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The Knowledge Base for Geography Teaching (GeoKBT): A Preliminary Model

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Abstract

Funded by the National Center for Research in Geography Education, this study investigated the nature of the knowledge needed for geography teaching. Informed by existing research about science and mathematics teachers' pedagogical content knowledge (PCK), the research group developed a conceptual model of the knowledge base for geography teaching, identifying six key components: (a) orientations toward teaching geography, (b) knowledge of geography curricula, (c) knowledge of students' understanding of geography and responses to geography learning, (d) knowledge of instructional strategies appropriate to learning geography, (e) knowledge of assessment of geography learning, and (f) knowledge of educational contexts. The conceptual model was refined and revised according to the results of case studies of four expert geography teachers. Data analyzed included classroom observations, teacher interviews, geography lesson video-recordings, teachers' lesson plans and reflections, and student work samples. The resulting preliminary model (GeoKBT) is offered to the geography education community to inform both geography teacher education and further research on geography-related pedagogical knowledge.

Keywords: teacher knowledge, pedagogical content knowledge, geography education

Geography teachers have long known something that educational researchers began to explore only about 30 years ago: that teaching is an "outrageously complex activity" (Shulman, 1987, p. 11). Teaching requires multiple, intersecting, and interdependent types of specialized knowledge that are used in complex recursive processes before, during, and after interactions with students. When Lee Shulman (1986) named and described pedagogical content knowledge (PCK) as a key component of teachers' unique expertise in a 1985 presidential address to the members of the American Educational Research Association, it ignited decades of active research about the knowledge needed for teachers' specialized work. Although this scholarship has been pursued in many content areas (Park & Oliver, 2008), PCK has yet to be explored in depth in geography education research.

Education researchers, especially those exploring science and mathematics teaching, have been actively identifying and conceptualizing teachers' PCK since it was first introduced by Shulman in the mid-1980's (Hill, Schilling, & Ball, 2004; Loughran, Mulhall, & Berry, 2004; Magnusson, Krajcik, & Borko, 1999). More recently, geography education researchers have examined geography teachers' PCK via several case studies (e.g., Blankman, van der Schee, Volman, & Boogaard, 2015; Lane, 2009; Lane, 2015). These cases are context-specific, and as such, their results have limited applicability. Broader inquiries could inform research and practice that address the overall knowledge base needed for geography teaching.

This study explored a tentative model of the knowledge needed for geography teaching; the scope, nature, and components of the complete geography knowledge base used by secondary-level geography teachers. To do this, a working group of researchers and expert practitioners in geography and teacher education was established, funded by the National Center for Research in Geography Education. The group's expertise and experience in geography, educational research, and geography teaching provided this research with theoretical rigor and practical validity. This article describes both the processes used to create and refine the proposed knowledge base for geography teaching (GeoKBT), and the content and organization of the model itself.

This work helps to address the 13 recommendations put forth in the *Road Map for 21st Century Geography Education* (Bednarz, Heffron, & Huynh, 2013) by establishing the specific parameters of the knowledge needed by geography teachers as a comprehensive model. As such, the model can help researchers and teacher educators to pay "close attention to the content knowledge and pedagogical content knowledge necessary for effective teaching of geographic concepts, skills, and practices to foster geographic literacy..." (p. 59).

In the sections that follow, we explain what is known about the nature of teachers' knowledge across content areas, the methods we implemented to identify the specific knowledge needed for geography teaching, and the conceptual model of this knowledge base that we synthesized from past PCK research and our collaboration with four expert secondary geography teachers, illustrated with classroom-based examples. We end the article by discussing the potentially transformative nature of future research that could refine and use the proposed GeoKBT model.

Teachers' Knowledge

As Shulman (1987) explained, PCK:

> …identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue (p. 8).

Yet PCK – which has been the primary focus of research about teachers' knowledge – is only one of seven interconnected components of his conception of the knowledge base for teaching (Shulman,1987). This knowledge base comprises content knowledge, curriculum knowledge, PCK, general pedagogical knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes and values.

Content knowledge is disciplinary subject matter knowledge. According to Shulman, curriculum knowledge refers to awareness of the full range of available programs, learning materials, and tools that are used within a particular educational context, such as a school district. PCK is "subject matter knowledge for teaching" (Shulman, 1986, p. 9). PCK includes an understanding of why and how particular content topics are easier or more difficult for students to understand, and how to represent the topics in ways that help students to comprehend and use them effectively in their learning. General pedagogical knowledge is process-focused knowledge that guides the act of teaching; "those broad principles and strategies of classroom management and organization that appear to transcend subject matter" (Shulman,1987, p. 8). Unlike content, curriculum, and PCK, general pedagogical knowledge is not specific to different content areas, such as geography.

Shulman (1987) also theorized six simultaneous and interconnected processes that comprise teachers' pedagogical reasoning and action (PR&A):

1. comprehension of the content to be taught and the purposes for teaching it;

2. transformation of the content to be taught into conceptual models and learning activities that are adapted to specific learners' needs and preferences;
3. instruction, which is the acts of teaching that can be observed;
4. evaluation of both students' learning and instructors' own teaching practices;
5. reflection upon teaching and learning processes; and
6. new comprehension, which is built continually from reflexive experience of the other five processes.

These six PR&A processes operationalize Shulman's (1987) seven components of the knowledge base for teaching enumerated above.

Beginning in 2001, PCK was extended by multiple researchers to become technological PCK or technology, pedagogy, and content knowledge, abbreviated respectively as TPCK and TPACK (Angeli & Valanides, 2005; Keating & Evans, 2001; Koehler, Mishra, & Yahya, 2004; Niess, 2005; Pierson, 2001; Thompson & Mishra, 2007-2008). Although there are more than fifty different versions of TP(A)CK (Trevisan & De Rossi, 2018) represented in current literature (Harris, 2019), all note the necessity of adding technological (specifically digital-tool) knowledge (TK) to the knowledge base for teachers working in the 21st century. Adding TK modifies teachers' PCK in important ways, requiring new types of knowledge in both choosing content-specific digital materials and tools appropriately, termed technological content knowledge, and in teaching with those tools effectively, or technological pedagogical knowledge (Mishra & Koehler, 2006) within multiple and varied educational contexts (Porras-Hernández & Salinas-Amescua, 2013). This is the "total package," or TP(A)CK (Thompson & Mishra, 2007-2008) of teacher knowledge needed in this updated conceptualization of PCK to teach effectively with digital tools and resources.

More than 30 years ago, Shulman (1987) envisioned the need for such revisions of our understanding of PCK, and the larger knowledge base for teaching of which it is a part. He said:

> A knowledge base for teaching is not fixed and final. Although teaching is among the world's oldest professions, educational research, especially the systematic study of teaching, is a relatively new enterprise. We may be able to offer a compelling argument for the broad outlines and categories of the knowledge base for teaching. It will, however, become abundantly clear that much, if not most, of the proposed knowledge base remains to be discovered, invented, and refined. As more is learned about teaching, we will come to recognize new categories of performance and understanding that are characteristic of good teachers and will have to reconsider and

> redefine other domains. Our current “blueprint” for the knowledge base of teaching has many cells or categories with only the most rudimentary place-holders, much like the chemist's periodic table of a century ago (p. 12).

The work that we describe in this article is one such reconsideration and redefinition that explores the scope, nature and components of the complete knowledge base for geography teaching in particular. Given the nature of geography as a discipline, the geography education knowledge base has much in common with conceptualizations of science and mathematics PCK.

Science and Mathematics Teachers’ Knowledge

Magnusson et al. (1999)’s model for science teachers’ knowledge is cited often in PCK research. Built upon the work of Grossman (1990), Tamir (1988), and Shulman (1986, 1987), this model suggests that effective teaching synthesizes and operationalizes several types of knowledge. They are orientations toward science teaching, knowledge and beliefs about science curriculum, students’ understanding of specific science topics, assessment in science, and instructional strategies for teaching science. The authors acknowledge that teachers have differing levels of each of these types of professional knowledge, often distinguished by specific instructional topics. They warn that these inconsistencies in knowledge levels and types, both within and across teachers, along with acknowledged interactions among the knowledge components, challenge efforts to help teachers to develop their PCK in ways that support teaching efficacy. Still, the model has been adopted by many science education researchers to examine various types of teacher knowledge and their relationships to student learning (e.g., Kratz & Schaal, 2015; Park & Chen, 2012; Park & Olivia, 2008).

In mathematics education research, Deborah Ball and her colleagues have developed the construct of *mathematical knowledge for teaching* (MKT), which is defined as:

> ...the mathematical knowledge used to carry out the work of teaching mathematics. Examples of this ‘work of teaching’ include explaining terms and concepts to students, interpreting students’ statements and solutions, judging and correcting textbook treatments of particular topics, using representations accurately in the classroom, and providing students with examples of mathematical concepts, algorithms, or proofs (Hill, Rowan, & Ball, 2005, p. 373).

MKT comprises both subject matter knowledge and PCK that are related to mathematics teaching. Hill, Ball, and Schilling (2008) suggest that PCK includes knowledge of content and students, content and teaching, and curriculum. Subject matter knowledge comprises common content knowledge, specialized content knowledge, and knowledge at the mathematical horizon (p. 377). In this model, mathematics teachers need “content knowledge intertwined with knowledge of how students think about, know, or learn this particular content” (p. 375). MKT is the most commonly used way that mathematics teachers’ knowledge is presently conceptualized in mathematics education research.

Geography Teachers’ Knowledge

While several research teams have explored particular aspects of geography teachers’ knowledge (e.g., Lane, 2009; Ormrod & Cole, 1996), only one has conceptualized a model for geography-related PCK to date. Using a survey instrument, Blankman et al. (2015) explored 39 primary-level teacher educators’ perceptions of the geography-specific PCK needed by student teaching interns. They called this knowledge PCK-G, which they explained as:

> First, student teachers need well-developed geographic subject knowledge, skills, and drive (WHAT). Second, they need to transform such knowledge, skills, and drive into forms suitable for teaching (HOW)…[and] must do that from the perspective of helping pupils to become responsible and active global citizens (WHY) (p. 84 - 85).

The model is depicted visually as a three-part Venn diagram in which the “what,” “how,” and “why” elements intersect to form PCK-G.

Our analysis of this geography-specific model of teachers’ knowledge suggests that it incorporates PCK and other aspects of Shulman’s (1987) knowledge base for teaching, including content knowledge, curriculum knowledge, knowledge of learners and their characteristics, and knowledge of educational ends, purposes and values. It also seems to include the comprehension and transformation aspects of Shulman’s model of PR&A. These additions are recognizable in the encapsulated version of PCK-G that the authors offer for student teachers to consider: “What am I going to teach? How am I going to teach it? Why am I going to teach it in this way?” (Blankman, et al., 2015, p. 83). Similar conceptual expansions of latter-day PCK models are not unusual in more recent PCK (Park & Oliver, 2008) and TP(A)CK research (Phillips & Harris, 2018).

Instead of adding elements from Shulman’s (1987) knowledge base and/or PR&A models to PCK, we sought to conceptualize and vet (with experienced geography teachers) a comprehensive depiction of teachers’ geography-related knowledge, including, but not limited to, their PCK. We grounded this work in Shulman’s original knowledge base model, since the great majority of educational research done about the nature of teachers’ knowledge is rooted in Shulman’s conceptualizations (Park & Oliver, 2008). Our processes for creating this model are described next.

Research Design

We used a three-step strategy to develop a comprehensive conceptual model of the knowledge base for geography teaching:

1. literature review that suggested an initial draft of the model;
2. data generation as classroom observations and interviews with experienced geography teachers; including review of corresponding lesson plans, grading rubrics, and student work samples; and
3. data analysis of the observations and interviews to refine the literature-based draft of the model.

Research team members communicated synchronously and asynchronously, online and face-to-face, throughout this work to discuss it and make decisions together about next steps to take. In the next section, we describe each step of this process.

First, we reviewed extant literature about Shulman's conceptualizations of the knowledge base for teaching in science, mathematics, and social studies education, since these curricula are the most similar to current notions of geography as it is taught at the secondary level (Schell, Roth, & Mohan, 2013). We decided to base our model on Magnusson et al. (1999)'s PCK model for science teaching. As described earlier, this model has been adopted widely in science and mathematics education research. Geography—particularly physical geography—addresses content similar to that of science (e.g., the physical processes that shape the patterns of Earth's surface; the characteristics and spatial distribution of ecosystems and biomes on Earth's surface). Although this model was used to describe science teachers' PCK, its components are also similar to many elements in Shulman's knowledge base for teaching (1987). We added components and renamed the knowledge categories as necessary to ensure that our model addresses all seven original knowledge base components.

While developing the initial conceptual model, we obtained Institutional Review Board approval from one researcher's institution and administrative approval from the teachers' school district. Once granted, we began to recruit expert high school geography teachers and middle school social studies teachers to observe and interview who had subject matter knowledge, expertise, and confidence in geography teaching (cf. Berliner, 2001). Since we planned to develop a broad and heterogeneous knowledge model that could inform as many grade levels of geography teaching as possible, we sought teacher participants who taught at different grade levels. Given that we needed to visit the participating teachers' schools to do classroom observations in a limited amount of time, we limited our search to one southeastern metropolitan area. We recruited all of the teachers from the same school district with the help of an experienced geography teacher who taught in the district. The school district's social studies professional learning specialist also provided us with a list of experienced geography and social studies instructors. Four teachers agreed to participate in the study: one 6th grade social studies, one 7th grade social studies, one 9th grade world geography, and one 9th grade Advanced Placement Human Geography (APHG) teacher. They had between 4 to 19 years of teaching experience, averaging 11 years. Each participant received a $400 stipend.

Our first meeting with the teachers was an hour-long webinar in late January 2018, during which we introduced our research team members and shared project goals, background, and steps for the teachers' participation. We then scheduled classroom visits with each teacher. Before visiting their classrooms, we secured their building principals' approvals. One researcher visited their classrooms in March 2018 and video-recorded their teaching with their permission. The topics that they taught were: Latin America physical geography (6th grade), populations in Southeast Asia (7th grade), water scarcity (World Geography), and ethnicities and universal religions (APHG). The APHG teacher gave a lecture, then asked his students to work on individual research projects, while the other three teachers led group activities. Following the classroom observations, we requested to see the teachers' lesson plans, grading rubrics, and samples of students' work that were related to the lessons that were observed.

We analyzed the video-recorded teaching and other collected materials using the knowledge categories included in our conceptual model draft as *a priori* coding categories. The analyzed data helped us to adjust descriptions and add applicable classroom-based examples for each knowledge component in the model. Although we gathered useful information about our participants' teaching approaches from the classroom observations, we knew that we had to talk with the teachers to discern the nature of the knowledge that they were using to teach the lessons that we observed. Therefore, we conducted follow-up interviews with each of the teachers individually.

We developed a list of questions to guide the interviews (Table 1). Each teacher was asked all of these, plus individual follow-up questions that were based upon the content of their responses. The number of questions posed to each teacher ranged from 16 to 20. The interviews were conducted and video-recorded, with participants' permission, at times that were convenient for the teachers in early May 2018. The interview recordings were transcribed using Temi (https://www.temi.com), with transcript corrections made manually. The content of the interviews served as useful and important data to help us to complete and refine our conceptual model.

Table 1. Initial interview questions.

Categories	Questions
Orientations	What is geography?
	Why do you think students need to learn geography-for what purposes?
Geography curriculum	Where and how do you acquire resources related to geographic content and/or curriculum?
Students' understanding of geography	What are some ways that you vary the ways in which you help students to develop geographic understanding?
	What are some of the ways in which you learn about students' conceptualization of geography and geography learning?
	Which concepts, phenomena, models and/or theories in geography are the ones that students find most difficult to learn? Why?
	What are some examples of abstract geographic concepts that students have trouble learning/understanding?
	What assumptions or beliefs do you hold about students' extant geographic knowledge?
Instructional strategies	How do you choose the specific instructional strategies that you use to help student to understand specific geography topics and concepts?
	Please give us an example or two of choosing a specific instructional strategy to help students to learn a specific geography topic or concept.
Assessment	How do you select the assessment methods that you use to assess students' geography learning?
	Why do you use these assessment methods? What are their advantages and disadvantages?

Results: A Conceptual Model of the Knowledge Base for Geography Teaching

The resulting conceptual model of GeoKBT has six components:

1. orientations toward teaching geography;
2. knowledge of geography curricula;
3. knowledge of students' understanding of geography and responses to geography learning;
4. knowledge of instructional strategies appropriate for geography;

5. knowledge of assessment of geography learning; and
6. knowledge of educational contexts.[1]

Below we introduce each component and its corresponding knowledge categories. We also provide illustrative examples derived from both extant literature and data generated with the teachers who participated in this study.

Component 1: Orientations toward teaching geography

This component refers to teachers' overarching conceptions of teaching geography. These orientations serve as tools for understanding teachers' instructional decisions, influencing teachers' purposes for and beliefs about teaching geography. They can affect the nature of other components in the model greatly. We included seven of these orientations from the work of Catling (2004) and Morley (2012) (Table 2) in the GeoKBT model. Teachers may have more than one orientation toward teaching geography (Morley, 2012). In our study, each of the four participating teachers expressed two or three different orientations. Interestingly, all shared the interactionist orientation. In Walford's (1996) study, approximately 43% of the participating geography preservice teachers identified themselves as interactionists.

Table 2. Orientations to teaching geography (Catling, 2004, p.153; Morley, 2012, p. 129).

Orientations	**Definitions**
Globalists (Global 'fact finder')	Geography as the study that develops an informed knowledge and understanding of the world, its human and physical features and environments, and of the countries of the world
Earthists (Global 'processor')	Geography as the study of the Earth, its physical and human features and environments, and of the forces and processes that shape them
Interactionists	Geography as the study of the interactions between and the interdependence of people and their natural and social environments, of the processes that sustain these interrelationships, and of their affects and influences as outcomes
Placeists	Geography as the study of people's lives and activities in places, communities and cultures to understand, what

[1] Since we adapted Magnusson et al. (1999)'s PCK model for this study, the names of the components and the knowledge categories are very similar to those in their model.

	they are like, why they are as they are, what this means for them, and how they related to others
Environmentalists	Geography as the study of environmental concerns and issues, locally and globally, and about sustainability
Facilitators	Geography as the study that facilitates opportunities to engage with the environment, explore the outdoors and gather evidence/information
Synthesisers	Geography as the study that draws from a variety of disciplines, knowledge and understanding about people, places, cultures, the physical world and their interactions to develop a sense of global responsibility for managing human engagement with the Earth, i.e. synthesizing the range of perspectives from within the discipline and beyond

Component 2: Knowledge of geography curricula

Teachers' knowledge of geography curricula comprises knowledge of geography learning goals and objectives and knowledge of specific geography curriculum programs and materials. We introduce each category with examples below.

2.1. Knowledge of geography learning goals and objectives.

Geography curriculum knowledge includes teachers' knowledge of the goals and objectives for learning geography, as well as their awareness of the articulation of these goals and objectives across all of the geography topics that are addressed during the school year. Knowledge of goals and objectives addresses the vertical curriculum in geography; that is, topics that students learned in previous years and will be learning in the future. The National Geography Standards (Heffron & Downs, 2012) include six essential elements and 18 geographic standards, skills, and perspectives. These function as common learning goals and objectives for K-12 geography in the U.S. With only one exception, the teachers in this study were aware of the National Geography Standards, but they used their state standards instead. District-level standards related to geography education may be used in other locations. Teachers need to be aware of the similarities and differences among different sets of geography standards if they are required to use more than one set in their planning.

2.2. Knowledge of specific geography curriculum programs and materials.

This category refers to teachers' knowledge of the programs and materials that are relevant to teaching geography, plus the specific topics that are included within geography curricula. Examples include teachers' knowledge about the College Board's APHG course description, and student learning materials produced by organizations such as National Geographic, the National Council for Geographic Education, and the Geography Education National Implementation Project, for geography teachers' use. This category also includes teachers' knowledge about sources where they can obtain curriculum materials. The teachers in this study knew about these organizations and materials, along with other sources, such as the National Council for the Social Studies and state and county-level professional development opportunities, and their school district's digital library for teachers.

Component 3: Knowledge of students' understanding of geography and responses to geography learning

Two categories encompass teachers' knowledge of this GeoKBT component: students' knowledge and ways of knowing geography, and aspects of geography that students find difficult to learn.

3.1. Knowledge of students' knowledge and ways of knowing geography.

This category addresses teachers' knowledge of the prerequisites that students need to be able to understand specific geography concepts, plus an understanding of prior learning or experiences that are required when students are engaged in geography-related learning. For example, students need to understand latitude and longitude before learning about map projections and must be able to read a map and understand map scales before learning how to interpret geospatial data at various scales. Teachers may be able to obtain this knowledge from their previous teaching experiences, particularly when they teach similar or lower grade levels over multiple years. They can also gain this knowledge from current students via the results of pre-tests and formative assessments, or by observing students during in-class learning activities.

Teachers also need to be aware of varying conceptualizations that students have about geography. For example, without understanding the importance and impact of geography, students may think that it is primarily about locations and place names. Other students may understand it to be the study of exotic places in the world. There may also be students who have never thought of what geography is about and how learning geography can benefit them. The knowledge in this category also includes teachers' awareness of variations in students' approaches to the development of geographic understanding. Individual students have different geography-related learning needs, so it is important for teachers to have knowledge of learners' variability (Meyer & Rose, 2005) within their discipline.

3.2. Knowledge of areas of student difficulty in geography learning.

This category includes teachers' knowledge of the particular geography concepts or topics that students find difficult to understand, and why this is so, along with the ways in which students find learning difficult in geography. With the participating teachers' help, we were able to identify many examples and aspects of geography learning that many students find particularly difficult. For example, the teachers shared that many students have difficulty understanding interconnections and interdependency among people and places in the world. Acquiring information about a country is not a difficult task, but it is challenging for students to understand the different relationships one country has with other countries in economic, historical, and political contexts. Students also have a difficult time understanding how geographic knowledge and ways of thinking can inform decision-making that can affect their daily lives.

The teachers also said that there are some geographic concepts that students often confuse. One example is the concept of *region*. Many students use *region* and *continent* interchangeably and think Latin America is the same as South America; the Middle East is the same as Southwest Asia, etc. Not surprisingly, the teachers also shared that students often have difficulty understanding larger-scale geographic phenomena in depth, such as the Earth-Sun relationship, climate zones, and natural hazards, mainly because those phenomena are too large in scale to directly observe or analyze. This learning often occurs abstractly, using spatial representations such as maps, diagrams, models, or video clips, but students are not likely to understand these representations well without teachers' guidance. These examples illustrate just a few of the geographic concepts that the participants highlighted as difficult for students to grasp.

Component 4: Knowledge of instructional strategies appropriate for geography

This component comprises three categories: knowledge of (a) *general* geography instructional strategies, (b) *topic-specific* instructional strategies, and (c) ways to combine and sequence *general* and/or *topic-specific* instructional strategies when helping students to learn particular geographic content.

4.1. Knowledge of general geography instructional strategies.

This category refers to teachers' knowledge of instructional strategies that can be useful overall when teaching geography. Strategies addressed in this category are not exclusive to geography, but they are used often by expert geography teachers. To identify the instructional strategies with which the participating teachers were familiar, we gave them a list of the different types of learning activities in social studies (Hofer & Harris, 2011; Table 3) and asked them to indicate all that they use in their geography teaching. The activities marked with asterisks below were used by all four teachers, while the ones without asterisks were used by one or more teachers, with only one exception; no participant had asked students to conduct interviews as a geography learning activity.

Table 3. General instructional strategies for geography (Reproduced from Hofer & Harris, 2011).

Knowledge-Building Read text* Read maps, charts, and tables* Listen to audio* View images* View presentation* Discuss* Debate* Take notes* Experience a field trip Sequence information Consider evidence Compare/contrast* Engage in a simulation Conduct an interview Research* Engage in artifact-based inquiry Engage in data-based inquiry*	**Convergent Knowledge Expression** Answer questions* Create a timeline Create a map* Complete charts/tables Complete a review activity Take a quiz/test* **Written Divergent Knowledge Expression** Write an essay* Write a report* Generate a narrative* Create a diary Create a poem **Visual Divergent Knowledge Expression** Create an illustrated map* Create a picture/mural* Draw a cartoon	**Conceptual Divergent Knowledge Expression** Develop a knowledge web Generate questions* Develop a metaphor **Product-Oriented Divergent Knowledge Expression** Produce an artifact Build a model Design an exhibit Create a newspaper/news magazine Create a game Create a film* **Participatory Divergent Knowledge Expression** Present* Role play Perform Engage in civic action

4.2. Knowledge of topic-specific instructional strategies in geography.

This category refers to teachers' knowledge of instructional strategies that help students comprehend specific geography concepts and/or topics. Teachers should be familiar with multiple ways to represent specific concepts and principles to most effectively facilitate student learning (Meyer & Rose, 2005).

For example, several of the participating teachers shared that using satellite imagery to explain landscape change over time and maps instead of globes can help students understand map scale as they compare, contrast, and use the characteristics of maps created with differing scales and features.

4.3. Knowledge to combine general and topic-specific instructional strategies in geography.

This category addresses teachers' knowledge of combining and sequencing general and/or topic-specific instructional strategies to help students learn particular geographic content and skills. Teachers should have knowledge of both general and topic-specific instructional strategies and effective ways to integrate them into students' classroom-based learning. For example, one teacher in this study reported designing "experiences" to help student develop "feelings" that people around the world have in response to specific issues like water scarcity. Students discussed the issues in relation to their experiential learning. This type of activity can help students to understand geography-related situations from multiple perspectives.

Component 5: Knowledge of assessment of geography learning

This component includes two categories: (1) knowledge of which dimensions of geography learning to assess and (2) knowledge of methods of assessing geography learning.

5.1. Knowledge of dimensions of geography learning to assess.

This category refers to teachers' knowledge of the various dimensions of students' geography learning that should be assessed. The dimensions are based, in part, on the nature of geographic literacy, which comprises geographic concepts, such location, place, regions, and scale; geographic ways of thinking, such as spatial pattern recognition, scale transformation, and overlaying; geographic skills, such as asking geographic questions; acquiring, presenting, and interpreting geographic information; and developing and testing geographic generalizations (Backler & Stoltman, 1986). Geography teachers should realize that all three dimensions of geographic learning need to be assessed.

5.2. Knowledge of methods of assessing geography learning.

This category refers to teachers' knowledge of particular methods that can be used to assess specific dimensions and aspects of students' geography learning. This includes knowledge of specific instruments, techniques, procedures, approaches, and activities that can be used for assessment of students' geographic knowledge, skills, and applications of both. Participating teachers identified paper-pencil tests, performance-based tasks, projects, presentations, group quizzes and exams, Socratic seminars, debates and graded discussions as examples of assessment methods.

Beyond being familiar with these forms of assessment, the participating teachers shared that it is important to understand the advantages and disadvantages of using each of these methods. For example, fill-in-blank questions may not be appropriate to use when students can easily look up answers using their smart phones. Asking a question verbally during instruction may be more efficient and effective than requiring a response in writing, if immediate feedback from the students is needed. Having students explain a complex concept orally or in writing would be more effective in helping teachers to check for student misunderstandings or misconceptions than asking them to respond to a series of true-false questions.

Component 6: Knowledge of educational contexts

The last component of our proposed GeoKBT model encompasses knowledge of educational contexts. This knowledge ranges from group, classroom, and school functioning, to funding and management of school districts, to the characteristics and cultures of local, regional, national and international communities (Shulman, 1987). Students' socioeconomic status and demographics (e.g., ethnicities, cultures, parents' political views, religions, and native languages) are also applicable in this component. For example, one teacher in the study mentioned that knowing the ratio of ESOL (English for Speakers of Other Languages) to native English-speaking students in his classroom was important so that he can adjust how he selects and creates learning materials, such as vocabulary lists or readings' difficulty levels. Magnusson et al. (1999)'s PCK model does not include this contextual component, but Shulman's (1987) knowledge base does.

Now that the six essential components of this provisional knowledge base for geography teaching have been identified and described, what work should follow that builds upon this effort? In the next section, we propose future directions for work with the GeoKBT model.

Discussion and Conclusions

Lee Shulman's PCK (1986) and PR&A (1987) frameworks were transformative to the field of teacher education. History has demonstrated that these essential constructs

> …led to a shift in understanding and a new valuing of teachers' work such that research began to focus on understanding teaching from the teacher's perspective rather than the previous approach that focused on evaluation and labeling of teachers and teaching behaviors (Loughran, et al., 2004, p. 371).

The National Science Foundation defines transformative research, in part, as "ideas… that radically change our understanding of an important existing … educational practice…. Such research challenges current understanding…" (https://www.nsf.gov/about/transformative_research/definition.jsp). The long-term, pervasive, and continuing impact of Shulman's work on both educational research and the education of current and future teachers demonstrates the transformative nature of his ideas.

Geography education research has yet to make a similar transformative shift with reference to its conception of teachers' knowledge. When contrasted with pedagogical subdisciplines such as mathematics, science, and literacy education, geographers know comparatively little about the types of knowledge that teachers need to effectively teach geography. Indeed, in the *Road Map for 21st Century Geography Education*, research about the nature of geography teachers' knowledge is described as a key component of essential future research:

> We need to know more about teachers' content knowledge, pedagogical knowledge (e.g., sequencing, organization), pedagogical content knowledge, and the balance among the three. Future research should identify what teachers know, what they need to know, how they deploy their knowledge, and how their knowledge of geography and geography education can be promoted and supported (Bednarz, Heffron, & Huynh, 2013, p. 47).

The purpose of this study, therefore, was to draft what might become a viable model of the knowledge base for geography teaching. Based in extant, related research about teachers' knowledge in general, and their knowledge for science teaching specifically, we identified and described six components of GeoKBT, the geography knowledge base for teaching.

We believe that this work will help researchers better understand the nature of the knowledge that underlies effective geography teaching. The GeoKBT model can assist research and professional learning designs by identifying the multiple dimensions of knowledge for geography teachers. We acknowledge, however, that there are limitations in the development of the GeoKBT model. Due to funding and time restrictions, only four expert geography teachers participated in this study. Although the participants' expertise and input were enormously helpful, their insights could be expanded upon in future work. We urge other geography education researchers to test the model with more geography teachers serving different grade levels, locations, and student demographics. This continued work over time will make the GeoKBT model as comprehensive and broadly applicable as possible, thereby increasing its utility and theoretical power. We invite our colleagues to join us in this important work.

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