Eerika Virranmäki is a geographer who completed her doctoral studies at the Geography Research Unit at the University of Oulu. In her doctoral thesis, she seeks to understand how teaching geography can enhance students' thinking skills and powerful geographical knowledge. In this research, she brings together theoretical discussions about powerful geographical knowledge with thinking skills and knowledge dimensions from a revised version of Bloom's taxonomy. More generally, her research interests are in the fields of geography and biology education, teaching, and learning. In addition, Eerika is a geography and biology lecturer and trainer for student teachers at Oulu University Teacher Training School. Besides researching and teaching, Eerika loves gardening, sewing, knitting, and spending time with her family.

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Eerika Virranmäki

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Abstract

Finnish upper secondary geography education has faced major changes within the last decade. In 2014, geography lost one of its compulsory courses in the distribution of lesson hours. Afterward, curriculum reforms were conducted in 2015 and 2019, and the geography test in the Finnish matriculation examination was digitalized in 2016. Similar major changes have occurred across the globe over the last 20 years as geography's position in schools has weakened. Therefore, geography educationists have engaged in discussion regarding the kinds of knowledge and thinking skills that geography encourages young people to learn during their years in school. This thesis acknowledges that geography involves much more than teaching and learning simple facts about world's topography, regions, and places, which is how geography is usually understood in popular views.

The aim of this thesis is to widen our understanding of thinking skills and powerful knowledge in the context of geography education. Theoretically, the thesis brings together discussions of powerful geographical knowledge with thinking skills and knowledge dimensions from a revised version of Bloom's taxonomy, and it suggests that these can be used as two "lenses" through which to examine geography. The main objective of the thesis is to examine geography's potential to engage students in thinking skills and powerful geographical knowledge, using Finnish upper secondary geography education as an example.

This thesis is based on three individual research articles, and thus the empirical part of the thesis consists of multiple research materials: in-service upper secondary teachers' concept maps and in-depth interviews; the geography test questions from the paper-based and digital forms of the Finnish matriculation examination between fall 2013 and spring 2019; students' answers to the paper-based and digital geography test questions between fall 2015 and spring 2017; and learning objectives in upper secondary geography curricula documents from the years 2003, 2015, and 2019, which are examined through the qualitative research methodology approach. Both inductive and deductive content analysis are used as methods of analysis. Additionally, quantification, descriptive statistics, and statistical analyses are used to comprehensively understand the researched phenomenon.

In this compilation part of the thesis, the findings from the three original research articles are examined through the two "lenses" to reveal which geographical thinking skills and knowledge are emphasized. The findings suggest that the various thinking skills and knowledge dimensions, as well as powerful geographical knowledge types, are all present to some extent in Finnish geography's learning objectives and test questions, students' answers, and teachers' conceptions. However, the majority of the learning objectives and test questions emphasize lower-order thinking skills, i.e. powerful geographical knowledge types 2 and 5. However, to some extent, teachers additionally emphasize higher-order thinking skills, i.e. powerful geographical knowledge types 1 and 4. The digitalization of the matriculation examination and the curriculum reforms slightly shifted the emphasis toward higher-order thinking because the requirement to use analytical thinking skills—i.e. powerful geographical knowledge type 4—increased. Additionally, the findings suggest that students have difficulty answering questions that require them to use analytical (in digital tests only), evaluative, and creative thinking or procedural knowledge, i.e. powerful geographical knowledge types 4, 3, and 1.

The findings indicate that geography has the potential to enhance students' higher-order thinking skills and engage them in powerful geographical knowledge, but further development is needed. First, there is a need to reevaluate the optimal distribution between lower- and higher-order thinking skills in the geography curriculum's learning objectives and the geography test questions in the Finnish matriculation examination. Additionally, there is a need to engage geography teachers and students in reflection on thinking skills and powerful geographical knowledge. Moreover, there is a need to consider the possibility of placing more emphasis on higher-order thinking skills, because this will enable the development of students' powerful geographical knowledge in greater depth.

In conclusion, this thesis provides one perspective on geography education and presents one framework for understanding thinking skills and powerful knowledge in geography. This framework can be used to plan the aims of geography education, or to choose teaching artifacts, methods, or assessments tasks. Moreover, it can be applied in order to "speak the same language" so as to develop geography education, and above all to develop students' powerful geographical knowledge and thinking skills.

Keywords revised Bloom's taxonomy, powerful geographical knowledge, upper secondary education, geography education, geography curriculum, learning objectives, summative assessment, teachers' conceptions, students' performance, higher-order thinking skills

List of original publications

Article I Virranmäki E, Valta-Hulkkonen K & Rusanen J (2019) Powerful knowledge and the significance of teaching geography for in-service upper secondary teachers – a case study from Northern Finland, *International Research in Geographical and Environmental Education* 28(2): 103–117. https://doi.org/10.1080/10382046.2018.1561637

Article II Virranmäki E, Valta-Hulkkonen K & Pellikka A (2020) Geography tests in the Finnish Matriculation Examination in paper and digital forms – an analysis of questions based on Bloom's revised Taxonomy. *Studies in Educational Evaluation* 66(100896): 1–13. https://doi.org/10.1016/j.stueduc.2020.100896

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Original articles are available in the appendices of the printed version of this thesis.

Author's contributions

The author of this thesis had the principal responsibility for data-gathering and analyzing as well as writing of the manuscript drafts in all three studies. For Article I, the author of this thesis and KV-H conceived the ideas and study design. The author of this thesis collected and analyzed the data and wrote the text with major contributions from KV-H and JR. In Articles II and III, the author of this thesis, KV-H and AP conceived the ideas and study design. The author of this thesis collected the data and had the main contribution on data analysis at the preliminary phase. After this, all authors of Articles II and III took part in analyzing the empirical material and contributed to writing of the manuscripts, although, the author of this thesis had the principal responsibility.

Author abbreviations: EV (Eerika Virranmäki), KV-H (Kirsi Valta-Hulkkonen), JR (Jarmo Rusanen), AP (Anne Pellikka)

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Eerika Virranmäki

1 Introduction

1.1 Thinking skills and knowledge in geography education

The dilemma in education is that we do not know what kind of world we are educating and raising today's young people for. What should be taught to young people so that they will be able to act in a future world about which there is no certainty? In the field of geography education research, there have been discussions regarding what kind of knowledge our geography curricula should emphasize and teach to young people. Béneker (2018) rightly states that a strong knowledge base underpins reliable teaching and education, and the teacher's task should be to show students how knowledge is created and found—and also how it is sometimes used for the wrong purposes. In today's age of "fake news," the importance of this should be emphasized even further. Current-day news is filled with information about climate change, tourism, refugees and migration, the global economy, deforestation, forest fires, the threat of global pandemics, etc., and the origins of this knowledge can sometimes be contested. Moreover, these all are geographical phenomena—even though they are not acknowledged as such by popular views of geography, which understand it to involve knowledge of topographical and other facts about the world's regions and places (see e.g. Favier & Van Der Schee 2012: 666).

All of this has affected the status of geography education across the globe. We have witnessed a discussion of geography's weakened position in schools during the last 20 years, and researchers (see e.g. Bednarz *et al.* 2014; Chang 2014; Lane & Bourke 2017b; Van Der Shcee *et al.* 2010) have reflected on issues such as decreased credit hours, falling student intakes, and geography's position as an umbrella topic or optional subject in the curriculum. National school systems and educational aims vary widely. In some parts of the world—for example, the Netherlands, China, Sweden, and parts of the United States and South America—geography is taught as part of social studies (see e.g. Brooks *et al.* 2017a: 8; Butt & Lambert 2014: 9; Uhlenwinkel *et al.* 2017: 336), whereas, for example, in Hong Kong, Singapore, Ontario, Australia (see Maude 2017: 36), and Finland, geography curricula blend physical and human geography. However, it is quite common across the globe for geography to have status as a named subject in upper secondary education—for example, in Sweden, the Netherlands, China, parts of the United States, Argentina, Brazil, Chile, Guyana, Paraguay, and Uruguay (see Bednarz *et al.* 2014; Brooks *et al.* 2017a; Uhlenwinkel *et al.* 2017) as well as Finland.

Furthermore, geography educationists have argued that geography involves a general "body of knowledge that is common across the globe" (Butt & Lambert 2014: 1) as well as "some congruence in general understandings of what the goals of geographical education might be" (Chang & Seow 2018: 32). In 2016, the International Geographical Union's Commission of Geography Education (IGU-CGE) proposed the International Charter on Geographical Education, in which geography is described as follows:

> "Geography is concerned with human-environment interactions in the context of specific places and locations and with issues that have a strong geographical dimension like natural hazards, climate change, energy supplies, migration, land use, urbanization, poverty and identity. Geography is a bridge between natural and social sciences and encourages the 'holistic' study of such issues." (IGU-CGE 2016: 10)

Therefore, rather than teaching simple facts about the world, as described in the popular view of geography, Favier and Van Der Schee (2012: 666) propose that geography education should be seen "more like an activity that students can engage in." Additionally, students should be enabled to learn, acquire, and use geographical knowledge, skills, and attitudes so as to be able to do geography (Favier & Van Der Schee 2012: 666; Van Der Schee *et al.* 2010: 7; see also Chang & Kidman 2019: 2). Béneker and Van Der Vaart (2020: 228) have suggested that by combining concrete geographical facts with abstract ideas and knowledge, geography has the potential to enhance people's thinking and opinion-making skills. Additionally, Bednarz (2019: 523) has argued that geography educationists should be able to summarize the thinking processes and core content of our discipline, so as to be able to communicate more effectively with the wider public.

1.2 Current debates in geography education

In the field of geography education, an international project named GeoCapabilities started in 2012 (see Lambert *et al.* 2015; Solem *et al.* 2013). The project is inspired by the writings of the philosopher Amartya Sen and the economist Martha Nussbaum, and it aims to discuss the purposes and values of geography education with the help of the "capabilities approach" (Solem *et al.* 2013). GeoCapabilities has widely influenced geography education research over the years (see Biddulph *et al.* 2020) by inspiring and engaging geography educationists to discuss powerful knowledge (Young 2008; see also Young *et al.* 2014), "Future 1–3" scenarios (Young & Muller 2010), and curriculum-making (see e.g. Lambert & Hopkin 2014; Lambert & Morgan 2010), as well as what the Nordic tradition calls subject didactics (see Uhlenwinkel *et al.* 2017) in the context of geography education.

The concept of powerful knowledge was originally introduced into educational debates over a decade ago by the British educational sociologist Michael Young, who was inspired by the work of two other sociologists, Basil Bernstein and Emile Durkheim (see Young 2008). The concept has its origins in social realism, which is said to be a response to (Béneker 2018) or critique of (not replacement for) (Young 2008: 18) the social constructivism that currently dominates discussions of education. Social constructivism is a theory of knowledge that assumes that knowledge (including scientific knowledge) is always related to and dependent on cultural norms and values. Knowledge is therefore socially constructed (Butt 2017: 16). In this view, the emphasis is on the student as a learner and thinker, and the learning of general skills is pursued through learning objectives (LOs). Knowledge is seen as personal and relative (Béneker 2018: 6).

On the other hand, social realism assumes that reality exists independently of individuals, i.e. "knowledge is about an objective world," even though knowledge is open to change because it is socially produced by communities of experts (Huckle 2017: 76). Based on social realism's view of knowledge, Young (2013: 108) has focused on the characteristics of knowledge, stating that powerful knowledge is specialized, differentiated, and fallible, i.e. open to change. Young (2014: 74–75) sees powerful knowledge as 1) separated from everyday knowledge, 2) categorized systematically into concepts, which form subjects or disciplines, and 3) produced by specialized communities. Additionally, Young (2008: 14) has also focused on describing what this knowledge can do for those that have it, i.e. "what intellectual power it gives to those who have access to it." According to Young (2008: 14), powerful knowledge should engage students to participate in political, moral, and other kinds of debates as well as providing new ways of thinking. These two definitions of knowledge have come to comprise two ways of interpreting the concept in the context of geography education (see e.g. Maude 2017: 28–29), as I will explain in the theoretical sections of this thesis.

In opposition to a focus on generic skills and learning outcomes, the concept of powerful knowledge "is part of a broader argument for the importance of subject knowledge in the school curriculum" (Maude 2016: 70). Young and Muller (2010) have formed three possible or ideal educational scenarios for the future based on social realism and powerful knowledge (see also Béneker 2018). "Future 1," *the knowledge-based curriculum*,[1] is based on positivism, which assumes that knowledge is given and static, and therefore the boundaries between subjects are clear. Knowledge is "under-socialized" and transmitted by the teacher, i.e. in teacher-centered teaching (Puustinen & Khawaja 2020) where there is limited student engagement. The aim of education is the reproduction of knowledge, often called rote learning. Béneker (2018: 5) links this traditional curriculum to geography teaching with an emphasis on regional knowledge, as it was taught mainly in the 19th and early 20th centuries. However, this type of teaching is also found today, for example, when the geography curriculum emphasizes topographical facts.

According to Young and Muller (2010), "Future 2," *the skills-based curriculum*, relies on constructivism, and knowledge is seen as socially constructed and personal. Subject boundaries are weakened, and knowledge is "over-socialized." The aim of education shifts from reproducing knowledge to learning skills, and to learner-centered learning, i.e. the teacher's role is facilitative. Moreover, formative assessment is emphasized. Biesta (e.g. 2013, 2015) calls this the "learnification of education." According to Béneker (2018: 6), this future has been present in the curriculum (together with Future 1) since the end of the last century.

The third possible educational scenario is "Future 3," *the knowledge-led curriculum*, which is based on social realism. It emphasizes crossing and maintaining boundaries between subjects as a prerequisite for the acquisition of new knowledge. Knowledge is seen as independent of individuals, albeit socially produced and therefore changing. This is where powerful knowledge is introduced as a guiding principle of the curriculum, and therefore students are offered access to knowledge that is outside their own experience. Puustinen and Khawaja (2020: 26) highlight teacher-led pedagogy, i.e. the teacher's key role is to guide students beyond their everyday knowledge. Béneker (2018: 8) calls this knowledge an emerging future in geography education that offers alternatives to Futures 1 and 2.

Social realism is said to have implications for the curriculum, since it places knowledge back at the core of education (see e.g. Béneker 2018; Butt 2017; Huckle 2017). It emphasizes students' access to disciplinary knowledge in schools (Butt 2017: 16) and aims for the acquisition of knowledge (Huckle 2017: 76). Drawing on Young (2008: 14), Butt (2017: 16) argues that it is a matter of social justice that students should gain access to this knowledge and thereby be enabled to take part in debates, make decisions, or address problems in society. Young and Muller (2010: 23) argue for Future 3, which has since been suggested as the preferred direction for geography education by many geography educationists (see e.g. Biddulph *et al.* 2020; Lambert & Biddulph 2015;

[1] These English concepts (italics) have been coined by the author and do not appear in the original sources in these particular forms.

Lambert & Hopkin 2014; Lambert *et al.* 2015: 10; Maude 2020; Mitchell & Lambert 2015; Morgan 2011; Uhlenwinkel *et al.* 2017).

It has been noted that Future 3 cannot be achieved simply by making curricula and other educational documents include the idea of powerful knowledge; we also need specialized teachers to interpret curriculum documents (see e.g. Lambert & Hopkin 2014: 75; Lambert *et al.* 2015: 731). Muller and Young (2019: 16) have acknowledged that "teachers are crucial mediators of the transformative capacity of powerful knowledge in their subjects," and teachers need to interpret the curriculum in order to decide what knowledge is powerful for students (see also Young *et al.* 2014). The GeoCapabilities approach has focused on to engage geography teachers in the roles of curriculum leaders (Biddulph *et al.* 2020), curriculum makers (Lambert *et al.* 2015; see also Lambert & Morgan 2010), or curriculum theorists (Deng 2018: 380). Bladh *et al.* (2018) state that this resembles the didactic tradition where teachers' didactical choices and practices are in focus. Deng (2018) argues that it is important to introduce didactical perspectives into the discussion of powerful knowledge because this will give

> "insights into teaching and teachers from the perspective of education as the cultivation of human powers and dispositions in and through content." (Deng 2018: 372)

Moreover, it is said to be an important contribution to the discussion of how powerful knowledge can be viewed (Bladh *et al.* 2018: 403). This perspective on powerful knowledge demands more attention to and research about how powerful disciplinary knowledge is taught in schools and how it is applied in the context of different subjects, including geography. Bladh *et al.* (2018: 403) note that the interpretation of Young's second idea of powerful knowledge—what it can do for those that have it—is rather close to subject didactics, because it demands that the curriculum and pedagogy to be considered relationally.

The concept of powerful knowledge has been criticized more recently by many scholars, for example White (2018, 2019) and Hordern (2019). White (2018: 325) has stated that the concept has too strong and positive an emotional charge, while Hordern (2019: 34) suggests another term to be used instead: "specialized knowledge." Additionally, Hordern (2018: 30) suggests that the concept of powerful knowledge may be understood to be "more about seeing the world differently or acquiring a specialized lens." The same suggestion has also been made by Béneker and Van Der Vaart (2020: 222), who note that geographical knowledge (and that of other academic disciplines) has an "essential set of lenses through which to explore the world around us."

1.3 Finnish upper secondary education: the context of this study

1.3.1 General upper secondary education

Education is largely intertwined with national contexts. Therefore, I will now introduce the Finnish national school system,[2] focusing on general upper secondary school. The

[2] For more information about the Finnish education system, see https://www.oph.fi/en/education-system; for general upper secondary education, see https://minedu.fi/en/general-upper-secondary-education; for the Finnish matriculation examination, see https://www.ylioppilastutkinto.fi/en/.

Finnish system is organized around levels of education. Early childhood education and care are provided to children before their compulsory education. The latter consists of one year of preprimary education for six-year-olds, and nine years of basic education (in comprehensive schools) for children aged seven to 16. Traditionally, after their ten-year compulsory education, almost all students would head into post-compulsory education, which consisted of three years of general or vocational upper secondary education and training. In 2021, an extension of compulsory education came into force, one age group at a time.[3] Therefore, compulsory education now additionally extends to the upper secondary level, and it usually applies to students aged 16–18. Students can finish their compulsory education by completing general upper secondary education, which leads to the matriculation examination (ME), or by completing vocational education, which leads to a vocational qualification.[4] After completing one of these, students can continue their studies in higher education at universities or universities of applied sciences.

In Finland, upper secondary education is mainly regulated by the Act on General Upper Secondary Education (714/2018, partially renewed in 1217/2020), while the ME is mainly regulated by the Act on the ME (502/2019). The Finnish government decides on the common national objectives for upper secondary education as well as the distribution of lesson hours among different subjects. The Finnish National Agency for Education (FNAE; previously, until 2016, the Finnish National Board of Education (FNBE)) determines the upper secondary school curriculum, which contains for example the objectives and core content of each subject and study module, the principles for the assessment of students' learning, good learning environments, and working approaches, and the mission and underlying values, as well as conceptions of learning, and guidance and support for students. However, the national curriculum leaves room for local variations, and all education providers (e.g. municipalities) form their own local curricula. Moreover, teachers have great pedagogical autonomy, and they can select suitable teaching methods, textbooks, and other teaching and learning materials for themselves. In upper secondary schools, and in upper comprehensive schools in seventh to ninth grade, the teachers are subject specialists, with master's degrees in the subjects they teach as well as university pedagogical training. Student assessment is mainly conducted by the teachers in the form of continuous assessment throughout the course and at the end of it. The first national examination is at the end of upper secondary education in the form of the ME. In Finland, there are no national testing or school inspection systems.

The Finnish national ME is the dominant large-scale (approximately 40,000 participants per year) summative assessment of learning outcomes administered at the end of upper secondary school (a final examination), and it has been in place since 1852. It aims to examine whether students have accomplished the skills and competences defined in the National Core Curriculum for General Upper Secondary Schools (see FNAE 2019; FNBE 2003, 2015) as well as whether they have acquired the adequate level of maturity. The ME consists of at least four compulsory tests in different subjects. For all participants, the mother tongue examination (in Finnish, Sami, or Swedish, depending on the candidate's native language) is the only compulsory subject.

[3] For more information about the extension of compulsory education, see https://minedu.fi/en/faq-about-the-extension-of-compulsory-education.

[4] From now on, I will refer to general upper secondary education simply as "upper secondary education."

The participants select the other three compulsory tests from four categories: a second national language, a foreign language, mathematics, or one test from the general studies battery of tests (natural sciences and humanities). Additionally, participants can include optional tests in the examination. The tests are held biannually, in spring and fall, in all Finnish upper secondary schools simultaneously. Students receive an ME certificate showing the details of the examinations passed, after successfully completing the compulsory tests in the examination and receiving a general upper secondary education or vocational upper secondary certificate. The Finnish ME Board (FMEB), selected by the Ministry of Culture and Education, is in charge of all arrangements concerning the examination, and it takes care of the guidelines and instructions concerning the examination as well as developing the examination.

1.3.2 Upper secondary geography education and the digitalization of the ME in geography

From the perspective of Finnish upper secondary geography education, there have been four major changes during recent years. Previously, geography had two compulsory courses and two national specialization courses defined in the national curriculum. The first radical change occurred in 2014, when geography lost one of its compulsory courses as a result of the Finnish government's decision concerning the distribution of lesson hours among different subjects (Valtioneuvosto 2014). Second, in 2015, the FNAE conducted a reform of the upper secondary curriculum, which had last been revised in 2003 (see FNBE 2003, 2015). The result of the 2015 reform was that the content of the geography curriculum remained almost the same, but the order of the courses changed (see Table 1). The former GE3 course became the first and only compulsory course in the 2015 curriculum; the former GE1 course was positioned second; the former GE2 course was placed third; the GE4 course changed its name in the 2015 curriculum. Curriculum reform is usually carried out every tenth year; however, the curriculum was additionally reformed in 2019, and students who started their studies in 2021 will do so according to the new curriculum (see FNAE 2019). Under this reform, the traditional course structure (based on individual courses in different subjects, with at least 75 courses in total) has been replaced with modules within subjects, consisting of credits (at least 150 credits in total). As upper secondary education is based on basic education, it should be mentioned in this context that before the reform of the upper secondary curriculum in 2015, the national core curriculum for basic education was also reformed in 2014. This reform shifted the emphasis of the basic education geography curriculum away from traditional regional geography and more in the direction of understanding processes and phenomena (in both natural and human geography).

Third, a major reform was carried out during 2016–2019, when the ME was converted to digital format following a decision of the Finnish government in 2011 (Valtioneuvoston kanslia 2011: 33). The digitalization process was organized in a project called Digabi. The whole examination process was digitalized: the exam system and questions; assessment by the teachers in schools and the censors nominated by the FMEB; and the results of the examination. The need to digitalize the examination has been justified by the argument that students will need new skills in future, especially digital skills, for example (see e.g. Tulevaisuuden lukio… 2013: 30). On the other hand, digitalization is also said to offer new possibilities to formulate test questions and to use new materials in the examinations (Ruth 2015: 239).

Table 1. Content of geography in Finnish upper secondary schools according to National Core Curriculum for General Upper Secondary Schools 2003, 2015, and 2019 (source: FNAE 2019; FNBE 2003, 2015).

2003 curriculum	2015 curriculum	2019 curriculum
GE3: The world of risks Hazard geography. Hazards related to the system of nature, and to natural resources, and the environment. Hazards related to humankind. Technical hazards.	*GE1: The world in change* Geography as a field of science. Key global risk areas related to the system of nature. Key global risk areas related to natural resources and the environment. Global risk areas and essential development questions of humankind.	*GE1: The world in change* Geography as a field of science. Environmental changes and solutions for them. Changes in humankind.
GE1: The blue planet Geographical thinking. Planetary movement. Atmosphere. Hydrosphere. Weather and climate. Topography of the earth. Vegetation zones of the earth. Interpretation of natural landscapes.	*GE2: The blue planet* Geographical thinking related to physical geography. Planetary movements of the earth and phenomena caused by these. Atmosphere and hydrosphere in motion. Structure and variable topography of the earth. Use of physical geographic data in society and daily life.	*GE2: The blue planet* Geographical thinking related to physical geography. Planetary movements of the earth and phenomena caused by these. Atmosphere and hydrosphere. Lithosphere. Vegetation zones of the earth.
GE2: A common world Human geography. Population and settlements. Natural resources. Primary production and the environment. Industry and energy. Movement and interaction. Regional structure of human activity. Development control and sustainable development.	*GE3: A common world* Geographical thinking related to human geography. Population and settlements. Primary production and the environment. Industry and energy. Services, movement, and interaction. Regional structure of human activity. Use of human geographic data in society and daily life.	*GE3: A common world* Geographical thinking related to human geography. Population, settlements, and cultures. Cities and urbanization. Regional characteristics of production and sustainable use of natural resources. Movement, services, and interaction.
GE4: Regional research Cartography and geographical research materials. Geographic information systems. A geographic study.	*GE4: Geomedia – explore, participate, and get involved* Use of geomedia in daily life, the world of work, and the promotion of sustainable development. Geomedia and geographic research skills. Development control and sustainable development. A geographic study, or a participation and involvement project.	*GE4: Geomedia – explore, participate, and get involved* Geographical research. Regional planning and principles of participatory planning. A geographic study, or a participation and involvement project.

Geography, philosophy, and German were the first subjects to be digitalized in the fall of 2016, while mathematics was the last in the spring of 2019. Between 2012 and 2020 there were approximately 4,200 participants in geography tests in the ME annually. During the digitalization process, changes were made both to the geography test structure and to the knowledge and cognitive process requirements of the geography tests. The paper-based tests consisted of ten assignments, of which students had to answer six. There were no compulsory assignments (unlike in the digital tests), and the total maximum score was 42 points (see FMEB 2017a). Of the ten assignments, the last two (marked with a + sign) were designed to be more demanding in terms of knowledge and cognitive process requirements. The current digital geography test consists of three different parts, Parts I–III, containing a total of nine assignments, of which students are required to answer five. The maximum score is 120 points, and each assignment can give 20–30 points (see FMEB 2017b).

During digitalization, the FMEB (n.d.: 2) issued instructions to apply a revised version of Bloom's taxonomy (explained in more depth in the theory section of this thesis) as a guiding principle for the formulation and design of the new digital test's assignments and structure. Aksela *et al.* (2012) have stated that the taxonomy can be used as a background for scientific thinking, and according to Houtsonen (2012: 87) it is useful for reflecting on the development of geographical thinking skills. The use of a revised version of Bloom's taxonomy is reflected in different parts of the geography test as described by the FMEB's (2018) geography subject section. Part I (compulsory for all students) contains assignments that evaluate students' primary knowledge in geography, and consists mainly in remembering and understanding; Part II is mainly focused on the application of knowledge, but it overlaps with assignments that require students to analyze information; the last part of the test, Part III, requires a comprehensive knowledge of geography, and it requires students to analyze, evaluate, and create knowledge as well as to use problem-solving skills in different contexts. Parts II and III each have four assignments, and students choose two assignments from each part to answer.

In addition to these three major changes, the fourth change concerns the ME which gained significantly in importance in spring 2020. The majority of upper secondary school students are now accepted into higher education based on their success in the ME, while the role of entrance exams has been reduced. It is said (see e.g. Baird *et al.* 2017: 340) that assessment has an impact on teaching and learning, because "the ways students are assessed on their knowledge" (Ormond 2019: 6) helps to determine what knowledge is taught to students. Torrance (2011: 459; see also Torrance 2017) issues a note of caution by stating that assessment procedures and processes should not be used to "frame the curriculum and drive the reform of schooling," and assessments may have negative backwash effects if used in a way that leads to teaching to the test and a "standards-based curriculum" (Torrance 2011: 464). However, it is an often-ignored fact that assessment can improve teaching and learning (Stoltman *et al.* 2014: 193; Wertheim & Edelson 2013: 15), and assessment should not merely rank students but should produce "information about the nature of student understanding" (Pellegrino 2017: 365). In a large review article on assessment in geography, Lane and Bourke (2017a: 12) come to the conclusion that more research is needed concerning the knowledge and skills that students must learn and develop during their studies in geography.

1.4 The aim of the thesis

1.4.1 Two theoretical "lenses"

With reference to the discussion of the four changes that have occurred in Finnish upper secondary geography education—especially the digitalization of the ME, and the use of a revised version of Bloom's taxonomy to formulate geography tests—as well as the threats posed to geography education globally, and current research themes in geography education, this thesis aims to contribute to widen our understanding of thinking skills and powerful knowledge in the context of geography education. I acknowledge that the concept of powerful knowledge has its origins in sociological theory, and my aim here is not to challenge or debate the concept per se. Rather, I focus more on the practical perspective of developing geography education in terms of thinking skills and geographical knowledge. My background as a geography teacher, teacher educator, and geography education researcher has guided my approach toward this more practical orientation. Brooks *et al.* (2017b: 3) acknowledge that schools must be considered as important places to ensure that the idea of powerful knowledge in geography is recognized and passed on to young learners for them to further explore and engage with.

During my years as a PhD researcher, I have found myself engaged with the question of what kinds of powerful geographical thinking and knowledge Finnish upper secondary schools pass on to their students. Theoretically inspiring questions during these years have revolved around what powerful geographical knowledge "can do for those who have it" (Maude 2018: 180), "what intellectual power it gives to those who have access to it" (Young 2008: 14), and "whether the somewhat abstract ideas and concepts in powerful knowledge can be taught to all students, and if so, how" (Maude 2017: 39). Additionally, Bouwmans and Béneker (2018: 457–458) have inspired me by proposing that we should ponder the consequences and meaning of the dominance or absence of one or more types of geographical knowledge. Moreover, the revised version of Bloom's taxonomy (Anderson *et al.* 2014) used to formulate the digitalized geography tests' structure and questions in the ME has guided me to examine geographical thinking skills throughout my thesis process. Most recently, I have engaged with Bednarz's (2019: 521) proposal that we should refocus our attention on how geography education can help "students to become empowered to participate actively in society." To paraphrase Bednarz (2019: 527), we should focus our teaching *for* world, not just *in* and *about* the world.

As stated above, in terms of theory, this thesis brings together discussions of powerful knowledge in geography, especially powerful geographical knowledge as defined by Maude (e.g. 2018), with thinking skills and the knowledge dimensions of a revised version of Bloom's taxonomy (Anderson *et al.* 2014). The typology of powerful geographical knowledge produced by Maude (e.g. 2018) and applied by other researchers has attempted to capture the concept's concrete nature in the context of geography education: what powerful knowledge can be in geography education. However, I see powerful geographical knowledge to be more theoretically orientated, while the revised version of Bloom's taxonomy is more practically orientated, forming an analytical tool for teachers and others to evaluate students' intended learning outcomes in terms of thinking skills and knowledge dimensions (see Anderson *et al.* 2014). I suggest that if we look at geography through the theoretical perspective of the revised version of Bloom's taxonomy, we can approach powerful geographical knowledge more easily. In other words, I propose that it is possible to understand the abstract ideas and concepts of powerful geographical knowledge by using the concept of cognitive skills, which describes students' thinking when they are working with knowledge.

Therefore, in this thesis, I suggest that these two theoretical ways of seeing geography can be used as "lenses" through which to examine geographical knowledge and thinking, so as to be able to enhance students' (higher-order) thinking and therefore give them intellectual power. Additionally, this way of seeing geography can reveal whether there is an absence or dominance of some knowledge types or thinking categories in geography. The aim is not to collect a list of concepts or contents that constitute powerful geographical knowledge (see Lambert 2016; Lambert *et al.* 2015; Maude 2016; Uhlenwinkel *et al.* 2017), but to describe the thinking skills that powerful geographical knowledge encourages students to use when they are working with geographical phenomena. This information can be used when one is planning the aims of geography education and the teaching artifacts to be used, as well as when one is choosing teaching methods and assessment procedures. This framework will provide teachers with the tools to examine, plan, and evaluate their own teaching towards to powerful geographical knowledge.

1.4.2 Objective and research questions

The main objective of this thesis is to examine geography's potential to engage students in thinking skills and powerful geographical knowledge, using Finnish upper secondary geography education as an example. Empirically this is done by using a qualitative research methodology approach to examine the thinking skills and powerful geographical knowledge found in 1) upper secondary geography teachers' concept maps and in-depth interviews, 2) the geography test questions in the ME's paper-based and digital forms between fall 2013 and spring 2019, 3) students' answers to the paper-based and digital geography test questions between fall 2015 and spring 2017, and 4) the LOs in upper secondary geography curricula documents from the years 2003, 2015, and 2019. The two theoretical perspectives or "lenses" onto geography are used as a framework for the analysis. For this thesis, I formulated three research questions, which are answered by the findings in the three original research articles on which the thesis is based. Figure 1 presents a summary of the theoretical and empirical context of the thesis as well as the methodological approaches used.

Q1) *With what kinds of geographical thinking skills and knowledge types do students engage during their upper secondary geography education, according to the geography curricula and teachers' conceptions of geography?* Through this question, I intend to shed light on the curriculum reforms conducted in 2015 and 2019 as well as the Finnish government's decision to decrease the number of compulsory geography courses to only one in 2014. I attempt to examine the aims of geography education in terms of the thinking skills and powerful geographical knowledge defined in the geography curricula and teachers' conceptions.

Q2) *To what extent—if at all—did the thinking skills and knowledge requirements of the Finnish ME in geography or the students' performance change during the digitalization process?* The ME, which is the summative assessment at the end of upper secondary school, was digitalized in 2016. Therefore, through this question I attempt to give insights into changes to the examination in geography in terms of thinking skills and geographical knowledge requirements, as well as students' performance when they answer the geography test questions.

Q3) *How should geography curricula, assessment, and teaching be developed in terms of thinking skills and powerful geographical knowledge types?* Here, I make proposals for the development and improvement of geography education both nationally and internationally, although the practical emphasis is on the national context, since my empirical findings arise from the Finnish context.

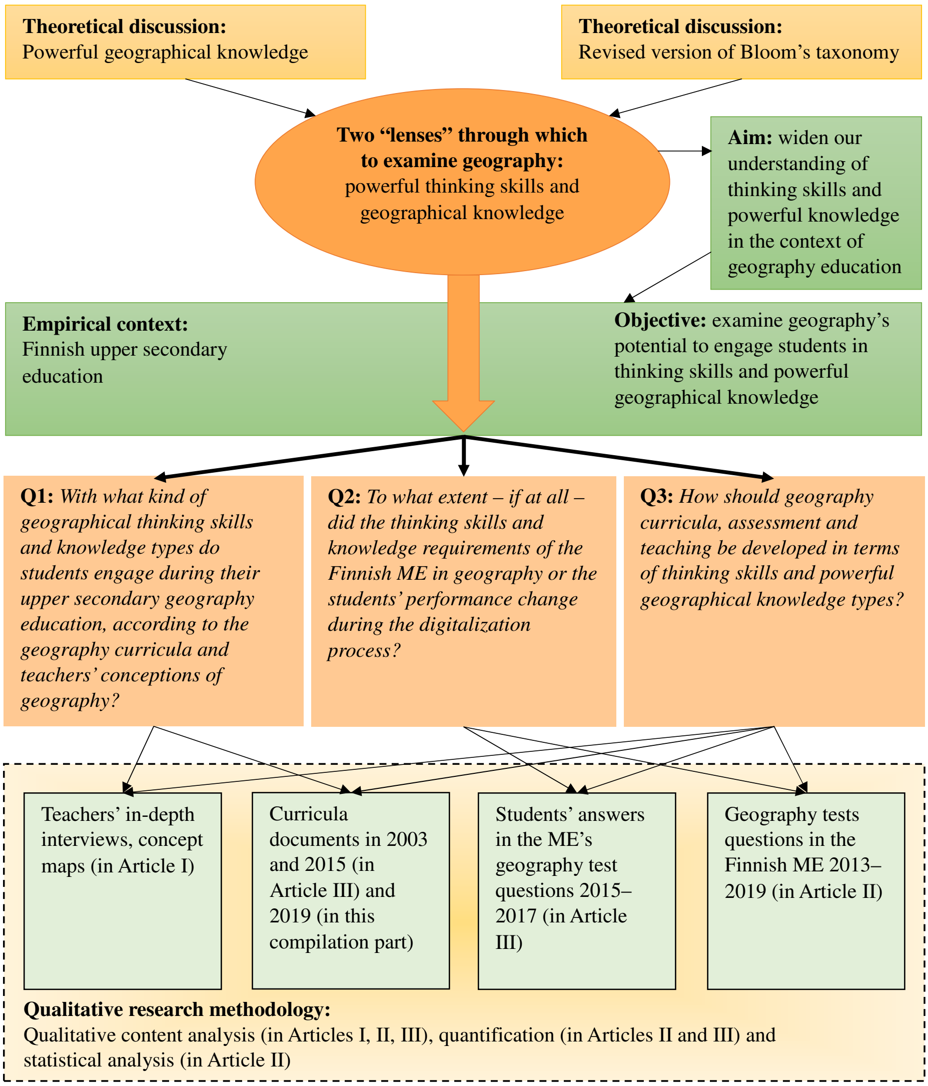

Figure 1. The theoretical and empirical context and methodological approach of this thesis.

1.4.3 Articles' contributions and the structure of the thesis

This thesis consists of a compilation part and three original research articles as an attachment. Table 2 sets out the contributions of the original articles in more depth, as this thesis is based on the findings from the three research articles published during the research process. The findings from Articles I and III are used to answer the thesis' first research question, while the findings from Articles II and III answer the second research question. The third research question is answered by the findings from all three research articles.

Article I aimed to examine the kind of geography is taught in Finnish upper secondary schools and whether this geographical knowledge is a form of powerful knowledge, using Maude's (2018) typology of powerful geographical knowledge. The aim was pursued through the analysis of 11 in-service Finnish upper secondary geography teachers' conceptions of geography, by gathering teachers' concept maps and conducting in-depth interviews. These findings increased the understanding of in-service geography teachers' conceptions of geography and contributed to research on powerful geographical knowledge by presenting the forms that powerful geographical knowledge can take in teachers' understandings of geography.

Article II pursued the aim of studying possible changes in cognitive processes and geographical knowledge requirements during the digitalization of the ME in geography (digitalized in fall 2016), using a revised version of Bloom's taxonomy (Anderson *et al.* 2014) as a theoretical framework. The analysis was based on 12 examinations (six tests in paper-based and six in digital format) between fall 2013 and spring 2019, comprising a total of 331 questions. This article presented the application of the revised version of Bloom's taxonomy in the context of geography education and assessment. The article increased our understanding of the geographical thinking skills and knowledge emphasized in the ME in geography.

The main aim of Article III was to evaluate the geography LOs (n=107) of the Finnish National Core Curriculum for General Upper Secondary Schools, published in 2003 and 2015, in terms of the cognitive and knowledge domains of the revised version of Bloom's taxonomy (Anderson *et al.* 2014). It also examined students' higher-order cognitive outcomes in geography tests in paper-based and digital forms, using a sample of 800 students from northern Finland that participated in the ME geography tests between fall 2015 and spring 2017. Thus, in total, 1,585 students' answers to 33 higher-order thinking skills (HOTS)-type questions (*analyze*, *evaluate*, or *create*; *conceptual* or *procedural* knowledge) were analyzed. This article contributed to the application of the revised version of Bloom's taxonomy to geography education.

The thesis is structured into five main sections, which consist of subsections (Figure 2). Section 1 ("Introduction") discusses current debates in geography education and introduces the Finnish context of the study by explaining the four major changes that have occurred to Finnish upper secondary education. Additionally, this section discusses the research aim, research objective, research questions, and articles' contributions. Section 2 ("Theoretical foundations") first introduces the main academic discussions of powerful geographical knowledge and the revised version of Bloom's taxonomy. Then it connects the two theoretical perspectives together and introduces two "lenses" through which, I suggest, we can see geography education. Section 3 ("Research design and process") explains the methodological choices made and how the research was conducted, and it introduces the research materials and methods of analysis used. Section 4 ("Discussion with the findings from the original articles") uses the findings

Table 2. Articles' contributions to this thesis.

Article	I) Powerful knowledge and the significance of teaching geography for in-service upper secondary teachers: a case study from northern Finland	II) Geography tests in the Finnish matriculation examination in paper and digital forms: an analysis of questions based on revised Bloom's taxonomy	III) Geography curricula objectives and students' performance: enhancing the students' higher-order thinking skills?
Aim of the study	To study in-service Finnish upper secondary schoolteachers' conceptions of geography: what kind of geography they currently teach in school, whether this knowledge is powerful, and if it is, in what way.	To study possible changes to cognitive process and geographical knowledge requirements during the digitalization of the ME in geography (digitalized in fall 2016).	To evaluate the geography LOs of the Finnish National Core Curriculum for General Upper Secondary School, published in 2003 and 2015, in terms of the cognitive and knowledge domains of a revised version of Bloom's taxonomy, and to examine students' higher-order cognitive outcomes in geography tests in the ME's paper-based and digital forms.
Research questions	1) How do in-service Finnish upper secondary geography teachers conceptualize geography? 2) Is powerful geographical knowledge seen in teachers' conceptions of geography?	During the ME digitalization process, how did the geography test questions change in terms of 1) the geographical cognitive processes and knowledge required, 2) the types of attached material, and the related cognitive processes and knowledge required, and 3) the types of assignment and related cognitive processes and knowledge required?	1) To what extent, if at all, might geography curricula's LOs emphasize students' higher-order thinking skills (HOTS)? 2) Are students capable of answering HOTS-type questions in both paper-based and digital tests?
Research material used	Concept maps and in-depth interviews with 11 in-service geography teachers, gathered in 2014–2015.	ME geography tests between fall 2013 and spring 2019 (12 in total). Examinations (six tests in paper-based and six in digital format) consisting of 331 questions.	Geography LOs (n=107) of the National Core Curriculum for General Upper Secondary Schools, 2003 and 2015. Sample of 800 students from northern Finland who took ME geography tests between fall 2015 and spring 2017 (1,585 students' answers to 33 HOTS-type questions in total).
Method of analysis	Qualitative content analysis.	Qualitative content analysis, quantification, statistical analyses: contingency table and chi-square test.	Qualitative content analysis, quantification.

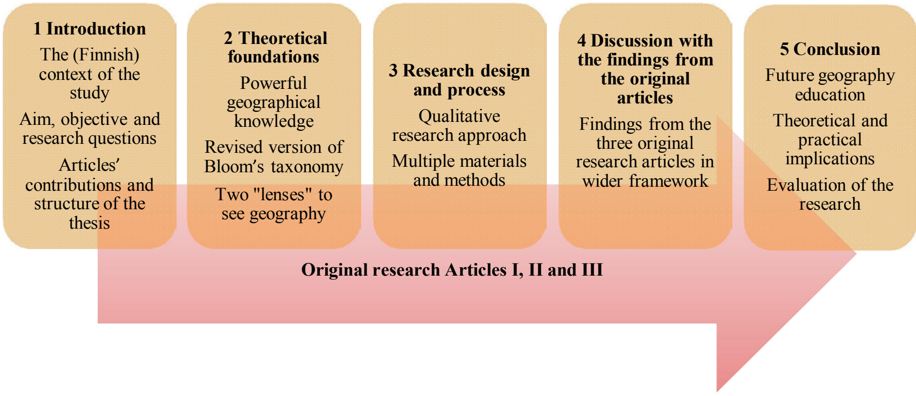

Figure 2. The structure of this thesis.

from the three original research articles to answer the research questions posed in this thesis in light of the theoretical framework of two "lenses" through which to see geography. Section 5 ("Conclusion") discusses future geography education and presents the theoretical and practical implications of this thesis, as well as offering an evaluation of the research.

2 Theoretical foundations

In this part of the thesis, I present and widen the theoretical foundations of the three original research articles that form the background of the thesis. First, a brief overview of powerful knowledge is discussed in the context of geography education. I attempt to paint a general picture of the conversation about the somewhat abstract concept of powerful knowledge and how it has been interpreted within geography education research. I focus on a more concrete definition of powerful knowledge—i.e. Maude's (2018) powerful geographical knowledge—and its application to geography. Second, I describe the main characteristics of the revised version of Bloom's taxonomy produced by Anderson and Krathwohl in 2001. I introduce the wide application of the taxonomy to geography teaching and learning. Last, I draw together these two theoretical perspectives, aiming to build a novel approach to powerful geographical knowledge and thinking. In other words, I suggest that these two theoretical perspectives can be used as two "lenses" through which to see geography education.

2.1 Powerful geographical knowledge

It is acknowledged that sociologists of education have made a major contribution to "the debate about the place, role, and function of knowledge" (Brooks *et al.* 2017b: 10). They have brought many ideas and concepts to the attention of the geography education community, and the last decade has witnessed a large amount of geographical research into the concept of powerful knowledge (see e.g. Béneker 2018; Béneker & Van Der Vaart 2020; Bouwmans & Béneker 2018; Catling 2014; Catling & Martin 2011; Chang & Kidman 2018; Huckle 2017; Lambert 2014a, 2014b, 2016, 2017; Lambert *et al.* 2015; Maude 2015, 2016, 2017, 2018, 2020; Morgan 2011; Puttick *et al.* 2018; Roberts 2014; Slater & Graves 2016; Stoltman *et al.* 2015; Tani *et al.* 2018, 2020; Uhlenwinkel *et al.* 2017; Vernon 2020). Thus, geographers and geography educationists have challenged themselves to debate the concept of powerful knowledge in geography, and how—if at all—geographical knowledge can be considered powerful (Brooks *et al.* 2017b).

The literature has mainly focused on the characteristics of knowledge, based on Young's (2014: 74) first definition of knowledge as "features of the particular knowledge itself that is included in the curriculum". Lambert was among the first to introduce the concept of powerful knowledge to geography (see Lambert 2011, 2014a; see also Stoltman *et al.* 2015). Lambert (2014a) introduced three levels of powerful knowledge, which were then further developed by Lambert *et al.* (2015) in the context of the GeoCapabilities project. According to Lambert *et al.* (2015: 10), the three levels of powerful disciplinary knowledge are 1) descriptive but deep world knowledge, 2) critical conceptual knowledge that has explanatory power and systematicity, and 3) a propensity to think through alternative social, economic, and environmental futures in spatial contexts. Later, in the context of the same project, Uhlenwinkel *et al.* (2017) concluded:

> "The powerful disciplinary knowledge in all four countries is described in terms of world knowledge and understanding the world using geographical perspectives such as looking at human and nature interactions, using the concepts of scale and of local-global relationships, studying geographical issues (e.g. climate change) and

linking these to personal (or individual or communal) choices." (Uhlenwinkel *et al.* 2017: 336)

However, geography education researchers have not straightforwardly adopted Young's ideas about powerful knowledge, and there have been critical views of the concept (see e.g. Catling 2014; Catling & Martin 2011; Huckle 2017; Roberts 2014; see also Butt 2017). Maude (2015, 2016, 2017, 2018; see also Slater & Graves 2016) has criticized Lambert *et al.*'s (2015) perspective on powerful disciplinary knowledge because of their insufficient identification of powerful knowledge, i.e. their assumption that all disciplinary knowledge can be identified as powerful knowledge (see Young 2014: 74) even if it does not have powerful outcomes. According to Maude (2017: 29, 37), the assumption cannot be made that all geographical knowledge taught in schools is disciplinary knowledge. There are always differences between disciplinary knowledge and school subjects, because the content of school subjects always consists in interpretations made by educational bureaucracies, curriculum designers, and administrators or teachers (Maude 2017). Moreover, in the context of primary education, Catling and Martin (2011: 319) argue that Young's idea is insufficient, because it emphasizes academic knowledge over the everyday knowledge of young children (see also Roberts 2014). Roberts (2014: 193) argues that if curriculum documents do not pay attention to students' experiences and personal geographies, little if any attention will be given to these in the classroom. Additionally, Roberts (2014) notes that school geography may not always meet the criteria for powerful knowledge, but it does promote new and powerful ways of looking at the world. It is argued (see Butt 2017: 23; Roberts 2014: 205) that if we want students to gain access to powerful knowledge, we need them to acquire a wide range of skills that will enable them to use and critique knowledge. We need to see the discipline of geography as a resource or foundation from which to draw out "subjects' intellectual traditions and ways of thinking" (Butt 2017: 23).

According to Béneker and Van Der Vaart (2020), Maude is the only researcher in the field of geography education to adopt Young's (2014: 74) second definition of powerful knowledge, i.e. what it can do for those who have it. However, Maude (2018: 181) notes that this type of knowledge is interrelated with Young's first type of knowledge, because knowledge of the first type is the best type of knowledge available. According to Maude (2017: 29), the word "power" represents an ability to do something that has some kind of effect. By this, he means that if knowledge is to be described as powerful, it should have powerful outcomes. Maude (2018) suggests that knowledge is powerful if

> "it enables young people to discover new ways of thinking, better explain and understand the natural and social worlds, think about alternative futures and what they could do to influence them, have some power over their own knowledge, be able to engage in current debates of significance and go beyond the limits of their personal experience." (Maude 2018: 180–181)

In his research, Maude (2015, 2016, 2017, 2018, 2020) has outlined five types of powerful geographical knowledge to describe what geography enables students to learn, using the Australian geography curriculum as an example (see Maude 2015; to understand how Maude interpreted Young's ideas when formulating his typology, see also Maude 2016, 2017). Maude's (2018) five types are:

Type 1: knowledge that provides students with "new ways of thinking about the world." This knowledge type includes geography's major concepts—place, space, and environment—and may change "students' perceptions, values and understanding" (Maude 2018: 181) or even their behavior. This type is "the most powerful component" (Maude 2018: 185).

Type 2: knowledge that provides students with powerful ways of analyzing, explaining, and understanding. This type of knowledge encompasses 1) concepts that have analytical or 2) explanatory power, 3) geographical generalizations, and 4) the skills to use these concepts. Maude (2018) connects this knowledge type to the second level of powerful disciplinary knowledge introduced by Lambert *et al.* (2015).

Type 3: knowledge that gives students some power over their own geographical knowledge. This knowledge type includes critical independent thinking and geographical reasoning, as well as information about how knowledge is created, tested, and evaluated.

Type 4: knowledge that enables young people to follow and participate in debates on significant local, national, and global issues. This knowledge type refers to geography's ability to integrate the natural and social sciences with the humanities. Thus, geography engages and enables students to participate in social debates. According to Maude (2018), this knowledge type connects to the third level of powerful disciplinary knowledge introduced by Lambert *et al.* (2015).

Type 5: knowledge that teaches students about unfamiliar places and helps them to understand the "world's diversity of environments, peoples, cultures and economies" (Maude 2018: 183). This knowledge type is connected to the first level of powerful disciplinary knowledge introduced by Lambert *et al.* (2015; see Maude 2018).

Maude's typology has subsequently been widely used by geography educationists. Béneker and Palings (2017) have used it to examine student teachers' conceptions of geographical knowledge, together with geography textbooks and curriculum documents in the Netherlands. Béneker and Palings (2017: 83) conclude that Maude's type 2 is mentioned by two-thirds of their students, and Maude's type 4 is emphasized by half of their students as important knowledge that secondary school students should learn in geography. In Béneker and Palings's (2017) research, only one student refers to type 3 knowledge. Examining upper secondary textbooks, they find knowledge types 2 and 5 to dominate (Béneker and Palings 2017: 84). Moreover, they conclude that in upper secondary education, curriculum documents are dominated by types 1, 2, and 5, while type 3 is difficult to find (Béneker and Palings 2017: 84). Indeed, in Maude's (2015) own analysis of curriculum documents in Australia, type 3 is often missing. Maude (2015: 23) argues that the Australian curriculum overemphasizes technical skills and underestimates the need for critical thinking. The same conclusion is reached in Bouwmans and Béneker's (2018) study of the interdisciplinary (human and societal) domains of written curricula in four schools in the Netherlands. They find that type 3 is almost absent from the curricula (Bouwmans & Béneker 2017: 456). The main emphasis in the integrated curricula is on type 2, and to a lesser extent type 5 (Bouwmans & Béneker 2017: 457).

Tani *et al.* (2018) examine Finnish geography teachers' views through an online survey, asking teachers to choose the five most valued aims of geography education from the general LOs found in the 2015 geography curriculum. They use Maude's typology and the three levels of powerful disciplinary knowledge (Lambert *et al.* 2015) to analyze the data. Tani *et al.* (2018: 11) conclude that all of the knowledge types defined by Maude, as well as all three levels of powerful disciplinary knowledge (Lambert *et al.* 2015), are represented in the subject's most valued objectives. Additionally, Tani *et al.* (2018: 11) argue that Finnish geography teachers place more emphasis on critical thinking skills than do the Australian curriculum (Maude 2015) or textbooks and curriculum documents in the Netherlands (Béneker & Palings 2017). However, Tani *et al.* (2018: 14) add that there seem to be challenges in fulfilling the aims defined in the curriculum, because of the curriculum's fragmented and illogical content and the limited time available for teaching. More recently, Tani *et al.* (2020) have used the three levels of powerful disciplinary knowledge (Lambert *et al.* 2015) to analyze Finnish ME geography test questions between 2006 and 2019. Tani *et al.* (2020) conclude that all three levels of powerful disciplinary knowledge are found in the Finnish geography tests. However, during the digitalization process, the first level was reduced, while the second level remained almost the same, and the third level increased. Additionally, they note that questions requiring students to use their own experience or to evaluate value-based issues are not acknowledged in geography tests (Tani *et al.* 2020).

Walshe (2018) has used Maude's typology to consider how the use of geographic information systems (GIS) can develop students' powerful geographical knowledge. Walshe (2018) concludes that using GIS can enhance students' knowledge types 2, 4, and especially 3, by supporting students to evaluate and test knowledge. Additionally, Fargher (2018: 8) examines how a curriculum artifact based on WebGIS can be used to support the construction of powerful geographical knowledge, using the example of the 2004 Indian Ocean earthquake and tsunami. Fargher (2018) acknowledges that the WebGIS approach can especially support the development of knowledge types 2 and 3. However, both Walshe (2018) and Fargher (2018) recall the need for expertise from geography teachers to develop appropriate pedagogies that support students' thinking (see also Roberts 2014). More recently, Healy and Walshe (2020: 184) have used Maude's typology to analyze "how use of real-world geography experts might support students' geographical knowledge" in the context of GIS education. Based on student interviews and questionnaire responses, they conclude that real-world geography experts support students to develop knowledge types 2, 4, and 5, whereas type 3 is difficult to find in the students' answers (Healy & Walshe 2020).

Béneker (2018; see also Bouwmans & Béneker 2018) acknowledges that Maude's typology has helped to concretize the concept of powerful knowledge in geography, but she states that there is a risk of seeing the five types as separate, even though all five are needed to form powerful knowledge (see also Béneker & Van Der Vaart 2020). Béneker (2018) has been inspired by Maude's work to form a typology consisting of five fields of knowledge in geography. She notes that the only way for knowledge to be truly powerful is to connect the types together so that they overlap (Béneker 2018: 10). According to Béneker (2018; see also Krause *et al.* 2021), the first type is conceptual and theoretical knowledge, which comprises "the geographical lens and the grammar of the subject" (Béneker 2018: 10). The second is concrete geographical knowledge, which is the vocabulary of the field of study, i.e. the basic concepts and more factual knowledge that contribute to the acquisition of a geographical world view (Béneker 2018: 11). In the third type, the first and second types of knowledge overlap to form systematic knowledge, i.e. "'knowing how' to work with geographical methods" (Béneker 2018: 11). The fourth is the field of knowledge that "comprises knowledge and language that enable you to *participate* in major societal debates, and to *imagine* desirable futures" (Béneker 2018: 11, her italics). The fifth type is "knowledge of knowledge" (Béneker 2018: 11).

Maude's five types of knowledge are said to be necessarily general, but they may help to guide teachers when they are selecting and evaluating the geography content to be taught (Maude 2018: 7). However, Maude (2016: 75; Maude 2017) has suggested that his typography should not be used as a list of what to teach. Moreover, Lambert (2016) has argued that there is no need to list concepts or definitions that are powerful, because there is a risk that this information may be used too literally, to select content to be taught or to design the aims of school geography (see also Lambert *et al.* 2015; Uhlenwinkel *et al.* 2017). Therefore, Maude (2017, 2018) suggests that his typology is suitable for identifying the types of geographical knowledge that enable students to gain intellectual power and help students to "progress well beyond factual knowledge to higher levels of thinking" (Maude 2017: 38). The same suggestion has been made by Béneker and Van Der Vaart (2020: 228), who argue that by combining abstract ideas with concrete facts, as well as with knowledge about how to do geographical research, "geographical knowledge has great potential in helping people to develop their opinions in a well-substantiated way."

Moreover, Béneker and Van Der Vaart (2020: 225) note that Maude's five knowledge types consist of knowledge components that can be found at all levels of abstraction and explanatory power, and that a prerequisite of powerful geographical knowledge is the making of combinations among various types of knowledge. They present a "knowledge curve" whereby various types of knowledge are combined and related, resulting in and perhaps even defining powerful thinking (Béneker & Van Der Vaart 2020: 224). Additionally, the importance of moving between different types of knowledge has been advocated by Vernon (2020). It is acknowledged (Béneker & Van Der Vaart 2020: 229; see also Maude 2017) to be important that students should learn to use knowledge and "to be conscious and mindful about their thinking processes" (Bednarz 2019: 525), because even when students learn powerful knowledge, they may not be able to apply that knowledge in real-life situations.

2.2 The revised version of Bloom's taxonomy: thinking skills and knowledge dimensions

Bloom's taxonomy was originally presented by Benjamin S. Bloom in 1956. It was revised by Anderson and Krathwohl in 2001 (Anderson *et al.* 2014). Krathwohl (2002: 212) describes the taxonomy as "a framework for classifying statements of what we expect or intend students to learn as a result of instruction." Teaching is intentional (because it is always for some purpose) and reasoned (i.e. teachers teach their students material they judge to be worthwhile), and therefore objectives are an important part of teaching—they answer the "what" and "why" questions of teaching (Anderson *et al.* 2014: 3). Anderson *et al.* (2014: 15–17) argue that the taxonomy is designed to work with the educational objectives that form the basis of curriculum. However, there are also global objectives, which are broad in scope and are used to provide a vision of future education, as well as narrower instructional objectives that inform the design of classroom teaching (Anderson *et al.* 2014: 15–17). It is important to differentiate educational objectives from instructional objectives, in order to avoid a negative impact on student learning (Anderson *et al.* 2014: 233). By this Anderson *et al.* (2014) mean that if the emphasis is on instructional objectives, students may prefer to perform the activity per se rather than learning from the activity. However, it is acknowledged that not all learning outcomes "can, should, or must be stated as a priori objectives" and that "not all students learn the same things from the same instruction even when the intended objective is the same" (Anderson *et al.* 2014: 21). Additionally, the instructional objectives should be in line with the assessment, in order to ensure that the assessment captures evidence of the learning that has happened. The nonalignment of objectives and assessments may lead to underestimates of the effectiveness of the instruction (Anderson *et al.* 2014: 233). However, Torrance (2011) notes that not all student learning and educational objectives can or should be assessed.

Therefore, the taxonomy can be used to provoke discussion about the planning and delivery of learning aims (learning questions) and instructions (instruction questions) and the design of assessment tasks (assessment questions), and to ensure that the instructions and assessments are in line with the educational objectives (alignment questions) (Anderson *et al.* 2014: 6, 256). Additionally, Airasian and Miranda (2002: 253–254) state that the taxonomy table can be used to analyze nationwide assessments and to determine the kind of cognitive processes and knowledge types on which we should focus. Therefore, the taxonomy has often been used to analyze curriculum objectives and test items (Krathwohl 2002: 213).

The revised taxonomy, named the "taxonomy table," is two-dimensional, and it includes cognitive processes and knowledge dimensions. The former comprises six domains of cognitive processes—*remembering*, *understanding*, *applying*, *analyzing*, *evaluating*, and *creating*—while the latter consist of four domains of knowledge: *factual, conceptual*, *procedural*, and *metacognitive* knowledge (Anderson *et al.* 2014: 4–5). Anderson *et al.* (2014: 14) use the term "cognitive process" because they focus on the intended learning outcome, i.e. what they want students to learn, rather than on how they expect students to demonstrate their learning. Additionally, they choose to use the term "knowledge" because, for them, knowledge refers to the changing nature of disciplines and therefore to the knowledge that is accepted within the discipline (Anderson *et al.* 2014: 13).

The categories in the taxonomy are hierarchical, but they also overlap (Krathwohl 2002: 215). They form a continuum where the cognitive complexity increases from the least (*remembering*) to the most complex cognitive processes of *evaluating* and *creating*, and from concrete (*factual*) to abstract (*metacognitive*) knowledge (Anderson *et al.* 2014: 4–5). The cognitive process categories of *understanding* and *analyzing* are interrelated with the more complex process categories of *evaluating* and *creating*, and therefore *analyzing* is seen as an extension of *understanding* as well as a prerequisite for *evaluating* (and *creating*) (see Anderson *et al.* 2014). Usually, but not always, there is a link between the knowledge types and cognitive processes: *factual* knowledge is *remembered*, *conceptual* knowledge is *understood*, and *procedural* knowledge is *applied*, while the more complex cognitive processes of *analyzing*, *evaluating*, and *creating* can connect to all kinds of knowledge. However, the most abstract knowledge, *metacognitive* knowledge, is expected to be used by all students to enhance their learning (Anderson *et al.* 2014: 239–241).

The first three cognitive processes can be called lower-order cognitive skills, while the last three can be called higher-order cognitive skills (e.g. Tikkanen & Aksela 2012; Zoller & Pushkin 2007). Additionally, as in this thesis, they can be called lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS) (see e.g. Zoller & Pushkin 2007). It is acknowledged that there are some differences between cognitive skills and thinking skills (see Zoller & Pushkin 2007), but the main point is that higher- and lower-order skills in thinking or cognition are distinguished. Moreover, it should be said that the division between LOTS and HOTS is contested: sometimes remembering is said to be the only lower-order thinking skill (see e.g. Anderson *et al.* 2014). LOTS measure aspects such as students' ability to remember or understand knowledge or to solve routine problems, whereas HOTS relate to areas such as the ability to select and organize knowledge for analysis, solve real-life problems, and think critically (e.g. Tikkanen & Aksela 2012; Zoller & Pushkin 2007). When students are dealing with HOTS, they cannot rely solely on memory (Anderson *et al.* 2014: 71), and teachers must "assume a less direct role in facilitating student learning" (Anderson 2005: 110).

The more complex cognitive processes, HOTS, have wide applicability, meaning "they hold the keys to the transfer of learning and problem solving" (Anderson *et al.* 2014: 235). Krause *et al.* (2021: 11) argue:

> "It is only through higher order thinking tasks that students learn to apply complex ideas on their own, relate them to exemplary materials, structure their ideas, build up their argumentation and, by doing this, produce valid texts." (Krause *et al.* 2021: 11)

Anderson *et al.* (2014: 235) suggest that by doing activities that require the use of HOTS, students are more likely to make connections between different elements of knowledge. It is therefore suggested that to enhance meaningful learning, teaching and learning should focus on HOTS and develop students' metacognition skills (see Airasian and Miranda 2002; Bijsterbosch *et al.* 2017; Krathwohl 2002). Additionally, Kumpas-Lenk *et al.* (2018) propose that when learning outcomes are designed to demand higher-order thinking, students are more engaged, motivated, and satisfied with their studies. However, Stes *et al.* (2012) note that even if the learning process is designed to target HOTS, students may not produce their answers at the same level (see also Anderson *et al.* 2014: 21).

Anderson *et al.* (2014: 259) note that the taxonomy should be seen as an "abstraction of reality that simplif[ies] in order to facilitate perceptions of underlying orderliness." The value of the taxonomy lies in its applicability. In the field of geography education, many researchers have examined the application of the revised version of Bloom's taxonomy over the years. Additionally, the taxonomy has been applied in the field of science education, in biology (see e.g. Neiro & Johansson 2020; Zheng *et al.* 2008), chemistry (see e.g. Karamustafaoğlu *et al.* 2003; Tikkanen & Aksela 2012; Tsaparlis & Zoller 2003; Zoller & Pushkin 2007), and mathematics (see e.g. Radmehr & Drake 2018). To name just a few studies in the field of geography education, Bijsterbosch *et al.* (2017) and Wertheim and Edelson (2013) have examined geography assessment questions. The former analyzed internal school-based geography examinations in prevocational secondary education in the Netherlands, while the latter examined classroom and large-scale assessments in kindergarten to 12th grade classrooms in the US. Both studies concluded that LOTS were emphasized—mainly *remembering* and *understanding factual* and *conceptual* knowledge—whereas the most complex cognitive skills were rarely evaluated. In the Finnish context, Kuisma and Nokelainen (2018) examined how the progressive inquiry method might improve Finnish middle and upper secondary school geography students' cognitive learning results, using the revised version of Bloom's taxonomy to design pre- and post-test questions.

Moreover, geography textbook questions have been examined by Yang (2013), Yang *et al.* (2015), Yasar (2009), Krause *et al.* (2017, 2021), Şanli (2019), Jo and Bednarz (2009), and Mishra (2015), for example. Yasar (2009), Şanli (2019), Yang (2013), and Yang *et al.* (2015) conclude that questions requiring higher-order thinking increased in textbooks after national educational reforms in Turkey and China. However, Yang (2013: 62) note that the majority of questions still focus on lower-order thinking, and the changes were small, although they do indicate a new direction toward higher levels of thinking. Krause *et al.* (2017: 256; see also Krause *et al.* 2021) conclude that a large number of tasks in Dutch textbooks appeal to lower-order thinking, whereas German textbooks contain fewer tasks but more of them aim for higher-order thinking. Jo and Bednarz (2009) analyze textbook questions in the US, and Mishra (2015) examines textbook questions in India, both using a geospatial thinking taxonomy, which is an application of Bloom's taxonomy. Both studies conclude that remembering and recalling information is emphasized in the textbooks, and only 13% (Jo & Bednarz 2009: 9) or 22% (Mishra 2009: 123) of questions require evaluation or creation.

Additionally, there has been a great deal of research on how digital technologies can enhance students' geographical thinking skills and knowledge, especially higher-order thinking (see e.g. Collins 2018; De Miguel González & De Lázaro Torres 2020; Favier & Van Der Schee 2014; Kim & Bednarz 2013; Liu *et al.* 2010; Palladino & Goodchild 1993; Van Der Schee *et al.* 2010). Some geography educationists (see e.g. Collins 2018; De Miguel González & De Lázaro Torres 2020; Favier & Van Der Schee 2014; Liu *et al.* 2010; Palladino & Goodchild 1993) note that digital technologies, including digital representations such as digital maps and GIS, may be suitable for enhancing students' HOTS. For example, combining "different sources such as digital maps, photos and video simultaneously" with the help of modern technology offers new possibilities for teaching and learning (Van Der Schee *et al.* 2010: 7).

Thus, as previous research reveals, the taxonomy has been widely applied during recent years in different geographical contexts, and it can be used as an analytical tool. Anderson *et al.* (2014: 7) argue that by looking at the curriculum through the lens of the taxonomy, teachers can gain a more complete understanding of the curriculum, and this can guide their curriculum decisions. However, they note that the taxonomy works as a guide when teachers work as curriculum implementers, but when teachers are seen as curriculum makers, the taxonomy should be regarded more as a heuristic framework (Anderson *et al.* 2014: 11). Additionally, the taxonomy can be seen as

> "a common way of thinking about and common vocabulary for talking about teaching that enhances communication among teachers themselves and among teachers, teacher educators, curriculum coordinators, assessment specialists, and school administrators" (Anderson *et al.* 2014: 11).

2.3 Connecting powerful geographical knowledge with thinking skills and knowledge dimensions

Next, I will combine the theoretical perspectives explained above by focusing on Maude's powerful geographical knowledge types and cognitive and knowledge dimensions of the revised version of Bloom's taxonomy. These two theoretical perspectives are ways to see geography (see Anderson et al. 2014; Béneker & Van Der Vaart 2020; Hordern 2018), and they share some similarities, although their origins lie in different theoretical fields.

The cognitive categories in the revised version of Bloom's taxonomy, and the types of powerful geographical knowledge, are hierarchical to some extent, but also overlapping. It is argued that all cognitive categories, especially the categories of higher-order thinking, are needed for learning to be meaningful (see e.g. Airasian & Miranda 2002; Anderson *et al.* 2014; Bijsterbosch *et al.* 2017), and all the knowledge types must be used together so that students can access powerful geographical knowledge (see e.g. Béneker & Van Der Vaart 2020; Bouwmans & Béneker 2018). Moreover, in both cases, knowledge is seen as a continuum from concrete to more abstract knowledge (Anderson *et al.* 2014; Béneker & Van Der Vaart 2020). Both emphasize the need for teachers' expertise, and both ways of seeing geography can be used by teachers to choose the content to be taught in schools (see e.g. Anderson *et al.* 2014; Lambert & Hopkin 2014; Lambert *et al.* 2015; Maude 2018; Muller & Young 2019). However, it is said that even if educators design learning outcomes to target HOTS, or use powerful geographical knowledge in their teaching, students may not always learn this kind of knowledge (Anderson *et al.* 2014; Béneker & Van Der Vaart 2020; Stes *et al.* 2012).

The suggested connections between the two perspectives are presented in Table 3, which I examine in the following paragraphs in depth. I follow the structure of the revised version of Bloom's taxonomy, as I start from the lowest cognitive process category, *remembering*, and conclude with the highest category, *creating*. In each cognitive category, I explain in more depth what it means in the context of geography education, and how it connects with the knowledge dimensions of the taxonomy as well as with Maude's typology of powerful geographical knowledge. However, it is important to note that the combination of these two cannot be used as a strict, hierarchically structured categorization framework, because the boundaries between the categories are overlapping and to some extent blurred: between powerful geographical knowledge types 5 and 2, there lies *understanding*; between types 2 and 4, there lies *analyzing*; between types 4 and 3, there lies *evaluating*. Nonetheless, I suggest that if we use the cognitive and knowledge dimensions of the revised version of Bloom's taxonomy, it is possible to make visible the geographical thinking and knowledge that give students intellectual power and might therefore be powerful. Additionally, this way of seeing geography reveals whether there is a dominance of one type or a lack of another type. Thus, we can think about the consequences that the absence or dominance of some knowledge types or thinking categories might have for geography education (see also Bouwmans & Béneker 2018).

It should be noted that the most abstract knowledge dimension, *metacognitive* knowledge, is not presented as a separate knowledge domain in Table 3, because it is expected to be used with all cognitive processes and in all learning (Anderson *et al.* 2014: 44, 239–241). The other three knowledge dimensions entail forms of subject matter developed through consensus, while *metacognitive* knowledge is knowledge about cognition and about oneself in relation to various subject matters (Anderson *et al.* 2014: 44). Thus, *metacognitive* knowledge includes the idea of strategic knowledge (knowing how to read geographical information), knowledge about cognitive tasks (knowing how to construct a geographical answer, e.g. recalling versus critiquing), and self-knowledge (knowing one's own weaknesses and strengths) (see Anderson *et al.* 2014: 55–60).

Table 3. The connections between powerful geographical knowledge and the cognitive and knowledge dimensions of the revised version of Bloom's taxonomy.

Types of powerful geographical knowledge (Maude 2018)	**Cognitive thinking skills in the revised version of Bloom's taxonomy** (based on Anderson *et al.* 2014)	**Knowledge dimensions in the revised version of Bloom's taxonomy** (based on Anderson *et al.* 2014)
5) "Knowledge of the world" (teaching about unfamiliar places and helping to understand the world's diversity).	1) *Remember*: recognize geographical symbols from the material presented; remember simple facts, and recall concepts and pictures from long-term memory. 2) *Understand*.	*Factual*: demonstrate knowledge of simple facts, specific details, concepts, elements, or phenomena. *Conceptual*.
2) "Knowledge that provides students with powerful ways of analyzing, explaining, and understanding" (analytical methods when analyzing relationships between phenomena; relative locations and explanatory power; generalizations from phenomena).	2) *Understand*: describe different geographical phenomena by listing and explaining concepts; give examples, compare, and classify geographical concepts; infer and explain how geographical processes work from the information presented; translate and summarize information from a given representation into a different form. 3) *Apply*: apply simple geographical models or theories to explain different phenomena; apply knowledge about geographical methods, e.g. draw a map from the given material. 4) *Analyze*.	*Conceptual*: demonstrate knowledge of causalities between concepts by connecting things; explain theories, models, structures, classifications, categories, principles, and generalizations with the help of examples. *Procedural*: use knowledge of geographical methods and criteria to use methods in certain situations; demonstrate an understanding of the grounds of the specific method and be able to use it in a real-life situation.
4) "Knowledge that enables young people to follow and participate in debates on significant local, national, and global issues" (ability to follow and participate in public debates).	4) *Analyze*: select relevant information from the material presented, and organize it to form a coherent conclusion such that causalities between phenomena or concepts are visible; analyze the values and attitudes in the material presented. 5) *Evaluate*.	*Conceptual*. *Procedural*.
3) "Knowledge that gives students some power over their own geographical knowledge" (how to be a critical and independent thinker, geographical reasoning, how knowledge is created, tested, and evaluated).	5) *Evaluate*: draw conclusions and judgments from the given phenomena based on known criteria and standards, by justifying views; be critical, i.e. critical thinking is visible.	*Conceptual*. *Procedural*.
1) "Knowledge that provides 'new ways of thinking about the world'" (for example, if students change their thinking about their relationship with the environment, it could change their behavior) (the most powerful component).	6) *Create*: put elements together in such a way that it forms a coherent whole that offers a new way to see phenomena, and hypothesize how the phenomena are going to proceed—i.e. by answering a "what then?" question; show creative and holistic thinking by reorganizing elements.	*Conceptual*. *Procedural*.

2.3.1 Remember (and understand) knowledge of the world

The lowest cognitive category in the revised version of Bloom's taxonomy, *remembering*, concentrates on recalling and recognizing discrete elements (Anderson *et al.* 2014), such as geographical symbols from the material presented, or simple facts, concepts, or pictures from long-term memory. The category of *remembering* is usually combined with *factual* knowledge, which consists of facts, terms, and concepts, which are separate parts of information and form the basic elements that students must know in order to be acquainted with the discipline (Anderson *et al.* 2014: 42, 45). Remembering knowledge is a prerequisite for other cognitive processes, because the recognized and recalled information is often used in more complex tasks (see Anderson *et al.* 2014: 66, 70).

In my understanding, remembering factual knowledge can be combined with powerful geographical knowledge type 5, knowledge of the world (see Maude 2018). Learning to remember factual knowledge about the world takes students beyond their own experience; it teaches the diversity of environments, cultures, societies, and economies (Maude 2015: 23). Additionally, it relates to the acquisition of knowledge about world's places and regions (Bouwmans & Béneker 2018: 450). This knowledge is closest to the popular view of geography, and it may be referred to as students' "general knowledge" (Béneker & Palings 2017: 80; Bouwmans & Béneker 2018; see also Fargher 2018).

However, powerful geographical knowledge type 5 additionally includes understanding the characteristics of unfamiliar places (Maude 2018: 183), and therefore type 5 also overlaps to some extent with the cognitive category of *understanding*. Béneker and Palings (2017) have acknowledged some problems with distinguishing between Maude's knowledge types 2 and 5. Bouwmans and Béneker (2018) argue that type 5 is about learning facts about regions, while type 2 is about using regions or facts as examples to illustrate concepts or theories. This supports my interpretation that type 5 is mainly combined with remembering factual knowledge, whereas type 2 mainly indicates *understanding* and *applying conceptual* and *procedural* knowledge, and to some extent *analyzing* (explained in more depth next). Moreover, Maude's types 2 and 5 are referred to as the vocabulary of geography (Béneker & Palings 2017), while the cognitive processes of *remembering*, *understanding*, and *applying* are called LOTS, which are a prerequisite for the more complex cognitive processes, HOTS.

2.3.2 Understand and apply (and analyze) analytical and explanatory concepts and generalizations

The cognitive process of *understanding* is the largest and most comprehensive category. It includes the construction of connections between prior and new knowledge (Anderson *et al.* 2014: 70), and it therefore differs from remembering. In my understanding, when students understand knowledge, they can describe different geographical phenomena by listing and explaining concepts, give examples, compare and classify geographical concepts, infer and explain how geographical processes work from the information presented, or translate and summarize information from a given representation into a different form (see also Anderson *et al.* 2014: 70). Understanding therefore includes many subcategories that are all important parts of geography education, and they have huge potential to enhance the learning of geography (see also Bijsterbosch *et al.* 2017: 18). Thus, Krause *et al.* (2021: 12) suggest that this category should be named the "use of thinking strategies." The category of *understanding* is usually connected to *conceptual* knowledge, which consist of terms, facts, and concepts that are connected to form a larger system of ideas or are transferred to learners' everyday experience (Anderson *et al.* 2014: 42); it thus differs from *factual* knowledge.

The last cognitive process of lower-order thinking is *applying*. In my understanding, *applying* is seen as the capability to use geographical procedures to solve familiar and unfamiliar exercises and problems (see also Anderson *et al.* 2014: 77). Therefore, students use their prior knowledge of geographical models, theories, methods, or procedures to solve and explain geographical phenomena. The category of *applying* is often connected to *procedural* knowledge, which is understood as knowledge of how to do something subject- or discipline-specific (e.g. skills, methods, and techniques) (see Anderson *et al.* 2014).

I suggest that the cognitive processes of *understanding* and *applying* are intertwined with powerful geographical knowledge type 2, "knowledge that provides students with powerful ways of analyzing, explaining, and understanding" (see Maude 2018). Knowledge is said to be powerful if it enables students to explain and understand phenomena with the help of analytical and explanatory concepts and generalizations (Maude 2018: 182; see also Béneker & Palings 2017). This includes comparing places, investigating phenomena, identifying factors that have an influence, making connections between concepts, seeing the interconnections between places, or understanding relative locations (see Maude 2015; see also Fargher 2018), as well as making sense of a lot of information by generalizing it (Maude 2017: 33).

There are some risks of misunderstandings, because generalization includes the idea that generalizations can be used to predict and think about futures (Maude 2015), and therefore this could be connected to hypothesizing, i.e. to the category of *creating*. However, in this context, I understand the use of generalizations for prediction to be part of the category of *understanding*, because if students use their understanding of geographical processes to make predictions, they are drawing logical conclusions and forming causal relationships regarding what might and possibly will happen because of some phenomenon. This indicates that the students can infer (i.e. predict), which is a subcategory of understanding (Anderson *et al.* 2014).

Knowledge type 2 includes the "method of analyzing spatial distribution of a phenomenon" as well as causal relationships (Maude 2018: 182), and therefore type 2 is to some extent also connected to the category of *analyzing*. Béneker and Palings (2017: 86) note that it is difficult to make a distinction between powerful geographical knowledge types 2 and 4. I argue that they do overlap to some extent, but we can explain the difference by combining knowledge type 4 with the cognitive category of *analyzing*, as I will explain next.

2.3.3 Analyze (and evaluate) knowledge to enable young people to engage in public debates

I understand the category of *analyzing* to be a continuation of *understanding*, because it requires students to process and organize knowledge from different sources (see Anderson *et al.* 2014: 79). However, the difference between *analyzing* and *understanding* is as follows. In *understanding*, the knowledge is given, and it should only be understood from the material presented; in *analyzing*, the knowledge is not given but must be compiled from many sources. This means that when students analyze, they select relevant information from the material presented, decide on the suitable information to use in a given situation, and reorganize it to form a coherent conclusion where the causalities between concepts and phenomena are visible (see Anderson *et al.* 2014: 79). Additionally, *analyzing* refers to attributing, i.e. seeing the values and attitudes presented in the material (see Anderson *et al.* 2014: 79). In my understanding, all knowledge dimensions are related to the category of *analyzing*; however, *conceptual* and *procedural* knowledge is emphasized.

Thus, the first cognitive process of the HOTS, *analyzing*, is combined with knowledge type 4, which "enables young people to follow and participate in debates on significant local, national, and global issues" (see Maude 2018). This knowledge type indicates that geography examines current issues (such as earthquakes, tsunamis, climate change, development, or water and energy security) on different scales (Béneker & Palings 2017: 80; Fargher 2018: 8; Maude 2017: 36) by combining the natural and social sciences and the humanities (Béneker & Palings 2017: 80; Maude 2017: 36). My interpretation is that teaching current issues and enabling students to follow and participate in debates is not possible without teaching students to analyze, i.e. to understand causalities, organize knowledge, and determine the point of view or values in the presented information.

Additionally, knowledge type 4 refers to some extent to the cognitive category of *evaluating*, because when using type 4 knowledge, students need to form informed opinions about current debates and therefore engage with type 3 knowledge (see Maude 2015). In other words, the cognitive process of *evaluating* is combined with type 4 when the evaluation of causes or explanations is needed but there is no need to make judgments or to evaluate the knowledge or its origins (because in that case, it would be connected to knowledge type 3).

2.3.4 Evaluate knowledge of knowledge

The cognitive process category of *evaluating* is an extension of analyzing, because students are expected to make justifiable arguments and draw firm conclusions based on the analysis they have conducted beforehand. In other words, in the process of *evaluating*, students are drawing conclusions and making judgments by using "standards of performance with clearly defined criteria" (Anderson *et al.* 2014: 83), and therefore they are checking or critiquing something from a certain perspective, i.e. critical thinking is required. Thus, not all judgments made by students are understood to be evaluative. Evaluative thinking is connected to *conceptual* and *procedural* knowledge, with a slight emphasis on *procedural* knowledge, in my understanding.

The cognitive process of *evaluating* is connected to knowledge type 3, which is about answering the question "how do you know?" (Maude 2015: 23; see also Béneker & Palings 2017). Knowledge type 3 engages students to

> "evaluate claims about knowledge and gives them an ability to be independent thinkers able to be critical of the opinions of others" (Maude 2017: 36).

This type of knowledge additionally refers to "how to find knowledge" (Maude 2015: 73). Thus, students need to learn the epistemic tools of the discipline, i.e. they have to know the ways in which geographical knowledge is created, evaluated, and tested (Maude 2017: 36). Moreover, students need to learn geographical reasoning (Maude 2018: 183), in which consistent and logical thinking leads to different types of conclusions (e.g. explanations, predictions, statements) on the basis of explained assumptions and arguments (see Hooghuis *et al.* 2014: 244). Despite its importance, type 3 knowledge is seen as an underdeveloped area of geographical education (Maude 2017: 23; see also Béneker & Palings 2017).

2.3.5 Create new ways of thinking about the world

The most comprehensive cognitive process category is *creating*, in which students solve a given problem by planning how to do it, generating different outcomes, or producing a real solution (Anderson *et al.* 2014: 85). Creating requires students to put elements together, i.e. to synthesize scattered material into an organized whole that offers a new way to see the phenomenon. It also requires them to hypothesize how the phenomenon might proceed, i.e. to answer a "what then?" question (this is not possible by understanding or inferring from the material—see my explanations above of *understanding* and knowledge type 2). Sometimes writing is seen as producing, i.e. creating something (Anderson *et al.* 2014: 85; see also Tikkanen & Aksela 2012). However, in my understanding, creating requires a deep understanding that goes beyond the student's own experience and knowledge (see Anderson *et al.* 2014: 85), and therefore not all writing can be seen as creating. Creative, holistic thinking and the making of syntheses are part of creating knowledge. All the knowledge dimensions are embedded in the cognitive process category of *creating*, with the emphasis on *conceptual* and *procedural* knowledge.

Creating knowledge is intertwined with powerful geographical knowledge type 1, "new ways of thinking about the world" (see Maude 2018). Geography's major concepts—such as place, space, environment, and interconnection—shape how we perceive the world (Maude 2017: 30; see also Béneker & Palings 2017; Fargher 2018), and therefore understanding geographical ways of thinking may even "change students' perceptions, values and understandings" (Maude 2017: 30). Maude (2018: 185) claims that this is the most powerful component of his typology, and it influences the ways in which we explain, ask questions, and address geographical phenomena (Maude 2015: 73). Knowledge type 1 requires a considerable amount of knowledge of geography as a basis on which to understand its ways of thinking (Maude 2015: 20). Thus, in my interpretation, knowledge type 1 refers to the way geographers see the world, formulate questions, examine the world around us (i.e. methods of analysis), and form new knowledge about geographical phenomena by producing possible explanations and outcomes. This requires the creation of knowledge, where planning, producing, and solving geographical problems is emphasized. Additionally, this way of seeing the world requires holistic thinking, which should guide students to think broadly and deeply when investigating geographical phenomena or proposing holistic explanations for their investigations (Maude 2017: 31).

3 Research design and process

In this part of the thesis, I present the research process, which has been nonlinear, continuous, and dynamic. First, I discuss the research approach taken in this thesis, which is qualitative research methodology. Second, I present the multiple research materials and methods, together with the research process used in this thesis.

3.1 Research approach

According to Lichtman (2013)

> "Research is a process by which we seek answers to questions. The kinds of questions and the ways we seek answers are up to the researcher." (Lichtman 2013: 33)

Willig (2014) argues that researchers hold different kinds of assumptions about

> "what is important and what is worth paying attention to, as well as what can be known about and through the data." (Willig 2014: 137)

In other words, the ontological and epistemological underpinnings acknowledged by the researcher affect the research questions asked and the methods used.

One overarching dichotomy in how knowledge and research are understood is the division between quantitative and qualitative research. Usually, quantitative research is described as seeking correlations and causalities and testing hypotheses (see e.g. Lichtman 2013: 15), i.e. it is research that seeks to explain and identify causes, factors, or correlations in order to generate knowledge to predict the future (Biesta 2010: 104). On the other hand, qualitative research seeks to understand and foreground qualities (see e.g. Lichtman 2013: 15), i.e. it is research that seeks to understand and interpret phenomena (Biesta 2010: 104). However, several researchers have suggested that we should abandon the binary understanding of qualitative and quantitative research and combine elements from both (see e.g. Creswell 2010: 51; Lichtman 2013: 104) because they complement each other, allowing the "researcher to draw conclusions that would not be possible using either method alone" (Maxwell & Mittapalli 2010: 148). This is called mixed methods research (Creswell 2010: 51).

According to Elwood (2010: 106), "mixed methods research contests quantitative-qualitative or inductive-deductive divisions and disrupts efforts to constrain epistemological diversity." Usually, mixed methods research refers to the use of both quantitative and qualitative data as well as multiple methods of analysis (see Lichtman 2013: 16). However, some researchers deploy mixed methods research utilizing only quantitative or only qualitative data, which is then analyzed by using both quantitative and qualitative types of analysis (see Onwuegbuzie *et al.* 2007). Lichtman (2013: 16) calls this kind of research multimethod research rather than mixed methods research. Moreover, Creswell (2010: 51) suggests that mixed methods can be understood as a method approach rather than a methodology approach, and therefore mixed methods is sometimes argued to be one form of qualitative research methodology (see Cheek 2011: 264). In other words, if the original data is qualitative, then the research process as a whole is guided by qualitative methodology. Both the qualitative and the quantitative methods used gather information that is interpreted from the viewpoint of qualitative methodology, i.e. from the same epistemological and ontological principles.

The aim of this thesis—*to widen our understanding of thinking skills and powerful knowledge in the context of geography education*—is approached through qualitative research methodology. Qualitative research is said to provide description, understanding, and interpretation of a phenomenon (see e.g. Lichtman 2013: 17). Denzin and Lincoln (2018) provide a generic definition of qualitative research:

> "Qualitative research is situated activity that locates the observer in the world. Qualitative research consists of a set of interpretative material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense or interpret phenomena in terms of the meanings people bring to them." (Denzin and Lincoln 2018: 10)

According to Lichtman (2013: 17–22), qualitative research provides holistic in-depth description and interpretation by studying things as they exist through thick description. MacKian (2010: 361) argues that qualitative researchers have an interpretivist epistemology: "the belief that we can only know the world through examining interpretations of it." For qualitative researchers, the world is not fixed: instead, multiple interpretations and constructions of reality exist, and reality is in flux and open to change over time (Merriam 2002b: 3–4). Moreover, Merriam (2002b: 4) argues that interpretations are dependent on context and time, while Denzin and Lincoln (2018: 22) argue that qualitative interpretations are constructed (see also Lichtman 2013: 21). The researcher acts as a primary instrument for data collection and data analysis in qualitative research (Merriam 2002b: 5), and "all information is filtered through the researcher's […] experience, knowledge, skill, and background" (Lichtman 2013: 21). Therefore, according to Lichtman (2013: 21), all the interpretations, understandings, and descriptions made in qualitative research are based on the researcher's ability to collect, organize, and integrate research data.

To make interpretations, qualitative researchers use different kinds of interpretative methods and practices, each of which makes the world visible in a different way, and therefore there is usually a commitment to use more than one interpretative practice in any research (Denzin & Lincoln 2018: 10). Usually, qualitative researchers deal with the interpretation of various types of written or spoken material (Willig 2014: 137): observation, interviews, surveys, and archival documents, for example (Cohen *et al.* 2011: 537). Additionally, all forms of logical reasoning—induction, abduction, and deduction (Reichertz 2014: 123)—are applicable in qualitative research. In the inductive i.e. data-driven (Tuomi & Sarajärvi 2018) or conventional approach (Hsiesh & Shannon 2005), the researcher starts the analysis process from the data and uses the data to gain an understanding of the phenomenon (Lichtman 2013: 19). In the deductive (Lichtman 2013: 19) i.e. theory-driven (Tuomi & Sarajärvi 2018) or directed approach (Hsiesh & Shannon 2005), an already-known theory guides the analysis process, and the theory is tested (Reichertz 2014: 127).

However, purely inductive logic has been contested by many researchers because research is bounded by the epistemological and ontological assumptions made by the researcher (see Saaranen-Kauppinen & Puustniekka 2006; Tuomi & Sarajärvi 2018). Thus, in-between the inductive and deductive approach, there lies the abductive i.e. theory-orientated approach (Tuomi & Sarajärvi 2018). According to Reichertz (2014: 126), abduction starts from the empirical data (as in induction), but the researcher's theoretical understanding guides the analysis process, although the aim is not to test theories or hypotheses (as in deduction). In the abductive approach, a prior theory can be extended with new knowledge (Saaranen-Kauppinen & Puustniekka 2006) as the researcher moves back and forth between the data and the theory (Tuomi & Sarajärvi 2018: 110). Tuomi and Sarajärvi (2018: 113) argue that the abductive approach can be categorized as an inductive or a deductive approach, and it is up to the researcher when to introduce the theory into the process of analysis. They explain that if the theory is included early, at the beginning of the process, the method is close to the deductive approach, whereas if the theory is introduced at the end of the process, the method is close to the inductive (Tuomi & Sarajärvi 2018: 113).

Lichtman (2013: 9) argues that there is no single way of doing qualitative research. She explains that some researchers design their research to fit a particular type of qualitative research, while others approach their research "from more eclectic mode," referred to as a "generic approach to qualitative research" (Lichtman 2013: 114–115). Merriam (2002b: 6–7) describes this approach as "basic interpretive qualitative study" in which the researcher "seeks to discover and understand a phenomenon, a process, the perspectives and worldviews of the people involved," rather than focusing on culture, studying a single unit, or building a grounded theory, for example (see Lichtman 2013: 115). Ellingson (2009, 2013) describes the field of qualitative methodology as a continuum: on the far left is the artistic/interpretive paradigm (e.g. autoethnography, performance); on the far right is realist/positivist social science; in the middle lie the vast social constructionist or postmodernist-influenced perspectives. These three categories are not mutually exclusive, and there are no firm boundaries but "infinite possibilities for blending and moving" within the continuum (Ellingson 2009: 6).

Therefore, I position myself as a researcher, and this thesis, in the middle ground of Ellingson's (2009, 2013) continuum, and additionally in Lichtman's (2013) generic approach to qualitative research. My aim is to construct situated knowledge, generate description and understanding, and draw out pragmatic implications for practitioners, rather than to discover the objective truth or to generate art or personal truths. My background as a geography teacher and teacher educator has guided my approach toward a practical orientation. I feel that I have been able to utilize the knowledge gained through this research process in my teaching. At the same time, as a researcher, I have been able to use my knowledge and skills as a geography teacher while conducting this research. Thus, I acknowledge that my "personal biography" (Denzin & Lincoln 2018: 16) has affected the research process conducted for this thesis.

The research materials used are qualitative in nature: in-depth interviews and concept maps in Article I, and written documents (curriculum documents and test questions) and students' answers in Articles II and III. However, this thesis reaches out from the middle of Ellingson's (2009, 2013) continuum toward the right-hand end (realist/positivist social science) rather than the left (artistic/interpretative), mainly because of its use of a qualitative content analysis method (in Articles I, II, and III), quantification (in Articles II and III), and statistical analysis methods (in Article II). Thus, this thesis has characteristics of the mixed method approach (Creswell 2010; see also Elwood 2010), or more accurately the multimethod (Lichtman 2013) approach.

3.2 Multiple materials and methods

The research process for this thesis has been somewhat traditional qualitative research, because it has been nonlinear, dynamic, fluid, and ever-changing (see Lichtman 2013: 17–18, 23–24). The research questions examined in this thesis evolved during the research process, and as a researcher I moved back and forth between data-gathering and data analysis over the years. According to Elwood (2010: 100; see also Cope 2010: 32), "geographers have long asked research questions that require investigating multiple data sources," while Cope (2010: 35) argues that the integration of research methods is about a way of seeing the world as a geographer, a way to weave together information from multiple sources. My background as a geographer guided me to approach my research objective—*to examine geography's potential to engage students in thinking skills and powerful geographical knowledge*—with multiple materials and methods in order to understand the research aim comprehensively. Elwood (2010: 11) talks about triangulation, "an interpretive practice in which researchers examine different data or results in relation to one another." In this thesis, triangulation is used to enrich the understanding of the researched phenomenon, rather than to validate results.

Despite the multiple materials and methods used, this thesis is guided by the principles of qualitative research methodology explained in the previous section. This means that both the qualitative and quantitative (contingency table and chi-square test) methods used in this thesis are interpreted within a qualitative methodology framework. Biesta (2010: 101) suggests that combining numbers and text does not raise any philosophical or practical problems: numbers and texts are just two forms of information, i.e. representations (see also Onwuegbuzie *et al.* 2007). Additionally, qualitative researchers can use statistics, tables, graphs, and numbers (Denzin & Lincoln 2013: 11–12) as well as frequency counts (Schreier 2014: 173) when analyzing research materials and presenting findings. Table 4 presents the research materials and methods utilized in Articles I, II, and III, on which the empirical part of this thesis is based.

This thesis includes research with human participants. Therefore, I followed the ethical principles laid down for human sciences by the Finnish National Board on Research Integrity (FNBRI 2019). Throughout the research process, I ensured that I followed the two general ethical principles set out by the FNBRI (2019: 8) for all researchers to follow: to respect the dignity and autonomy of human research participants, and to conduct the research so that it does not cause harm to the research participants. The people who participated in this research did so voluntarily and had the right to discontinue their participation at any time. They gave their informed consent to participate in this research and were able to withdraw that consent at any time. However, none of the participants withdrew after the research process had started. Additionally, I ensured that participants received information on the content of the research, and above all on the aims, effects, and potential benefits of the research (see FNBRI 2019: 9–10). Moreover, during the research process, I preserved the anonymity of the human participants. I chose to use numbers for participant identification during the data collection and analysis. Therefore, the identity of the human participants remained entirely confidential, known only to me.

Table 4. Summary of research materials and methods utilized.

Type of data	In-depth interviews and concept maps.	Students' answers in the ME in geography.	Geography test questions in the ME.	LOs in geography curricula in 2003, 2015, and 2019.
Gathered	November 2014 to March 2015; interviews transcribed spring 2015.	Between fall 2016 and spring 2018, under research license from FMEB.	November 2017 and October 2019, from Yle.fi.	Spring 2020, from National Core Curriculum for General Upper Secondary Education 2003, 2015, and 2019.
Description	11 in-service geography teachers from northern Finland. Interviews: total duration approx. 22 hours. Concept maps: 11 in total, A4 size.	800 students' answers to geography test questions: 400 students' answers in the two paper-based tests between fall 2015 and spring 2016; 400 students' answers in the two digital tests between fall 2016 and spring 2017. Result: total 1,585 students' answers to 33 HOTS-type geography test questions.	Total 331 geography test questions from 12 geography tests: six paper-based tests between fall 2013 and spring 2016; six digital tests between fall 2016 and spring 2019. Result: total 413 categorizations.	173 LOs found in three different curricula: 50 LOs from 2003 curriculum; 57 LOs from 2015 curriculum; 66 LOs from 2019 curriculum. Result: total 288 categorizations.
Methods of analysis	Qualitative content analysis, conducted fall 2017.	Qualitative content analysis and quantification, conducted January 2018 (paper-based) and April 2018 (digital).	Qualitative content analysis and quantification, conducted between November 2017 and January 2018, and between August 2019 and October 2019. Statistical analyses: contingency table and chi-square test, conducted March 2020.	Qualitative content analysis and quantification, conducted spring 2020.
Reported and utilized	Article I.	Article III.	Article II.	Article III, except the 2019 curriculum (utilized in this thesis).

3.2.1 Collecting materials

The research materials for this thesis were collected during 2014–2020, at different times and with different methods. The research process started in 2014, when my aim was *to study in-service Finnish upper secondary schoolteachers' conceptions of geography—what kind of geography they currently teach in schools, whether this knowledge is powerful, and if it is, in what way* (Article I). I chose in-depth interviews and concept maps (see Åhlberg 2002) as suitable methods. The data was gathered from 11 in-service geography teachers working in upper secondary schools in northern Finland. The teachers who took part in this research responded to an email I sent to all teachers who worked in upper secondary schools in northern Finland asking them to take part. I acknowledge that these teachers may have been keen to develop and reflect on their teaching and therefore their views may not represent the shared views of all Finnish teachers. Hence, I chose to conduct a case study to reflect on the teachers' conceptions. The group of teachers was heterogeneous at the time of the data-gathering: four of the teachers were male, and seven were female; they were between 32 and 59 years of age; they had between five and 33 years of teaching experience. The national context where the interviews were conducted was full of uncertainty, because the digitalization of the ME and the curriculum reform were in progress.

During December 2014 and at the beginning of February 2015, teachers were asked to produce a concept map on the topic "what is geography?" Afterward, in February and March 2015, I conducted ten individual face-to-face interviews and one online interview. The interviews were recorded for analysis purposes. The purpose of using multiple materials was to gather rich descriptions of teachers' conceptions: the concept maps were gathered first, to guide teachers to consider their own understandings of geography before the interview; the interviews were conducted afterward, to secure the interpretations made from the teachers' concept maps. The individual in-depth interviews were semi-structured, with themes to guide an otherwise free discussion between interviewer and interviewee (see Lichtman 2013: 195–206). Interviewing is an interpretative methodology that aims to produce detailed understandings (McDowell 2010: 158) and descriptions of how interviewees experience their world (Brinkman 2018: 580). However, I acknowledge that the interview is not a dominance-free dialogue, because the interviewer sets the guidelines, agenda, and rules for the conversation (Brinkman 2018: 588). Thus, during the interview process, my presence may have influenced the research material gathered. However, I strived for an equal discussion in which the interviewees' thoughts were central. I wanted to give an opportunity for teachers to reflect on their own work and their relationship to geography.

In fall 2016, the first digital geography test was realized. This was the turning point for my research, as I additionally focused my interest on the geography tests in the ME. I formulated two aims: *to study possible changes in the cognitive processes and geographical knowledge requirements of the Finnish ME in geography during the digitalization process* (Article II), and *to examine students' higher-order cognitive outcomes in geography tests in the ME's paper-based and digital forms* (Article III). To fulfill these research aims, it was necessary to collect data before and after the digitalization in fall 2016. The collection and analysis of these two data sets were intertwined, as I collected and analyzed them simultaneously over the years, moving back and forth with each set of material.

The data-gathering process started in 2016, when I applied for a research license from the FMEB to allow me to use students' answers to geography tests in the ME as research material. The aim was to study the geography tests' transition phase from the paper-based form to the digital form. Therefore, the last two paper-based tests (in fall 2015 and spring 2016) and the first two digital tests (in fall 2016 and spring 2017) were chosen. This data was received from the FMEB in full in spring 2018. It consisted of 400 students' participation in two paper-based geography tests, and 400 students' participation in two digital geography tests. Thus, altogether the research material contained answers from 800 students in four different geography tests in the ME. The students' answers to the paper-based tests were delivered in the original paper format by the FMEB to the Oulu library of the National Archives of Finland. The answers to the digital tests were received in digital form. According to the terms of our research license, the students' answers in the ME were confidential documents. Therefore, it was not possible to present direct quotations from the original students' answers in the findings section of Article III or on this thesis.

Data-gathering continued in 2017 and 2019 with the collection of geography test questions from Yle.fi (a public broadcasting company, see Yle.fi 2021), where they are publicly available. At the time of the data-gathering, altogether six digital geography tests had been released. Therefore, it was natural to include all six digital geography tests (from between fall 2016 and spring 2019) in the data. To enable me to examine possible changes, in addition six paper-based geography tests (from between fall 2013 and spring 2016) were included in the research material. Thus, this data set consisted of 114 assignments with 331 questions (when all the subsections of the assignments were considered) from 12 geography tests in the ME between fall 2013 and spring 2019.

By this point in the research process, I had been studying ME geography test questions, students' answers, and teachers' conceptions of geography. In 2020, I decided to include geography LOs in my study. The geographical skills and competences i.e. geography LOs defined in the National Core Curriculum (FNBE 2003, 2015; FNAE 2019) guide the formulation of geography test questions. Moreover, teachers have a great deal of autonomy in Finland, and the national curriculum is the only official document that guides teachers' work, i.e. teachers follow the LOs defined in the curriculum when planning their teaching.

Thus, I aimed *to evaluate the geography LOs of the Finnish National Core Curriculum for General Upper Secondary School published in 2003 and 2015, in terms of the cognitive and knowledge domains of the revised version of Bloom's taxonomy* (Article III). These two curricula were chosen because they were used in upper secondary schools during the period of my research. For this thesis, I additionally gathered LOs from the 2019 curriculum, so as to be able to look for the future direction of the geography LOs defined in the national curriculum. The LOs from the 2019 curriculum are included in the data when I report the results in this thesis. Thus, the data in this thesis consists of a total of 120 LOs found in three different curricula. These are further divided into 173 smaller LOs, because some LOs include two or more objectives. Thus, the data consists of 50 LOs from the 2003 curriculum, 57 LOs from the 2015 curriculum, and 66 LOs from the 2019 curriculum. These include both the general objectives and the course-specific objectives found in the geography curricula.

All the research materials gathered during this research process were collected in the context of Finnish upper secondary geography education, and therefore they are context-related. The research materials consist of multiple different types of qualitative materials. The material gathered from the teachers (concept maps and in-depth interviews) and the students' answers to geography test questions are material that was produced by individuals, i.e. they represent teachers' conceptions of geography and students' knowledge and skills in geography. The curricula and geography test questions are specific institutional and administrative regulations and documents. Moreover, the material gathered from the teachers differs from the other material because it was produced by the researcher, i.e. the researcher's subjectivity is visible in the data-gathering process, while the three other materials were derived from archival and document sources by the researcher. Such documents have a certain type of strength, according to Merriam (2002a: 13), because they already exist in the situation—they are not dependent on the researcher—whereas the interviews and concept maps were affected by the researcher's presence during the data-gathering process, as explained earlier.

3.2.2 Conducting analyses

Content analysis was chosen as the main method of analysis for the multiple materials used in this study. Here, content analysis is understood as qualitative content analysis, defined by Hsieh and Shannon (2005) as a

> "research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns." (Hsieh and Shannon 2005: 1278)

The aim is to achieve a thick description of the phenomenon (Elo & Kyngäs 2008: 108) and to "arrive at generalizable statements by comparing various materials" (Flick 2014: 5). Therefore, the choice of method aimed to fulfill the research's overall aim *to widen our understanding of thinking skills and powerful knowledge in the context of geography education*.

Qualitative content analysis is regarded as one of numerous qualitative methods to analyze textual data (Hsieh & Shannon 2005: 1279). More broadly speaking, qualitative data analysis involves organizing and explaining data (Cohen *et al.* 2011: 537) and "making statements about implicit and explicit dimensions and structures of meaning-making in the material and what is represented in it" (Flick 2014: 5). Hence, it is almost inevitably an interpretative and reflexive interaction between the researcher and the decontextualized data (Cohen *et al.* 2011: 554). Content analysis has been criticized for being too simple a method (Elo & Kyngäs 2008: 113) and for treating words "as brute data waiting to be coded, labeled with brute words" (St. Pierre & Jackson 2014: 715). However, it is a widely used analysis technique in different research fields because of its ability to handle large amounts of any written material (see e.g. Cohen *et al.* 2011; Elo & Kyngäs 2008). According to Elo and Kyngäs (2008: 109), content analysis can be used in an inductive or deductive way; both are utilized in this thesis.

For Article I, the teachers' interviews were transcribed in 2015 using NVivo qualitative data analysis software. Additionally, the concept maps were included in the same data set and analyzed as a text document. I conducted the actual analysis process in 2017, using inductive content analysis (Elo & Kyngäs 2008; see also Hsieh & Shannon 2005), where predetermined categories are avoided, since the categories are allowed to flow from the data (Hsieh & Shannon 2005: 1279). The advantage here is that this analysis allows the researcher to gain "direct information from study participants without imposing preconceived categories or theoretical perspectives" (Hsieh & Shannon 2005: 1279–1280). However, I acknowledge that the method is not purely inductive, since the themes do not arise directly from the analyzed material, and their formation requires active reasoning and interpretation by the researcher. Therefore, the method could also be called abductive content analysis (see Tuomi & Sarajärvi 2018).

During the analysis process, I examined the concept maps and interview transcripts in tandem, working back and forth between them, starting from the concept maps. I applied Lichtman's (2013: 250–255) analysis method: coding, categorizing, and conceptualizing. The research process started with my reading the research material several times to obtain a sense of the whole. Then I started to find similarities, i.e. I started to derive codes inductively from the material. After the coding process, it was time to connect and find patterns and similarities i.e. to categorize the coded material. Then, three major concepts were formed from the categories. According to MacKian (2010), this is the analysis—the rough coding, cutting, and grouping, something that is done systematically. Finally, I formed an interpretation, i.e. I moved beyond the analyzed data (see MacKian 2010: 316) and formed an understanding of teachers' conceptions of geography by using the theoretical framework of powerful geographical knowledge (Maude 2018). Roulston (2014: 308) comments that interview data is never complete, and thus "analysis is a partial representation of the data set." In order to increase the trustworthiness of the analysis, I included authentic extracts from the original texts in Article I (see Elo & Kyngäs 2008: 112).

The three other research materials—geography test questions (in Article II), students' answers (in Article III), and geography LOs (in Article III)—were all approached through deductive content analysis (Elo & Kyngäs 2008; see also Hsieh & Shannon 2005; Tuomi & Sarajärvi 2018), where a prior theoretical framework is used to guide the analysis process. However, the method was not purely deductive, as I was not interested in testing theory or hypotheses. Thus, this method could also be called abductive content analysis where the theory is included at the beginning of the process (see Tuomi & Sarajärvi 2018). In other words, the coding starts immediately with predetermined codes, and any data that is not coded according to the framework is identified and analyzed later (see Hsieh & Shannon 2005: 1282). A framework based on the revised version of Bloom's taxonomy (discussed in the theory section of this thesis, and presented in more detail in Articles II and III) was formulated by all the coauthors of Articles II and III. I was responsible for the processes of analysis of the research materials in Articles II and III. However, my coauthors helped to secure the systematicity of the categorization and analysis processes.

Thus, the research material was interpreted through a predetermined framework. For example, each geography test question, student answer, or LO was read repeatedly and interpreted according to the framework, and then coded and categorized. I was cautious not to treat words as brute data but to think with theory (see St. Pierre & Jackson 2014: 715). Thus, the analysis process did not use word searches or calculate word counts, which would be referred to as quantitative content analysis or summative content analysis (see Hsieh & Shannon 2005). However, quantification and descriptive statistics (frequencies and percentages) were used (see Cohen *et al.* 2011) to illustrate special characteristics of the data. Additionally, the methods in Article II included statistical analyses. By using numbers, I tried to reveal information and patterns that could not be observed with qualitative methods; thus "results from quantitative analysis complement and provide additional insights to the interpretation of the results of the qualitative part" (Bergman 2010: 389).

The research material, consisting of 331 geography test questions, was analyzed in two different periods: between November 2017 and January 2018, and in fall 2019 (reported in Article II). First, a classification of the questions was conducted according to the theoretical framework. In this classification, each assignment or question was divided into one or more categories, resulting in a total of 413 classification according to the framework. In order to ensure the reliability of the analysis, this phase included several steps explained in more detail in Article II. But to sum up, I was responsible for producing a preliminary written categorization of the questions, which was then sent to my coauthors to be analyzed individually. Afterward, the categorization was scrutinized collaboratively in joint meetings, and all authors could agree on the accuracy of the categorization. Moreover, in order to examine and compare the categorized questions within the categories in which they were classified, I produced an in-category comparison of the analyzed questions. Lastly, the ongoing dialogue between my coauthors and me during the research process strengthened the reliability of our analysis.

Additionally, we aimed to examine the changed test structure, and therefore the 331 questions were allocated to different categories based on the type and amount of material attached to them and the kinds of answers students were required to produce (e.g. texts or diagrams). Again, I produced a preliminary categorization for my coauthors to review. Afterward, the results of this categorization were produced collaboratively. Last, the statistical analyses (contingency table and chi-square test) were conducted in 2020 using SPSS statistical software. These analyses aimed to examine whether there were any statistically significant relationships between the cognitive processes (categorized in two groups, LOTS and HOTS) or types of geographical knowledge and 1) the different parts of the tests (i.e. the last two assignments, or Part III assignments), 2) the types of material attached, or 3) the types of assignment. Again, I produced the statistical analyses themselves. Afterward, my coauthors evaluated the results individually. The decision to include the results of the statistical analysis in Article II was made jointly by my coauthors and me.

During the analysis of the geography test questions conducted between November 2017 and January 2018 (in Article II), 33 HOTS-type questions (*analyzing*, *evaluating*, or *creating conceptual* or *procedural* knowledge) were found in the four geography tests between fall 2015 and spring 2017. These findings guided the data analysis process regarding the students' answers to the geography test questions (reported in Article III), since the aim was to examine students' HOTS. Therefore, the research material, consisting of 800 students' participation in four geography tests in the ME, was analyzed in 2018, using these 33 HOTS-type questions to limit the amount of data to analyze. In order to limit the subjectivity of the classification of students' answers, I did a preliminary categorization of a sample of the students' answers to a digital test from the fall of 2016. To ensure that all the authors agreed on the categorization principles, we organized several joint meetings where we discussed and evaluated the results of the preliminary categorization. Finally, I conducted the final analysis process.

For every question (n=33), a sample of 50 students' answers from the data set of 200 students' answers was analyzed and categorized according to the predetermined framework. During the analysis process, we found that the data became saturated after 50 students' answers. However, in some cases only some of the 200 students had answered a particular question, and the rest had not answered. Therefore, in some cases there were fewer than 50 answers available from the 200 students' answers in the research material (see the more detailed description in Article III). This resulted in a total of 1,585 categorized students' answers: 650 from the paper-based tests, and 935 from the digital tests.

Finally, in 2020, the LOs from the 2003 and 2015 geography curricula (reported in Article III) and from the 2019 curriculum were analyzed according to the predetermined framework. To mitigate the subjectivity of the analysis process, I repeatedly read the LOs, and I constructed a table presenting all the LOs categorized according to the framework. This was then read and examined by my coauthors individually. Afterward, a joint meeting was organized to ensure a common understanding of the categorization criteria. Finally, I produced a final categorization of the LOs with the help of my coauthors, who repeatedly checked the consistency of the categorization throughout the process. The final categorization was then approved by my coauthors. This material consisted of 173 LOs, including 15 LOs that we could not categorize according to the framework. These are reported separately in Article III and in this thesis (as Hsieh and Shannon (2005: 1282) suggest). Therefore, 158 LOs were allocated to one category or more, resulting in a total of 288 categorizations (67 LOs from the 2003 curriculum, 107 LOs from the 2015 curriculum, and 114 LOs from the 2019 curriculum) according to the framework.

4 Discussion with the findings from the original articles

In this empirical part of the thesis, I intend to draw together and further conceptualize the key outcomes of the three original research articles that form the foundation of this thesis. The main objective—*to examine geography's potential to engage students in thinking skills and powerful geographical knowledge in the context of Finnish upper secondary geography education*—is examined through the thesis' three research questions. I intend to make a concluding empirical analysis using the two "lenses" to view geography, i.e. thinking skills and knowledge dimensions, and powerful geographical knowledge.

4.1 Geographical thinking skills and knowledge types emphasized in geography curricula and teachers' conceptions of geography (Q1)

The findings from Articles I and III answer the first research question: *with what kinds of geographical thinking skills and knowledge types do students engage during their upper secondary geography education, according to the geography curricula and teachers' conceptions of geography?* This research question relates to the curriculum reforms conducted in 2015 and 2019, as well as the Finnish government's decision concerning the distribution of lesson hours among different subjects, in which geography lost one of its compulsory courses in 2014. The discussion here is based on the findings from Article III, in which the revised version of Bloom's taxonomy is used as a framework to analyze the geography LOs in the Finnish National Core Curriculum for General Upper Secondary Schools (produced in 2003 and 2015). It is also based on the findings from Article I, in which Maude's typology of powerful geographical knowledge is used as a theoretical perspective to see whether geography teachers' conceptions of geography are a form of powerful knowledge. Additionally, I present a complementary analysis of the geography LOs found in the more recent 2019 curriculum.

The findings are provided in Figure 3, which presents the distribution in percentages of the geography LOs from the 2003, 2015, and 2019 curricula according to the cognitive and knowledge dimensions of the revised version of Bloom's taxonomy. The main findings of Article III indicate that the geography LOs mainly emphasize the cognitive process of *understanding* (39% in the 2003 curriculum, 36% in the 2015 curriculum) and the *conceptual* knowledge dimension (60% and 54% respectively). The complementary analysis of the 2019 curriculum shows a strengthening of this emphasis: 44% of the LOs emphasize the cognitive process of *understanding*, and 62% of the LOs require the use of *conceptual* knowledge.

Looking at these findings through Maude's powerful geographical knowledge, I suggest that LOs that emphasize knowledge type 2 are the most common (in total, slightly over 50% of LOs are categorized as requiring the cognitive processes of *understanding* and *applying*). In other words, knowledge that gives students "powerful ways of analyzing, explaining, and understanding" (Maude 2018) is emphasized in Finnish geography LOs. Béneker and Palings (2017) reached the same conclusion when they researched upper secondary geography textbooks and curriculum documents in the Netherlands (see also Bouwmans & Béneker 2018). In Finnish geography curricula, approximately 15% of the LOs emphasize evaluative skills, meaning knowledge type 3, where knowledge of knowledge and geographical reasoning are emphasized (see Maude 2018). This contrasts with findings from the Netherlands (Béneker & Palings 2017; Bouwmans & Béneker 2018) and Australia (Maude 2015), where type 3 is often

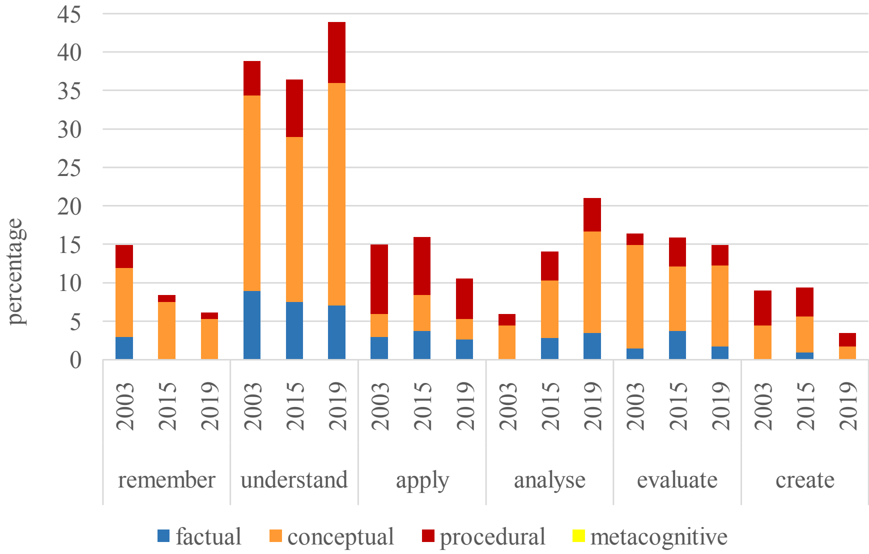

Figure 3. The distribution (in percentages) of the geography LOs in the 2003 (n=67 LOs), 2015 (n=107 LOs), and 2019 (n=114 LOs) curricula, according to the cognitive and knowledge dimensions of the revised version of Bloom's taxonomy.

missing from curriculum documents. However, this may be because of the differences between the categorizations of the revised version of Bloom's taxonomy and powerful geographical knowledge, whereby the cognitive process of *evaluating* overlaps with knowledge types 3 and 4.

When we look at the impact of the curriculum reforms of 2015 and 2019, the findings from Article III and the complementary analysis of the 2019 curriculum suggest that the geography LOs shifted slightly toward higher-order thinking, while the knowledge dimension requirements remained almost the same (see Figure 3). In the 2015 and 2019 curricula, 61% of the LOs emphasize lower-order thinking (*remembering*, *understanding*, *applying*), while 39% require higher-order thinking (*analyzing*, *evaluating*, *creating*). The percentages are 69% and 31% respectively in the 2003 curriculum. However, this change is mainly because of the increased requirement for analytical thinking skills (up from 6% to 14% and then to 21%) and the decreased requirement for the cognitive process of *remembering* (down from 15% to 8% and then to 6%) during the reforms. The cognitive category of *evaluating* remained almost the same during the reforms, while the cognitive categories of *creating* and *applying* decreased slightly, and the category of *understanding* increased slightly. If we inspect the knowledge dimensions of the LOs of the three curricula, there are only minor differences in the emphases on *conceptual* knowledge (60% in the 2003 curriculum, 54% in the 2015 curriculum, and 62% in the 2019 curriculum), *procedural* knowledge (24%, 27%, and 23% respectively) and *factual* knowledge (16%, 19%, and 15% respectively). *Metacognitive* knowledge is missing from the LOs of the analyzed geography curricula.

Using Maude's typology, my interpretation is that since the curriculum reforms, there has been more emphasis especially on the geographical knowledge that enables young people to participate in social debates by requiring them to use analytical skills (type 4). In other words, students are required to organize and select knowledge that reveals causalities within and between the social and natural sciences and the humanities.

Additionally, types 1 and 5—i.e. remembering factual knowledge about the world, and seeing the world in new ways—decreased, while type 3—i.e. evaluating knowledge of knowledge—remained fairly steady during the reforms. However, the overall emphasis is on knowledge type 2, i.e. understanding and applying (as well as analyzing) analytical and explanatory concepts and generalizations.

To look more closely at the HOTS emphasized in the geography curricula, Table 5 presents the distribution in percentages of the different HOTS and knowledge dimensions between the general LOs and course-specific LOs in the three different curricula (the 2003 and 2005 curricula from Article III, and the 2019 curriculum from the complementary analysis). The findings from Article III suggest that the curriculum reform in 2015 improved the distribution of HOTS between general LOs and course-specific LOs: analytical and evaluative thinking and conceptual and procedural knowledge were emphasized in all geography courses in the 2015 curriculum. Unfortunately, the situation suffered a setback in the 2019 curriculum reform, where analytical and evaluative thinking and factual knowledge are absent from course GE4, and the highest level of thinking (i.e. creating) is pursued in GE4 only.

Moreover, the curriculum reform of 2015 resulted in only one compulsory course (GE1), which is quite one-sided, as it lacks *factual* knowledge and creative thinking: 60% of the LOs in GE1 emphasize *remembering* and *understanding conceptual* knowledge. This indicates that the distribution of the different HOTS and knowledge dimensions between the general LOs and the course-specific LOs is illogical to some extent. In other words, the cognitive processes of *analyzing*, *evaluating*, and *creating* are not practiced in all four geography courses. The work of Tani *et al.* (2018) provides interesting insights into teachers' views about the content of the only compulsory geography course. They conclude that according to teachers, there are challenges in fulfilling the requirements of LOs that emphasize Maude's powerful geographical knowledge types 3 and 4, because of the fragmented and illogical content and structure of the course (and curriculum) (Tani *et al.* 2018: 14).

So far, I have described the thinking skills and knowledge types that students engage with during their studies in geography in Finnish upper secondary schools in terms of the curricula documents produced in 2003, 2015, and 2019. However, Finnish teachers have a high degree of autonomy concerning their teaching and pedagogical choices. Teachers are seen as the real interpreters of a curriculum (see e.g. Lambert & Hopkin 2014: 75; Lambert *et al.* 2015: 731; Muller & Young 2019: 16; Young *et al.* 2014), i.e. curriculum makers (Lambert *et al.* 2015; see also Lambert & Morgan 2010), as discussed in the introduction to this thesis. Moreover, teachers' conceptions "[shape] how that subject is actually taught" (Alexandre 2016: 168). The research findings from Article I give insights into geography teachers' conceptions of geography and geography teaching. These findings indicate that the geography teachers who participated in the research have a conception of geography where all of the powerful geographical knowledge types presented by Maude (2018) can be found. However, Article I conclude that there are three dominant concepts or themes running through the teachers' conceptions of geography: a *holistic* and inquiry-based *approach* (referring to knowledge type 1), the investigation and understanding of *phenomena* (connecting to knowledge type 2), and *spatial* knowledge and causal relationships (representing knowledge type 4).

Maude's knowledge type 1, "new ways of thinking about the world," is visible in the teachers' conceptions. The findings from Article I show that they attempt to provide students with a knowledge that goes beyond the students' own experience, by using geographical concepts and skills as well as a holistic and inquiry-based approach to the

Table 5. The distribution (in percentages) of the different HOTS and knowledge dimensions between general and course-specific LOs in the 2003, 2015, and 2019 curricula.

Geography objectives	HOTS			Knowledge dimension		
	Analyze	Evaluate	Create	Factual	Conceptual	Procedural
2003 curriculum						
General	25	45	17	45	33	31
GE1 The blue planet	0	0	0	18	18	6
GE2 A common world	50	18	0	36	20	0
GE3 The world of risks	0	36	0	0	25	6
GE4 Regional research	25	0	83	0	5	56
Total	100	100	100	100	100	100
N	4	11	6	11	40	16
2015 curriculum						
General	27	24	20	25	29	28
GE1 The world in change	7	12	0	0	16	3
GE2 The blue planet	20	18	0	25	17	17
GE3 A common world	27	29	0	25	19	17
GE4 Geomedia	20	18	80	25	19	34
Total	100	100	100	100	100	100
N	15	17	10	20	58	29
2019 curriculum						
General	29	29	0	35	31	27
GE1 The world in change	21	24	0	6	18	12
GE2 The blue planet	25	24	0	29	21	19
GE3 A common world	25	24	0	29	18	19
GE4 Geomedia	0	0	100	0	11	23
Total	100	100	100	100	100	100
N	24	17	4	17	71	26

teaching of geographical phenomena. Moreover, they support students to investigate geographical problems related to the students' own daily lives and geographical experiences. As teacher number 9 in Article I puts it:

> "That you wake up the inner three-year-old, who always asks what, where, why, and why there. So that they get an understanding that if something happens somewhere -- they realize why it happens just there and they start to realize what probably happens next and what impacts it has on a local, regional, and global level." (teacher number 9)

In my interpretation, this conception of geography additionally resembles the cognitive process of *creating*, where planning, producing, and solving geographical problems and phenomena is emphasized.

Maude's knowledge type 2, "powerful ways of analyzing, explaining, and understanding," is also found in the teachers' conceptions analyzed. In Article I, teachers describe geographical knowledge as teaching students about how to investigate and understand geographical phenomena and relative locations with the help of geographical concepts. Moreover, the application of geographical information in new situations is emphasized. In Article I, teacher number 6 describes geography as expanding one's own understanding of the world: "Some kind of understanding of the world is developed slowly." In my interpretation, this kind of geographical knowledge enables students to explain and understand phenomena, which is said to be powerful (see Maude 2018: 182; see also Béneker & Palings 2017). The cognitive processes of *understanding* and *applying* are visible, because students are describing, explaining, inferring, comparing, and classifying geographical phenomena and using their knowledge in different situations.

Additionally, in my understanding, teachers are engaging students in Maude's knowledge type 4 and therefore in the cognitive process of *analyzing*, in which the understanding of causalities and the organization of knowledge provide possibilities for students to follow and participate in debates. In Article I, teacher number 4 described geography by saying: "We always have to look for causalities. How these phenomena link to each other." In Article I, teachers describe geographical relationships between humans, places, and spaces as important aspects for the understanding of geographical phenomena. Additionally, through their assessment tasks, teachers aim to see whether students can demonstrate their understanding of the spatial dimensions of phenomena. Moreover, according to Article I, teachers attempt to engage students in knowing their own living environment and developing their abilities to read the surrounding world and topical phenomena. According to the findings of Article I, teachers encourage students to take part in society and to affect things: "So something that makes them believe in the future" (teacher number 3).

My interpretation of the findings from Article I is that, to a minor extent, the teachers' conceptions of geography resemble knowledge types 3 and 5. In the teachers' conceptions, knowledge type 3—i.e. evaluating knowledge of knowledge—is focused mainly on the evaluation and understanding of map production. In my understanding, this type of knowledge seems to be a rather narrow view of knowledge type 3. Evaluative and critical thinking, making judgments and claims about geographical knowledge and its origins, or asking "how do you know?" (Maude 2015: 23) are almost absent from the teachers' conceptions. This knowledge type has been seen as an underdeveloped area of geographical education (Maude 2017: 23; see also Béneker & Palings 2017). Additionally, knowledge type 5—i.e. remembering knowledge of the world—has a minor role. Teachers attempt to develop students' understanding the world as a diverse place and to evaluate students' ability to remember information about the world.

In summary: Maude's knowledge types 1, 2, and 4 are found in teachers' conceptions of geography, and knowledge types 3 and 5 are also found to a minor extent. Previous research on Dutch student teachers' conceptions of geography showed that knowledge types 2 and 4 were emphasized, while type 3 was almost absent (Béneker & Palings 2017). Tani *et al.* (2018) asked Finnish geography teachers to choose the five most valued aims of geography education from the general LOs found in the 2015 curriculum. They concluded that all of Maude's knowledge types were represented in the teachers' views, and therefore they support the interpretations made in this thesis (Tani *et al.* 2018). They also argue that Finnish geography teachers place more emphasis on critical thinking skills, i.e. knowledge type 3 (Tani *et al.* 2018: 11); this finding suggests a different conclusion than previous research findings (see Béneker & Palings 2017; Bouwmans & Béneker 2018; Maude 2015) and this thesis. It seems to me that this can be explained by methodological aspects. Tani *et al.* (2018) asked geography teachers to choose from pregiven geography LOs (which, according to Article III, included LOs representing critical thinking skills and knowledge type 3), while previous research, and the research conducted in Article I, approached the topic by interpreting teachers' conceptions of geography, whereby teachers freely described their own thinking about the importance of geography education.

Moreover, Article I has increased our theoretical understanding by adding a sixth knowledge type to Maude's typology. According to Article I, teachers teach geographical knowledge that engages students to learn according to the broader educational aims of schooling— i.e. cross-curricular themes of the curriculum—as well as value-based content, i.e. teaching geography that supports a sustainable way of life and develops eco-social knowledge, active citizenship, global responsibility, multiliteracy, and internationality. Furthermore, Article III showed that geography curricula included LOs that emphasized geographical knowledge where the value-based aims of education also matter. In the 2003 curriculum, three out of 50 LOs emphasized value-based issues (acting as a global citizen, having tolerance and respect for cultural diversity and human rights, promoting sustainable development, and gathering experience of and interest in geography); in the 2015 curriculum, this figure was seven out of 57 LOs, and in the 2019 curriculum it was five out of 66 LOs. Teaching values is an important part of geography teaching and learning (see e.g. Uhlenwinkel *et al.* 2017). In my understanding, geography has the ability to teach values that are important in helping students to appreciate the diverse and complex world around them, where everyone has the opportunity to take a stance and actively participate (see also Bednarz 2019).

Looking the findings from Articles I and III through the two "lenses", I suggest that not *all* geography students are engaged with *all* powerful knowledge types. This is because the HOTS are not pursued in all geography courses—in particular, creative thinking is missing from geography course LOs (see Table 5)—and teachers do not emphasize all knowledge types equally. Butt (2017: 16) and Young (2008: 14) have argued that it is a matter of social justice for students to engage with powerful knowledge. Additionally, it is said (see e.g. Lambert *et al.* 2015; Roberts 2014) that students should engage with meaning-making and connect their own lived experience to the discipline of geography. However, Article III showed that LOs requiring *metacognitive* knowledge were absent from the curricula analyzed. Yet the teachers' conceptions analyzed in Article I suggest that teachers attempt to engage students in teaching and learning geography in their classrooms, and *metacognitive* knowledge is said to develop over a long period of time (see Anderson *et al.* 2014: 238). Therefore, I propose that learning *metacognitive* knowledge requires the action and guidance of teachers to engage students in discussions about knowledge of one's own cognition. In other words, teachers are and should be discussing metacognitive issues with their students in classrooms.

Based on the discussion of the findings from Articles I and III, as well as the complementary analysis of the LOs in the 2019 curriculum, I conclude that Finnish geography curricula LOs mainly emphasize LOTS, i.e. knowledge types 2 and 5. However, the teachers who participated in my research emphasized HOTS to some extent, i.e. knowledge types 1 and 4 along with knowledge type 2. Therefore, the Finnish geography curriculum has the potential to enhance students' HOTS and engage students in powerful geographical knowledge, but we need competent, specialized geography teachers to interpret curriculum documents—i.e. to "make curriculum"—in order to achieve this goal.

How are the geography LOs found in geography curricula and teachers' conceptions evaluated in assessments? Are students able to perform in geography test questions that require the use of the cognitive processes of *analyzing*, *evaluating*, or *creating conceptual* or *procedural* knowledge (i.e. HOTS-type questions)? I now turn my attention to the (digitalized) ME, which aims to examine whether students in Finnish upper secondary schools have accomplished the skills and competences defined in the LOs of the National Core Curriculum for General Upper Secondary Schools.

4.2 Geographical thinking skills, knowledge types, and students' performance in the ME during the digitalization process (Q2)

To answer my second research question (*to what extent—if at all—did the thinking skills and knowledge requirements of the Finnish ME in geography or the students' performance change during the digitalization process?*), the discussion here is based on the findings from Articles II and III. The ME, which is the summative assessment at the end of upper secondary school in Finland, was converted to digital format in 2016, and my discussion here attempts to capture any changes to the examination in geography in terms of the thinking skills and geographical knowledge required. Articles II and III analyze the ME geography test questions between fall 2013 and spring 2019, and students' answers to HOTS-type geography test questions between fall 2015 and spring 2017, using the revised version of Bloom's taxonomy as a framework.

Figure 4 summarizes the findings from Article II by presenting the distributions in percentages of the geography test questions in the paper-based and digital forms of the ME according to the cognitive and knowledge dimensions of the revised version of Bloom's taxonomy. The findings reveal that the majority of the ME geography test questions (in paper-based tests, n=172; in digital tests, n=241) emphasize LOTS: 71% of the questions in the paper-based tests and 70% of the questions in the digital tests emphasize the cognitive process categories of *remembering*, *understanding*, and *applying*. These results are supported by previous research findings (e.g., Bijsterbosch *et al.* 2017; Jo & Bednarz 2009; Mishra 2015; Şanli 2019; Yang 2013; Yang *et al.* 2015; Wertheim & Edelson 2013; see also Tani *et al.* 2020). In both test formats, the majority of questions emphasize the cognitive process of *understanding*: 34% of the questions in the paper-based format and 41% in the digital format are in this category. Additionally, the questions in both test formats emphasize *conceptual* (49% of the questions in the paper-based format, 47% in the digital format) and *factual* (35% and 39% respectively) geographical knowledge.

Looking at these findings through Maude's powerful geographical knowledge, I suggest that the ME in geography mainly emphasizes knowledge type 2, although type 5 is also evident. In knowledge type 2, students are engaged with knowledge that enables them to use "powerful ways of analyzing, explaining, and understanding" (Maude 2018). According to Article II, this is done by requiring students to explain how something is formed, interpret diagrams, compare differences, give regional examples, explain causalities, and infer or predict geographical phenomena. All of these are important parts of geographical thinking and learning (see Bijsterbosch *et al.* 2017: 18; see also Favier & Van Der Schee 2012). The questions requiring the use of knowledge type 5 require students to remember world knowledge. In other words, the students need to do something by relying on memory alone. According to Article II, this means that they are required to explain geographical concepts, mention or name something, and draw and explain pictures. Article II concludes that these *remembering*-type questions are usually subsections of assignments, i.e. they support more comprehensive assignments

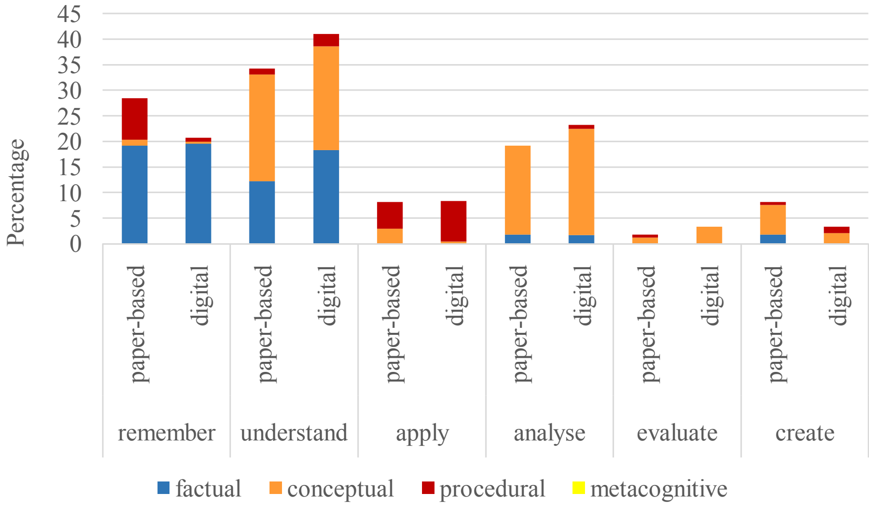

Figure 4. The distributions (in percentages) of geography test questions in the paper-based (n=172 questions) and digital (n=241 questions) forms of the ME between fall 2013 and spring 2019, according to the cognitive and knowledge dimensions of the revised version of Bloom's taxonomy.

and are integrated with other cognitive processes (see also Anderson *et al.* 2014: 66–69). The findings from Article II show that the questions requiring the use of *factual* or *conceptual* knowledge include knowledge of geographical phenomena such as: climate change; state development; the state of the environment; the mining industry; refugees; the distribution of human populations, species, or industries; urbanization; accessibility; tourism. These themes are also included in the International Charter on Geographical Education (see IGU-CGE 2016: 10).

My interpretation is supported by the research of Tani *et al.* (2020), who used three levels of powerful disciplinary knowledge (see Lambert *et al.* 2015) to analyze geography test questions in the Finnish ME between 2006 and 2019. According to Tani *et al.* (2020: 13), the second level was emphasized in over half (52% in the paper-based tests, and 54% in the digital tests) of the questions analyzed, while the first level was emphasized in 28% of the questions in the paper-based tests and 14% in the digital tests. According to Maude (2018), the second level is the same as his knowledge type 2, and the first level is same as his knowledge type 5. According to Tani *et al.* (2020: 5), the second level is about relational understanding, in which the local and the global are connected together, and the relationships between nature and humans, space and place are examined; the first level refers to basic world knowledge.

Additionally, Article II inspects possible changes to thinking skills and geographical knowledge requirements during the ME digitalization process. It reveals an increase in questions categorized as the cognitive processes of *analyzing* (from 19% in the paper-based tests to 23% in the digital tests) and *understanding* (from 34% to 41% respectively). Moreover, a reduction in questions categorized as the cognitive processes of *remembering* (from 28% to 21%) and *creating* (from 8% to 3%) is also observed (see Figure 3). Additionally, there is a slight increase in *factual* knowledge (from 35% to 39%). This is explained in Article II by the increase in the number of question subsections that require the explanation of concepts.

In my interpretation, and viewing these findings through Maude's typology, knowledge types 4 and 2 increased, whereas knowledge types 5 and 1 decreased. This indicates that the digital tests more often engage students in the use of knowledge type 4 (in addition to knowledge type 2, which is the most emphasized, as previously explained), where the understanding of causalities and the organization of knowledge are required to examine current geographical phenomena. According to the findings from Article II, this is done by requiring students to combine geographical information from different sources (i.e. the knowledge is not directly interpreted from the given material) and to form coherent conclusions where causalities and a spatial perspective are visible. Moreover, the digital tests require less use of knowledge type 1 (together with knowledge type 5, as previously explained), which refers to "new ways of thinking about the world" (Maude 2018), i.e. creating and examining deeply geographical phenomena. According to Article II, this means that the digital tests require students to generate possible outcomes or ponder the future directions of geographical phenomena, and to plan or produce things to a lesser extent than was required in the paper-based tests.

The research findings presented above are supported by the research of Tani *et al.* (2020: 13), who conclude that the third level of powerful disciplinary knowledge (see Lambert *et al.* 2015) increased (from 20% in the paper-based tests to 32% in the digital tests), while the first level decreased (from 28% to 14% respectively), and the second level remained fairly steady (increasing only from 52% to 54%). According to Maude (2018), the third level is the same as his type 4, the first level connects to his type 5, and the second level corresponds to his type 2. However, it should be said that these categorizations and typologies must be compared and interpreted cautiously. To me, it seems that the third level in Tani *et al.*'s (2020) research additionally resembles critical thinking skills and to some extent creative thinking, since they explain that the third level includes a propensity to think about possible or alternative futures and to use critical thinking (Tani *et al.* 2020: 5). Therefore, in the research by Tani *et al.* (2020), the third level includes not only the cognitive process of *analyzing* but also the cognitive processes of *evaluating* and *creating*. However, in my understanding, the use of the revised version of Bloom's taxonomy gives more detailed information about the presence or absence of HOTS by differentiating among the categories of *analyzing*, *evaluating*, and *creating*.

The findings from Article II (see Figure 3) suggest there is an overall lack of questions that require students to use the most complex cognitive processes of *evaluating* and *creating* or to use *procedural* knowledge. Additionally, *metacognitive* knowledge is missing. This reveals a lack of critical, creative, and holistic thinking, as well as a lack of the use and application of geographical skills, techniques, and methods, in the ME geography test questions (see similar results in Bijsterbosch *et al.* 2017; Jo & Bednarz 2009; Mishra 2015; Wertheim & Edelson 2013). In my understanding, this indicates a lack of powerful geographical knowledge type 3, i.e. the evaluation of knowledge of knowledge and geographical reasoning (Maude 2018). Furthermore, the results from Article II show that the questions categorized by the cognitive processes of *evaluating* and *creating* are limited in their cognitive demands: these questions mainly require students to ponder the pros and cons of a phenomenon, to make judgments based on some aspect, or to ponder the possible outcomes or future directions of geographical phenomena.

Now, combining the above with the results from Article III, which examined how geography students perform when they answer HOTS-type geography test questions in the ME, I propose that students have difficulties when questions require them to use the cognitive processes of *analyzing* (albeit only in digital tests), *evaluating*, or *creating*, or to use *procedural* knowledge. The findings from Article III are presented in Tables 6 and

7. Table 6 shows the distributions of students' answers at different levels of cognitive skill (from *remembering* to *creating*) when HOTS-type questions require them to analyze, evaluate, or create, in both test formats. Table 7 presents the same distributions, this time showing the knowledge dimensions (from *factual* to *procedural*) when students are required to use *conceptual* or *procedural* knowledge.

The findings from Article III revealed that when students in the digital tests analyzed diagrams about climate change or wind energy, for example, or GIS methods, analytical thinking was seen in only 35% of students' answers (Table 6). Thus, students had difficulties answering digital geography test questions that required them to use the cognitive process of *analyzing*. This indicates that students had difficulties selecting relevant information and organizing it so as to make causal relationships visible. The same difficulty was not detected in the paper-based tests. Additionally, Article III showed that students had difficulties when they were required to *evaluate* knowledge (Table 6). Evaluative thinking was visible in only 34% of students' answers in the paper-based tests, and in only 15% of their answers in the digital tests. In other words, students had difficulties reaching justified conclusions and judgments. According to Article III, the majority of students were incapable of evaluating errors in GIS, or of evaluating the pros and cons of the mining industry, for example.

When questions required students to use the cognitive process of *creating*, students seemed to perform well, because creative and holistic thinking were evident in the majority of their answers (75% in the paper-based tests, and 54% in the digital tests) (Table 6). This was because students were able to create a map representing a larger geographical area, plan a geographical study, or draw an altitude profile. However, these assignments all demanded the use of *procedural* knowledge, with which students had difficulties: only 36% of students' answers demonstrated *procedural* knowledge in the digital tests (Table 7). Similar difficulties were not detected when students used *conceptual* knowledge (Table 7). In other words, students were able to create a study plan or an altitude profile, and thus, these answers were categorized as the cognitive process of *creating*; but they lacked *procedural* knowledge, and therefore, their answers were not categorized as *procedural* knowledge. Moreover, students had difficulties hypothesizing how to improve the world's food production, or what impacts the mining industry might have.

Looking at these findings through powerful geographical knowledge (Maude 2018), I suggest that students had difficulties using knowledge types 1 and 3 in both test formats, and knowledge type 4 in the digital test format. In other words, even though the questions required students to understand causalities in order to draw coherent conclusions and justify their views (i.e. using critical thinking), or to hypothesize possible changes in geographical phenomena, some students were incapable of demonstrating these thinking skills in their answers. Therefore, the research findings from Article III support research by Stes *et al.* (2012) and Anderson *et al.* (2014), who conclude that not all students produce their answers at the required level.

During the digitalization process, the test structure was also reformed (as presented in the introduction to this thesis). Article II used statistical analysis to examine the reformed structure in greater depth. According to the analysis, the new test structure seemed to be in line with the guidelines introduced by the geography subject section of the FMEB (2018): the majority of questions in Parts I and II (94.5% and 75.6% respectively) emphasized LOTS (i.e. the cognitive processes of *remembering*, *understanding*, and *applying*), while the majority of Part III questions (51.3%) mainly required the use of HOTS (i.e. the cognitive processes of *analyzing*, *evaluating*, and *creating*). Additionally,

Table 6. Distributions of students' answers as percentages (in numbers) at different levels of cognitive skill when HOTS-type questions require them to analyze, evaluate, or create in the paper-based and digital forms of the ME.

	Question:	**Student answer: cognitive dimension**						
	cognitive dimension	Remember	Understand	Apply	Analyze	Evaluate	Create	Total
Paper-based test: 650 students' answers to 13 HOTS-type questions	Analyze	3.5 (16)	37 (165)		54 (245)	5.5 (24)		100 (450)
	Evaluate	4 (2)	24 (12)		38 (19)	34 (17)		100 (50)
	Create		7 (10)		17 (26)	1 (2)	75 (112)	100 (150)
Digital tests: 935 students' answers to 20 HOTS-type questions	Analyze	9 (60)	53 (361)		35 (238)	3 (22)		100 (681)
	Evaluate	4.5 (7)	34 (51)		46.5 (70)	15 (22)		100 (150)
	Create	17.5 (18)	13.5(14)		15 (16)		54 (56)	100 (104)

Table 7. Distributions of students' answers as percentages (in numbers) at different levels of geographical knowledge when HOTS-type questions require conceptual or procedural knowledge in the paper-based and digital forms of the ME.

	Question:	**Student answer: knowledge dimension**			
	knowledge dimension	Factual	Conceptual	Procedural	Total
Paper-based test: 650 students' answers to 13 HOTS-type questions	Conceptual		100 (550)		100 (550)
	Procedural		27 (27)	73 (73)	100 (100)
Digital tests: 935 students' answers to 20 HOTS-type questions	Conceptual	10 (76)	90 (705)		100 (781)
	Procedural	12 (18)	52 (80)	36 (56)	100 (154)

Article II revealed that Part I questions mainly required *factual* knowledge (81.8%), whereas the majority of questions in Parts II and III required the use of *conceptual* knowledge (58.1% and 63.5% respectively). The majority of the *procedural*-level questions were found in Part III.

Furthermore, Article II (see Figure 2 in Article II) revealed that digitalization increased the number of attached materials included in the geography tests: the average in the paper-based tests was 12 attached materials, while the average in the digital tests was 19.5 attached materials. Additionally, the attached materials became more diverse. According to Article II, traditional materials included maps, texts, and diagrams, while digitalization saw the emergence of new materials including videos, interactive maps, statistics, and charts. The findings from Article II (see Figure 3 in Article II) showed that digitalization also diversified the types of assignments: there was the completely new introduction of multiple-choice questions and questions requiring the production of charts or diagrams (e.g. climate diagrams and altitude profiles), while mathematical exercises (requiring statistical numeracy skills) increased, and simple drawing decreased. Overall, however, most questions still required text-based answers.

The statistical analysis in Article II revealed that the new types of attached materials and assignments mainly required the use of LOTS and factual knowledge, indicating that the digitalized geography tests had not yet applied all of the options made possible by the digitalization of the examination. Previous research has concluded that digital technologies (especially GIS) could be used to develop students' HOTS (see e.g. Collins 2018; Favier & Van Der Schee 2014; Palladino & Goodchild 1993; Van Der Schee *et al.* 2010) and to support the development of students' powerful geographical knowledge types 2, 3, and 4 (see e.g. Fargher 2018; Walshe 2018; see also Healy & Walshe 2020). However, Article II concluded that digital tests required the more diverse and comprehensive use and production of materials, as well as the more frequent use of media literacy, and the ability to cite the used materials correctly. Therefore, digital tests gave students more opportunities to demonstrate their knowledge and skills in geography.

Based on the findings from Articles II and III and the discussion presented here, I conclude that the digitalization of the ME only slightly changed the requirements in terms of geographical thinking skills and knowledge. The majority of geography test questions emphasize lower-order thinking (71% in the paper-based tests, and 70% in digital tests), i.e. powerful geographical knowledge types 2 and 5, with an emphasis on *understanding conceptual* knowledge. Although the digitalization slightly increased the need for analytical thinking skills, i.e. powerful geographical knowledge type 4, and introduced new types of attached materials and assignments, not all of the options made possible by digitalization have yet been applied. Additionally, students have difficulties answering the geography test questions in the ME. These difficulties are seen when students are required to use *analytical* (in digital tests only), *evaluative*, and *creative* thinking and *procedural* knowledge. Therefore, I propose that students have some difficulties when they are asked to use powerful geographical knowledge types 1, 3, and 4.

How then can the ME in geography be developed? Can students' ability to use HOTS and powerful geographical knowledge be improved? Turning to the thesis' next research question, I present some developmental aspects to improve geography education and engage geography students in work with HOTS and powerful geographical knowledge.

4.3 Developing geography education in terms of thinking skills and powerful geographical knowledge (Q3)

I see the development and enhancement of geography education to be important, since geography education faces different kinds of challenges, both nationally in Finland and internationally in different educational contexts. Additionally, my own background as a geography teacher, teacher educator, and researcher guides me to focus my attention on how geography education can be developed. The three original articles have introduced the reader to some development aspects related to the topics researched in each article. Therefore, my third research question (*how should geography curricula, assessment, and teaching be developed in terms of thinking skills and powerful geographical knowledge types?*) will be answered by using the findings from Articles I, II, and III.

The two research questions posed earlier in this empirical part of the thesis examined the thinking skills and powerful geographical knowledge found in three different curricula, teachers' conceptions of geography, and geography test questions and student answers during the digitalization of the ME. The findings were viewed through the revised version of Bloom's taxonomy (Anderson *et al.* 2014) and powerful geographical knowledge (Maude 2018). They revealed that some thinking skills and powerful knowledge types are emphasized to a minor extent in Finnish geography education, since the majority of the Finnish geography curricula LOs (61% in the 2015 and 2019 curricula, see Article III) and ME geography test questions (70% in the digital tests, see Article II) emphasize LOTS.

When looked at more closely, the findings indicate several inadequacies. The Finnish geography curricula LOs emphasize the cognitive processes of *analyzing*, *evaluating*, and *creating*, i.e. powerful geographical knowledge types 1, 3, and 4 to a minor extent (Article III). HOTS are not distributed evenly between the general and course-specific LOs found in the geography curricula (Article III). According to the teachers' conceptions of geography, powerful geographical knowledge types 3 and 5 (the cognitive processes of *evaluating* and *remembering*) are only partly emphasized (Article I). The ME geography tests lack questions categorized as the cognitive processes of *evaluating* and *creating* or *procedural* knowledge, i.e. powerful geographical knowledge types 1 and 3 (Article II). Lastly, students have difficulty answering geography test questions that require them to *analyze* (in digital tests only), *evaluate*, *create*, or use *procedural* knowledge, i.e. powerful geographical knowledge types 1, 3, and 4 (Article III). To me, it seems that there is a particular lack of the cognitive process of *evaluating*, i.e. knowledge type 3, which is said to be the underdeveloped area of geography education (Maude 2017: 23; see also Béneker & Palings 2017).

I start my suggestions for development by proposing that we need more discussion about the preferred distribution between LOTS and HOTS in geography education at upper secondary level (suggested in Articles II and III). According to the literature, emphasis should be placed on achieving HOTS (see e.g. Airasian & Miranda 2002; Bijsterbosch *et al.* 2017; James & Gipps 1998; Krathwohl 2002; Tsaparlis & Zoller 2003; see also Kumpas-Lenk *et al.* 2018; Radhmer & Drake 2018). Moreover, it has been noted (Kumpas-Lenk *et al.* 2018) that students are more motivated and engaged in their studies when the teaching is geared toward achieving higher-order thinking. However, LOTS are needed for students to be able to employ HOTS, and all of the powerful geographical knowledge types are needed in geography education in order to achieve powerful geographical knowledge (see also Béneker 2018; Béneker & Van Der Vaart 2020; Bouwmans & Béneker 2018). Articles II and III revealed that the cognitive process of *understanding* (i.e. Maude's knowledge type 2) was the most emphasized in both the Finnish curricula LOs and the geography test questions. The category of *understanding* is the most comprehensive cognitive category, and it includes many subcategories (see Anderson *et al.* 2014), all of which have huge potential to enhance the learning of geography (see Bijsterbosch *et al.* 2017: 18).

Second, I propose that there is a possibility to gear digital geography examinations toward HOTS and powerful geographical knowledge. According to Article II, only 30% of digital geography test questions emphasize HOTS, and only analytical thinking skills, i.e. knowledge type 4, increased during the digitalization process. According to the findings from Article III, 39% of the LOs in the 2015 and 2019 curricula already required the use of HOTS. Examinations aim to examine whether students have acquired the skills and competences defined in the curriculum LOs, and therefore the digital geography examination could be directed toward higher-order thinking. Additionally, based on the findings from Article II, I suggest that not all the options made possible by digitalization have yet been applied. Previous research has noted that digital technologies could develop students' HOTS (see e.g. Collins 2018; De Miguel González & De Lázaro Torres 2020; Favier & Van Der Schee 2014; Liu *et al.* 2010; Palladino & Goodchild 1993) and improve students' powerful geographical knowledge types 2, 3, and 4 (Fargher 2018; Walshe 2018; see also Healy & Walshe 2020). Therefore, digitalized geography tests present significant opportunities in the near future to develop geography education toward higher-order thinking and powerful geographical knowledge. Moreover, assessments affect (Baird *et al.* 2017: 340; see also Bijsterbosch *et al.* 2017; Chang & Seow 2018; Ormond 2019) and can improve (Baird *et al.* 2017; Stoltman *et al.* 2014: 193; Wertheim & Edelson 2013: 15) teaching and learning, and therefore we should pay careful attention to assessment practices and policies.

Third, I suggest that we should reevaluate the structure of the geography curriculum (as proposed in Article III) in order to be able to engage *all* geography students with HOTS and powerful geographical knowledge during their studies in upper secondary education. Researchers (see e.g. Butt 2017; Young 2008: 14) have argued that it is a matter of social justice for students to gain access to powerful geographical knowledge that goes beyond their own knowledge. The results from Article III show that HOTS are not evenly distributed between the general and course-specific LOs found in three different geography curricula, although the situation improved during the curriculum reforms. Most of all, there is a need to reevaluate the thinking skills and geographical knowledge emphasized in GE1, which is the only compulsory course for all upper secondary students. Therefore, when formulating the next geography curriculum's content and LOs, we should pay attention to the different thinking skills and powerful geographical knowledge types. Moreover, Articles I and II conclude that there are value-based aims both in teachers' conceptions of geography and in geography curricula LOs. However, these are not assessed in geography tests (Article II; see also findings from Tani *et al.* 2020). Values such as sustainable development and diversity are seen as important parts of geography education (see e.g. Uhlenwinkel *et al.* 2017), and therefore I additionally suggest the reevaluation of value-based issues in the geography curriculum, teaching, and assessment. However, it would be important to consider whether value-based issues should assessed in summative assessments at the end of a course or school year, or in formative assessments during the courses.

My fourth developmental aspect relates to teachers. I propose that we need specialized geography teachers who know the discipline of geography well (as proposed in Article I), but we also need training for teachers and student teachers (as suggested in Articles II and III). Teachers are the real interpreters of the curriculum (see e.g. Lambert & Hopkin 2014: 75; Lambert & Morgan 2010; Lambert *et al.* 2015: 731; Young & Muller 2019: 16), and therefore, if we only change curriculum documents in terms of thinking skills and knowledge dimensions, we will not be able to change the teaching and learning of geography. The finding (from Articles II and III) that the majority of geography test questions and LOs emphasize LOTS does not mean that teachers do not emphasize HOTS in their teaching. Article I showed that of the HOTS, only evaluative thinking (i.e. knowledge type 3) was lacking in teachers' conceptions. However, more training is needed about thinking skills and powerful geographical knowledge types, as well as about how to use these theoretical perspectives to plan teaching and learning, and about the importance of engaging students with different thinking skills and powerful geographical knowledge types.

For the fifth and last developmental aspect, I propose that we should engage students in planning the teaching and learning of geography, i.e. they should know what skills and knowledge they are required to use while learning geography (as proposed in Article III). Geography students especially need practice in their evaluative thinking skills, because as Article III concluded, students have difficulties drawing firm conclusions and justifying their views. Additionally, Articles I, II, and III show that evaluative, critical, creative, and holistic thinking, i.e. knowledge types 3 and 1, are emphasized to a minor extent in curriculum documents, teachers' conceptions, and assessment questions (see also research by Béneker & Palings 2017; Bouwmans & Béneker 2018; Maude 2015). By being engaged, students can "learn to use knowledge" (Béneker and Van Der Vaart 2020: 229) and "be conscious and mindful about their thinking processes" (Bednarz 2019: 525). I suggest that by introducing students to the different thinking skills and powerful geographical knowledge types, and by enabling them to practice using their own knowledge, we might empower students to be critical and creative thinkers. By understanding and being conscious of their thinking skills, students are able to understand how to create, test, and evaluate geographical knowledge—in other words, how to do geography (see also Maude 2018). Additionally, this increases students' *metacognitive* knowledge, which is missing from the materials analyzed in Articles I, II, and III. I suggest that when students gain knowledge about cognition itself, and about self-regulation strategies (see Anderson *et al.* 2014), they are introduced to powerful geographical knowledge (see also Krause *et al.* 2021).

Based on the research findings from Articles I, II, and III and my discussion here, I conclude that there is a need to ponder how to develop geography education in terms of thinking skills and powerful knowledge, in order to develop students' powerful geographical knowledge and thinking skills. Therefore, I propose that we need: 1) to carefully reevaluate the preferred LOs in the geography curriculum and the aims of assessment in geography—more precisely, the optimal distribution of LOTS and HOTS; 2) to consider guiding the formulation of geography test questions toward the assessment of HOTS, which is enabled by the new digital examination format; 3) to reevaluate the structure of the geography curriculum by looking at the distribution of LOs emphasizing HOTS between different geography courses; 4) to take care of teachers' continuing education about thinking skills and powerful geographical knowledge; 5) to engage students to practice their thinking skills in geography, i.e. students must learn to use geographical knowledge.

5 Conclusion

5.1 Future geography could enhance students' higher-order thinking and engage them in powerful geographical knowledge

> "There is no one 'correct' set of things that students should know; there is no one 'proper' way of learning; there are no 'self-evident' goals of education. Instead, there are only ever *choices* about what to teach, how to teach and to what ends." (Castree 2005: 246, italic in the original)

The above quote from Castree describes the challenge of education by stating that there are no right ways of doing things in education; there are only continuous choices to be made by the people involved in the education system. This brings me back to the introduction to this thesis, where I proposed a question: what should be taught to young people so that they will be able to act in a future world about which there is no certainty? In this thesis, I have attempted to provide one perspective from which to ponder the answer to this challenge in the context of geography education. My aim—*to widen our understanding of thinking skills and powerful knowledge*—was approached through my research objective: *to examine geography's potential to engage students in thinking skills and powerful geographical knowledge, using Finnish upper secondary geography education as an example*. Empirically, the thesis examined the thinking skills and powerful knowledge types currently emphasized in Finnish geography curricula LOs, assessment questions, teachers' conceptions, and students' answers.

Theoretically, this thesis connected two perspectives together by suggesting that the theoretical concept of powerful geographical knowledge (Maude 2018) becomes more approachable if we look at it through the theoretical perspective of the revised version of Bloom's taxonomy (Anderson *et al.* 2014). I suggested that these two ways of seeing geography could be used as "lenses" to examine geography education, to see the thinking skills, knowledge, and intellectual power that geography education could enhance. The combination of these two can be used to see the kind of thinking and knowledge that powerful geographical knowledge could give to students, as well as the kind of powerful geographical knowledge that different thinking processes and knowledge dimensions enhance. Additionally, this way of seeing geography reveals whether there is a dominance of one type of knowledge or a lack of some types, and it is important to think about what consequences the absence or dominance of some knowledge types or thinking categories might have for geography education (see also Bouwmans & Béneker 2018). Table 8 presents the framework of the powerful geographical knowledge, thinking skills, and knowledge dimensions of the revised version of Bloom's taxonomy and complements it with the findings and examples presented in this thesis. I propose that this framework can be applied so as to "speak the same language" in order to develop geography education.

It is important to note that the most abstract knowledge dimension, *metacognitive* knowledge, is not presented as a separate knowledge domain in the framework. *Metacognitive* knowledge is understood as strategic knowledge about cognition, and about oneself in relation to various subject matters (Anderson *et al.* 2014: 44). Thus, it is expected to be used with all cognitive processes and in all learning (Anderson *et al.* 2014: 44, 239–241). The results of this thesis revealed that *metacognitive* knowledge per se is absent from geography LOs and test questions. However, this does not mean that *metacognitive* knowledge is completely missing from the upper secondary school

Table 8. A framework for seeing geography education through the "lenses" of powerful geographical knowledge and the revised version of Bloom's taxonomy.

	Type of powerful geographical knowledge (Maude 2018) (Article I)	**The students can show that they are able to…** (based on Anderson *et al.* 2014) (Articles II, III)	**The students can show that they are able to…** (based on Anderson *et al.* 2014) (Articles II, III)	**Examples of LOs from 2003 and 2015 geography curricula: the student…** (Article III)	**Examples from ME geography questions 2013–2019** (Article II)
LOTS	5) "Knowledge of the world" (teaching about unfamiliar places; helping to understand the world's diversity).	*1) Remember:* recognize geographical symbols from presented material; remember simple facts, and recall concepts and pictures from long-term memory. *(2) Understand.)*	*Factual:* demonstrate knowledge of simple facts or specific details, concepts, elements, or phenomena. *(Conceptual.)*	Knows different cultures (GE2, 2003). Knows which professions and work duties require geographical competence (general, 2015).	Recognizing map symbols, e.g. naming the biomes presented on a map. Recalling geographical concepts, e.g. what "renewable energy resources" means. Drawing a picture of the structure of the atmosphere from memory alone.
	2) "Knowledge that provides students with powerful ways of analyzing, explaining, and understanding" (analytical methods to analyze relationships between phenomena; relative locations and explanatory power; generalizations from phenomena).	*2) Understand:* describe different geographical phenomena by listing and explaining concepts; give examples, and compare and classify geographical concepts; infer and explain how geographical processes work from the information presented; translate and summarize information from a given representation into a different form.	*Conceptual:* demonstrate knowledge of the causalities between concepts by connecting things; explain theories, models, structures, classifications, categories, principles, and generalizations with the help of examples.	Is able to use the basic concepts of human geography (GE2 2003). Understands how and why natural landscapes change, and knows how to interpret the structures, origins, and development of natural landscapes using images and maps (GE2, 2015).	Interpreting a given map to show how the percentage of the population aged between seven and 15 varies regionally in Finland. Giving regional examples for each phenomenon. Classifying concepts, e.g. whether they refer to the climate or weather. Summarizing the content of a video in an essay title. Inferring how a mountain in a given picture was formed. Comparing how the climate in a given area differs from the climate in Finland. Explaining the causes of earthquakes.
		3) Apply: apply simple geographical models or theories to explain different phenomena; apply knowledge of geographical methods, e.g. calculate a surface area. *(4) Analyze.)*	*Procedural:* apply knowledge of geographical methods and criteria by using the methods in certain situations; demonstrate an understanding of the grounds of a specific method and use it in a real situation.	Is able to use GIS applications (GE4, 2015). Is able to use information and communication technology to acquire, analyze, and present data on global issues (GE1, 2015).	Executing a simple calculation, e.g. surface area. Implementing, e.g. using information from spatial data to determine the location of a new mall.

	4) "Knowledge that enables young people to follow and participate in debates on significant local, national, and global issues" (ability to follow and participate in public debates).	*4) Analyze:* select relevant information from the presented material, and organize it to form a coherent conclusion so that causalities between phenomena or concepts are visible; analyze the values and attitudes in the material presented. *(5) Evaluate.)*	*Conceptual. Procedural.*	Is able to analyze demographic development and settlement in different regions of the world, as well as the causes and consequences of urbanization (GE2, 2003). Is able to analyze positive development in different areas of the world and the factors affecting it (GE1, 2015).	Differentiating information on maps and charts about free-time living in Finland. Organizing, e.g. structuring a view of how global risks affect Finland. Attributing, e.g. noticing the values presented in a text (not found in ME 2013–2019).
	3) "Knowledge that gives students some power over their own geographical knowledge" (being a critical and independent thinker; geographical reasoning; knowing how knowledge is created, tested, and evaluated)	*5) Evaluate:* draw conclusions and judgments from given phenomena, based on known criteria and standards, and justifying their views; be critical, i.e. critical thinking is visible.	*Conceptual. Procedural.*	Is able to compare and assess the susceptibility of different areas to risks, globally and locally (GE3, 2003). Is able to analyze regional characteristics of human activity and evaluate how these are affected by opportunities provided by natural resources and the environment (GE3, 2015).	Checking what advantages are related to the measurement of happiness through self-assessment. Critiquing, e.g. judging the social impact of the Olympics by analyzing the games' pros and cons for the organizing city and its citizens.
HOTS	1) "Knowledge that provides 'new ways of thinking about the world'" (for example, if students change their thinking about their relationship with the environment, it can change their behavior) (the most powerful component).	*6) Create:* put elements together in a way that forms a coherent whole offering a new way to see phenomena, and hypothesize how the phenomena are going to proceed—i.e. by answering a "what then?" question; show creative and holistic thinking by reorganizing elements.	*Conceptual. Procedural*	Is able to consider potential solutions to economic problems and social inequality (general, 2003). Is able to pose geographical questions and use geomedia to solve geographical problems (GE4, 2015).	Generating, e.g. hypothesizing how to improve world food production by using given material. Planning an essay outline based on the given material. Producing a plan or map of a trip to North America.
	6) Knowledge that introduces students to learning in relation to the broader educational aims of schooling, cross-curricular themes of the curriculum, and respect for and development of values (teaching geography that supports e.g. sustainable ways of life, active citizenship, global responsibility, multiliteracy)			Acts as an active global citizen, and promotes sustainable development (general, 2015). Appreciates their own and other cultures' diversity, and respects human rights (GE3, 2015).	

curriculum, teaching practices, or Finnish ME. It is acknowledged that students can demonstrate their *metacognitive* knowledge when they plan their answers or make choices about which test questions to answer. Additionally, teachers attempt to engage students in the teaching and learning of geography in their classrooms, i.e. to guide students to use their *metacognitive* knowledge.

When we talk about geography education, it is important to consider value-based aims (see e.g. Bednarz 2019; Uhlenwinkel *et al.* 2017). This thesis aimed to increase our theoretical understanding by differentiating and adding a sixth knowledge type to Maude's typology, because it found that geography teachers teach geographical knowledge that engages students to learn in relation to the broader educational aims of schooling (see Table 8, column 1). Moreover, according to this thesis, the value-based aims of education are emphasized in the geography LOs found in the Finnish upper secondary curriculum, although they are not assessed in the geography examinations (see Table 8; see also findings from Tani *et al.* 2020).Thus, I have differentiated value-based issues in the framework as a powerful geographical knowledge type. However, I suggest that the achievement of value-based aims requires the use of all of the thinking skills and knowledge dimensions as well as all levels of powerful geographical knowledge. Nonetheless, I have wanted to emphasize value-based issues in the framework as a separate knowledge type, because they reflect geography's ability to engage students to appreciate the diverse and complex world around them and participate actively in society (see also Bednarz 2019). Value-based issues include cross-curricular themes in the curriculum as well as value-based content, i.e. teaching geography that supports sustainable ways of life and develops eco-social knowledge, active citizenship, global responsibility, multiliteracy, and internationality.

The framework presented here could be used to plan the aims of geography education and to choose teaching artifacts, teaching methods, and assessments tasks—in other words, to make continuous choices. The material in Table 8, column 1—powerful geographical knowledge—helps the teacher to select the content to be taught (see also Maude 2018: 7), while the material in columns 2 and 3—the thinking skills and knowledge needed to achieve the intended learning outcomes—informs students' learning or actions. Columns 4 and 5 give insights into the kinds of LOs and assessment questions that can be connected to the different powerful geographical knowledge types and thinking skills. This can help teachers to interpret curriculum documents, and it can also help curriculum and assessment specialists to weigh up which LOs or assignments to include in the curriculum or geography tests. It is important to note here that these examples are based on the existing geography LOs and assessment questions. Therefore, I encourage others to actively use and interpret the framework in order to form LOs and test questions that will utilize different thinking skills and powerful geographical knowledge types. I am cautious not to make a list of what to teach (see Lambert 2016; Lambert *et al.* 2015; Maude 2016; Uhlenwinkel *et al.* 2017), and therefore I suggest that this framework should be used as a "lens" to see geography education and to inspect thinking skills and powerful geographical knowledge types.

Practically, this thesis aimed to give valuable insights into the digitalization of the ME in geography in 2016 and the curriculum reforms conducted in 2015 and 2019. The findings of this thesis could be used to further develop national geography tests and curricula. Overall, the different thinking skills, knowledge dimensions, and powerful geographical knowledge types are all present to some extent in the Finnish geography curriculum LOs, geography test questions, students' answers, and teachers' conceptions investigated in this research. Therefore, in light of the findings presented in this thesis, I agree that geography is much more than learning simple facts about the world (see also Favier & Van Der Schee 2012: 666). It is about learning *for* world, not just *in* and *about* the world (Bednarz 2019: 527). This thesis has thus argued that geography could enhance students' higher-order thinking skills.

In summary, the findings indicate that the ME in geography is in line with the educational LOs found in the geography curriculum: the majority of geography LOs and test questions emphasize LOTS, i.e. powerful geographical knowledge types 2 and 5. However, the teachers who participated in this research seemed additionally to emphasize HOTS to some extent, since powerful geographical knowledge types 1 and 4 were emphasized in their conceptions. The emphasis shifted slightly toward higher-order thinking, i.e. powerful geographical knowledge type 4, during the digitalization of the ME and the curriculum reforms. Therefore, more analytical thinking skills are needed. The findings showed that students have difficulties answering questions that require them to use *analytical* (in digital tests only), *evaluative*, and *creative* thinking and *procedural* knowledge, i.e. powerful geographical knowledge types 1, 3, and 4. However, it is important to note that the students' answers analyzed in this research do not describe the students' overall geographical competence or performance; rather, they describe the students' performance in relation to the questions asked in the exam.

In Finland, the geography curriculum LOs and ME geography test questions need to be reevaluated in terms of the thinking skills and powerful geographical knowledge requirements. The cognitive categories and powerful geographical knowledge types are not emphasized evenly in the context of Finnish geography education. All cognitive categories, especially the categories of higher-order thinking, are needed for learning to be meaningful (see e.g. Airasian & Miranda 2002; Anderson *et al.* 2014; Bijsterbosch *et al.* 2017), and all knowledge types are needed to form powerful geographical knowledge (see e.g. Béneker & Van Der Vaart 2020; Bouwmans & Béneker 2018). Maude and Caldis (2019) state that HOTS and powerful geographical knowledge can be developed and taught together. Krause *et al.* (2021: 11) argue that only through higher-order thinking can students learn to apply and structure their own ideas and build up their argumentation. Therefore, I suggest that there is a need to consider putting more emphasis on HOTS, because these skills enable the development of students' powerful geographical knowledge in greater depth (see Maude & Caldis 2019) and can thus guide geography education toward the Future 3 educational scenario (see Young & Muller 2010), which is said to be the preferred direction for geography education (see e.g. Biddulph *et al.* 2020; Lambert & Biddulph 2015; Lambert & Hopkin 2014; Lambert *et al.* 2015: 10; Maude 2020; Mitchell & Lambert 2015; Morgan 2011; Uhlenwinkel *et al.* 2017).

This thesis aimed to widen our understanding of thinking skills and powerful geographical knowledge in the context of Finnish geography education. However, important aspects remain to be examined: for example, teachers' assessment practices, the learning tasks they use, and the thinking skills and knowledge types they emphasize in their classroom assessments and tasks. Moreover, there is a need for more research about digital geography tests—for example, regarding how students' scores relate to the thinking skills they use in their answers. This is important, because there is a need for more external evaluation of the ME, since the majority of upper secondary school students are accepted into higher education based on their success in the ME. Therefore, the assessment conducted in the ME has recently gained significantly in importance.

Additionally, the research could be extended to examine all levels of education, from primary geography education to higher geography education. How are thinking skills and powerful geographical knowledge developed, and how should they be developed across the years of education? This could be examined to a larger extent by also using quantitative research methodology. Additionally, further research is needed about the known similarities and differences between geography education in different countries, because education is largely intertwined with national contexts. The practical implications presented here are mainly applicable in the context of upper secondary education in Finland. However, the framework presented here could reveal important insights into geography education across the globe regarding preferred thinking skills and geographical knowledge. I therefore encourage other researchers to inspect geography education in their own national contexts through the "lenses" of the revised version of Bloom's taxonomy and powerful geographical knowledge.

5.2 Evaluating the research

It is important to note that the interpretation of the revised version of Bloom's taxonomy and the powerful geographical knowledge types is always a matter of subjective statements (see also Anderson *et al.* 2014: 33; Maude 2016: 72). For this reason, I have attempted to describe the framework produced, i.e. the combination of the two theoretical perspectives, as accurately as possible so that others can evaluate its usefulness. The theoretical foundations of this thesis aimed to explain the theoretical principles behind the classifications used in the thesis. Additionally, they aimed to guide and encourage the readers of the thesis to ponder the categorizations found in Maude's powerful geographical knowledge types and the revised version of Bloom's taxonomy. However, it should be said that the boundaries between the categories (in both Maude's typology and the revised version of Bloom's taxonomy, as well as in the combination of the two) are sometimes blurred. Therefore, when using this framework one should exercise caution, constantly pondering the boundaries between categories and their overlapping nature.

Moreover, to mitigate the subjectivity of the interpretation of classifications, the framework of the revised version of Bloom's taxonomy (used in Articles II and III) was formulated collaboratively by three researchers: thus, it was not simply my personal or subjective interpretation. The process of producing the framework required a constant dialogue among the three researchers. Several joint meetings were organized, in which the production of the framework was discussed and evaluated carefully. During this process we especially addressed the problematics of categorizing everything in (overlapping) categories. We had lengthy discussions about the difference between the categories of *understanding* and *analyzing*. Additionally, there were discussions about the categories of *applying* and *evaluating*, how to describe them, and what questions, LOs, or students' answers to include in them. The results of these discussions were scrutinized collaboratively into the produced framework.

I suggest that the revised version of Bloom's taxonomy is suitable for use in geography education to examine thinking skills and knowledge dimensions and to develop LOs and assessment tasks. However, I acknowledge that this may not be the only suitable perspective to use for the inspection of thinking skills. I understand that the theoretical perspectives used to interpret the research materials have guided the research results. In other words, the chosen theoretical frameworks have given a certain perspective on the researched phenomenon, whereas other perspectives may have not been detected by these frameworks. This means that the same research materials might yield different interpretations because of the different questions asked by interpreters (see Lichtman 2013).

During the process of data-gathering and analysis, I moved along the qualitative continuum, from an inductive approach with interviews to a deductive approach with quantification, statistical analyses, and written administrative documents—all interpreted through a qualitative research approach. Thus, the content analysis utilized in this thesis did not entail counting and categorizing brute words, but interpreting and understanding their meaning in context. I have examined and widened our understanding of geography education in the context of Finnish upper secondary education, with geographical thinking skills and powerful knowledge as my focus. This aim was approached by using multiple research materials, each of which told their own story about the researched phenomenon. The curricula, geography test questions, and students' answers I used were derived from archival and document sources, and therefore they already existed in the situation and were not dependent on the researcher (see Merriam 2002a: 13), whereas the interviews and concept maps were affected by the researcher's presence during the data-gathering process.

Thus, the process was nonlinear and dynamic, guided by the researcher's positionality—my personal background as a geography teacher and teacher educator. During this research process I was aware of my own background. Thus, I tried to keep my teacher educator and geography teacher practice in the background, allowing myself to conduct and focus on the research. However, I acknowledge that my twofold role affected the research process. I was able to utilize the knowledge gained from my teaching practice when conducting this research, as well as to utilize the knowledge gained from this research in my teaching and teacher educator practice. For example, the produced framework inspired my thinking and teaching. I learned a lot not only as a researcher, but also as a geography teacher and teacher educator.

Moreover, as is typical of qualitative research, the research findings reported in this thesis are related to the context where they were produced and interpreted. During the research process for this thesis, the context for data-gathering and interpretation was unique, since the digitalization of the ME and curriculum reform were in progress in Finland. It is important to note that the curriculum for basic education was also reformed just a year before the upper secondary curriculum. Thus, the students who received their basic education according to the reformed basic education curriculum entered upper secondary schools in fall 2020. Therefore, in order to evaluate the overall picture of all the changes that have occurred in the Finnish geography education scene, there is still a need for further research.

This thesis has shed light on the thinking skills and powerful geographical knowledge emphasized in this particular context. However, this thesis has not revealed how students' higher-order thinking skills develop through their studies, or how other possible factors (e.g. different teaching practices or school subjects, students' lived experiences or motivation, the impact of the basic education curriculum) might affect the development of thinking skills. This underlines the need of further research, as proposed earlier. However, this thesis has provided one perspective from which to see geography education, and it has presented a framework for how thinking skills and powerful geographical knowledge can be understood in geography.

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