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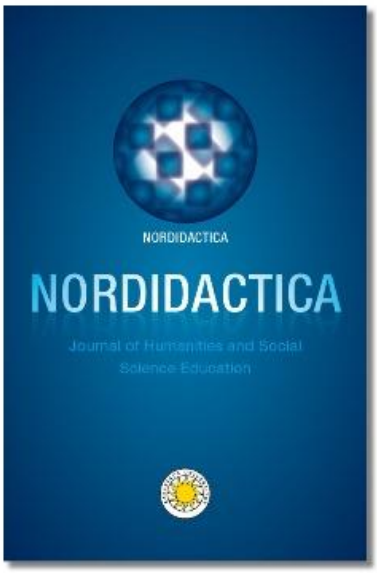
Sofie Nilsson & Gabriel Bladh



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Thinking Geographically? Secondary Teachers' Curriculum Thinking when Using Subject-Specific Digital Tools

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Abstract: In this paper we explore Swedish secondary social science teachers' curriculum thinking when they engage in constructing lesson plans with the purpose to develop students' geographical thinking while conducting geographical analyses with subject-specific digital tools (SSDTs). Framed as a case study with a workshop design, a group of secondary social science teachers constructed lesson plans that were implemented with their students. Different data were collected during the case study process, such as a survey, recorded workshops, written lesson plans and reflection documents. The findings were analysed based on a synthetic model of geographical thinking and the Graphical Assessment of TPACK Instrument, GATI, in order to consider teachers' professional knowledge base. The results indicated that most of the teachers engaged in geographical thinking when planning the lessons, but there is an imbedded difficulty in the transformation of such thinking into lesson plans and student instructions. The knowledge base, displayed as their personal GATI models, differed among the teachers and integrating of SSDTs in the lesson plans turned out to be a threshold. Teachers with less technological knowledge did not manage to construct lesson plans even though their content knowledge was solid. Similarly, teachers with a less developed geographical knowledge base did not manage to integrate geographical thinking in their lesson plans. This implies that the integration between the different aspects of the knowledge base is crucial alongside developing each knowledge.

KEYWORDS: CASE STUDY, GEOGRAPHY TEACHING, SECONDARY SCHOOL, GEOGRAPHICAL THINKING, SUBJECT-SPECIFIC DIGITAL TOOLS, KNOWLEDGE BASE, TPACK, GATI, SECONDARY EDUCATION

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Introduction

The object of teaching and learning in geography education is the earth and world including all relations, connections, diversities, interactions and changes. These aspects of geography education need to be framed by high-quality geography teaching. Hence, geography teachers' pedagogical content knowledge has to be extensive when constructing and implementing lesson plans to enhance students' geographical knowledge and understanding. This could include asking geographical questions, using different geographical concepts and perspectives and engaging in geographical analyses; in other words, applying what can be defined as geographical thinking (Lambert, 2015).

There are a multitude of opportunities to visualise the complex world and analyse geographical information by using different kinds of geospatial technology, geographical information systems (GIS) and geomedia. There is a consensus among researchers (see Baker et al., 2012; Baker et al., 2015; Fargher & Healy, 2021, Favier & van der Schee, 2014a; Favier & van der Schee, 2014b; Gryl et al., 2014; Jo & Bednarz, 2014; Lee & Bednarz, 2009) that these digital resources and tools can potentially provide different ways for students to develop their spatial knowledge and geographical understanding. Especially the development of the internet and 'web 2.0' and new types of geomedia have significantly changed the geography classrooms (Gryl, 2012; Gryl et.al., 2014; Fargher, 2018b; Parkinson, 2018). However, sometimes technology is thought of as a solution to all kinds of pedagogical issues that challenge geography teachers, hence a critical reflection on what digitalisation means for geography teaching is needed. It is essential that geography teachers are empowered as professionals to navigate in this complex context (Healy & Walshe, 2021a). This implies that geography teaching requires access to several aspects of teachers' professional knowledge base, that is a combination of content knowledge, pedagogical knowledge, technological knowledge (Shulman, 1986, 2015; Mishra & Koehler 2006, 2007) and management competence (Baumert & Kunter, 2006; Nilsson & Bladh, 2020). Over all, this adds to teachers' situation where they find themselves in different types of pressures where they have to respond to the changing contexts they work in (Mitchell, 2016). Here teacher identity as well as teachers' collaborative work are important components to understand teachers' choices as curriculum makers (Brooks, 2021). In Sweden, secondary school teachers teaching geography often identify themselves more broadly as social science teachers, since teachers usually teach four subjects: geography, history, civics and religion (Bladh, 2014).

In its early stages, the digitalisation process in Swedish schools was detached from the subject-specific teaching, adding demands for generic computer skills to be taught. Recently the digitalisation process has taken a more subject-specific turn. For teachers this means managing both subject-specific content and capabilities as well as subject-specific technological understanding and skills. According to the Swedish geography curriculum, secondary geography education should include: "Methods for collecting, processing, assessing and presenting geographical data, covering climate, health and trade, using maps, Geographical Information Systems (GIS) and geographical tools

available on the internet, such as satellite images." (The Swedish National Agency for Education [SNAE], 2011, p. 202). In the upcoming revised curriculum version, asking geographical questions and analysing the world are connected to the use of geographical tools. Conducting geographical analyses and asking geographical questions require a geographical language including the use of geographical concepts, perspectives and skills. In all, students should be introduced to and practice *geographical thinking*.

Results from a recent study reveal a positive attitude towards digitalisation in geography education among secondary teachers in social science (Nilsson & Bladh, 2020). However, the results also show a tendency of a large spread in the usage of digital tools and subject-specific tools. Depending on geographic teaching elements, the usage varies. Also, digital tools that provide spatial representations and geographical information were not as commonly used. About 1/3 of the teachers who teach geography in Sweden do not have university studies in geography, and many in this group tend not to deepen certain geography teaching elements that they find more demanding (Bladh, 2014). Managing and integrating geographical methods and perspectives, such as in geographical analyses, are generally regarded as more complex aspects of geography teaching. This is also reflected in the teachers' choices and usage of digital tools. Such aspects are highly present when teachers make didactical choices when recontextualising the curriculum. Processes of recontextualisation can be interpreted as the ways in which knowledge is selected from the fields in which it is produced, and transformed into school curricula, textbooks, lessons and ultimately into what students learn (Fargher et al., 2021). Here we focus on how geographical knowledge, and more specifically aspects of geographical thinking, are selected through teachers' curriculum thinking in their planning process. Since teachers find complex aspects of geography teaching, where different forms of geographical knowledge, skills and tools are combined, challenging, it appears fruitful to investigate such aspects of teachers' curriculum thinking (Bladh, 2020).

The purpose of the study presented in this article is to explore the curriculum thinking of Swedish secondary social science teachers. The focus is on lesson plan construction aiming to develop students' geographical thinking as they conduct geographical analyses with subject-specific digital tools (SSDTs). This study is a part of a research school (FUNDIG) and based on the overall aim to develop empirical knowledge and contribute to teachers' communities of practice in relation to digitalisation as a part of education and teaching.

The theoretical framing of this study is twofold. First, the concept of geographical thinking will be discussed, and a synthetic model of geographical thinking is developed to analyse teachers' curriculum thinking. Second, teachers' professional knowledge base will be explored through using the technological, pedagogical content knowledge (TPACK) framework. This will further be operationalised in the GATI model (Krauskopf et al., 2018) to analyse teachers' professional knowledge base.

The study sought to answer the following **research questions:**

RQ 1: How does recontextualisation of geographical thinking appear in the teachers' lesson plans?

RQ 2: What aspects of the teachers' professional knowledge base are elucidated in the teachers' utterances and written lesson plans?

Thinking geographically in geographical analyses

The ability to describe, compare, contrast, analyse and understand geographical objects, changes and interaction is often referred to as geographical thinking (see Morgan 2013, 2018). This entails complex, subject-specific aspects of geography teaching and learning. The concept has not yet been firmly established, thus similar, but varying terminology, can be found within the research field of geography education. In short, the ability to understand and categorise geographical information and knowledge can, besides geographical thinking, be described in terms of *spatial thinking* (see Jo & Bednarz, 2014), *geospatial thinking* (see Baker et al., 2015; Bryant and Favier, 2015; Donert et al., 2016; Favier & van der Schee, 2014a; van der Schee et al., 2015 and Ishikawa, 2013), *relational thinking* (see Jackson, 2006) and *geoliteracy competence* (see Kerski, 2015).

Our study will more explicitly draw on ideas and models connected to geographical thinking and spatial thinking as a theoretical foundation and an analytical framework. The following section seeks to outline these terms.

In the geography education context, the concept geographical thinking has been frequently used (Brooks et al. 2017). Within the GeoCapabilities research framework, Lambert et al. (2015) have described geographical thinking as part of powerful geographical knowledge, that is "a critical conceptual knowledge that has explanatory power and systematicity, providing a relational understanding of people living on the planet" (Lambert et al., 2015 p. 732). Thus, geographical thinking is underpinned by using systematic conceptual knowledge, especially key concepts such as place, space and environment (the grammar of geography), and can together with world knowledge (the vocabulary of geography) and geographical skills and methods (procedural knowledge) enable engagement with powerful geographical knowledge in teaching and learning. The use of relational perspectives and thinking are central when exploring spatial relations or environmental relations, which is central in geographical thinking. Taylor (2008) has discussed how asking geographical question and thinking geographically involve the use of differentiated system of concepts including big ideas or key concepts, such as place and space, put in relation to organising concepts, such as change or interaction. Drawing on the underlying key concepts, Taylor promotes organising concepts as helpful when asking geographical questions, analysing geographical phenomena, comparing and contrasting, and formulating explanations. Thus, these can function as drivers of enquiry sequences in teaching while "doing" geography. The organising concepts are generic, but transform into geographical organisational concepts in a geographical context. They can be used as bridging concepts to structure teaching and enable geographical thinking (see also Dessen-Jankell et.al, 2021).

The discussion in the American geography educational context have been more focused on the concept of spatial thinking (Jo, 2018). In line with the definition presented in the American publication Learning to Think Spatially (National Research Council [NCR], 2006) spatial thinking is "problem-solving and decision-making by flexibly using spatial concepts, tools of representation, and processes of reasoning" (Jo, 2018, p. 201). Here, *spatial concepts* are subject-specific concepts that define space and assist in obtaining and communicating knowledge and understanding. Different geographical materials and geomedia, such as maps, geospatial tools, geographical information, diagrams and models are defined as *representations*. The representations facilitate the actions of spatial thinking. *Reasoning process* is the abstract process that combines spatial concepts and knowledge with representations and hence make meaning of complex and abstract information. Jo & Bednarz (2014) have used the three basic components of spatial thinking to explore how pre-service teachers' pedagogical content knowledge for teaching spatial thinking could be developed. Their research design has been an inspiration for our current study (see the methodology section).

There is a close connection between thinking geographically, spatial thinking and geospatial technologies. Favier & van der Schee (2014b) maintain that geospatial technologies can offer many opportunities to stimulate students' geographic relational thinking. Especially where geospatial technologies, such as geographical information systems (GIS), functions as a frame, the concept geospatial thinking has been used to stress how spatial thinking are used in a geographical context (Baker et al., 2015). Worldwide research on the use of GIS and geospatial technologies in geography education is expanding. Baker et al. (2012) argue that GIS can help students think critically, use authentic data and connect to their community. However, they also state that educational research on GIS worldwide is rather loosely connected and in the Nordic context, few studies have focused on the use of GIS in geography education (see Andersland, 2011; Ratinen & Keinonen, 2011; Schubert & Johansson, 2019; Anunti et al., 2020). Results from three survey studies with teachers indicate a fairly limited use of GIS and similar types of subject-specific digital tools in secondary geography education (Bladh, 2014; Nilsson & Bladh, 2020; Witzel Clausen, 2016).

For the purpose of this study and throughout the different stages of the study (from data collection to article writing), the term *geographical thinking* will be used. Geographical thinking is more clearly linked to the two types of relations that are central to the school subject of geography, spatial relations between place-space or local-global and environmental relations between nature-society. Geospatial thinking can be understood as more or less a synonym for geographical thinking, but it has a less explicit connection to the subject of geography. Considering the didactical practice of geography education, the term geographical thinking has an appealing semantic connotation both for teachers and pupils.

Framing of geographical thinking in this study

In this study geographical thinking is used in two ways, both as an analytical tool to enable analysing teachers' geographical thinking and as a didactical model used by the

teachers while planning their lessons (Jank & Meyer, 2006; Sjöström et al., 2020; Wickman et al., 2018).

Based on the research overview, we created a synthetic model (see table 1) which will be used as an analytical framework. The model includes different kinds of geographical knowledge (propositional (contextual and conceptual) and procedural knowledge) as well as representations needed when conducting geographical analyses using geographical thinking. It combines elements from the GeoCapabilities perspective (Lambert, 2015) and components from the spatial thinking approach (Jo & Bednarz, 2014). It also includes elements from Taylor's discussion on concepts as classifiers (Taylor, 2008), which especially discern organising concepts. In line with their function as drivers of enquiry sequences in teaching, organising concepts can be interpreted as central for geographical reasoning processes. This makes clear how organising concepts can function as bridges, connecting contextual (world knowledge) and conceptual knowledge (different types of geographical concepts). Here key concepts are central for directing the geographical perspective (Taylor, 2008). When making a geographical analysis, the organising concepts functions as addressing procedural knowledge in thinking geographically, when for example exploring and reasoning about different types of geographical interactions or changes.

TABLE 1

The synthetic model of geographical analysis, including geographical thinking and representations

Geographical thinking while engaging in a geographical analysis				**Material used in the analysis**
World knowledge:	Geographical concepts:		Reasoning process:	Representations:
Knowledge of places and regions	Key concepts E.g. place, space, time scale, environment	Substantial concepts E.g. content concepts as forest, river or urbanisation	Organising concepts E.g. interaction, change	Different kinds of analogue and digital geomedia E.g. physical maps or subject-specific digital tools (SSDTs)

Geomedia can be used as an umbrella concept for geographical ways of gathering and presenting geographical information thus specifying the concept of representations (Hilander, 2016).

The terms digital tool and subject-specific digital tool are also used in this study. In order to contrast digital tools in general to digital tools with specific geographical content, the term subject-specific digital tools (SSDTs) is used. "A *subject-specific digital tool* was defined as a digital tool or learning resource that is developed to manage geographical data/information" (Nilsson & Bladh 2020 p. 6). This, for instance, includes different types of geomedia such as, geospatial technologies, online programs

and software that contain geographical information, visualisations and maps, GIS programs and geographical games.

Further, to establish a platform for mutual understanding of how to explain and discuss geographical thinking with the participating teachers, a model was created drawing on Taylor (2008) (see figure 1). (Compare with a similar approach by Dessen Jankell et al., 2021, see also Béneker and van der Vaart, 2020).

In the study, the model was used as a prompt and helpful tool when the teachers were planning the lessons. Thus, it can be understood as a didactical model which can be used in different teaching and learning situations, for instance when students are to engage in geographical thinking. It can help students connect their everyday knowledge, experience and language with abstract subject-specific language and knowledge (Roberts, 2014). The model also provides a professional language for collegial discussions (Wickman et al., 2018). The level of abstraction increases in the centre of the model, with the key concepts and perspectives. The outer circle is made up of substantial concepts. It is worth noting that the concepts in the outer circle come in numerous variations and therefore need to be specified, preferably with support from images, enabling enriched and fortified vocabulary. In particular, this could be fruitful for second language learner students. Here, the bridging and structuring qualities of the organising concepts are visualised with the arrow.

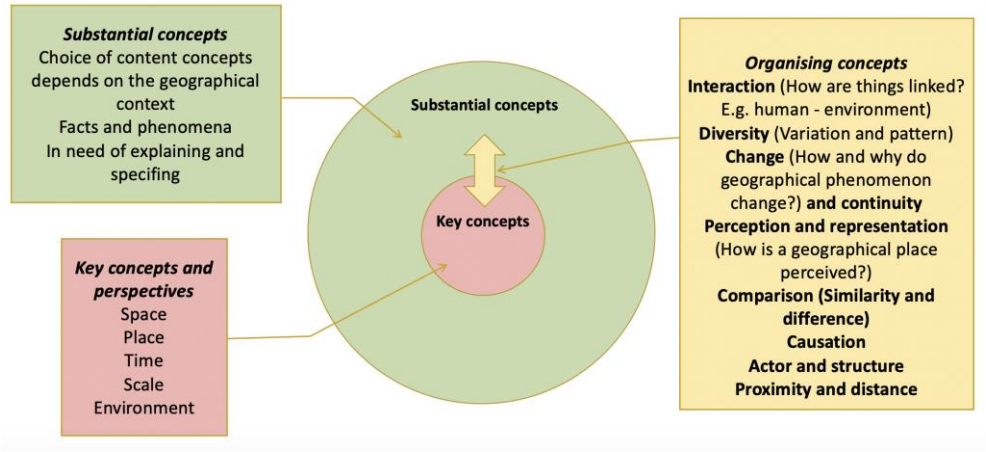

FIGURE 1.

Didactical model of geographical thinking used as a prompt in the study, inspired by Taylor (2008).

The model could also be useful in the transformation of implicit conceptual descriptions in the Swedish geography curriculum (see Örbring, 2017) to an explicit level by combining concepts and perspectives.

Teachers' professional knowledge base

Shulman (1986, 1987, 2015) designed the framework of pedagogical content knowledge (PCK) which describes teachers' specific professional understanding of

content knowledge combined with pedagogical knowledge. Shulman (1987) took the discussion further by describing what teachers' professional knowledge is in relation to categories of their knowledge base. The professional knowledge base includes different aspects of knowledge: pedagogical knowledge, content knowledge and pedagogical content knowledge. Theorists within educational research have further drawn on Shulman's ideas (see Gess-Newsome, 2015, on the usage of PCK in geography education research see for instance Martin, 2008; Jo and Bednarz, 2014 and Walshe & Driver, 2019).

In order to discuss issues regarding the integration of technology in teaching and learning and what technological competences and knowledge important to include in teachers' knowledge base, the technological pedagogical content knowledge framework (TPACK) was developed (Mishra & Koehler, 2006; Mishra & Koehler, 2007 and further developed in Koehler et al., 2014). The TPACK framework enabled discussions on what teachers need to know in order to integrate technology in their teaching. The TPACK model[1] also provides a visual description of the complex interaction between the different components and emphasises how the connections between teachers' understanding of content, pedagogy and technology interact to produce effective teaching. The impact of the TPACK framework has increased and it has frequently been used, developed and problematised in educational research (see Fargher (2018a) for an example in geography education or Hong & Stonier (2015) on how to develop in-service teachers' TPACK when integrating GIS in social science teaching). There is also critique towards the limitations of the framework, for instance describing it as insufficient (Ollinen, 2019). Cox & Graham (2009) describe the definition of technological knowledge (TK) as fuzzy and vague. Therefore, modifications of the TPACK model have enabled the development of methodological frameworks and analytical tools useful when investigating or developing teachers' TPACK. In the context of our study, the Graphical Assessment of TPACK Instrument (GATI) will be used. This will be outlined in the analytical frameworks section.

Methodology

This study is constructed as a case study, with a workshop design, inspired by Educational Design Research, EDR. Several research studies within the research field of geography education have been based on EDR (see Béneker et al., 2014; Béneker & van der Schee, 2015; Favier & Van der Schee, 2012; van den Akker, 2013; Anunti et al., 2020). In our design, the teachers took part in workshops where they discussed and planned ideas for a lesson design. The researcher presented lesson material, the didactical model and, gave a presentation as an inspiration for the lesson planning. Bladh et al. (2018) argue that the collaboration between researcher and teacher is crucial in order to deepen the understanding of the didactical teaching practice. Organising

[1] See http://tpack.org (Reproduced by permission of the publisher, © 2012 by tpack.org)

teachers in groups is also a way to support teachers in developing their own teaching practice (Willermark, 2018). Our workshop design could make up a base for further collaborative interventions such as professional development ventures, which also is a point of departure for the framing of this study.

The design

Seven secondary school social science teachers recruited from an existing network[2] of teachers from a medium-sized municipality in Sweden were asked to take part in the study. Two teachers declined, giving the group five participants. The participating teachers, three women and two men, were given fictional names: *Aron, Beatrice, Cecilia, Doris* and *Eric*. The teachers and their headmasters were e-mailed and informed about the project. The headmasters' approvals were obligatory since the teachers needed time off teaching when taking part in the workshops. The participants also signed consent forms before taking part of the study.

Jo & Bednarz's (2014) study, with pre-service teachers, was used as an inspiration when designing the workshops and the different stages of our study. In Jo & Bednarz study, the pre-service teachers took part in a workshop design in order to develop their spatial thinking and also their teaching skills regarding how to incorporate such thinking in their own teaching practice. Our project seeks to investigate in-service teachers' geographical thinking when constructing lesson plans, but in our case adding subject-specific digital tools. Also, in line with Jo & Bednarz (2014), Hong & Stonier (2015) and Willermark (2018), the lesson plans, and teachers' utterances during the workshops, were considered to be a valid indicators of a teacher's PCK and TPACK, as part of their knowledge base.

In short, the design was built up by nine stages: 1) introduction by the researcher (first author[3]), 2) a survey, to obtain background information of the participants, 3) teacher preparation (prompts), text and instruction films on how to use the subject-specific tools, 4) first workshop: group discussion on a geographical theme and ideas for a lesson plan and what subject-specific tools to use, 5) the teachers formed their own written lesson plans based on the overall ideas and notes from the workshop, 6) teachers implemented their lesson plans with their students, 7) teachers reflected on their lessons, 8) second workshop: teachers took turns to present their lesson plans, and then the group reflected on the lesson plans and outcome of the lessons and 9) individual follow up on teachers' GATI (see table 2 for a more outlined presentation of the stages). Throughout the different stages of the design, the teachers had creative autonomy. The design made collection of different types of data feasible: data from the survey, the teachers' recorded and transcribed utterances from the workshops and written lesson plans and reflection documents.

[2] The teachers belong to a subject-specific network, where professional development and knowledge exchange take place. The teachers can be understood as a collegial community of practice.
[3] The first author carried out the workshops and data collection.

In line with the study by Bladh et al. (2018), different prompts were used in order to introduce the teachers to the research perspectives and thematic content. The prompts functioned as a foundation for a mutual understanding of geographical thinking and the subject-specific digital tools. The following prompts were used: a presentation on geographical thinking and research on geography education in Sweden, the model of geographical thinking (see figure 1 p. 4), a chapter from a textbook (Schubert et al., 2020) about using digital tools and GIS in secondary schools, descriptions and instructional videos on how to use the subject-specific digital tools (SSDTs). Prior to the first workshop, three examples of SSDTs were chosen as a base for the teachers' lesson planning: Google Earth (https://www.google.se/intl/sv/earth/) Globalis (www.globalis.se) and Gapminder (www.gapminder.org). The teachers were free to bring in other examples of SSDTs into the case. The choices of SSDTs were based on their level of familiarity and usage in geography education in secondary school (Nilsson & Bladh, 2020).

The researcher formulated a mind-map structure, a lesson plan template and a reflection document to guide the teachers' thoughts and ideas throughout the process. All prompts and material were put in files, shared between the individual teachers and the researcher, making it possible for the researcher to follow the process.

TABLE 2

Stages in the design

Project stages		**Time**	**Empirical data**
1	E-mailed project information to headmasters	September 2020	
2	E-mailed information to teachers and communication through the digital platform used by the schools in the municipality.	September	
3	Digital **survey** – to gather background information about the participating teachers.	5-10 min September	Results from the survey
4	Digital **presentation** by the researcher on: background of the study and the main components of the research plan, an overview of geographical research relevant to the research project and the history of geography subject in the Swedish school system and a presentation on geographical thinking	2 hours October Online via the communication platform provided by the municipality.	
5	Preparation before the workshop. **Prompts:** A book chapter about teaching with GIS in secondary school and instructional videos on how to manage the following SSDTs: Google Earth, Gapminder and Globalis All material was shared by the researcher and distributed in a digital folder in the cloud-based school platform, provided by the municipality.	October	

6	**Workshop 1** The researcher introduced the workshop and repeated the concepts in the model of geographical thinking. The group of teachers made a mind-map, one each, where they displayed their ideas of a lesson plan about geographical thinking in a thematic context while using subject-specific digital tools. Prompts: Geography curriculum (SNAE, 2011, revised 2018) and a draft of the revised curriculum (which will be implemented in July 2022) Together, the teachers discussed ideas of a lesson plan. They also discussed a theme for the lesson plan and what subject-specific digital tools should be used during the lessons.	October 3-hour session at Karlstad University	Recorded planning session (teachers' utterances), and teachers' written lesson plan notes based on the overall theme in a lesson plan template.
7	The teachers prepared lesson plans to be implemented with a group of eighth-graders or ninth-graders[4]. Based on the general idea from the first workshop, the teachers created their own lesson plan, in a template including the components from the curriculum. Students at the schools taking part in the study all had their own computer supplied by the municipality. After the lesson/lessons, the teachers made a written reflection on the outcome of their own lesson plan.	October-January On the teachers' individual schools	Teachers' documented lesson plans (in a template) Teachers' documented reflections.
8	**Workshop 2** The teachers met in a recorded Zoom session. They presented and reflected on the lessons and the outcome of the lesson plans (based on their individual lesson plans, the lessons carried out and the reflection documents). The teachers also discussed how to tweak the lesson plan to improve it further.	January 2021 Online (Zoom)	Recorded Zoom session (teachers' utterances) including the teachers' reflections on the lesson plans
9	Individual follow-up on the teachers' GATI. Complementary questions or comments (if needed).	April 2021 Online (Zoom)	The teachers were able to reflect and comment on their GATI models.

The workshops were constructed in such a way that the teachers' conversations would not need an interviewer. The teachers had the material (prompts) and instructions

[4] Implementing the lesson plans in groups of eighth-graders or ninth-graders was recommended since these students have more experience of geography education and they are generally more used to the digital equipment provided by the schools.

to guide them. The researcher assumed a low-key role and only when needed asked clarifying questions and summarised the conversation. The questions asked by the researcher had an open structure and were posed in a similar manner to all participants.

Teachers taking part in the study

The background information of the teachers was assembled through a survey. Most of the questions were in a likert scale format and some open-ended questions were included to allow the teachers to elaborate their answers. The participating teachers (see table 3) are all experienced teachers: two have more than 10 years of teaching experience and three have more than 20 years of teaching experience. They work at four different schools in the municipality. All teachers are educated in geography and they teach all four social science subjects: geography, religion, history and civics. In Sweden, teachers in secondary school usually teach four subjects: geography, history, civics and religion. Four teachers identify themselves foremost as civics teachers. None of the teachers regard themselves primarily as a geography teacher. The teachers' confidence in using digital tools in social science teaching varies from fairly sure to very sure.

While all teachers have an extensive experience of teaching, and all the participants have university education in geography as part of their initial teacher education, they still express an insecurity towards teaching some aspects of geography. Four out of five express a lack of in-service training in geography and put their educational needs into words. Aron states that "It feels like there has been a huge technical development in geography as a result of different ways of using GIS, but one isn't up to the task". Beatrice specifically mentions technology, digital tools like Gapminder and GIS, and sustainable development as two aspects of desired in-service training in geography. Cecilia expresses the need of in-service training in order to adequately meet the central content in the geography curriculum and to make student assessments. Eric mentions how to work with solutions to the problems of the future and how to incorporate fun digital technology (in all subjects). Based on the lack of in-service training, the teachers were positive towards being able to take part in the workshop study.

TABLE 3

Information about the participating teachers

	Aron	**Beatrice**	**Cecilia**	**Doris**	**Eric**
Teaching experience	>20 years	>10 years	>20 years	>10 years	>20 years
Subject identification	Civics	Civics	Civics	Civics	History
University credits[5]:					
Geography	60	30	30	30	<30
Civics	30	60	60	30	60
History	60	30	60	-	60
Religion	60	30	30	30	<30
Other subjects		>90	90	90	
Confidence in using digital tools in social science teaching	Fairly sure	Sure	Very sure	Fairly sure	Sure
Subject where digital tools are used the most	Geography	Equal usage	Equal usage	Equal usage	Equal usage
Subject where digital tools are used the least	Religion	Equal usage	History	Equal usage	Religion

Analytical framework

The empirical data consists of the transcribed recordings of the participants' utterances and the written documents (lesson plans and reflections). The analysis was conducted by using two analytical frameworks. First, the synthetic model (see table 1) was used as a base to construct a coding system for analysing geographical thinking in the teachers' lesson plans. Second, the GATI model was used to analyse teachers' professional knowledge base.

Inspired by the coding based on Jo and Bednarz's (2014) taxonomy of spatial thinking, the teachers' utterances and written documents were coded by 1) world knowledge, whether mentioned or/and written or not, 2) geographical concepts used in the lesson plans, from not used to developed use of several substantial concepts, 3) reasoning process and the use of organising concepts from not used to developed use of several organising concepts and 4) representations and use of SSDTs, from not used to

[5] 30 credits equal one semester of university studies in that particular subject.

developed usage. To facilitate qualitative content analysis (Bryman, 2018), the codes were given the values 0, X and XX (see table 4).

TABLE 4

Coding of the planning process and lesson plans concerning teachers' world knowledge, geographical thinking and use of subject-specific digital tools.

	Geographical thinking while engaging in a geographical analysis				**Material used in the analysis**
	World knowledge:	Geographical concepts:		Reasoning process:	Representations:
Aspects of content	Knowledge of places and regions	Key concepts E.g. place, space, time, scale, environment	Substantial concepts E.g. content concepts as forest, river or urbanisation	Organising concepts E.g. interaction, change	Different kinds of analogue and digital geomedia Examples of Subject-specific digital tools (SSDTs)
Codes	Not mentioned/written Mentioned/written	Not used Partially used and mentioned Developed usage of several key concepts	Not used Partially used and mentioned Developed usage of several substantial concepts	Not used Partially used and mentioned Developed usage of several organising concepts	Not used Partially used Developed usage of SSDTs
Value	0, X	0, X, XX	0, X, XX	0, X, XX	0, X, XX

In addition, the GATI-model was used to analyse the teachers' professional knowledge bases. The GATI model, developed by Krauskopf et al. (2018), is a visual VENN diagram (figure 2), similar to the TPACK model, but with a focus on a teachers' personal estimation of their technical development when integrating technology in teaching practices (Ollinen, 2019). In our study, the GATI-model was used in the same way as in the proof-of-concept study (Krauskopf et al., 2018), when visualising the relation, the overlapping, between the different aspects of TPACK (TK, CK, TCK and so on). The size of the circles symbolises the expressed knowledge, based on the utterances and written documents. Depending on the expressed level and connection of the different knowledge aspects, the size and overlapping of the knowledge circles

differ. We used the GATI-model as a heuristic tool to visualise aspects of teachers' knowledgebase and their intrinsic relation. The circles do not give an absolute measure instead they visualise tendency and proportions. There are no standards how to visualise the overlaps nor the sizes of the circles in the GATI-model, neither have we beforehand decided upon exact variations.

In this study, the pedagogical aspect of the GATI-model is not the main focus. The participants are all experienced teachers thus the pedagogical circle will remain constant. Further classroom observations would have been needed in order to perform detailed analysis on the pedagogical aspect of the teachers GATI. However, the overlap between the three circles, including the pedagogical aspect, is an important aspect of the visualization.

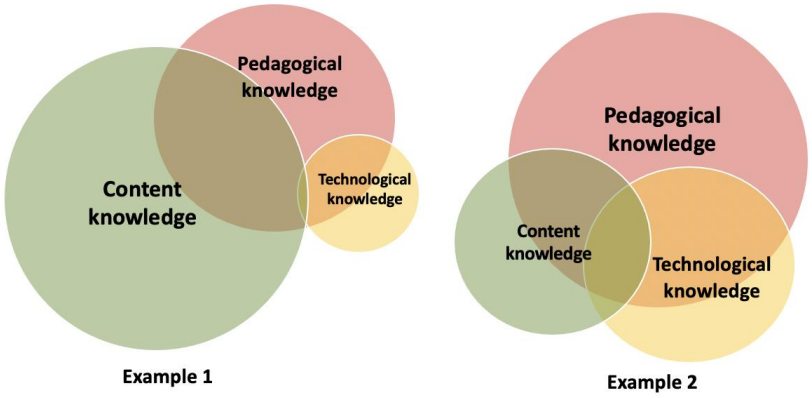

FIGURE 2.

The GATI model, based on Krauskopf et al. (2018).

The GATI model was developed to enable teachers' estimation of their personal level of TPACK as well as their aspired level of TPACK (Krauskopf et al., 2018). In the end of our research process the analysis was communicated to each participating teacher, hence enabling reflection on the interpretation of the results as well as self-reflection on their personal level of TPACK.

Ethical considerations

In order to meet the changeable situation caused by the Covid-19 pandemic the study had to adapt a flexible design. Throughout the study there were several changes in the participants' teaching conditions, as well as changes in the planned research design. Instead of a physical meeting, the second workshop was conducted and recorded in Zoom, but here only the audio recording was used. Consent forms had been collected before the workshops. During the whole process, the researcher and the teachers communicated by email in order to keep up with the volatile situation. As the study did

not treat any sensitive personal information, no further ethical review was actualised (Swedish Research Council, 2017).

The research design put demands on the researcher's reflection on the role as researcher and the research process as a whole, since conducting research *with* teachers also, in our case, partly means research *on* teachers. Thus, the researcher took on a dual role, both taking (a low-key) part in the process, *with* the teachers, and taking on the role as the interpreter, looking into the results *on* the teachers' process. By presenting the GATI model to the teachers, the researcher also invited each teacher to reflect and comment on the analysis. However, the results presented here are based on the researchers' analysis.

Results

The results are organised in three sections in order to interweave the of process of the workshop design and the different analyses. The analyses are based on how the participating teachers' individual knowledge base were elucidated in their lesson planning and their reflections on their realized lesson plans in relation to geographical thinking and the use of subject-specific digital tools. The first part focuses on the framing of the lesson plans, where the teachers' discussed and decided on a common theme for the lessons. The analysis of how geographical thinking appeared in the teachers' individual lesson plans and reflections (RQ 1) will be presented in the second part. In the third section, an analysis of the different aspects of the teachers' knowledge base that became apparent in the lesson planning and reflections (RQ 2) is presented. The synthetic model of geographical thinking and the GATI model are used in the analyses. Since the study focuses on the individual teachers' knowledge base, and as this study only includes a small group of teachers, we here highlight the description and analysis of the individual teachers. However, some patterns are discussed in the final parts.

The quotes presented are in our translation from the original Swedish transcripts (based on the two workshops) and texts (written lesson plans and reflection documents).

Framing of the lesson plan

The first part of the results concerns the teachers' framing and development of a general theme or idea for a lesson plan. The results are mainly based on the survey and the first workshop with the teachers.

The aim of the first workshop was to come up with a general idea for a lesson plan including a common geographical theme. The theme should be aligned with the central content of the geography curriculum, and have an educational potential for integrating geographical thinking and SSDTs. The didactical model (figure 1) was used as a prompt. Early in the joint discussion the key concept of place was established and a theme was selected. In the end the decision fell on *vulnerable places in the world* as a theme for the lesson plans. Vulnerable places were discussed from different geographical perspectives, both physical and human aspects, causes, consequences and

conflicts (see table 5 for a summary). Two areas were more in focus in the discussions. First, the organising concepts transformed into reasoning processes, where especially the possibility of comparing vulnerable places was discussed. Second, the potential to use different SSDTs when comparing vulnerable places was considered.

The teachers also reflect on the complexity of this geographical theme, by comparing the amount of time they *could* use working with this with their students. Eric sates: "We have filled the whole year now!".

TABLE 5

Summary of the ideas for a lesson plan concerning vulnerable places

Subject content (what)	**Examples of geographical thinking students will engage in.**	**Subject-specific digital tools (SSDTs) (What)**	**Lesson content/ procedural (how)**
Theme: vulnerable places	Describe what a vulnerable place is Compare vulnerable places Describe the relation between people, nature and the places Conflicts of interests and resources connected to a vulnerable place Investigating and interpreting statistics – find relations between flooding and human prerequisites (for example literacy) Find patterns between vulnerable places	Google Maps Google Earth Globalis	Instruction by the teacher, regarding the SSDTs and the geographical theme Worksheet with questions that guide the students to what knowledge they should engage in Constructing Power Points (PPs) Oral presentations in groups Class discussions

After the first workshop, the teachers worked out detailed, individual lesson plans based on the theme. Apart from the age of the students, from 12-13 in year seven, to 15-16 in year nine, the prerequisites for implementing the lessons plans were more or less similar (see table 6). Beatrice and Doris did not have the opportunity to implement their lesson plans with older students and therefore ended up conducted the lessons in year seven. The teachers had between 26 and 31 students in their classes and used 1-3 lessons. A majority of the teachers used one lesson for preparations, for instance explaining instructions and giving the students time to familiarise with the SSDTs. All students (and the participating teachers) had access to similar digital equipment.

TABLE 6

Framing school context of the participating teachers' lesson plans

	Aron	**Beatrice**	**Cecilia**	**Doris**	**Eric**
School year	8	7	8	7	8
Nb students	30	27	27	31	26
Time (nb lessons[6])	1,5	1	2-3	2	2
Digital equipment	Computer	Computer	Computer	Computer	Computer
Subject-specific digital tools (SSDTs)	Globalis	Globalis	Google earth, Gap-minder, Globalis, Google maps	Google Earth (Navigator)	Google Earth

Recontextualisations of geographical thinking in the teachers' lesson plans

In order to detect signs of geographical thinking, the transcribed material from the first and second workshop and written lesson plans were analysed according to coding in table 4. The first workshop focused on the lesson planning, while the second workshop also included reflections on their teaching. Examples of geographical thinking can appear without close connection to the digital representations. However, during the workshops the teachers discussed the technological aspects integrated with the content of the lesson plan.

This section begins with a presentation of the recontextualisation process of Doris, Eric and Cecilia who planned their individual lessons according to the mutual theme, vulnerable places, but orchestrated their individual lesson plans differently. This is followed by a presentation of Aron and Beatrice, who did not stick to the initial idea and developed their lesson plans in alternative directions. A summary of the assembled results is presented in table 7.

Doris expressed few signs of geographical thinking during the first workshop. Her initial idea was to integrate SSDTs in history studies influenced by her current lesson plans in history. Doris showed interest in using SSDTs with her students. When turning to creating a lesson plan on her own, Doris changed her initial idea and constructed a lesson plan where her students fully engage in making geographical analyses of vulnerable places, whilst using Google Earth voyager. During this process she managed to construct a plan where the students engage in geographical analyses on places vulnerability caused by sea level rise. Doris's use of world knowledge, geographical

[6] Lesson time varies approximately between 50-70 minutes.

concepts and reasoning process increased when she continued working with the lesson plan.

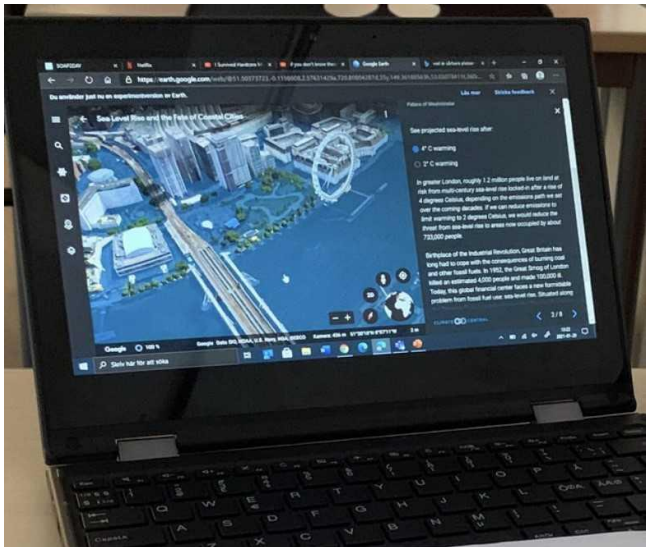

FIGURE 3

Students using Google Earth during Doris's lesson

During the first workshop Eric mostly reflected on and reacted to the ideas of the other participants. He agreed to their suggestions and he did not elaborate his own lesson ideas further. He discussed examples of vulnerable places and what causes a place to become vulnerable (flooding for example). Most of Eric's focus was drawn to how to understand and integrate the SSDTs (Google Earth and Globalis) with his students and most of his questions revolved around how to use the different SSDTs, for instance: "How did you do to search for vulnerable places in Globalis?". Eric implemented a lesson plan where his students were to construct a Power Point (PP) presentation about vulnerable places, using information from the SSDTs. When the students were finished preparing their vulnerable places, they presented their PPs in groups. Eric's students were engaged in analysing vulnerable place using SSDTs. Even though examples of Eric's recontextualised geographical thinking were not explicitly expressed during the different stages of the study, his lessons plan may imply he has managed recontextualising geographical thinking during his own planning sessions.

Cecilia came in to the project with an elaborated idea about analysing vulnerable places with different SSDTs. She emphasised starting her lesson planning in making the choices of SSDTs. She explained "…I have a ready-made page on Google Maps[7] where lots of vulnerable places are listed. Then I thought this page could be connected to Google Earth and we can make one of these projects". Cecilia continued explaining her

[7] See: https://www.google.com/maps/d/u/0/edit?mid=1NTDS-3x1bYs6xOTp6dNrQIxmYeuBYRFD&usp=sharing

idea and the connection to the curriculum, the core content on identifying places. The idea was to include human-environment interactions and the connection between human and nature. "That is, what makes places vulnerable".

Cecilia shared several examples of how to integrate the reasoning process in her lesson plan. She mentioned looking into diversity, what is typical for a vulnerable place, and change "…how to prevent [vulnerability] and how vulnerable places change over time. Are there any differences due to climate change, and so on". She also added understanding diversity to her idea:

> *Looking into where vulnerable places are situated in the world, taking it from there … the students try to find patterns in Google Earth based on where the vulnerable places are. In the best of worlds, maybe this could be done.*

Cecilia expressed several examples of geographical thinking throughout the research process. In discussions and in writing, she used the different geographical concepts and reasoning process and also wanted to try out and using SSDTs with her students. She made a written plan where her students were to analyse different vulnerable places using different SSDTs. She also mentions having given her students background information about vulnerable places beforehand implementing the lesson plan and focusing on not making a lesson plan to difficult for her students. When reflecting on the outcome of the lessons Cecilia mentioned, her students managed the instructions well. They engaged in geographical analysis, but to reach more depth in their understanding they would have needed more time.

Aron and Beatrice both had troubles moving the geographical theme into their own lesson plans and into classroom practice. During the first workshop, the close connection between geography and civics was discussed specifically when dealing with lesson content focusing on making comparisons between countries (places). Aron specifically focused on conflicts in the world and how these conflicts could be discussed from different geographical perspectives. Beforehand he had looked into how to use the SSDTs and discussed various ways in which the different SSDTs could be used during the lessons. Aron also expressed insecurity conceptualising what a geographical analysis actually is: "…the aim is to make a geographical analysis of the surrounding world. That feels sort of, well not fine really. Well, maybe this [referring to his ideas] counts as a geographical analysis." When Aron turned to creating his lesson plan, he was influenced by the current term plan, hence ending up with a lesson plan comparing the democratic development of countries, in different continents, during a time period. This led to a lower presence of geographical content and geographical thinking, but aspects of substantial concepts and world knowledge were present. However, Aron's lesson plan, and the results from implementing it with his students, indicated a developed idea how to use the SSDTs with his students. During the second workshop, he also reflected on the students' understanding while using the SSDTs:

> *It was a simple task, planned as a competition. The students worked in pairs and were active throughout the lesson. The students shared many ideas (about democratic development in different countries in the world) during the discussions after the exercise.*

Beatrice did not construct a lesson plan on her own. She explained the need of more time putting a lesson plan into action. Therefore, she asked for help with ideas from the other participating teachers and ended up using a similar lesson plan as Aron. Beatrice, however, did not express the same doubts towards geographical analysis as Aron. During the first workshop, she developed her ideas about the key concept place, using Somalia as an example, where migration could be studied. She explained her lesson idea using both geographical concepts, asking geographical questions (why is migration taking place) and using reasoning process, for instance exploring causes and consequences. In Beatrice's words:

> *I am thinking about starting from a meta-perspective, giving the students a place, Somalia for example. Then moving to making descriptions of the place, nature, environment, people, demography, population pyramid, well everything, then compare. If migration is the base (of the lesson plan), why do people want to leave their country, what is it all about?*

According to Beatrice, by zooming in and out from a place, migration could be studied from many different perspectives. However, when it comes to using SSDTs Beatrice expressed a reluctance and insecurity. She expressed a hesitation based on not being sure about what the SSDTs could bring to the lesson plans and whether the students would manage the tools. She explained: "But they should also learn to deal with the digital. It is not obvious they will know what to do. [And] that is also a part of knowing".

When summarizing the individual aspects analysed in the teachers planning some possible patterns can be identified (table 7).

TABLE 7

Summary of the teachers' geographical thinking when creating and constructing the lesson plans

	Geographical thinking while engaging in a geographical analysis				**Material used in the analysis**
	World knowledge:	Geographical concepts:		Reasoning process:	Representations:
	Knowledge of places and regions	Key concepts	Substantial concepts	Organising concepts	Subject-specific digital tools (SSDTs)
Aron	X	X	X	X	XX
Beatrice	X	XX	XX	X	0
Cecilia	X	XX	XX	XX	XX
Doris	X	X	0	X	XX
Eric	X	X	0	0	X

Regardless of different practical challenges (e.g., diverging from the geographical theme and lack of time), most of the teachers expressed examples of recontextualized geographical thinking. However, not all teachers expressed or elaborated all aspects of

it (table 7). The results reveal that three of the teachers, Aron Beatrice and Cecilia, easily have access to the different concept levels (key and substantial) and the reasoning process (organising concepts) while discussing the concepts in comparison to geographical content, such as areas of conflict, migration and vulnerable places. They also expressed ways to implement their ideas into teaching, lesson plans and instructions. However here Beatrice has problems combining her geographical thinking perspectives with the SSDTs. Doris and Eric did not express examples of geographical thinking and developed use of geographical concepts during the first workshop, but realised lesson plans on their own during the planning process and conducted lessons where their students were able to carry out geographical analyses while using SSDTs.

Aspects of the teachers' professional knowledge base

Here the teachers' individual knowledge base, their personal GATI, will be described, focusing on content knowledge and technical knowledge and how the different knowledge aspects are integrated.

During the first workshop Doris did not explicitly express geographical content knowledge and she was influenced by her current lesson plans, focused on world war history. She also expressed feeling less confident teaching geography in comparison to civics and religion. However, as she turned to constructing a lesson plan on her own, she created instructions, that included geographical analysis and geographical thinking. Throughout the case, Doris was positive towards incorporating SSDTs with her students. Doris describes planning the lessons for the students to grasp the SSDTs as challenging but also fun. Her students liked it:" They thought it was very stimulating to work like this". Hence, Doris's GATI (see figure 4) contains a smaller content knowledge circle, but her technological knowledge was more solid, therefore a larger circle. Since Doris constructed a lesson plan with all parts integrated, her circles overlap.

Cecilia's lesson plan contained the aspects needed for her students to engage in geographical analysis and geographical thinking while using the SSDTs. Through the statements and the written documents, she elaborated her ideas and examples of geographical thinking were visible. Cecilia expressed a pragmatic attitude towards using SSDTs in her teaching:

> *We could actually just try things. Let the students try and play a bit. Let them look closer. And even if we do not know this to a 100 percent, I still feel I cannot wait letting the students try this out until I know this to a 100 percent. I have to be brave and have a go and at the same time learn for my own sake.*

The different aspects of knowledge in Cecilia's GATI (see figure 4) were evenly distributed, both regarding the size and the overlapping.

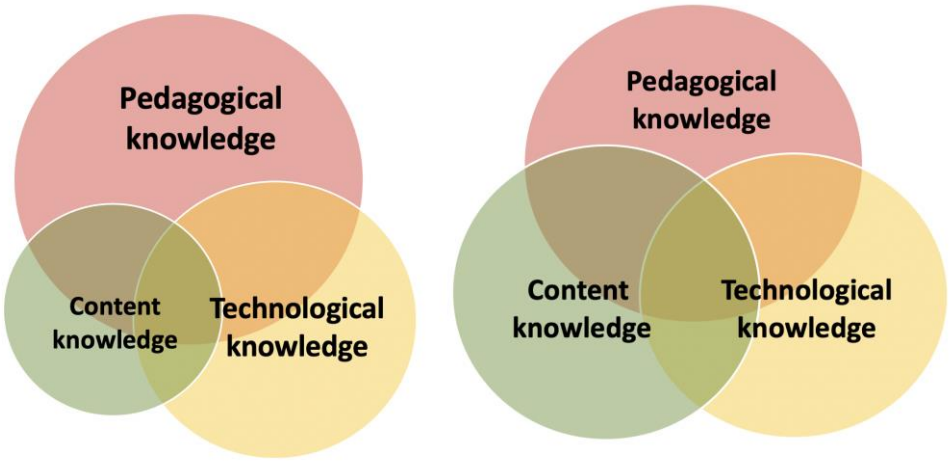

FIGURE 4

Doris's and Cecilia's knowledge base (GATI)

Eric's GATI was similar to Doris's but with one major difference: the technological knowledge in Eric's GATI was smaller. During the workshops, a majority of his questions revolved around the technical aspects and how to manage these. In similarly to Doris, Eric did not elaborate his geographical thinking during the first workshop but when reflecting on his lesson plan during the second workshop, he explained letting his students engage in geographical analysis.

Aron described the process of integrating SSDTs in the lesson plans as time-consuming. He discussed with his colleges and spent some time thinking about how the SSDT could be manageable for his students at the same time ensuring a learning process. He first tried out one lesson plan that was too complicated for the students. Aron says: "Finally, I landed in a quite simple instruction, and it worked". Aron did not let his student specifically engage in geographical analysis during the lessons, but his students analysed countries from a political perspective, thus framing his lesson plan more in a civic subject content. Aron's technological knowledge proved to be well established throughout the study. Aron was not surprised when he saw his GATI (see figure 5), but in general, he would describe his geographical content knowledge in general as more developed.

During the first workshop, Beatrice expressed different ideas for a lesson plan concerning geographical content, giving examples of a well-developed geographical knowledge base. However, on a number of occasions she indicated an uncertainty about how to use the SSDTs with her students. Also, she expressed an uncertainty towards not being able to deal with the students' questions concerning the SSDTs. Beatrice states:

> *But, if we [the teachers in the study] then ask questions to the students, can they use this tool (Globalis for instance) to extract statistics that show humans' vulnerability in a vulnerable place, for instance when having to cope*

> *with a flood? If I only know what they will encounter when they use the SSDT, it will be easier.*
>
> *Because then they will find things that I haven't thought about and they will ask questions [like] what does this mean? And that is all good, but….*

Even though Beatrice's geographical knowledge appeared more solid than her technological knowledge, it did not bridge her insecurity about using the SSDTs with her students. Since Beatrice expressed her technological knowledge in relation to the pedagogical situation in the classroom and not being able to answer her students' questions, the technological aspect hardly overlaps her pedagogical knowledge (see figure 5). Further, she did not express ways to integrate the SSDTs with the geographical content.

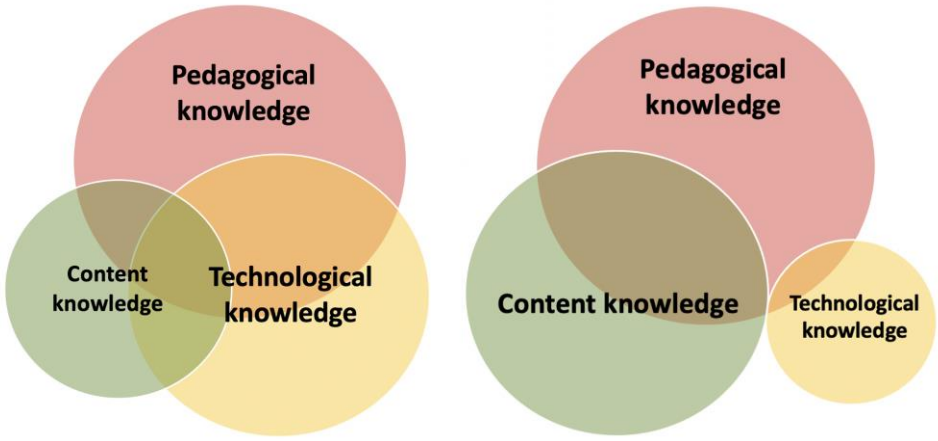

FIGURE 5

Aron's and Beatrice's knowledge base (GATI)

In conclusion, the visualizations enabled by the GATI model present a pattern of well-developed contra less developed components in the teachers' knowledge base. In Doris's, Aron's and Erik's case, the geographical content knowledge is less developed, while Beatrice shows less developed technological knowledge. The analysis also indicates that how well the teachers manage to integrate the different components is crucial for a positive outcome when implementing the lesson plans.

Discussion

This study sought to investigate how teachers recontexualise geographical thinking and what aspects of their knowledge base that were elucidated when planning lessons in geography. Teaching geography in Swedish secondary schools, in most cases, also means teaching all social science subjects. Four participants in our study identify themselves foremost as civics teachers and one, Eric, as history teacher. This reflects similar results from Bladh's study (2014) which indicated that few social science

teachers identify primarily as geography teachers. Geography is also the least accredited subject among secondary social science teachers (Nilsson & Bladh, 2020). The teachers taking part in our study, clearly relate to all social science (SO) subjects. Teacher's identity is an important component when discussing teachers' professional compass (Brooks, 2016).

Both Aron and Beatrice think like social science teachers and thus the geographical context was adapted to civics instead of geography. They adapted the lesson plans to the context of civics instead of geography. Their lesson plans turned out to have more of an interdisciplinary character which may be explained by their professional compass, that is planning, handling and thinking like a social science teacher. This can also be explained by the insecurity in their subject-specific knowledge when it comes to specifically dealing with geographical thinking and analyses, as in Aron's and Doris's case. Aron also mentions having difficulties understanding what a geographical analysis is, and by that implying in comparison to other types of analyses. This is also highlighted by Örbring (2021), namely that geographical thinking is not explicitly explained in the national geography curriculum, and thus interpretation and understanding of that aspect of the curriculum is up to teachers themselves. In Beatrice's case, the insecurity of using the SSDTs with her students clearly overshadowed the lesson plan as a whole.

The participants are all educated in geography but there are individual differences in their relation to the subject. Aspects of geographical thinking appeared explicitly for three teachers. The teachers found the didactical model of geographical thinking (see figure 1) helpful in the process. By using the didactical model, the teachers could organise their thoughts and ideas in their planning process (compare Sjöström et al., 2020). The study shows that the model may become a helpful tool when creating student tasks involving geographical analysis and geographical thinking. The collegial planning also provided an arena for discussing how geographical thinking could be developed in their teaching. Here, especially the use of organising concepts (Taylor, 2008) transformed into reasoning processes (Jo & Bednarz, 2014) and activities were helpful for constructing the lesson plan. This is also in line with result from a study by Dessen Jankell et al. (2021).

The teachers' individual GATI models turned out differently, reflecting their varying knowledge bases (RQ 2). Cecilia's GATI mirrors her access to both content knowledge and technological knowledge. It is clear that managing, planning and implementing lessons where students carry out geographical analysis with SSDTs is demanding since it involves different kinds of knowledge. Apart from pedagogical knowledge, the teachers need access to both geographical content and technological knowledge to pull it through. Moreover, all aspects of the teachers' TPACK need to be integrated. If one of the knowledge aspects in the knowledge base is less developed, or less accessible, this will affect the lesson plans.

Even though understanding the potential of using the SSDTs during the lessons, as in Beatrice's case, the learning curve to put it into practice was too steep. This could be compared to results about individual and institutional barriers which affect teachers' engagement with technology in geography teaching (Healy & Walshe, 2021b). This may also explain teachers' reluctance to using GIS in geography teaching (Fargher &

Healy, 2021). In contrast, if the technological aspect of the knowledge base is accessible, but there is an insecurity about how to understand and manage geographical analyses, the geographical content in the lesson plan is slightly overshadowed, as in Aron's case and partly Doris's. Fargher (2018a) argues that teachers need to be familiar with a range of areas of knowledge when engaging in curriculum thinking and curriculum development. Our study shows that the aspects of teachers' knowledge base, as part of their TPACK, need to be developed in different ways (compare Beatrice and Doris). Despite the prompts, including the didactical model, collegial discussions and lesson plans, the implementations in the teachers' individual classrooms were demanding and not all teachers managed to realize the lesson plans according to the decided geographical theme. This again emphasise the presence of individual and institutional barriers (Healy & Walshe, 2021b).

The complexity of the integration between the content knowledge, the technological knowledge and the pedagogical knowledge is clearly visible in our case. We would specifically like to stress the importance of developing the relation between teachers' pedagogical and geographical content knowledge, their PCK, and the use of subject-specific digital tools. This is also highlighted in an ongoing discussion concerning the role of GIS in geography education (see Fargher, 2018a; Hong & Stonier, 2015; Walshe & Driver, 2019 and Schubert & Johansson, 2019).

The participating teachers express a lack of in-service training in geography both concerning subject content and the use of subject-specific digital tools. One important aspect is to design the in-service training in a such way that the digital technology becomes a means for teaching and not a learning goal in itself (Willermark, 2018). Hence, it would be fruitful to integrate subject-specific technological knowledge in a content knowledge in-service training context.

Finally, the results must be considered from the Covid-perspective. The teachers did express an increase of stress levels, not being able to plan ahead as they used to. In January 2021, schools moved into online teaching. Even though the teachers expressed the project was not affected by the present situation, this is still something that might have affected the results in some ways.

Conclusions and recommendations

Finally, these results point out some significant aspects of geography teaching. First, teaching how to engage in geographical analysis and thinking geographically is complex. The teachers had troubles managing the different aspects of knowledge included, but by using a didactical model of geographical thinking (see figure 1) they integrated different types of concepts and reasoning processes when making geographical analyses. Such a model has an apparent potential for developing geography teaching, both for practicing teachers, in professional development ventures, and in initial teacher education.

Second, teaching geographical analyses with SSDTs includes all aspects of teachers' knowledge base combined. Even when the geographical pedagogical content

knowledge is well established, the technological knowledge also needs to be in place. Hence, the integration of the aspects in the knowledge base is crucial. This is also an important factor to consider in relation to initial teacher education (see the discussion by Schubert & Johansson (2019).

Third, creating an in-service context where teachers together discuss and plan lessons that later could be evaluated and reflected upon is a useful method to enhance teachers' knowledge base. In our case, however, the participating teachers would have needed more time at group level to fully manage integration of SSDTs in their lesson plans. A second circle of the research design would have been preferable. Also, by using the GATI model throughout the different stages of the process, the teachers would be able to monitor their improvement. Design studies, for instance learning studies, can be useful when developing working methods in collegial communities of practice.

Navigating the digital world opens up new perspectives for teaching, learning and professional development in geography education (Walshe & Healy, 2021). From a Swedish perspective, there is a research deficit considering geography education combined with subject-specific digital tools. Also, practicing teachers are in need of in-service training, both regarding complex geographical content and how to incorporate SSDTs in their teaching. This is also confirmed by Hong & Stonier (2015). To combine these two areas would be fruitful in continued studies. The GATI model also proved to work well as an analytical tool for discussing teachers' professional development. An additional study where the GATI model is used throughout the process, could open up for interesting results, beneficiary for teachers, initial teacher education as well as the research field on geography education.

Acknowledgement

We would like to acknowledge the participating teachers and send them our warmest gratitude. Even though they expressed an increase in stress levels, caused by Covid-19 they still took part in the research process and gave it their best.

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