enhancing map quality (3%) (Table 1). In students' explanations, alongside colour choices the legend was recognised as a key route to attribute information about elevations and sea depths, because it provides the numerical ranges that guide how this information should be interpreted. Accordingly, students described the legend as directly stating elevation and depth information, as supporting understanding of the depicted variation, and as enabling interpretation of the mapped area based on the legend's descriptors. Some answers also connected the legend to location information by noting that its explanations help identify where specific mapped features are located. However, a substantial portion of legend-related statements could not be classified as either attribute or location information; instead, students emphasised the legend's general instructional function (i.e., it explains how to read the map) and contrasted map reading with and without a legend. In this vein, some answers suggested that without a legend readers would have to guess symbol meanings (supporting the "helps interpretation" category), while others stated that correct interpretation would be impossible without it (aligning with the "working tool" category). Unlike for several other elements, we found no notable misconceptions related to the legend.

> Reconstructed examples of how legend **delivers information**: *"[Legend] tells what is shown on the map."; "From the [legend], you immediately know what the symbols mean (even without prior knowledge)."; "(Through colours) the [legend] tells about elevation and sea depth.";*
>
> Reconstructed examples of how legend **helps interpretation**: *"[Legend] makes map interpretation easier."; "Without the [legend], you would have to infer what the symbols mean.";*
>
> Reconstructed examples of how legend acts as a **working tool for analysing information**: *"With the [legend], you can interpret the area's elevations and sea depths."; "With the [legend], you can tell where certain mapped features are located."; "[Legend] is essential to understand what is shown on the map."; "Without the [legend], it is impossible to interpret the map correctly.";*

> Reconstructed examples of how legend **enhances map quality**: *"[Legend] makes the map easy to use.";*

3.4. Scale bar

The scale bar was the second most mentioned map element after symbolism and colour (see Table 1). Most answers (68%) described it as conveying information about real-world distances, while many (51%) recognised its instrumental value in interpreting information, such as comparing sizes or estimating distances. As a single answer could include several types of reasoning, the percentages across categories may sum to more than 100. For location-based information, the scale bar was seen as essential for visualising distances and measurements. The most common understanding was that it represents the real-world length corresponding to a given map distance. However, a common misconception (28%) was that it functions like a numerical ratio scale, indicating how much real-world distance one centimetre on the map represents. This is especially problematic in digital maps because the scale changes with zoom level; in such contexts, a dynamic scale bar that updates with zoom is preferable.

> Reconstructed examples of how scale bar **delivers information**: *"[Scale bar] gives an idea of distances."; "The [scale bar] tells how long the length of the bar corresponds to in reality.";*

> Reconstructed examples of how scale bar **helps interpretation**: *"[Scale bar] helps to understand distances."; "The [scale bar] makes it easier to interpret distances."; "From the [scale bar], it is easier to grasp the order of magnitude."; "Without the [scale bar], the map would be harder to interpret.";*

> Reconstructed examples of how scale bar acts as a **working tool for analysing information**: *"With the [scale bar], you can compare sizes."; "With the [scale bar], you can measure distances."; "From the [scale bar], you can estimate distances on the map."; "By examining the [scale bar], you can relate the map's scale to reality.";*

> Reconstructed examples of how scale bar **enhances map quality**: *"[Scale bar] is an important part of a good map.";*

> Reconstructed example of **misconception**: *"The scale tells how many kilometres one centimetre on the map equals."*

3.5. Coordinate system

The coordinate system was most often described as a working tool for analysing information (40%; see Table 1). Students also framed it as delivering information (26%) and helping interpretation (22%), while only a small share linked it to enhancing map quality (2%). Most answers focused on the coordinate system's role in providing location information, such as identifying where the mapped area is situated on the globe and supporting the locating of specific points. Other answers mentioned its role in orientation (e.g., cardinal directions), especially when a north arrow is missing. Many emphasised its instrumental value in pinpointing and communicating precise locations.

> Reconstructed examples of how coordinate system **delivers information**: *"[Coordinate system] tells where the depicted area is located."; "From the [coordinate system], you can see how the area is positioned on the globe."; "The [coordinate system] tells what angle the map is in relative to the cardinal directions."; "From the [coordinate system], you can see the degree values.";*

> Reconstructed examples of how coordinate system **helps interpretation**: *"The [coordinate system] helps to grasp the area's relative location."; "The [coordinate system] helps to find features."; "The [coordinate system] helps in making sense of the map."; "With the [coordinate system], the map is easy to read.";*

> Reconstructed examples of **coordinate system** as a **working tool for analysing information**: *"With the [coordinate system], you can determine the area's location."; "With the [coordinate system], you can write down a precise location."; "With the [coordinate system], you can determine the cardinal directions.";*

References to attribute information were rare and occasionally reflected over-interpretation, such as using coordinates to infer unshown attributes (e.g., vegetation, wildlife, or climate). Misunderstandings also included the belief that the coordinate system could be used to determine local time or time zones, despite their dependence on additional political and practical conventions.

> Reconstructed examples of **misconceptions** (coordinate system): *"From the [coordinate system], you can infer the area's vegetation based on location."; "With the [coordinate system], you can think about the area's climate and weather."; "From the [coordinate system], you can determine the local time."; "With the [coordinate system], you can calculate times.";*

3.6. Index map

The index map was most often described as delivering information (36%) and helping interpretation (35%) (Table 1). A smaller share emphasised its role as a working tool for analysing information (14%), and references to enhancing map quality were rare (<1%). Many descriptions focused on location information: the index map helps readers situate the main map within a wider geographic context and understand where the mapped area is "in the world". Beyond location, the index map was valued for providing an overview, supporting comparison between the inset and the main map, and making map interpretation easier when the mapped area is unfamiliar. In this dataset, misconceptions about the index map were not prominent.

> Reconstructed examples of how **index map delivers information**: *"From the [index map], you can see sea depths over a wider area."; "The [index map] shows how urban areas are distributed in relation to the rest of Europe."; "The [index map] gives more precise information about where the area is located."; "From the [index map], you can see the area's relative location within the continent."; "The [index map] gives a better overall picture."; "From the [index map], you can see the countries outside the main map.";*

> Reconstructed examples of how index map **helps interpretation**: *"The [index map] helps to better grasp location."; "The [index map] clarifies the map's placement."; "The [index map] helps in interpreting the map."; "The [index map] makes it easier to understand the map without prior knowledge.";*

Reconstructed examples of index map as a **working tool for analysing information**: *"With the [index map], you can compare landforms over a wider area."; "With the [index map], you can examine location."; "With the [index map], you can understand the location without prior knowledge."; "The [index map] serves as a point of comparison for the main map.";*

3.7. Place names

Place names were mentioned in 55% of the essay answers (Table 1). Students most often described place names as either delivering information (32%) or helping interpretation (32%). Only a small share framed place names as a working tool for analysing information (3%) or as a feature that enhances map quality (2%). Students' descriptions of place names focused on how labels support recognising the countries shown and where they are located in the source map. Place names were also described as useful when the mapped area is unfamiliar, because they reduce the need for prior knowledge and make map reading quicker. In a smaller set of answers, place names were framed as enabling identification (e.g., naming a country seen on the map) or as adding clarity to the overall map presentation.

Reconstructed examples of how place names **deliver information**: *"[Place names] tell the locations of countries."; "From the [place names], you know where each country is located."; "[Place names] provide information about what countries are shown on the map."; "Thanks to the [place names], prior knowledge of the area is not needed.";*

Reconstructed examples of how place names **help interpretation**: *"With [place names], locating a feature is easier."; "[Place names] help to understand how countries are positioned."; "[Place names] help to grasp the map better."; "[Place names] make it easier to read the map without prior knowledge.";*

Reconstructed examples of place names as a **working tool for analysing information**: *"With [place names], you can identify the countries shown on the map.";*

Reconstructed examples of how place names **enhance map quality**: *“[Place names] add clarity to the map.”; “[Place names] belong in a good map.”;*

3.8. Border lines

Border lines were mentioned in 46% of the essay answers (Table 1). Students most often framed borders as delivering information (27%) and helping interpretation (25%). Smaller shares described borders as a working tool for analysing information (4%) or as a feature that enhances map quality (1%). Students emphasised that border lines make it easier to recognise which areas belong to which country and to distinguish neighbouring countries from one another. Borders were also described as conveying shapes of countries and helping readers grasp location and relative positioning. In a small share of answers, border lines were treated as enabling rough comparisons (e.g., comparing country sizes) or as improving the map’s clarity overall.

Reconstructed examples of how border lines **deliver information**: *“[Border lines] illustrate country sizes.”; “[Border lines] indicate where national borders run.”; “[Border lines] show the shapes of countries.”; “From [border lines], you can recognise which country an area belongs to.”; “[Border lines] separate countries from one another.”;*

Reconstructed examples of how border lines **help interpretation**: *“Marking [border lines] helps to grasp country sizes.”; “[Border lines] help to grasp where national borders run.”; “From [border lines], it is easy to notice where a country is located.”; “[Border lines] help to distinguish countries from one another.”; “[Border lines] make the map clearer to read.”;*

Reconstructed examples of border lines as a **working tool for analysing information**: *“Thanks to [border lines], country sizes can be compared.”;*

Reconstructed examples of how border lines **enhance map quality**: *“[Border lines] add clarity.”;*

3.9. Map title

The map title was mentioned in 35% of the essay answers (see Table 1). Students most often treated the title as delivering information (32%). Smaller shares described the title as helping interpretation (10%), as a working tool for analysing information (2%), or as a feature that enhances map quality (1%). Students typically described the title as a concise statement of what the map shows and which region it covers. In this dataset, the title ("Northern Europe"; see Figure 1) was often treated as immediate location context: it indicates the area shown and helps readers place the map without additional effort. Some answers also framed the title as supporting interpretation more generally by guiding the reader's expectations for what the map is about, and a few treated it as enabling simple inferences about the mapped region.

> Reconstructed examples of how map title **delivers information**: *"[Map title] tells which area the map is about."; "[Map title] defines the area covered by the map."; "[Map title] tells what kind of map it is."; "From the [map title], you find out what is shown on the map.";*

> Reconstructed examples of how map title **helps interpretation**: *"[Map title] helps to place the depicted area."; "Without the [map title], the map area would be difficult to locate without prior knowledge."; "[Map title] helps to interpret the map quickly."; "[Map title] guides understanding of what the map is about.";*

> Reconstructed examples of map title as a **working tool for analysing information**: *"From the [map title], you can infer the location of the depicted area on the globe."; "Based on the [map title], you can infer what the map aims to show.";*

> Reconstructed examples of how map title **enhances map quality**: *"[Map title] belongs in a good map.";*

4. Discussion and conclusions

4.1. Geomedia literacy: successes and misconceptions in student interpretation

Finnish curricula emphasise that students should be able to acquire, interpret, and evaluate geographical information using geomedia (Finnish National Agency for Education, 2019). In this study, students generally identified key map elements and often explained their role in supporting interpretation, but their justifications also revealed recurring misconceptions. In this sense, our findings resonate with broader discussions in map-reading research that distinguish between recognising cartographic conventions and applying them in context-sensitive interpretation (Arthurs et al., 2023).

Leivo et al. (2020) suggest that the skills targeted by similar geography matriculation examination tasks often align with lower levels of cognitive demand. Consistent with this, all 272 analysed essay answers contained at least some description of map elements and a justification of their usefulness for interpretation. Across elements, the dominant view was that map elements convey information to the reader, which can position the reader as relatively passive in the information-acquisition process. Prior work has likewise noted that map reading is not only about identifying elements, but also about the strategies and cognitive processes involved in using those elements to make meaning (Arthurs et al., 2023).

It was also common to see an understanding of how elements facilitate map interpretation. Since the task prompt stated that the visual elements of a good map should aid interpretation, it was important to identify why and how students believed these elements support interpretation. As part of the analysis, descriptions of how elements helped in interpreting both location data (such as positioning and regional perception) and attribute data were common. Elements such as colour and legend were recognised as facilitating the interpretation of attribute data due to the encoded information about elevation and depth. This corresponds to prior work emphasising that learners must connect what the legend encodes to the specific variable(s) shown on the map to interpret thematic symbology appropriately, and that such foundational symbol understanding underpins more complex map-reading tasks (Ooms et al., 2016; Arthurs et al., 2023). Descriptions of state boundaries also indicated that these elements helped students understand the relative sizes of countries, aligning with the information presented on the map.

However, the study also revealed common misunderstandings, particularly related to elements such as symbolism, colour coding, scale, and coordinate systems. These misconceptions are central to the contribution of the study because they show that students' difficulties were not simply missing knowledge but often over-confident interpretations of information that the map did not provide. Many students incorrectly assumed that certain elements could be used to infer attribute data not presented on the map, such as population, vegetation zones, or climate conditions. These misconceptions may stem from prior knowledge or experiences with maps in different contexts, where similar visual conventions have been used to represent other types of information (Ooms et al., 2016). From the perspective of critical geomedia literacy, this kind of over-inference highlights why map reading should include explicit discussion of what can be concluded from a representation and what cannot (Monmonier, 2019). Some answers also overextended what coordinates can provide, for example by treating them as a direct way to determine time zones, which depend on additional political and practical conventions. Overall, this pattern is consistent with research showing that map-reading difficulties often cluster around interpreting symbology, scale, and other abstract conventions rather than simply naming them (Szigeti-Pap et al., 2023; Arthurs et al., 2023).

These patterns also align with earlier findings that prior regional knowledge can predict how learners apply information and interpretation in map-reading tasks (Ooms et al., 2016). However, our results also suggest a critical caveat for critical geomedia literacy: students' background knowledge may support interpretation, but it can also prompt context-inappropriate assumptions when learners treat familiar cartographic conventions as universally valid across maps. This was visible, for example, when elevation colouring was interpreted as vegetation zones, or when symbols were used to infer population. Such "hardened" assumptions underline the need for regular practice with varied map types, datasets, and platforms to help students recognise the context-dependent and partly subjective nature of geographic representations (Moorman and Crichton, 2018; Monmonier, 2019).

When interpreted through the lens of critical geomedia literacy, these over-inferences can be understood as a gap between (a) identifying familiar cartographic conventions and (b) critically evaluating what the representation is actually evidence for. In critical cartography education, a core aim is to help learners question map neutrality and to treat maps as authored cultural texts that may privilege particular narratives or invite misleading readings if their design choices are taken for granted (Briwa and Wetherholt, 2020). In our dataset, students rarely questioned the evidential basis of their claims; instead, they sometimes transferred meanings across contexts (e.g., assuming that a certain colour scheme must represent vegetation zones). This suggests that students' skills often align with the GeoTAITO model's (a model for young people's geomedia skills and proficiency levels) basic and intermediate levels of "reading and interpreting geomedia", but that reaching the more advanced levels of critical geomedia literacy requires explicit practice in "evaluating geomedia datasets" (e.g., assessing what a map can validly show, how symbolisation and classification constrain interpretation, and how reliability depends on data choices and context) (Lammi et al., 2026).

A particularly notable finding was the widespread misunderstanding of the map's scale. Many students misinterpreted the scale as providing a direct measurement of distances, assuming that a centimetre on the map always corresponds to the same real-world distance. This confusion between ratio scales and graphical scale bars resulted in a substantial number of errors in descriptions of the scale element. Similar error patterns related to distance estimation and scale use have also been reported in broader map-reading assessments (Szigeti-Pap et al., 2023).

Difficulties with scale and coordinates also mirror the kinds of meaning-making challenges reported in digital geospatial environments. Although the exam task involved a static map image, students' reasoning often echoed assumptions that are common in everyday interaction with zoomable, rotatable geospatial interfaces, for example, treating scale as a fixed "conversion rule" or assuming that coordinate information enables direct conclusions about unrelated attributes. In research on learning with virtual globes, learners' interpretations were strongly shaped by their understanding of perspective, dynamic scaling, and the underlying technology (Moorman and Crichton, 2018). Translated to the present context, this suggests that critical geomedia literacy needs to include not only knowledge of map elements, but also metaknowledge about representation: how scale, resolution, orientation, and data layering constrain what a reader can reliably infer. Within the GeoTAITO model, such metaknowledge is central to advancing from "reading and interpreting geomedia" toward "evaluating geomedia datasets" in a critical way (Lammi et al., 2026).

At the same time, the present dataset does not allow us to examine how students' background factors may have shaped these patterns. Because the exam answers were provided as anonymised text without individual-level metadata, we could not assess the potential role of (for example) learning difficulties in quantitative or spatial reasoning, accessibility-related constraints (e.g., sensory limitations when interpreting visual information) (Jokisuu, 2022), or differences in language background and subject-specific vocabulary (Muukkonen, 2018). These factors may influence how students engage with map elements and how they express their reasoning. This limitation highlights the importance of inclusive map-reading instruction and multiple ways of practising and demonstrating understanding in classroom settings.

Future research should therefore move beyond a single examination task and compare students' reasoning across different map types and scales, including local maps connected to students' everyday environments, regional maps such as the one analysed here, and world maps. Such comparisons would help determine whether the observed over-inferences are tied to this specific regional physical map or reflect broader patterns in students' critical map interpretation. Future studies should also examine individual and classroom-level factors that could not be analysed here, including prior GIS experience, language background, accessibility needs, and teachers' approaches to scaffolding map interpretation. Finally, intervention studies could test whether explicit evidence-based questioning, repeated work with legends and scale bars, and digital map tasks that gradually introduce layers improve students' ability to distinguish what a map shows from what it does not show.

4.2. Suggestions for geography teachers

The main take-home message is that critical geomedia literacy should be treated as an evidential practice: students need to learn not only what map elements are called, but also what kinds of claims each element can support in a specific cartographic context.

Overall, the findings suggest a need for sustained teaching that links map elements to the specific information a given map can (and cannot) support. One useful way to frame this progression is the GeoTAITO model, which differentiates between learning to *read and interpret* geomedia and learning to *evaluate* geomedia datasets critically (Lammi et al., 2026). In classroom practice, this implies moving beyond naming elements toward making evidence-based claims, reflecting on uncertainty, and considering how data choices and visualisation decisions shape interpretation. Such emphases align with critical cartography pedagogy, which treats maps as cultural texts and explicitly teaches learners to question map neutrality and uncover latent meanings (Briwa and Wetherholt, 2020), as well as with geospatial literacy research that highlights the role of technology knowledge and multi-perspective viewing in making meaning from digital geospatial representations (Moorman and Crichton, 2018).

In practice, map elements, their purposes, and their operating principles are likely introduced through multiple platforms and materials during schooling. However, our findings suggest that this does not automatically translate into context-sensitive understanding. Especially for scale, students' explanations sometimes resembled a memorised rule (e.g., assuming that "one centimetre on the map equals a fixed real-world distance"), rather than reasoning grounded in what the particular scale representation allows. From the perspective of supporting diverse learners—including those who may already find spatial or quantitative reasoning challenging: it would be valuable to provide frequent, hands-on opportunities to test, compare, and discuss scale use across contexts (e.g., printed maps with ratio scales vs static images with scale bars vs zoomable digital maps where scale changes with zoom).

The present findings further highlight that elements such as the scale bar and the coordinate system are often understood as tools for doing something with the map (measuring, locating, or communicating positions), rather than merely as labels that “tell” information. Using these elements accurately typically requires knowledge that crosses subject boundaries (e.g., mathematics for proportional reasoning and degrees, and social studies for understanding conventions such as time zones), as well as awareness of how the viewing environment shapes what is measurable or stable. This is particularly relevant in digital everyday geomedia use, where zooming and rotating are often frictionless and user-friendly: students may therefore have limited experience reflecting on how scale changes with zoom, or on what coordinate information does and does not allow one to infer. To support curriculum-aligned critical geomedia literacy, we see that these tool-like elements should be practised regularly, scaffolded over time, and across multiple environments (see Puertas-Aguilar et al., 2022), while recognising that teachers operate with considerable pedagogical autonomy (Krokfors, 2017) and must adapt tasks to students’ differing levels of technological experience (Pellikka et al., 2024).

This recommendation is also supported by earlier research suggesting that teaching with digital and technology-based platforms (including GIS) can support the development of geospatial skills for students with different starting points and levels of prior experience (Anunti, 2023; Moorman and Crichton, 2018). Moreover, research on young people’s map-reading skills indicates that improvement depends strongly on education and repeated practice: low-level symbol knowledge and basic conventions form an essential foundation for more complex measurement and navigation tasks (Ooms et al., 2016). Our practical suggestions for geography teachers are:

- Teach students to ground every claim in evidence visible on the map (e.g., “What exactly on the map supports this interpretation?”) to reduce over-inference.
- Explicitly contrast graphic scale bars with ratio scales and practise distance estimation on both static images and zoomable digital maps, highlighting how zoom and screen size affect scale interpretation.
- Pair colour with the legend during map-reading routines and ask students to state what the colour scheme represents in that specific map (elevation vs vegetation vs climate) before drawing conclusions. Emphasise explicitly that the same colour (e.g., white) does not always denote the same phenomenon (e.g., glaciers) across maps.

- Compare the same element across local, regional, and world maps so that students can see how scale, context, and purpose change what can be inferred from a map.

Based on the recurring patterns and misconceptions observed in the essay answers, teachers can strengthen students' critical map reading and geomedia interpretation by building regular, low-stakes practice with diverse map types (topographic, thematic, web maps) and requiring brief written justifications. This can help students move beyond naming elements towards explaining how elements support interpretation and, ultimately, develop critical geomedia literacy.

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Data Availability Statement: The Matriculation Examination Board granted research permission for the data. The underlying dataset contains authentic student responses from the Matriculation Examination and is therefore confidential. For this reason, findings are reported only as aggregated summaries and reconstructed typical answers; the data cannot be made publicly available.

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