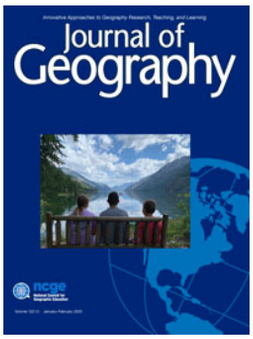

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Geography Teachers' Pedagogical Content Knowledge: A Systematic Review

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ABSTRACT

Pedagogical Content Knowledge (PCK) is the knowledge teachers use to teach a specific subject to a specific audience. The importance of PCK to quality teaching is widely recognized. However, an overview of research about geography teachers' PCK is missing. To fill this gap, we conducted a systematic review. We analyzed 43 empirical studies, but only 9 used PCK as a framework. Most studies addressed instructional strategies or teaching orientations. The studies were too diverse to draw conclusions on geography teachers' PCK in general. But portraits of 16 geography teachers emphasized the necessity of geographical knowledge and teaching experience for PCK-quality.

KEYWORDS

PCK; geography; subject pedagogy; earth sciences; social studies

Introduction

Pedagogical Content Knowledge or PCK (Shulman 1987) describes the "special amalgam of content and pedagogy" teachers use to teach a specific topic (content knowledge, CK) to a specific group of students (pedagogical knowledge, PK). The concept is widely used and cited in education research (Evens, Elen, and Depaepe 2015; Neumann, Kind, and Harms 2019). Teachers' PCK has been found to have a strong impact on students' progress (Coe et al. 2014) and a positive effect on their motivation (Kunter et al. 2013). An important feature of PCK is that it is content and context specific (Van Driel and Berry 2010). There is at present no overview of existing research on geography teachers' PCK, a knowledge gap we aim to fill by conducting a systematic review.

PCK conceptualization

Over the years, Schulman's original concept of PCK has been refined and extended. A much-used model of science teacher's PCK was developed by Magnusson, Krajcik, and Borko (1999). They distinguished five PCK-elements:

1. Teaching orientations refers to goals and purposes for teaching a specific subject in a particular grade.
2. Knowledge of curriculum is about mandatory goals and objectives.
3. Knowledge of students' understanding includes teacher's knowledge about different approaches to learning and their knowledge of student difficulties.
4. Knowledge of assessment focuses on knowledge of various assessment goals and methods.
5. Knowledge of instructional strategies represents general and topic specific approaches to teaching subject matter.

Although Magnusson, Krajcik, and Borko (1999) distinguish separate elements, they stress the importance of coherence between these PCK-elements. Teacher's instructional strategies should be in line with his or her orientations toward teaching and other PCK-elements. The strength of this coherence is said to be an indicator for the quality of a teacher's PCK (Barendsen and Henze 2019). Therefore, in order to teach effectively, teachers need to develop knowledge in all PCK-elements, and with respect to all topics they teach (Magnusson, Krajcik, and Borko 1999).

Magnusson's PCK-elements form the basis of the more recent PCK consensus model displayed in Figure 1 (as reported by Gess-Newsome 2015). The consensus model describes PCK in relation to the professional context. It makes a distinction between generic teacher knowledge and topic-specific professional knowledge, in which subject expertise plays a vital role. The model regards PCK from a dynamic perspective, for it emphasizes the interaction between teacher knowledge and teacher practice. Teacher knowledge informs classroom practice and vice versa. A teacher's beliefs, orientations, prior knowledge and context are, in this model, seen as amplifiers and filters between teacher knowledge and teacher practice.

PCK and geography education research

Although PCK has become an influential concept in the education community, the concept is not widely used in geography education research. In their review of intervention studies based on PCK, Evens, Elen, and Depaepe (2015)

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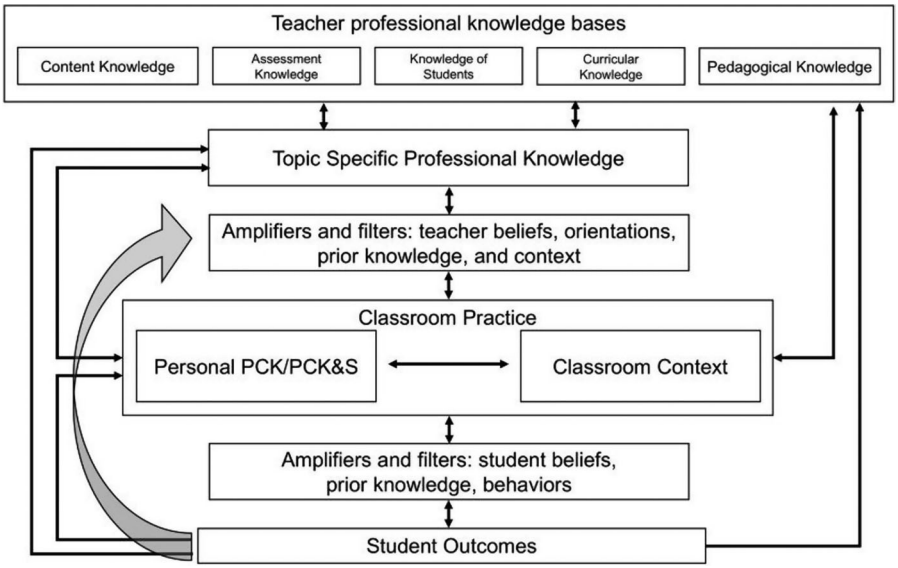

Figure 1. Consensus Model of PCK (reprinted from Gess-Newsome 2015, with permission).

found only one study related to geography (Ormrod and Cole 1996 is cited). And a review of PCK in social studies (Lotivio-Bedural et al. 2019) incorporates just three articles with a specific reference to geography. Geography education's research tradition is centered around different conceptualizations of teacher knowledge next to PCK, such as the curriculum making framework, Bildung-centered Didaktik or the capabilities approach (Deng 2018). Moreover, the role of subject matter knowledge in PCK is questioned. Brooks (2016) emphasizes the role of subject expertise as a key element in teacher's professional identities and their practice. And Martin (2008) stresses the role of everyday knowledge as influential for teachers' practice. Secondly, PCK has been criticized for being a static concept rather than one that changes over time due to context and personal factors (Brooks 2010; Seow 2016). In this research we take this debate into account, by using the conceptualization of the PCK-consensus model in which there is a central role for the school subject and which perceives PCK from a dynamic perspective.

PCK research

PCK-research tends to focus on one or more of Magnusson's PCK-elements. A literature review into history teacher's PCK (Tuithof et al. 2019), found an overrepresentation of (5) knowledge of instructional strategies and (1) teaching orientations. And a recent review by Lane and Bourke (2019) revealed a lack of research on assessment practices in geography.

Researchers have used different methods to capture and elucidate PCK. Qualitative instruments comprise, among others, the use of pre-post interviews, lesson observations, reflective journals and lesson plans (Kind 2009). In recent years, there has been a tendency to capture PCK by using quantitative instruments, such as surveys or PCK-tests (Evens, Elen, and Depaepe 2015). The theoretical background on PCK showed that in order to capture the quality of teachers' PCK, research methodology should ideally (a) focus on both teacher knowledge AND teacher practice (Gess-Newsome 2015) and (b) elucidate PCK in a way that coherence between PCK-elements is made visible (Magnusson, Krajcik, and Borko 1999).

Loughran, Mulhall, and Berry (2004) propose the use of Content Representations (CoRes) and Pedagogical and Professional experience Repertoires (PaP-eRs) to elicit the (coherence between) PCK-elements. A CoRe provides a format for teachers to discuss and elucidate their knowledge about teaching a certain topic. A PaP-eR is a narrative document in which a teacher explicates his/her teaching practice.

Research questions

In view of this theoretical background on PCK, we developed the following research question and sub questions:

How is (individual) geography teachers' PCK investigated in empirical educational research?

1. What is the research context in the studies?
2. How do these studies conceptualize geography teachers' PCK?
3. What approaches are used to determine individual geography teachers' PCK?
4. What can be learned about the consistency of individual geography teachers' PCK?

Methods

To answer our research questions, we followed the staged process of conducting a systematic review (Booth, Sutton, and Papaioannou 2016): define the scope; search and select studies based on inclusion criteria; assess quality of studies; extract and analyze data, and present findings. In the following section, we will describe our selection of studies and the analysis of data.

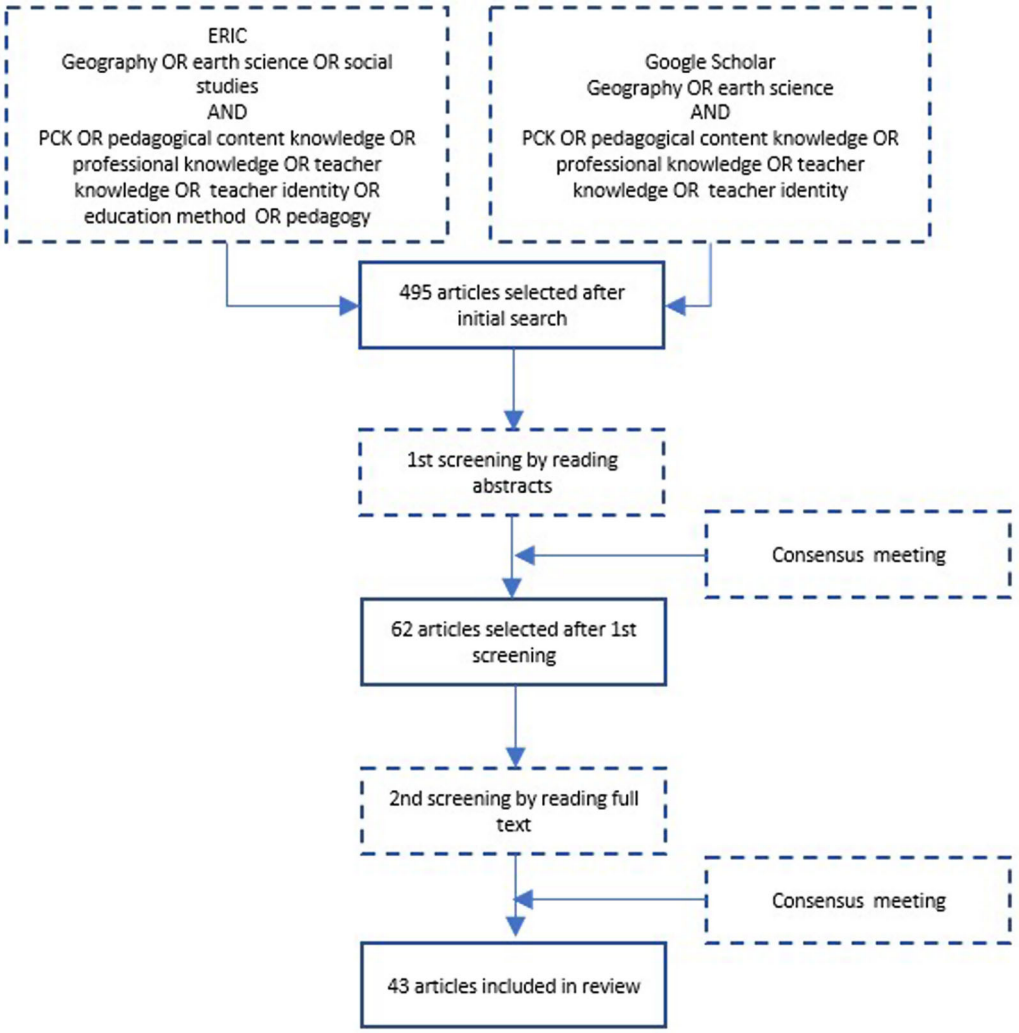

Figure 2. Flow chart of article selection.

Selection of studies

In order to find suitable studies for our review, we searched the databases Education Resources Information Center (ERIC) and Google Scholar in January 2021. A final check in Web of Science did not generate any extra titles. An overview of the selection process is presented in Figure 2.

Our search focused on the school subject of geography, which is in some countries (i.e. US and South Korea) subdivided in earth sciences and social studies. Since the concept of PCK is only used restrictively in geography education research, we expanded our query with concepts related to teacher knowledge, teacher identities and subject pedagogy. Our search was limited to full-text accessible and peer-reviewed empirical studies written in English (and therefore excluded studies in Korean, Turkish, German and Dutch). We selected articles published after 2000 for we wanted to create a current overview. Moreover, a review in history education (Tuithof et al. 2019) had taught us that most PCK-research originated after 2000.

Our initial search yielded 495 articles, which we then subjected to the following inclusion criteria:

- Studies had to have a focus on in- and/or pre-service teachers teaching in secondary education. Studies focusing on primary education were excluded, because primary teachers are often generalists, and subject matter knowledge is known to be a prerequisite for PCK-development (Van Driel and Berry 2010).
- Studies had to contain descriptions of teacher knowledge and/or behavior when teaching geography. Studies singularly focusing on teachers' subject matter knowledge were excluded.
- The main focus of the study had to be (the improvement of) geography education. Studies with a different purpose were excluded, even if participants were geography teachers. For example, Walker-Gibbs, Ludecke, and Kline's (2018) study on geography teachers in rural Australian schools focuses on what it is like to teach in a rural environment and was therefore excluded. We also excluded articles in social studies when it was unclear whether they had any specific focus on geography. For this reason, we excluded for example Quashigah, Eshun, and Mensah (2013) research on assessment practices in Ghana.

The selection process took place in two rounds, that is after reading the abstracts and after reading the full articles. Cases of doubt (i.e. the case of Walker-Gibbs mentioned

Table 1. Description of selected studies.

	Authors	year	Country	Method	n	Geography topic	Educational focus
1	Bednarz, Acheson & Bednarz	2006	USA	survey		maps	higher order thinking skills
2	Tiknaz & Sutton	2006	UK	interview	12	geography general	formative assessment
3	Monet & Etkina	2008	USA	survey, pre-post test, journals	10	earth science	professional development course
4	Reinfried	2008	Switzerland	survey, lesson plans	811	geography general	student/teacher perceptions
5	Lane	2009	Australia	interview, observation	2	tropical cyclones	student preconceptions
6	Alexandre	2009	Portugal	interview	4	geography general	epistemic knowledge
7	Wise	2010	USA	survey	183	climate change	influence of public controversies
8	Almquist, Stanley, Blank, Hendrix, Rosenblatt, Hanfling & Crews	2011	USA	survey, interview	24	geology, GIS	inquiry based teaching, fieldwork
9	Hanley, Davis & Davey	2012	USA	survey, pre-post test, interviews	50/13	earth science	geospatial technologies
10	Zohir, Jamil & Razak	2012	Malaysia	observation	9	geography general	productive pedagogies
11	Tuna	2012	Turkey	survey	90	geography general	active learning
12	Pickering, Ague, Rath, Heiser & Sirch	2012	USA	pre post test	47/23	land forms	inquiry based teaching / active learning
13	Bitso	2012	Lesotho	interview	82	geography general	information behavior
14	Jo & Bednarz	2014	USA	lesson plans, interview	24	settlement patterns in Canada	spatial thinking, higher order thinking skills
15	Hooghuis, Van der Schee, Van der Velde, Imants & Volman	2014	Netherlands	survey	307	geography general	geographical reasoning
16	Ababio & Dumba	2014	Ghana	survey teachers & students	7/80	geography general	teaching resources, teaching strategies
17	Mphathiwa	2015	Botswana	CoRe, lesson plans	5	water resource management	PCK description
18	Lane	2015	Australia	interviews, observation	16	tropical cyclones	PCK of students' ideas
19	Yoon & Peate	2015	USA	pre-post test, survey	106	geologic time	teacher biography
20	Zhang, Parker, Koehler & Eberhardt	2015	VS	survey	164	earth science	teacher needs
21	Hong & Stonier	2015	USA	interview	4	GIS	TPACK description
22	Ayas	2015	Turkey	interview, survey	134	geography general	use of media technology
23	Reitano & Harte	2016	Australia	focus-group interview	4	geography general	PCK description
24	Clausen	2016	Denmark	survey	55	climate & weather	PCK descripion
25	Seow	2016	Singapore	interviews, lesson plans	4	geography general	geography teacher identities
26	Puttick	2016	UK	interviews, observations	1	geography general	geography teacher identities
27	Alexandre	2016	Portugal	interviews, teaching materials	20	geography general	teacher biography
28	Thomas-Brown, Shaffer & Werner	2016	USA	survey, observations, interview, pre-posttest	28	global geography	constructivist learning
29	Campbell, Melville & Goodwin	2017	USA	interview, observation	1	pollution, oceanography	teaching orientations & trategies
30	Kocalar & Demirkaya	2017	Turkey	interview	19	geography general	teaching strategies
31	Kenna & Poole	2017	VS	interview	20	Asia	subject knowledge & teaching practice
32	Rajović & Bulatović	2017	Serbia	survey	250	geography general	use of education research
33	Clausen	2018	Denmark	observation, interview	4	weather and climate change	PCK description
34	Hong, Yong & Wen	2018	China	survey	95	geography general	Relationship SMK & PCK
35	Lee	2018	South Korea	interview	23	regions around the world	teacher orientations
36	Virranmäki, Valta-Hulkkonen & Rusanen	2019	Finland	interview, concept map	11	geography general	powerful knowledge & teacher orientations
37	Hanifah, Mohmadisa, Yazid, Nasir & Balkhis	2019	Malaysia	survey	200	geography general	Relationship SMK & PCK
38	Curtis	2019	USA	survey, interview	78	geopatial technologies	TPACK description
39	Seow, Chang & Irvine	2019	Singapore	observation, lesson plans, interview	6	water quality	inquiry based teaching, fieldwork
40	Bijsterbosch, Béneker, Kuiper & Van der Schee	2019	Netherlands	pre-posttest, survey, interview	8	geography general	assessment of higher order thinking skills
41	Fögele, Luber & Mehren	2020	Germany	interview	151	experiments	professional orientations
42	Knecht, Spurná & Svobodová	2020	Czech	survey	114	geography general	teaching orientations
43	Tezcan & Ütkür	2020	Turkey	survey	121	social studies	teacher identities

previously) were resolved in consensus meetings. This process resulted in a set of 43 selected studies.

Characterization of selected studies

Table 1 presents a brief characterization of the 43 selected studies (full references to these studies are available as online supplement). The studies vary in country of origin, research methodology, participant group, number of participants, and geographical topic (see online supplement for more detailed information).

With regard to the educational focus, we found studies with a specific focus on (Technological) PCK (9 studies) and studies with a focus on subject pedagogy, teacher identities or educational methods (32 studies).

An example in the first category is a study by Clausen (2018) who presents PCK-portraits of 4 Danish teachers teaching about weather & climate. His research focuses on

the PCK-elements of (1) teaching orientations and (5) instructional strategies (Magnusson, Krajcik, and Borko 1999). As an example in the second category, consider Tiknaz and Sutton (2006) who report on formative assessment practices of UK-based geography teachers. They don't refer to PCK as a framework, but in their study all PCK-elements except element (1) teaching orientations can be discerned. Studies like these, although not specifically using PCK as a framework, do provide useful insights in the knowledge and behavior of geography teachers.

As research methodology is concerned, the selected studies use quantitative (14), qualitative (21), or mixed methods (8) for their data collection. The samples in the qualitative studies are small, varying between 1 and 20 participants (Bitso 2012 is an exception). Methodology in the qualitative studies consisted primarily of (focus group) interviews. In 8 cases lesson observations and in 7 cases lesson plans and other teacher materials were examined. One study used the methodology of CoRes and PaP-eRs (Loughran, Mulhall, and Berry 2004). Most data in these qualitative studies are therefore self-reported.

Systematic analysis of selected studies

We performed a content analysis on the 43 studies, firstly by screening all papers for descriptions of geography teachers' PCK (either teacher knowledge or teacher behavior). This led to a collection of 612 quotes. Quotes could vary both in length and detail: where some quotes give elaborate descriptions of teacher practice, others only mention a teaching strategy without context. We then used descriptive coding (Saldaña 2021) to categorize these quotes according to Magnusson's five PCK-elements. We found that some quotes did not fit neatly into Magnusson's framework, but rather referred to uncertainties or lack of PCK. For example, "This high pressure and low pressure, it becomes very abstract for children, and I am a little unsure myself." (Clausen 2018, p. 271), refers to a teacher's lack of subject matter knowledge. We, therefore, added an extra category of experienced constraints and challenges. This category describes what teachers did not do or the difficulties they experienced. The team of authors first coded two articles together and the first author subsequently proceeded with the coding. Cases of doubt were resolved in consensus meetings.

In order to further structure the quotes within the main categories, we conducted a second round of analysis, using an open coding approach in which the codes emerge from the data (Saldaña 2021). The aim of this process was to create a manageable number of subcategories that would reflect the variety of topics addressed (the code book is available as an online supplement). In a final step, the first author coded all 612 quotes according to the codebook. Cases of doubt (29) were discussed among first and second author until consensus was reached.

Findings

In this chapter we first present the results of our content analysis of PCK-elements followed by a discussion on the visibility of PCK-quality in this analysis. This results in a more detailed analysis of 5 studies with elaborate PCK-portraits.

Elements of geography teachers' PCK

The results of our content analysis are visually presented in Figure 3. The size of a circle represents the number of quotes mentioning this PCK-element.

A large proportion of quotes is about the element of (5) instructional strategies (42%). Teacher and student activities in this category reflect the broad knowledge base of the school subject. Apart from general class discussions and inquiry based learning, quotes refer to practical work, fieldwork, the use of maps, geospatial technologies (GST), analyzing spatial problems and opinion forming.

Quotes in the main category of (1) teaching orientations (25%) provide insight into the school geography goals teachers aim at. Apart from knowledge and skills, the quotes also refer to student attitudes. Virranmäki et al.'s (2019) and Mphathiwa's (2015) research show that both Finnish and Botswanan teachers stress the importance of student attitudes toward sustainability as a goal for school geography.

Our data contain fewer quotes about (3) knowledge of students' understanding (9%). Difficulties students experience when learning geography were most frequently mentioned. An example: "Students experience difficulty with "the way cyclones spin," "the weather that goes with each [type of storm]" and "the way air flows [around a tropical cyclone]" (Lane 2015).

Nine percent (9%) of the quotes referred to (2) knowledge of curriculum. Quotes mentioned the national curriculum, textbooks and teachers' own interests as curriculum influences.

Only 4% of the quotes were categorized as (4) knowledge of assessment. In this category, quotes mainly referred to assessment methods and specific geographical test items, such as the ability to explain geographical relationships or to interpret maps.

Finally, our added category of constraints and challenges had 64 quotes. Quotes which refer to a lack of PCK were most frequently mentioned. These quotes show teachers' insecurities about teaching certain topics or their inability to address higher order thinking skills for instance. This category also refers to lack of subject matter knowledge (SMK) and its effects on teaching.

The quality of geography teachers' PCK

As pointed out in the introduction, the quality of PCK depends on the ways the different elements of PCK fit together (Magnusson, Krajcik, and Borko 1999) and the interactions between teacher knowledge and teacher practice (Gess-Newsome 2015). For example, in Reitano and Harte (2016) study pre-service teacher John remarks:

> Well, geography you're studying things that are outside and when you're in four walls it's hard to get a feel for these geographical concepts. So using multi-modals whether it's a video or pictures of landforms or anything that's to do with geography, given that multi-modal experience and then getting them to do something with that information is critical because you're stuck inside a box. (p. 285-286)

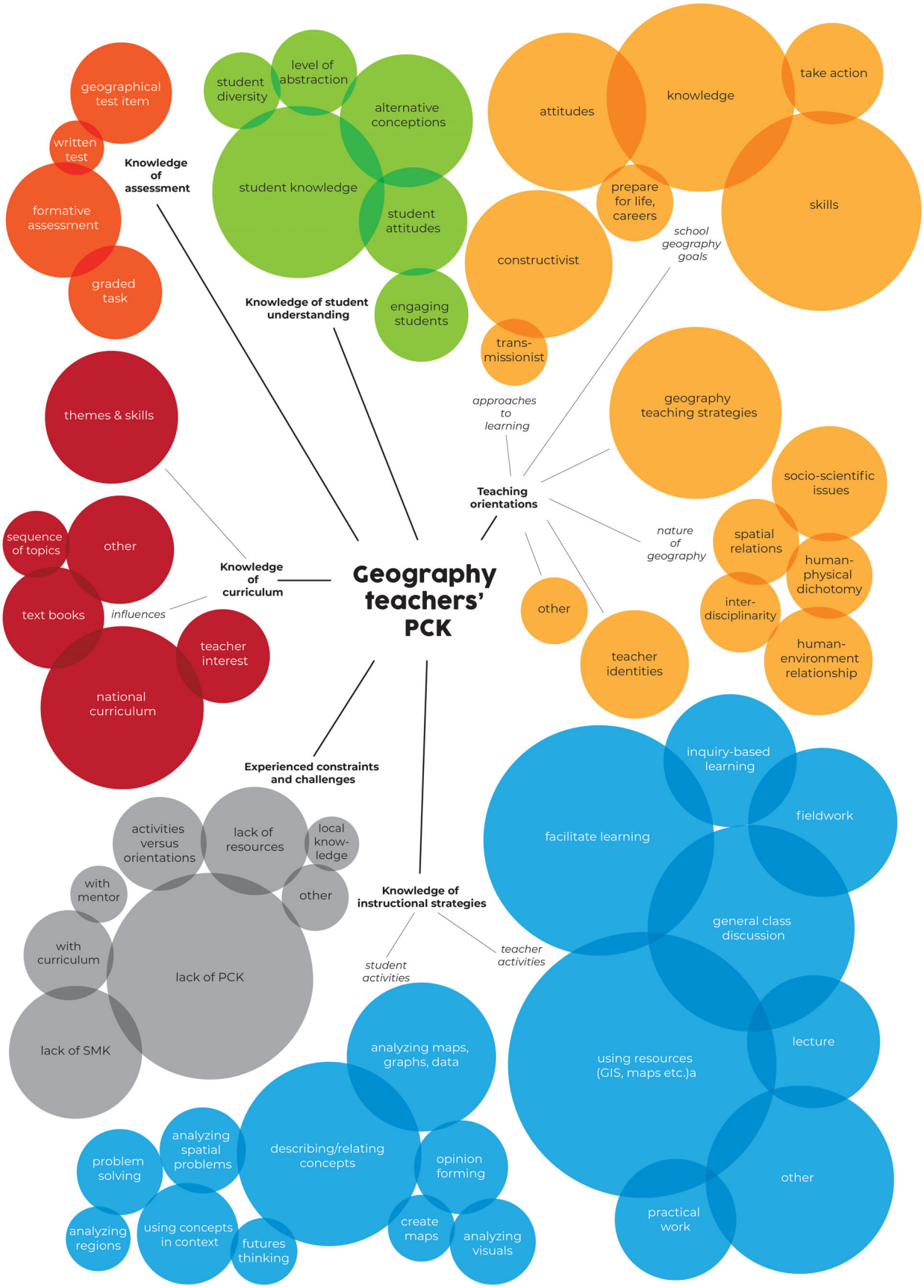

Figure 3. Concept map of geography teachers' PCK based on 612 quotes from 43 empirical studies.

This quote shows that John's knowledge of student understanding (i.e., the difficulty they have in grasping geographical concepts) inspires him to use videos or pictures of landforms.

Whereas our analysis in the previous section does provide insight in more and less dominant themes in geography PCK-research, it takes a different approach to assess the quality of geography teachers' PCK. In order to gain insight in the latter, we have to take a closer look into the coherence between PCK-elements (Barendsen and Henze 2019). For this purpose, we will examine five studies with elaborate PCK-portraits more closely, in the next section.

Coherence between PCK-elements and PCK in action

Five studies in our selection had noteworthy and elaborate PCK portraits of geography teachers. Although these studies had very few participants (1-5), their portraits gave us insight into the coherence between PCK-elements. These studies are (in chronological order) those by Lane (2009), Mphathiwa (2015), Reitano and Harte (2016), Campbell, Melville, and Goodwin (2017) and Clausen (2018). They all address at least two of Magnusson's PCK-elements.

Lane (2009) portrays two accomplished geography teachers. He particularly focuses on the elements (3) knowledge of student understanding (pre- and alternative conceptions) and (5) instructional strategies. One of these teachers, John, has 15 years of experience and shows extensive knowledge of student understanding when preparing and conducting his lessons on tropical cyclones. He uses research data to construct a pretest to investigate his students' preconceptions. John comments:

> I just looked at the data and thought, I need to do this, this and this in the lesson. All of the information that was in bold, that's where I thought I would target my lesson … if it was the general consensus [of the research] that students were finding these concepts difficult. I just figured that, if this is what kids did not get right or did not understand, then it was likely to apply to my class also. (p. 45)

This quote shows that his knowledge of student understanding seems to be at the basis of his lesson planning. The other geography teacher, Sue, has 5 years of experience. She demonstrates little knowledge of students' preconceptions. Her general approach was to "'assume that students came to her class with little if any useful background knowledge' and that it was often best to 'start from scratch and assume that they [the students] know nothing'" (Lane 2009, p. 44). This quote shows that a lack of knowledge of student understanding results in a lack of addressing these in her instructional strategies.

Mphathiwa's (2015) dissertation sketches PCK-portraits of five Botswanan teachers on the topic of water management. These five teachers have between 13 and 20 years of teaching experience, but only one of them studied environmental studies and teaching methods. The author uses CoRe's and PaP-eRs (Loughran, Mulhall, and Berry 2004) as research instruments and addresses all PCK-elements in his analysis. The teachers in his study demonstrate some general knowledge of student understanding. Teacher Irene remarks for example: "Students may fail to understand why enough water cannot be stored or why there can't be enough storage resources" (Mphathiwa 2015, p. 158). However, most of them were not able to connect this knowledge to their teaching strategies. Mphatiwa also reports a misalignment between their teaching orientations and their teaching practice. Although a majority of teachers promote sustainability and pursue participation in water conservation, strategies relating to sustainability are fairly absent from their lesson plans.

Reitano and Harte (2016) portray four Australian pre-service teachers. In their research, there is particular emphasis on elements (3) teachers' knowledge of student's understanding and (5) instructional strategies. All of the pre-service teachers in this study demonstrate the use of pedagogical knowledge in their lesson planning to some extent. The earlier quote from John recalls a teacher who is well aware of his student's needs and has strong beliefs about geography teaching (multi-modal experience). And, although pre-service teacher Mariam's knowledge is less profound, she takes into account her student's needs when demonstrating the compaction of waves by using a rubber band.

With regard to coherence between PCK-elements, Campbell, Melville, and Goodwin (2017) is of particular interest. This study portrays experienced earth science teacher Max who has constructivist beliefs about teaching: he supports his students in constructing their own evidence-based knowledge. The researchers follow Max in his earth science lessons on pollution and oceanography respectively. His constructivist teaching orientations were reflected in the pollution lesson, in which he asked students to design filtration systems to purify water. Students had to use online resources in order to decide on the best water purifying techniques. However, in the subsequent oceanography lesson Max teaches in a traditional, lecture-based way. He uses PowerPoint slides and transmits information with limited interaction with his students. Upon reflection Max realizes his orientations with the oceanography unit differ from those in the lessons on pollution: "With the oceanography unit, I see myself as a teacher as kind of a traditional teacher, 'Here's a bunch of stuff I know. I hope you eventually know it too'" (Campbell, p. 1274).

Finally, Clausen (2018) portrays four Danish geography teachers teaching weather formation and climate change. His research is of particular interest because of its focus on teachers' classroom conversation. Clausen interviewed the teachers and then observed their lessons. In doing so, he was able to compare elements (1) teaching orientations and (5) instructional strategies. Although Clausen found that the four Danish geography teachers he followed used different strategies, their enacted PCK seemed to be aligned with their diverse teaching orientations and beliefs. For example, he reports on teacher Erik who emphasized the importance of involving students in discussions when teaching socio-scientific issues. This is reflected in his teaching practice in which

he lets students rank activities on how much environmental impact they believed these activities caused.

In summary, based on these five studies we gained insight in the PCK-quality of 16 geography teachers. Ten teachers appeared to have rich(er) PCK, for they showed coherence between PCK-elements. Five of these teachers expressed coherence between (3) knowledge of students' understanding and (5) instructional strategies, judging from the use of preconceptions (Lane 2009) and the addressing of student needs and personal experience (Reitano and Harte 2016). Five of these teachers showed coherence between (1) teaching orientations and (5) instructional strategies. Campbell, Melville, and Goodwin (2017) study is interesting in this respect because it showed that a teacher can have different orientations with different geographical topics.

However, we also found examples of poorly developed PCK. Six teachers (Mphathiwa 2015; Lane 2009) express a lack of coherence between (3) knowledge of students' understanding and (5) instructional strategies. They are not able to translate their students' needs into meaningful instructional strategies. The five teachers in Mphathiwa's study also lack coherence between (1) teaching orientations and (5) instructional strategies. All teachers with poor PCK had either little teaching experience (such as teacher Sue with 5 years of experience) or a lack of SMK (such as the Botswanan teachers with limited background in environmental education). This is in line with what we know about teaching experience and SMK as prerequisites for PCK-development (Van Driel and Berry 2010).

Conclusion and discussion

By systematically reviewing 43 empirical studies we can conclude that there is little known about the PCK of geography teachers. Although we found elements of geography teachers' PCK in a wide variety of studies, only 9 of them used PCK as a framework. Moreover, most studies consisted of small scale case studies often based on self-reported data. The studies were too diverse to draw conclusions on the quality of geography teachers' PCK. We did find examples of individual geography teachers' PCK. Portraits of these 16 geography teachers emphasize the necessity of subject matter knowledge and teaching experience for PCK-development.

The studies in our review reflect the context and content dependency of PCK (Van Driel and Berry 2010) and confirm the need for subject-specific teacher training in order to pursue high quality geography teaching. As Reitano and Harte (2016) illustrate, PCK-courses in initial teacher education can enhance PCK-development. The reviewed studies also stress the importance of a central role for subject matter knowledge in teacher education. Our data showed an emphasis on elements (5) instructional strategies and (1) teaching orientations and a lack of (4) knowledge of assessment. This confirms prior research on these topics (Tuithof et al. 2019; Lane and Bourke 2019). Notable though, is the little amount of attention addressed to (3) knowledge of student's understanding. Where, for example, science teachers use alternative conceptions as a starting point for lesson planning, our data suggest that this practice is less common in geography education.

Moreover, the 43 studies held a fair amount of quotes referring to attitudes apart from knowledge and skills as school geography goals. Quotes in this category refer to environmental concerns, empathy with others, and wonder about earth's diversity. It is remarkable that these concerns are hardly reflected in quotes referring to (5) instructional strategies. Only a few quotes in this category refer to for example futures thinking or opinion forming. In the category of (3) knowledge of students' understanding, only a small number of quotes refer to student diversity or student attitudes. When geography as a school subject wants to make a fundamental contribution to the development of nowadays citizenship, we need to know more about the way geography teachers (can) transfer their attitude goals into meaningful instruction. The school subject could benefit from a focus on student diversity, student's preconceptions and handling controversial issues.

As is the case with many literature reviews, our findings are subject to uncontrollable variables. Our results are grounded in the subjective interpretations or representations by the authors of the selected studies. We tried to limit this uncertainty by only including peer-reviewed studies in our data. We also acknowledge our own subjectivity in the process of selection and analysis of these studies. We tried to limit our selection bias by building in consensus meetings during the entire process. Nevertheless, we did not perform a manual search in the selection process of studies. There is a possibility that using a "snowball procedure" would have added extra studies to our selection. Furthermore, the studies in our sample have an underrepresentation of studies from, for example, the UK, Nordic and German speaking countries. Research in these countries traditionally gear toward curriculum making or Fachdidaktik tradition as opposed to PCK. Another underrepresented area consists of human geographical topics. This is possible due to the origins of PCK in science and mathematics (Van Driel and Berry 2010).

To fully take advantage of the possibilities of PCK, we would like to encourage future researchers to investigate geography teachers' PCK based on larger target groups covering a wide range of geographical topics. Research should ideally incorporate evidence of teacher knowledge and teacher practice and preferably elucidate coherence between at least two PCK-elements. The use of CoRe's and Pap-eRs (Loughran, Mulhall, and Berry 2004) can help in elucidating this PCK.

Finally, it would be of value to gain insight into the ways in which geography teachers develop their PCK. How does this development take place and what prompts these teachers to gain coherence between PCK-elements? Knowing this could enhance future teacher education and professional development of geography teachers. All of this will bring us closer to our goal of high quality geography teaching.

Supplementary material

Online supplements are available through: https://www.hu.nl/onderzoek/publicaties/online-supplements-to-geography-teachers-pedagogical-content-knowledge-a-literature-review

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