Issues in improving geography and earth science teacher education: Results of the #IPGESTE 2016 conference

Viehrig, K.[1], Siegenthaler, D.[1], Burri, S.[1], Reinfried, S.[2], Bednarz, S.[3], Blankman, M.[4], Bourke, T.[5], Brooks, C.[6], Hertig, P.[7], Kerski, J.[8], Kisser, T.[9], Solem, M.[10], Stoltman, J.[11], Behnke, Y.[12], Lane, R. [13], Lupatini, M.[14], Scholten, N.[15], Siegmund, A.[16], Sprenger, S.[15]

[1] *Institute of Secondary Education, School of Education FHNW, Windisch, Switzerland*

[2] *University of Teacher Education, Lucerne, Switzerland*

[3] *Department of Geography, Texas A&M University, College Station, Texas, USA*

[4] *Inholland University of Applied Sciences, Department of Education and Innovation, Haarlem, The Netherlands*

[5] *Faculty of Education, Queensland University of Technology, Brisbane, Australia*

[6] *Institute of Education, University College London, London, United Kingdom*

[7] *HEP Vaud, Lausanne, Switzerland*

[8] *University of Denver and Esri, Denver, Colorado USA*

[9] *Department of Geography - Research Group for Earth Observation (ʳgeo), Heidelberg University of Education, Heidelberg, Germany*

[10] *AAG, Washington D.C. & Texas State University, USA*

[11] *Department of Geography and Mallinson Institute for Science Education, Western Michigan University, Kalamazoo, MI, USA*

[12] *Humboldt-University Berlin, Berlin, Germany*

[13] *Department of Educational Studies, Macquarie University, Sydney, Australia*

[14] *University of Applied Sciences of Southern Switzerland, Department for Formation and Learning, Locarno*

[15] *Faculty of Education, Geography Education, University of Hamburg, Hamburg, Germany*

[16] *Department of Geography - Research Group for Earth Observation (ʳgeo), Heidelberg University of Education; Heidelberg Center for the Environment (HCE) & Institute for Geography, Heidelberg University, Germany*

Provide full correspondence details here including e-mail for the corresponding author:

Dr. Kathrin Viehrig

Institute of Secondary Education, School of Education FHNW

Bahnhofsstrasse 6

5210 Windisch

Switzerland

kathrin.viehrig@fhnw.ch

Acknowledgements

The #IPGESTE conference was supported by a SNF-conference grant to Kathrin Viehrig (10CO19_167552/1) as well as funds from the School of Education FHNW.

Improving geography and earth science teacher education: selected results of the #IPGESTE 2016 conference

Earth Science and Geography teacher preparation have developed to some degree along different lines, despite sharing many of the same issues, especially with regard to challenges in teacher education. The conference "International Perspectives on Geography and Earth Science Teacher Education 2016" wanted to bring together educators from both sciences from around the world together to move the debate about these challenges forward. From the research presentations and the discussion during and after the conference, several issues emerged: (1) the importance of the two subjects not losing sight of each other; (2) the need to overcome language barriers; (3) the question of standards/ objectives for geography teacher education e.g. with regard to teachers' (P)CK; (4) media used in teacher education (including ways to improve them); (5) ways to improve learners' geography and earth science content knowledge; and (6) strategies to increase teachers' professionalism. We already suggest some specific steps teacher educators in the two fields can take to improve teacher education. Yet, it also became clear that more research and strengthening international collaborations is needed, as well as a better communication of the results of these efforts to practitioners.

Keywords: geography teacher education, earth science teacher education, research, international conference

Introduction

Geography and earth science education – are those different names for what is basically the same (or at least a very similar) thing? Are they something very different, as some educational policies that include geography with social studies and earth science with science seem to suggest? Should the two areas work together, or are they in competition with each other? Traditionally, both geography and earth science examine the earth as a dynamic entity undergoing continuous change – past, present, and future. Geography focuses equally on human-caused change (e.g. land use, migration, and energy consumption), and natural change (e.g. erosion, glaciation, and plate tectonics). Geography has focused more on understanding spatial patterns and scale than earth science. Earth science has focused more on the interaction of the lithosphere, atmosphere, and biosphere, where humans are important but not the emphasis. Both disciplines have shared certain core concepts, such as system or cycle (e.g. the hydrologic cycle). Both subjects can be seen as part of earth system science, i.e.

studying the earth as an integrated physical and social system (Pitman, 2005, pp. 138-139; Reinfried, 2016a, Ruszek, 2016). Teaching from such an approach can further blur distinctions between the two subjects.

No matter where exactly (if any) one draws the line between the two subjects, when it comes to teacher education, they seem to share very similar challenges. In many countries around the world teachers are said to be not qualified well to teach earth science (Huntoon & Baltensperger, 2012) or geography (Brysch, 2014). Moreover, there is a lack of research regarding which ways to prepare teachers are most effective. For instance, Lewis (2008, p. 445) emphasizes that very little is known about the relationship between earth science teacher education programs, the implementation of educational approaches by earth science teachers and student learning in earth science. Similarly, Kerr et al. (2013), based on a journal analysis, state that there is an "[…] underrepresentation of research related to geography teacher education [...]" (p. 47) (see also e.g. Catling, 2014). Thus, one of the 'important research questions' included in the new International Charter on Geographical Education (IGU, 2016) is "How can the education of geography teachers be improved to raise the quality of teaching and the levels of achievement in geography in schools?" (p. 6).

Teacher education in both areas might also share similar solutions. For instance, sharing strategies and research results, e.g. on how to prepare teachers to choose or develop materials or how to help students overcome misconceptions might be beneficial across countries and across the two subjects. On the other hand, there are location-specific contexts that may make results not transferable across cultures, regions, or nations as well as methods (e.g. hands-on-experiments) that work better in one area (e.g. physical geography/ earth science) than in another (e.g. human geography). These are important issues especially in light of the increasingly ubiquitous availability of online resources. Thus, successful strategies in one country or area might need to be adapted somewhat for others. Moreover, there are significant language barriers with regard to teacher education articles published in non-English language publications or even a different understanding of terms within one language.

Developing awareness and understanding through a conference

To begin to identify and address some of these challenges, concerns and potential solutions an international conference was held in Switzerland. This first "International

Perspectives on Geography and Earth Science Teacher Education 2016" conference took place at the FHNW School of Education in Windisch on September 26-27, 2016. The conference was attended by more than 70 people from four different continents. Participants were a mix of scholars, practitioners and students. They came from Australia, Germany, the Netherlands, Singapore, Switzerland, the UK and the USA. There were more participants from the area of secondary school (teacher) education than primary. The organizing committee consisted of Kathrin Viehrig and her colleagues Daniel Siegenthaler and Samuel Burri.

The conference program consisted of workshops, keynote presentations, paper presentations and a panel discussion. The keynote speakers were invited. There was also an open call for presentations and workshops.

The purpose of the conference was three-fold:"

1 to explore connections and differences between geography and earth science, with a focus specifically on teacher education, comparing perspectives from different countries,

2 to summarize the current state of art in teacher education in both fields and

3 to posit (research) questions for the future" (Viehrig, Siegenthaler, & Burri, 2016, p. 9).

The results of the workshops have been published elsewhere (Viehrig, Siegenthaler, & Burri, 2016).

This paper will discuss emerging issues from the conference of special interest to people who have responsibility for preparing teachers in geography and/ or earth science at their universities and colleges.

Emerging issues

There is a tradition of using conferences to move the debate in education forward. Thus, a conference was deliberately used to invite people to get together to discuss perspectives, challenges and potential solutions for teacher education in the two subjects.

After the conference, there was an iterative process of asking for reflections/ input from each contributor, synthesis and comments. This served to bring the debate beyond the conference.

In that way, six issues were identified:

(1) Geography and earth science – don't lose sight of each other

(2) Overcoming language barriers

(3) Standards to improve geography and earth science teacher education

(4) Media to improve geography and earth science teacher education

(5) Improving learners' geography and earth science content knowledge

(6) Strategies to increase geography and earth science teachers' professionalism

These issues as well as some of the possible consequences for teacher education are discussed below.

Issue 1: Geography and earth science – don't lose sight of each other

In many countries, geography and earth science education have developed along different paths:

- in K-12 school teaching, geography is often grouped together with the social sciences and the humanities (such as history and political education) in school while earth science is grouped together with the natural sciences (such as physics, biology and chemistry) (e.g. EDK, 2016; Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff, 2009; Schultz 2014; Siegenthaler 2016; Wardenga 2013).
- in large scale assessments, there are different tests for geography (TIGAS, www.tigas2023.com) and earth science (TIMSS, https://www.iea.nl/timss)
- at the university level, in many cases, there are separate departments and faculties for physical geography, earth science, and human geography
- there are different publication and conference venues for each area

The distinction between the two subjects can be seen as a consequence of the nature-culture dualism which is foundational to western modernity (Urban & Rhoads, 2003). Approaches that seek to bridge this dualism exist, but for instance, the term "earth system science teacher" is not well established, producing fewer than 12700 hits on Google (compared to 372000 for "earth science teacher" and 478000 for "geography teacher", 2017-02-14). Even in this conference, which explicitly wanted to include both geography and earth science, there were far more participants coming from a geography than from an earth science background. Thus, drawing both areas together seems to be difficult.

For teacher education drawing both areas together could be done by:

- having an earth system science approach in mind, which may help teachers – and learners – especially to more deeply understand the interrelationships between the natural and social sciences underlying the most pressing key problems of the 21st century (e.g. The Millennium Project, 2009, Reinfried, Rottermann, Aeschbacher, & Huber, 2010)

- not 'losing sight' of what's going on in the other area. For instance, publications dealing with students learning about volcanoes aren't just found in geography/ social studies education, but also in earth science education publications. Where possible, geography and earth science teacher students could even collaborate in methodology and *didaktics*. This may also include team teaching of those courses by colleagues from two different faculties or departments.

Issue 2: Overcoming language barriers

There is a saying "Publish in English or Perish", which highlights that research published in other languages, such as Arabic, Chinese, Dutch, German, Hebrew or Russian will likely be read and used by fewer researchers and practitioners across the world than articles in published in English. For instance, 96% of the articles "covered by Journal Citation Reports were in English" in the year 2000 (Rajagopalan, 2014). Studies show that articles published in English get cited significantly more than articles in other languages (Nassi-Calò 2016). This makes it sometimes difficult for teacher students who might not be fluent in (academic) English to access research results.

The conference showed that for publications written in English, it is very important to understand the connotations, or meanings, associated with different terms in different countries, in order to understand research results and overcome connotational barriers. For instance, "[...] didactics has a negative valuation in the Anglo-American mind. It denotes formalist educational practices that combine 'dogma' with 'dullness' (*Oxford English Dictionary*). It conjures up the unwelcome European ghosts of an unattractive educational past" (Hamilton, 1999, p. 135) while in the *German-speaking tradition*, "[...] didactics covers everything relevant to the science and art of teaching and learning with and about [.../ a specific area] – for instance content, methods, objectives, as well as persons and their relationships [...]" (Viehrig, 2015, p. 26, based on Baker, Kerski, Huynh, Viehrig, & Bednarz, 2012, Petersen, 2007, pp. 19-21; Uljens, 1997, pp. 44-46) and it thus has a neutral or positive meaning. To build a shared understanding of the term, consequently, it has been suggested to use the term *didaktics* for the German (and other countries') meaning (Brooks, 2016). A similar barrier seems to exist with regard to the term competence and competency-based education. As discussions during the conference showed, e.g. in the Australian context, it is perceived as negative. In the German context, it has a very positive connotation. Conceptual differences often do not yet translate well into another language also with regard to foundational models for teacher education, not just individual terms. For instance, in English, there is the TPACK model for teacher education (Technological Pedagogical Content Knowledge) (TPACK & Koehler, 2012). In German, there is a model consisting of *Fachwissenschaft* (the subject as a science), *Fachdidaktik* (subject specific didaktics) and *Erziehungswissenschaft* (educational science) (e.g. DGfG, 2010). The panel discussion also highlighted that the concept of geographical (or earth science) knowledge varies widely around the globe.

Even within one country, understanding of a term can vary. For instance, interviews with stakeholders conducted in Baden-Wurttemberg (Germany) (presented by Kisser and Siegmund 2016) showed that those working not just in school (*Gymnasium*[1]) but also at a regional council or teacher training seminary refer to a broad concept of competence-oriented geography education relating to literature-based definitions. These come from fields such as the educational standards for geography (German Geographical Society 2014), non-subject-specific definitions (Weinert, 2001; Leisen 2010; Ziener 2013) and the twelve elements of competence-oriented geography

[1] the most academically rigorous stream of secondary school

education developed by the Central Project Group Geography (ZPG) (Hoffmann, Rendel, Renz, Rothenberger & Scholliers n.d.). Most teachers practicing only at school do not know these or other scientific conceptualisations in detail, despite thinking that they are using competence-orientation methods (see also e.g. Horn & Schweizer, 2015, pp. 59-74). Teachers think of competence as being the same as methodical skills. Thus, despite using the same term, both groups refer to different concepts. Another example was raised in Bourke's (2016) presentation, namely that many researchers vary in their understandings of what professional standards in education entail. Over 25 years ago Gipps (1990), described 'standards' as the most loosely used term in education; teachers often being called to 'raise standards' without really knowing what they were been asked to do. Consequently, the intended concept of a term in the academic or regulatory discourse is not necessarily the same as how teacher practitioners end up understanding the term. Moreover, the panel discussion showed that there is a discernible difference between the understanding of a term in different contexts, e.g. everyday notions of geography knowledge (do I know the capital of France?), disciplinary knowledge that underpins academic geography and subject knowledge for teaching geography.

Thus, language can belie significant differences in meaning. Both between countries and within one country, then, geography and earth science teacher educators and researchers should:

- identify and discuss the connotational and conceptional differences of key terms and models in order to arrive at either different spellings/ terms to denote different connotations or at a shared understanding of a term in order to facilitate the debate. In the meantime, they should build greater awareness of different connotations and concept contexts.

- make sure that publications are written in simple language and include clear definitions as well as wherever possible practical illustrative examples to facilitate understanding (see also e.g. MacLellan, 2016, Williams & Coles 2003).

- develop ways to make the academic debate as well as research results more accessible to all involved – this includes making local language results available in English in order to become part of the international debate but also translating the international discourse to the local language to make it more accessible to practitioners.

Issue 3: Standards to improve geography and earth science teacher education

Standards or reference frameworks for teacher education have become a common feature of educational reform in many countries and reflect the range of ways that prospective teachers are prepared in different regions and countries (Germany: DGfG, 2010; Switzerland: VGD-CH, 2013; Netherlands: HBO-raad, 2009-2012, HBO-raad, 2011/2012, Meijerink, 2012; UK: Department of Education, n.d.; USA: http://www.nbpts.org,). They result from the understanding that the quality of teaching has a direct effect on student learning and that effective teaching is driven by several dimensions of knowledge and professional practice. The establishment of standards of what teachers should know and be able to do should provide guidance to individuals preparing teachers as well as the teachers themselves. It is generally argued that professional standards are a way to improve teacher quality and thus students' education. During the conference, standards where discussed by Theresa Bourke using examples from Australia. Moreover, the panel discussion dealt with possible standards for teachers' subject knowledge.

In her presentation, Bourke (2016) asked if practices such as the implementation of professional standards really are the magic ingredient for improving teacher quality in various corners of the globe. Bourke investigated two different standards documents from Australia - (1) the graduate standards which are the first career stage of the Australian Professional Standards for Teachers, and (2) the Learning and Teaching Academic Standards (LTAS) for graduate geographers. Whilst both documents provide lists of competencies for graduate teachers and graduate geographers respectively, the terms used and the nature of the lists are different. The graduate standards (AITSL, 2012) are a list of generic, unconnected sentences where dot points could be added or deleted with no difference to the framework. Bill Louden (2000) has been critical of this format, describing them as bullet points of duties with no explicit subject or regional context. According to Davies and Edwards (2001), following bullet point lists such as these is the pedagogical equivalent of painting by numbers. The geography standards on the other hand, not even referred to as standards but Threshold Learning Outcomes are statements of learning of deep disciplinary knowledge in geography. They are both context and subject specific.

Two of the discourses are the same for each document: "knowledge and understanding" and "skills"; however, the ways of knowing, understanding and doing are not the same.

The graduate standards are, as Beck (2009) would describe, generic modes which are profoundly reductive, or, as David Lambert's metaphor (though not referring to standards) describes: "Like using a sat-nav in your car, you let someone else do the thinking, and whilst this often gets you to your destination (though not always!), you don't always know how you got there or what you could have encountered on the way" (Lambert, 2013, p.91). He invites educators to be the map readers of their educational terrain and in some cases the cartographers rather than allowing governments to set the direction. On the other hand, the Threshold Learning Outcomes describe geography graduates who must know and understand their discipline to achieve "powerful knowledge" (Butt & Lambert, 2014; Williams, 2010; Young, 2008). The documents are also different with respect to the "discourse of skills". The geography standards promote higher order thinking, producing geography graduates who are "creative and critical", whereas the "discourse of skills" in the graduate standards represents a technical approach to teaching only. Disciplinary knowledge in the graduate standards is subordinated to a competency based outcome oriented pedagogy related to the world of work. This "cook book approach" (Biesta, 2007) has transcended expert knowledge; the real objective is producing disciplined workers.

Overall, the graduate teacher standards are a reductionist prescription of what counts as quality; in other words, a set of external competencies neatly packaged as professional standards. Bednarz, Stoltman and Lee (2004) maintain that initial teacher education has failed to produce quality geography teachers due to tensions between accreditation and deregulation wherein professionalism is lost. They argue that excellence in pedagogical knowledge and subject content is needed to achieve improved student learning outcomes. The LTAS geography standards, according to Bourke are a step towards achieving this excellence, however, the Australian graduate standards, although espousing quality, are too generic to achieve such excellence in either subject content or pedagogy.

The different approaches to teacher education standards identified by Bourke provide a useful starting framework for the future analysis of standard documents from other countries, both for teacher and school education. Moreover, it would be interesting to see in how far these approaches apply to geography and earth science (teacher) education similarly and in how far they are different.

The conference's panel discussion (Bednarz, Brooks, Hertig, Reinfried) focused on "How much of a geographer do you need to be to teach geography?". This is one of the areas for which different opinions on what the standard for teacher education should be exist. Everybody wants teachers to be knowledgeable yet there is little agreement on exactly what kinds or types of knowledge are most important for teachers to have. Do they need a deep knowledge of their subject matter obtained through higher education and perhaps research experiences in the practices of the discipline? Or do they need to understand how learners typically think when they approach a problem or idea, that is, student misconceptions, since we know that much of learning is unlearning naïve beliefs and understandings? Or is there some optimal combination of these different types of knowledge that teachers need to be effective?

In general, teachers' knowledge cannot be gauged simply through proxies like college degrees or courses taken. Moreover, the kind of knowledge a teacher needs is an important question. Shulman (1987) identified categories of knowledge teachers require to be successful, notably content knowledge, pedagogical knowledge, and pedagogical content knowledge (PCK). PCK is defined as "…[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" (Shulman 1987, 8). Research indicates that it is pedagogical content knowledge that is most powerful in predicting teacher effectiveness. Teachers who were able to identify students' misconceptions about key concepts and develop teaching approaches and lessons to help them refine their understandings were more effective (Saddler & Sonnert, 2016). Consequently, subject matter knowledge should be considered a necessary but not sufficient precondition of teaching. It also means that in addition to content knowledge teachers need to have models of how students tend to learn particular concepts (e.g. an understanding of the results of pre-conception studies; learning progressions; competence models) and techniques to counter naïve understandings. They also need knowledge about students' learning processes, the connections between content and teaching as well as content and curricula. The implication for teacher preparation is that an emphasis on increasing teachers' subject matter knowledge without sufficient attention to the preconceived mental models of students may be ineffective in improving student knowledge. This seems to suggest that earth science teachers wanting to teach geography (and vice versa) need to be aware that although the two subjects are closely related, they will need to read up on learner

concept and competence development for the new subject, especially for the topics that they have not yet dealt with in-depth.

Recent research in teacher education in the United States has focused on sociocultural approaches to knowledge integration, that is, strategies that link content knowledge to understanding of students, that develop PCK. Research at the University of Michigan indicates that there are specific activities that foster teachers' integration processes, e.g., discussing cases, action research, lesson study and reflection. There is also research that confirms teacher effectiveness is tied to the preparation they receive for teaching—their pedagogical understanding of the subject matter. The more "methods" classes and time in classrooms practicing teaching a program provides teacher students with, the more effective teachers are graduating from it. It has even been argued that teachers develop subject matter knowledge in and through their teaching practice. Through the practice of teaching and reflecting, teachers learn to systematize and unpack knowledge and practices, i.e. they produce knowledge for teaching through their own experiences. Based on these ideas Bednarz argues that to be an effective teacher of geography (and the same would also apply to earth science) one needs a deep understanding of the perspectives and practices of the discipline. However, one can argue that this expertise can be developed through practice as a geography or earth science teacher, not simply through formal educational experiences.

For teacher educators, the discussion of this issue might suggest:

- to take a critical look at the standards (both for teacher and school education) they have to work with and reflect the approach used there with their students
- help teacher students develop useful CK and especially PCK
- stress the importance of both CK and PCK and the need to continue to develop both throughout their teaching practice

Issue 4: Media to improve geography and earth science teacher education

Media – or more generally, learning environments – potentially play an important role in improving teacher education, both in terms of the student teachers' own learning and the student teachers learning to use or create media.

Digital media

The landscape of digital media available for geography and earth science (teacher) education (e.g. online learning platforms, blogs, wikis, GIS, satellite images, mobile apps, geocaches, simulation programs etc.) has changed considerably in the last decades and will continue to evolve. During the conference, two specific areas were discussed: online learning platforms and GIS/ story maps.

Rod Lane (2016) reported on the development of an online learning platform to improve pre-service teachers' depth and accuracy of knowledge of weather and climate processes. The results of previous studies indicate that prospective primary teachers hold a range of alternative conceptions about important concepts including evaporation, latitudinal temperature differences, and temperature change with altitude, air pressure and density (Lane, 2015). An online learning platform was used because it enabled the presentation of a range of multimodal resources including text, images (static or animated), audio and video. Students could control the types of resources they accessed and the timing of this access. Learning was scaffolded by presenting new information and example in manageable pieces with feedback that was timely and responsive to their needs. Using responsive learning platforms is one way how teacher educators can differentiate in their courses and thus react to the heterogeneity of their student body.

Joseph Kerski (2016) discussed the role of geospatial technologies, such as GIS and Story Maps, in teacher education. The use of Geographic Information Systems (GIS) in primary, secondary, university, and lifelong education has been modestly studied and advancing since the early 1990s. Today, key technological, instructional, and societal challenges remain, including issues of bandwidth, computer access, the availability of spatial data, monetary and time costs in investment in technology, competition and a lack of a home for spatial thinking in the curriculum, over-reliance on standardized tests, a lack of international coordinated efforts, the segmentation of education, a lack of awareness of the value of GIS in education, curricular components customized to local needs and language, and educator professional development and training in GIS.

Despite these challenges, there is great reason for optimism that we have arrived at a point in time where GIS is being adopted by a wider set of disciplines and at a broader range of educational levels than ever before. Advancements in software-as-a-service, particularly web-based GIS tools and data services, allow for spatial data and analysis to be engaged with in the classroom and in the field, by any device, at any time. A focus

on workforce development and 21st century skill building, inquiry, problem-based learning, storytelling, geo-enablement, citizen science, and the linking of geography to STEM education (Science Technology Engineering and Mathematics) is bringing new attention to the value of GIS in education. Kerski recommended that teachers and teacher educators take advantage of the data and tools available that allow educators to enhance their curriculum with real-world data and problem-solving that teaching with GIS offers. He gave an overview of the possibilities of using platforms such as ArcGIS Online, story maps, GeoInquiries, Learn ArcGIS and other lessons libraries. However, teachers and teacher educators should focus especially on teaching and inquiry rather than on the lessons or activities themselves, and get into the field with their students whenever possible — even if it is just on their school campus, using e.g. the Survey123 field app.

Analogue media

Despite the advances in the use of digital tools, analogue media such as e.g. textbooks, worksheets, hands-on models and original items (e.g. rocks, cultural artefacts) are (and will continue) playing an important role in both geography and earth science (teacher) education. During the conference, the discussion focused on the example of textbooks.

Yvonne Behnke (2016a) focused on learning-related challenges presented by graphic visualisations in geography textbooks. She argued that, notwithstanding the omnipresence of graphic information in everyday life, many students face challenges in decoding graphic information in a learning context as well as in learning involving text combined with graphic information (Behnke 2016b, 2017). Her (2016) eye-tracking study with school and university students revealed that little visual attention is paid to the depicted visuals in geography textbooks while completing a task, whereas a marked focus on text was observed, in line with other studies (e.g. Schnotz et. al 2014). However, graphic visualisations are increasingly utilised to communicate information, for instance in geography textbooks, and understanding them is thus crucial for successful knowledge acquisition. Moreover, studies from pedagogical psychology demonstrated that knowledge acquisition through graphics and text in combination (*multimedia effect*; Mayer 2009) is more successful than through text or graphics in isolation, when processing information from graphics has been learned and practised (Eitel & Scheiter 2014; Ullrich et al. 2012). Consequently, teacher educators, besides making sure that their students are able to decode graphic information, should also teach

them strategies on how to practice graphicacy and visual literacy more intensely with school students.

Behnke also outlined a number of design principles that can not only help teacher educators as authors of geography textbooks, but also in creating learning materials for their students. For instance, graphic visualisations should be visually, textually and contextually linked to related textbook content and/or tasks, and related textbook elements should complement each other (Hegarty 2011; Pettersson 2015). Furthermore, to avoid cognitive overload (Chandler & Sweller 1991), graphics should only contain information relevant to a related task and to the overall topic of the textbook spread. Moreover, graphic visualisations should not include too many different aspects of one topic in the same graphic. External characteristics (e.g. size, arrangement, quantity) should relate to the graphic content (Oestermeier & Eitel 2014). This is of specific importance, as students' visual attention to depicted textbook elements is knowledge driven and task dependent (Bojko 2014). It is also influenced by sensory parameters, such as visual saliency (Kovach & Adolphs 2015), and relies on students' interests or, more precisely, on the relevance of the depicted textbook element in the eye of the beholder.

In general, textbooks play the leading role when it comes to implement new curricula. From the view of teachers, textbooks often are regarded to be the most important element to implement the curricula in school lessons, and serve as an individual curriculum of the teacher in everyday school life. Part of the study presented by Thomas Kisser (Kisser & Siegmund, 2016) dealt with how the concept of competence-orientation is implemented in geography textbooks for *Gymnasium* (the highest stream of secondary school, classes 5–12) is perceived by different stakeholders. The study is based on qualitative expert interviews (Patton, 2007, Reinders, 2005, Reinders 2011), with practicing teachers at school, teachers that are also working at seminaries for teacher training and teachers that are also working at regional councils. During the nine interviews, the teachers provided detailed information on the use of textbooks when realizing their individual conceptions as well as on their beliefs regarding competence-oriented education. The teachers also analyzed double pages from three different textbooks (grade 7) to showcase possibilities to use these pages in their competence-oriented lessons.

The interviewed teachers struggled with the use of textbooks in competence-oriented education in general and with the selected double pages in particular. The interviews show that while some teachers use the provided textbook examples, others use the textbooks differently than as intended by the authors (e.g. only using the figures, interview 3). Thereby, stakeholders working at seminaries and regional councils perceive textbooks more critically than teachers teaching only at school. The former suggest a strong use of media other than textbooks, or a way of using the materials and tasks within a textbook that is different than what is intended. The latter, however, often stick to the combination of tasks and materials as arranged within the textbooks. Several interviewees criticized the way the textbook sample pages were designed, for instance that tasks aiming at a simple reproduction of the provided texts/ materials should be replaced by solving exemplary conflicts and problems (interviews 2, 6), students should be asked to develop structures and products for themselves (interviews 2, 3, 4, 5, 8) and supported to make interconnections between the new knowledge added as well as to existing knowledge (interview 4). Moreover, the amount of text (about 50% per page) should be reduced (interviews 1, 2, 3, 4, 8).

These results can help teacher educators in the design of learning materials for their students. Moreover, they imply that

- teacher educators need to keep abreast of new tools for teaching, so that they can both use them to improve their students' learning outcomes and introduce their students to them, including critically reflecting their use
- even for media that have been around for a long time, such as textbooks, teacher students need to be made aware of potential uses, problems and strategies. Thereby, the discussion of design principles for textbooks can also help the teacher students e.g. when designing worksheets that include both graphics and texts.

Issue 5: Improving learners' geography and earth science content knowledge

A key aspect concerning teaching and learning discussed at the conference concerned conceptual change.

Sibylle Reinfried (2016a) gave an overview of conceptual change theory and its practical implications. Conceptual change theory is an approach strongly related to a constructivist understanding of learning which states that all learning is based on prior

knowledge, everyday experiences and intuitive notions gained in a learner's everyday life. These conceptions are the cognitive resources learners refer to in their reasoning. Because conceptions constructed in everyday life are different from science concepts taught in school contexts misunderstandings are almost inevitable. In order to overcome these misunderstandings, learning processes have to be designed as profound conceptual change processes. Such an approach to teaching and learning aims at conceptual enrichment, restructuring and re-contextualization of the students' everyday conceptions in order to come closer to the science concept in question (Reinfried et al., 2015; Reinfried, 2016a; Vosniadou, 2008; diSessa, 1993).

An approach suited to achieve these aims is the Model of Education Reconstruction (MER) developed by Kattmann, Duit, Gropengießer & Komorek (1997). The MER is based on a constructivist perspective of learning. It provides a theoretical framework for instructional planning, the development of instruction and science education research that is relevant for improving instructional practice and teacher professional development programs (Duit, Gropengiesser, Kattmann, Komorek & Parchmann, 2012). A key concern of the model is that subject matter issues as well as student learning needs and capabilities have to be given equal attention in attempts to improve the quality of teaching and learning. The model consists of three major elements that are fundamentally interconnected: firstly, the analyses of the subject matter from scientific *and* educational perspectives; secondly, the investigation of student and teacher perspectives regarding the chosen subject and thirdly, the design and evaluation of learning environments (e.g. instructional materials, learning activities, teaching and learning sequences). The first two components of the MER form the basis on which the design of appropriate learning environments must be build step by step in a recursive way. Because learning environments designed according to the MER aim at improving instructional practice, their evaluation with empirical methods is essential (for further information see Duit et al., 2012). First results (see e.g. Reinfried, Rottermann, Aeschbacher, & Huber, 2010, Lane 2016, Reinfried 2016b) indicate that conceptual change learning environments lead to learning progress.

There are still only very few studies dealing with conceptual change learning environments for pre-service teacher students. A notable exception is Rod Lane's work (Lane 2016). His presentation discussed the development of an online learning platform to promote conceptual change. The platform fosters engagement and motivation by immersing students in real-world (authentic) problem solving. Each module is designed

to elicit students' pre-instructional knowledge and give them a voice in the learning process. Activities are designed to engage students in sustained/substantive conversations about their ideas and intuitive theories about weather and climate. The activities also help students build on productive prior conceptions (conceptual resources) and, where necessary, identify and restructure deeply held misconceptions. Learners are introduced to the scientific explanations in a direct, explicit manner using analogies, models and representations. Reflective tasks are then used to promote cognitive conflict and dissatisfaction with the intuitive conception. The final learning activity requires students to provide evidence of their understanding by applying their knowledge in a range of contexts. The purpose of this activity is to assist them to extend, elaborate and generalize their understanding of the five core concepts in the module.

The data from Lane's pilot study suggest that these tasks increase learners' awareness of their beliefs, enabling them to identify inconsistencies and restructure alternative conceptions. Findings of the pilot study also suggest that the depth and accuracy of preservice teachers' knowledge can be improved by combining the principles of conceptual change instruction with the affordances of online learning.

Sibylle Reinfried (2016b) dealt with the teaching and learning of a complex hydrological topic. Research has shown that laypeople's understanding of hydrological processes, especially the subsurface parts of the water cycle and processes related to groundwater pollution, are inadequate and characterized by erroneous conceptions (e.g. Dickerson & Dawkins, 2004; Dickerson, Callahan, Van Sickle & Hay, 2005; Dove, Everett & Preece, 1999; Reinfried, 2006, Reinfried et al., 2012), although issues related to drinking water belong to the most pressing problems of the 21st century (The Millennium Projekt, 2009). Based on the MER, Reinfried et al. (2015) developed a learning environment which dealt with geological and hydrological facts of the participants' region of residence as well as the dangers that threatened the quality of their regional ground- and spring water, i.e. drinking water. The learning environment is a good example of how to bridge the divide between geography and earth science, by combining hydrological, hydrogeological and environmental issues and relating them to the students' everyday lives. The knowledge progression and the persistence of the newly learnt knowledge gained by working with the learning environment was tested quantitatively with questionnaires involving 143 7th graders using an analysis of variance (ANOVA) with repeated measures. The learning environment led to a

relatively persistent knowledge gain and better understanding of hydrological processes underground and their relationship to ground- and spring water quality (Reinfried et al., 2015).

For teacher education, this suggests:

- the dire need for more studies dealing with teacher students' conceptions, that then can be used to create conceptual-change learning environments for teachers. This would not just help student teachers' conceptual development but also model the use of such learning environments.
- the importance of helping teacher students to become aware of both their own and their students' conceptions as well as the teacher's role in students' conceptual development
- raising the awareness of the benefits of conceptual-change inducing learning environments and teaching teacher students how to design them (e.g. with the help of the MER strategy)

Issue 6: Strategies to increase geography and earth science teachers' professionalism

Owing to numerous studies showing that teacher quality is pivotal for student learning (Hattie, 2009; Lipowsky, 2006) one task in research for geography in higher education is to identify the factors that constitute a professional geography teacher. The majority of research concentrates on teachers` dispositions such as knowledge facets (CK, PCK) or teacher`s beliefs and motivations. For instance, the panel discussion also showed that for teacher education, both improving the pre-service teachers' content knowledge and their pedagogical content knowledge is considered vital.

According to Dutch teacher educators who teach geography, primary student teachers do not possess sufficient knowledge and skills to provide good geography lessons when they leave training (Blankman, Van der Schee, Volman, & Boogaard, 2015). This is due to fact that primary student teachers in the majority are so called non-specialists and their knowledge of geography is fairly limited. This situation also is recognized internationally (Catling, 2004, 2017; Martin, 2008; Jo & Bednarz, 2014). Beyond this, preparing these student teachers to teach geography in primary schools is limited by the number of training hours available.

A possible solution was presented by Marian Blankman (see also Blankman, Schoonenboom, Van der Schee, Boogaard, & Volman, 2016), who designed a short geography course for first year primary student teachers called Consciously Teaching Geography (CTG) aimed at developing student teachers' PCK and teaching them how to give good geography lessons. The course was constructed around a framework that defines seven characteristics of a good geography lesson. Five of these characteristics are based on core geographic concepts (Haubrich, 1992; Taylor, 2008; Catling & Willy, Teaching Primary Geography, 2009). Each characteristic is formulated as a question that student teachers can use when preparing a lesson: *Where is it? Why is it there? What do I see if I zoom in or out? How does it change over time?* and *What are the consequences, advantages and disadvantages?* These questions are chosen instead of the abstract geographic concepts such as space, place, location, etc. to better connect with the target group: mainly non-specialist primary student teachers. In addition to those geographic questions, two general pedagogical questions were formulated: How can I start the lesson in a motivating way? and How can I end the lesson in a way that promotes transfer? The course consists of five 90-minute meetings. At the start of the course, the activities focus on raising student teachers' awareness of their own image of geography and their preconceptions (Martin, 2005; Corney, 2000; Catling, 2004; Alkis, 2009; Lane & Coutts, 2012; Van der Schee, 2000). Thereafter, these conceptions are compared with the geographies reflected in everyday activities (Martin, 2008), e.g. their journey from home to school or the breakfast they ate that morning. Each meeting subsequently starts with an everyday spatial problem. During the meetings all seven characteristics of a good geography lesson are paid attention to. The framework of the seven characteristics is used to help student teachers to make the connection between everyday geographic experiences and the core academic concepts of geography. In each meeting, the teacher educator models the characteristics of a geography lesson step-by-step in a sample lesson, making use of forms of active learning. By providing meta-commentary a (conscious) translation to the student teachers' own practice takes place, and a connection is created between exemplary behaviour and theory (Loughran & Berry, 2005; Lunenberg, Korthagen, & Swennen, 2007).

While Blankman focused more on teaching a good geography lesson overall, other presentations looked at specific examples of teacher professionalism, namely noticing, teaching public space, developing a geographic worldview and the choice of spatial examples.

Scholten and Sprenger's (2016) research aims at understanding pre-service teachers' geography specific noticing, based on frameworks by Sherin et. al (2011) and Blömeke et. al (2015). Teachers' noticing during instruction, or ability to observe a learning environment is one of the processes which links teachers` dispositions (knowledge and beliefs) to their performance (Blömeke, Gustafsson, & Shavelson, 2015; Sherin, Jacobs, & Philipp, 2011). Understanding this link is important to improve teacher education and thus student learning. Besides multiple aspects of classroom management, a professional geography/ earth science teacher needs to notice subject-specific aspects which are relevant for students` geography/ earth science learning. Scholten and Sprenger focused on the construction of a research instrument, since a teachers' noticing (observational) skills cannot be studied by using conventional paper & pencil tests due to its contextual nature. Their study therefore uses vignettes, a medium (Brophy, 2004) which represents a classroom situation. It is short, concise and self-contained (Rosenberger, 2016), and tries to show the situation without interpreting or analyzing it (Schratz, Schwarz, & Westfall-Greiter, 2012). Apart from this, the genre "vignette" encompasses different modes of presentation (written vignettes, video vignettes, audio vignettes), different styles of presentation (dialogue, narration) and different degrees of reality (scripted vignettes, actual teaching situations). They constructed a scripted, written vignettes in a dialogue style, which showed a geography classroom situation dealing with plate margins. A priori, incidents were integrated in the vignette, which showed indicators of students` geography specific cognitive activation. It was expected that professional geography teachers would notice and find meaning in these incidents.

Vignettes can be used in standardized testing to assess teacher competencies (Kaiser, Busse, Hoth, König, & Blömeke, 2015). In addition, vignettes are a promising, versatile and productive medium in pre-service teacher education because they aim to represent the complex, contextualized and situated nature of the classroom (Riegel, 2013). Vignettes offer various ways of classroom reflection because they can be stopped, repeated and analyzed collectively (Sherin, 2004) and most importantly they show knowledge in practice.

Marco Lupatini (2016) focused on how public space can be taught, based on a qualitative study with both lower secondary school teacher students and upper secondary school students. Public space is an interesting tool to teach students to work and reason as geographers, to develop their critical thinking competencies, help to form them as citizens and to connect this concept with students' daily life and experience. It is

important that teacher education deals explicitly with this topic, encouraging teachers to both reflect on the concept and include it in their teaching.

Joseph Stoltman (2016) discussed the importance of developing a geographic worldview as a component of teacher education. Among the advantages gained through geographic study, perhaps most important and enduring is the worldview that students weave into an understanding of, receptiveness to, and ways of thinking about the world. Worldview develops as a person conceptualizes and experiences Earth, its people, the natural environments, and issues which arise that have become 24/7 occurrences through the social media. A consequence of a meaningful education in geography is the ability to accommodate information and apply it to responsible decision making and citizen action. Teachers assume a critical role in guiding students in their construction of a worldview that extends beyond themselves or their locality, and they likely become worldviews since they often change over time. A worldview enables students to transition from local to global and back to local as they seek to comprehend and reflect in an informed manner about Earth and all that it encompasses. Conceptualizing the world and preparing to be a positive actor in its sustainability has been and continues to be a fundamental reason for studying and practicing geography throughout one's lifespan. With each new generation of students, geography educators assume responsibility for challenging them to hone a positive worldview through deliberations, planning, and public action. Worldview is not a principle of geography or education that is inserted directly into the minds of students. Rather it emanates from geographic content, skills, values, and dispositions that coalesce, re-emerge, mutate, and take form throughout one's life. It is an integration and construction of the new knowledge, attitudes, and principles that are the transformations of what is learned both in and out of school. Worldview is a response to both content and context in education. Worldview is a lofty idea that teachers of geography have the responsibility to germinate in the minds of students, to cultivate through the thoughtfulness and actions of students, and to propagate for future generations.

Kathrin Viehrig (2016) presented selected results of a small educational design research study with pre-service teacher students (see Viehrig, 2017). Very little is known specifically on the choice of spatial examples, both with regard to how teacher students choose spatial examples themselves (e.g. for teaching or preparing assignments) and with regard to how they want spatial examples to be chosen for their courses. While in some aspects, similar results were found (e.g. the pupils' interests, current events or an

important role in the discussion in the media/ organisations etc. were regarded as important factors), in other aspects, there are differences between what the students report doing themselves and what they want their educators to do. For instance, while they reported that their own interests play an important role when selecting spatial examples, the educators' interest ranks much lower in selecting spatial examples for the courses (rather the students' and pupils' interests are regarded as important). Moreover, being mandated by the curriculum ranked much higher on the list for how they want examples to be chosen for their courses than on the list of what they do themselves. The interests of the students in different spatial regions varied considerably. While the students seem to mostly agree that selecting a number of spatial examples for a course helps to gain an in-depth understanding, they also want to be able to choose the spatial assignments for assignments freely.

More research is needed, for instance to study on a larger scale the factors teacher (students) use when deciding spatial examples, how they negotiate between different conflicting factors (e.g. between a low interest on the one hand and a high importance in the media on the other hand) and which consequences their and their educators' choices have for the teacher students' and their pupils' learning. Taking the students' factors as well as their "wish lists" for specific examples into account when planning courses might be a way to model *Schülerorientierung* (student orientation, i.e. taking the students' interests, experiences, situation etc. into account).

With regard to teacher education, it would be interesting to exploit the first experiences with these different approaches in the international community of geography and earth science teacher educators to conduct comparative studies (i.e., do they work similarly in different countries?) and thus find best practices. Moreover, the different approaches presented here offer opportunity for reflection for teacher educators, e.g. in terms of which strategies to deal with worldviews and space they employ, how they choose their spatial examples, what they present (explicitly or implicitly) as good geography/ earth science education or how they could use vignettes to make the link of their classes to teaching practice more explicit as well as to improve student teacher outcomes.

Ways forward

The conference identified several challenges that seem to apply to both geography and earth science teacher education. The discussion of the issues that emerged from the conference suggest several ways to improve teacher education in these two fields and to move the academic debate forward.

Across issues, it became clear that more research, international collaboration as well as a better communication of the results of these efforts are needed. Initiatives in this direction exist e.g. for the area of assessing the impact of learning and teaching with geo-technologies (Baker et al. 2012) as well as finding best practices and strategies of teaching with geo-technologies, including GIS, remote sensing, and GPS. As another example, an international study group is working towards creating an international large-scale assessment for geography similar to what exists for earth science within TIMSS (Solem et al. 2018). This would enable, among other things, an empirical exploration of differences and similarities between geography and earth science education across different countries.

The IGU charter (2016) also includes chapters explicitly calling for both more research and international cooperation. One specific initiative discussed during the conference is the National Center for Research in Geography Education (NCRGE), headquartered at the American Association of Geographers and Texas State University. NCRGE is a research coordination network with over 150 members in 60 universities and organizations located in the U.S. and 10 other countries. NCRGE's mission is to build capacity for transformative research in geography education by supporting collaborative networks of researchers working in different thematic areas. By challenging convention with ideas that have potential to enact radical changes in science and education, 'transformative research' is what is necessary for achieving broad-scale improvements in geographic literacy in schools.

NCRGE was established in 2014 in response to the Road Map Project (Bednarz, Heffron, & Huynh, 2013, 60), which recommended 'the creation or designation of an institution to coordinate the implementation, dissemination, and knowledge transfer of research results. Members of the NCRGE research coordination network are working to implement lines of research that are consistent with the Road Map Project's vision for transformative research. With regard to research on teacher preparation in geography,

the Road Map Project argued that research should be conducted with the goal of determining what is needed to produce educators able to understand and teach for student mastery of the content and practices of geography. This might include studies that address the following topics (based on Bednarz, Heffron, & Huynh, 2013):

- Relationship of teachers' knowledge of geography content and skills and student achievement;
- Optimal ways of infusing geographic concepts, content, and skills into pre-service teacher education programs;
- Impact of licensure in science or social studies on teacher preparation to teach geography;
- Influence of teachers' beliefs about geography on pedagogy and classroom practices.

A research coordination network such as NCRGE can provide the infrastructure necessary for transformative research activities. Research coordination networks (RCNs) are distributed networks of researchers whose work is orchestrated in a manner that maximizes intellectual synergies and facilities the transfer of research findings to practitioners. RCNs enable potentially transformative research by (for example) fostering interdisciplinary and international collaborations, accumulating, sharing, and communicating a body of knowledge, supporting data collection at multiple sites and across diverse educational environments or setting community standards. Other geography education networks, such as the U.K. Geography Education Research Collective (GEReCo), also provide important opportunities for research collaboration and capacity building (Solem & Boehm, 2018). Moreover, the IGU-CGE can play an important role in international collaboration and debate.

References

Alkis, S. (2009). Turkish geography trainee teachers' perceptions of geography. *International Research in Geographical and Environmental Education, 18*(2), 120-133.

Australian Institute for Teaching and School Leadership (AITSL). (2011). *National professional standards for teachers*. Melbourne, VIC: AITSL.

Australian Learning and Teaching Council (ALTC). (2010). *Learning and Teaching Academic Standards Project: Arts, social sciences and humanities: Geography. Learning and teaching academic standards statement, December 2010*. Retrieved from http://disciplinestandards.pbworks.com/w/file/fetch/52684122/altc_standards_GEOGRAPHY_080211_v2.pdf.

Baker, T. R., Kerski, J. J., Huynh, N. T., Viehrig, K., & Bednarz, S. W. (2012). Call for an Agenda and Center for GIS Education Research. RIGEO, 2(3), 254-288.

Beck, J. (2009). Appropriating professionalism: Restructuring the official knowledge base of England's "modernised" teaching profession. *British Journal of Sociology of Education*, *30*(1), 3-14.

Bednarz, S. W., Stoltman, J. P., & Lee, J. (2004). Preparing geography teachers in the United States. *International Research in Geographical and Environmental Education*, *13*(2), 176-183.

Bednarz, S.W., Heffron, S., & Huynh, N. T. (eds.) (2013). A road map for 21st century geography education: Geography education research (A report from the Geography Education Research Committee of the Road Map for 21st Century Geography Education Program). Washington, DC: Association of American Geographers.

Behnke, Y., 2016b. How textbook design may influence learning with geography textbooks. *Nordidactica – Journal of Humanities and Social Science Education*, 1, pp.38–62. Available at: www.kau.se/nordidactica.

Behnke, Y., 2017. Mapping the Reading of Graphic Visualisation in Geography Textbooks.In: Noora Pyyry, Liisa Tainio, Kalle Juuti, Raine Vasquez, and Maiju Paananen (Hg. Studies in Subject Didactics 13. *Changing Subjects, Changing Pedagogies: Diversities in School and Education*. Finnish Research Association for Subject Didactics, 68–89, https://helda.helsinki.fi/handle/10138/231202

Biesta, G. (2007). Why "what works" won't work: Evidence-based practice and the democratic deficit in educational research. *Educational Theory*, *57*(1), 1–22.

Blankman, M., Van der Schee, J., Volman, M., & Boogaard, M. (2015). Primary teacher educators' perception of desired and achieved pedagogical content knowledge in geography education in primary teacher training. *International Research in Geographical and Environmental Education, 24*(1), 80-94

Blankman, M., Schoonenboom, J., Van der Schee, J., Boogaard, M., & Volman, M. (2016). Learning to teach geography for primary education: results of an experimental programme. *Journal of Geography in Higher Education*, 1-17.

Blömeke, S., Gustafsson, J.-E., & Shavelson, R. J. (2015). Beyond Dichotomies: Competence Viewed as a Continuum. *Zeitschrift für Psychologie, 223*(1), 3-13. doi: 10.1027/2151-2604/a000194

Bojko, A., 2014. *Eye Tracking the User Experience*, Rosenfeld.

Brooks, C. (2016). Paper presented at the IGU-CGE Conference, Singapore.

Brophy, J. (2004). Discussion. In J. Brophy (Ed.), *Using Video in Teacher Education* (Vol. 10, pp. 278-304). Amsterdam: Elsevier.

Brysch, C. P. (2014). Status of Geography Education in the United States. A report for the National Geographic Society Education Foundation. Available at http://gato-docs.its.txstate.edu/jcr:42d98ff7-42d2-418c-b14a-55f288f9d99c/State_of_Geography_Report.pdf

Butt, G., & Lambert, D. (2014). International perspectives on the future of geography education: An analysis of national curricula and standards. *International Research in Geographical and Environmental Education*, *23*(1), 1-12.

Catling, S. (2004). An understanding of geography: The perspectives of English primary trainee teachers. *GeoJournal 60*, 148-158.

Catling, S., & Willy, T. (2009). *Teaching Primary Geography.* Exeter: Learning Matters Ltd.

Catling, S. (2014). Pre-Service Primary Teachers' Knowledge and Understanding of Geography and Its Teaching: A Review. *RIGEO, 4*(3), 235-260.

Catling, S. (2017). Not nearly enough geography! University provision for England's pre-service primary teachers. *Journal of Geography in Higher Education. 41* (3), 434-458.

Chandler, P. & Sweller, J., 1991. Cognitive Load Theory and the Format of Instruction. *Cognition and Instruction*, 8(4), pp.293–332.

Corney, G. (2000). Student Geography Teachers' Pre-conceptions about Environmental Topics. *Environmental Education Research 6 (4)*, 313-329.

Davies, M., & Edwards, G. (2001). Will the curriculum caterpillar ever learn to fly? In M. Fielding (Ed.), *Taking education really seriously: Four years' hard labour* (pp. 98-109). London: RoutledgeFalmer.

Department of Education (n.d.). Teachers' Standards. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/283566/Teachers_standard_information.pdf

DGfG (Ed.) (2010). *Rahmenvorgaben für die Lehrerausbildung im Fach Geographie an deutschen Universitäten und Hochschulen*. Bonn: Selbstverlag Deutsche Gesellschaft für Geographie.

Dickerson, D.L. & Dawkins, K.R. (2004), Eighth grade students' understandings of groundwater: Journal of Geosciences Education, 52(2), 178–181.

Dickerson, D.L., Callahan, T., Van Sickle, M. & Hay, G. (2005), Students' conceptions of scale regarding groundwater: Journal of Geoscience Education, 53(4), 374–380.

diSessa, A. A. (1993). Toward an epistemology of physics. Cognition and Instruction, 10(2/3), 165-255.

Dove J.E., Everett, L.A. & Preece, P. (1999), Exploring a hydrological concept through children's drawings: International Journal of Science Education, 21(5), p. 485–497.

Duit, R, Gropengiesser, H., Kattmann, U., Komorek, M. & Parchmann, I. (2012). The Model of Educational Reconstruction – A framework for improving teaching and learning science. In D. Jorde & J. Dillon (Eds.), Science Education Research and Practice in Europe: Retrospective and Prospective (pp. 13–37). Rotterdam: Sense

Publishers. https://www.sensepublishers.com/media/1341-science-education-research-and-practice-in-europe.pdf (26.1.2017)

EDK. (2016). Lehrplan 21 (Vorlage). Available at http://v-ef.lehrplan.ch/ (21.8.2017)

Eitel, A. & Scheiter, K., 2014. Picture or Text First? Explaining Sequence Effects when Learning with Pictures and Text. *Educational Psychology Review*, pp.153–180.

Gipps, C. (1990). The debate over standards and the use of testing. In B. Moon, J. Isaac & J. Powney (Eds.), *Judging standards and effectiveness in education* (pp. 32-46). London: The Open University.

Hamilton, D. (1999). The pedagogic paradox (or why no didactics in England?). *Pedagogy, Culture & Society, 7*(1), 135-152.

Hattie, J. (2009). *Visible Learning: A synthesis of over 800 meta-analyses relating to achievement*. London: Routledge.

Haubrich, H. (1992). *International charter on geographic education.* Freiburg: IGU.

HBO-raad. (2009-2012). *Kennisbasis docent aardrijkskunde bachelor.* Den Haag: HBO-raad.

HBO-raad. (2011/2012). *Kennisbasis docent aardrijkskunde master.* Den Haag: HBO-raad.

Hegarty, M., 2011. The Cognitive Science of Visual-Spatial Displays: Implications for Design. *Topics in Cognitive Science*, 3(3), pp.446–474. Available at: http://doi.wiley.com/10.1111/j.1756-8765.2011.01150.x.

Hoffmann, T., Rendel, A., Renz, K., Rothenberger G. & Scholliers, M. (n.d.): 12 Elemente des kompetenzorientierten Unterrichts. In: Landesakademie für Fortbildung und Personalentwicklung an Schulen (Hg.); Fachportal Geographie Gymnasium. Available at: http://lehrerfortbildung-bw.de/faecher/geographie/gym/fb1/12_element/

Horn, M. & Schweizer, K. (2015): Ansichten von Geographielehrkräfte zum kompetenzorientierten Unterricht und ihr Zusammenhang mit Überzeugungen:

Ergebnisse einer empirischen Befragung. Zeitschrift für Geographiedidaktik, 43(1), 59-74

Huntoon, J., & Baltensperger, B. (2012). Increasing Expertise in Earth Science Education through Master's Education. *Journal of Geoscience Education, 60*(2), 147-158http://www.nagt-jge.org/doi/full/110.5408/5411-5224.5401.

IGU. (2016). International Charter on Geographical Education. Retrieved from http://www.igu-cge.org/charters.htm

Jo, I., & Bednarz, S. W. (2014). Developing pre-service teachers' pedagogical content knowledge for teaching spatial thinking through geography. *Journal of Geography in Higher Education*, 301-313.

Kaiser, G., Busse, A., Hoth, J., König, SJ., & Blömeke, S. (2015). About the complexities of video-based assessments: Theoretical and methodological approaches to overcoming shortcomings of research on teachers' competence. *International Journal of Science and Mathematics Education, 13*(2), 369-387. doi: 10.1007/s10763-015-9616-7

Kattmann, U., Duit, R., Gropengießer, H., & Komorek, M. (1997). Das Modell der didaktischen Rekonstruktion – Ein Rahmen für naturwissenschaftsdidaktische Forschung und Entwicklung [The model of educational reconstruction – a framework for science education research and development]. Zeitschrift für Didaktik der Naturwissenschaften, *3*(3), 3–18.

Kerr, S., Jo, I., Collins, L., Monroe-Ossi, H., Ray, W., Whitcraft, A., . . . Stoltman, J. P. (2013). Teacher Education and Geography: Research Perspectives. *Research in Geographic Education, 15*(2), 44-58.

Kovach, C.K. & Adolphs, R., 2015. Investigating attention in complex visual search. *Vision Research*, 116, pp.127–141. Available at: http://dx.doi.org/10.1016/j.visres.2014.11.011.

Lambert, D., & Morgan, J. (2010). *Teaching Geography.* Berkshire: Open University Press.

Lambert, D. (2013). Geography in school and a curriculum of survival. Theory and Research in Education, 11(1), 85-98.

Lane, R., & Coutts, P. (2012). Students' alternative conceptions of tropical cyclone causes and processes. *International Research in Geographical and Environmental Education, 21*(3), 205-222.

Lane, R. (2015). Primary Geography in Australia: Pre-service primary teachers' understandings of weather and climate *Review of International Geographical Education Online*, 5(2), 199-217.

Leisen, J. (2010): Lernaufgaben als Lernumgebung zur Steuerung von Lernprozessen. In: Lernaufgaben und Lernmaterialien im kompetenzorientierten Unterricht. In H. Kiper, W. Meints, S. Peters, S. Schlump & S. Schmit (Hg.), Lernaufgaben und Lernmaterialien im kompetenzorientierten Unterricht (60-67). Stuttgart: Kohlhammer.

Lewis, E. B. (2008). Content is Not Enough: A history of secondary earth science teacher preparation with recommendations for today. *Journal of Geoscience Education, 56(5)*, 445-464.

Lipowsky, F. (2006). Auf den Lehrer kommt es an: Empirische Evidenzen für Zusammenhänge zwischen Lehrerkompetenzen, Lehrerhandeln und dem Lernen der Schüler. In C. Allemann-Ghionda & E. Terhart (Eds.), *Kompetenzen und Kompetenzentwicklung von Lehrerinnen und Lehrern: Ausbildung und Beruf* (Vol. 51, pp. 47-70). Weinheim: Beltz.

Loughran, J., & Berry, A. (2005). Modelling by teacher educators. *Teaching and Teacher Education, 21*, 193-203.

Louden, W. (2000). Standards for standards: The development of Australian professional standards for teaching. *Australian Journal of Education*, *44*(2), 118-134.

Lunenberg, M., Korthagen, F., & Swennen, A. (2007). The teacher educator as a role model. *Teaching and Teacher Education 23*, 586-601.

Maclellan, Paul (2016): Why don't teachers use education research in teaching. https://eic.rsc.org/analysis/why-dont-teachers-use-education-research-in-teaching/2010170.article.

Martin, F. (2005). *The relationship between beginning teachers' prior conceptions of geography, knowledge and pedagogy and their development as teachers of primary geography.* Coventry: Unpublished PhD thesis.

Martin, F. (2008a). Ethnogeography: towards liberatory geography education. *Children's Geographies, 6*(4), 437-450.

Mayer, R.E., 2009. *Multimedia Learning*, Cambridge: Cambridge University Press.

Meijerink, H. (2012). *Een goede basis, Advies van de Commissie Kennisbasis Pabo.* Den Haag: HBO raad.

Mullis, I. V. S., Martin, M. O., Ruddock, G. J., O'Sullivan, C. Y., & Preuschoff, C. (2009). *TIMSS 2011 Assessment Frameworks*: IEA.

Nassi-Calò, L. (2016) Study shows that articles published in English attract more citations. http://blog.scielo.org/en/2016/11/04/study-shows-that-articles-published-in-english-attract-more-citations/#.WYMXAY5flGg (2017-08-03).

Oestermeier, U. & Eitel, A., 2014. Lernen mit Text und Bild. *Online Publikation von e-teaching.org*, pp.1–36. Available at: http://www.e-teaching.org/didaktik/.

Patton, M. Q. (2007): Qualitative research & evaluation methods. Thousand Oaks: Sage.

Pettersson, R., 2015. *Information Design 3. Image Design*, Wien: International Institute for Information Design.

Pitman, A. J. (2005). On the role of Geography in Earth System Science. Geoforum, 36(2), 137–148

Rajagopalan, J. (2014) Publish—in English—or Perish? How ESL authors can overcome the language barrier. https://www.editage.com/insights/publish%e2%80%94in-english%e2%80%94or-perish-how-esl-authors-can-overcome-the-language-barrier (2017-08-03).

Reinders, H. (2005): Qualitative Interviews mit Jugendlichen führen. München, Wien: Oldenbourg.

Reinders, H. (2011). Interview. In H. Reinders, H. Ditton, C. Gräsel & B. Griewosz (Hg.): Empirische Bildungsforschung: Strukturen und Methoden (85-97). Wiesbaden: VS Verlag für Sozialwissenschaften.

Reinfried, S., Rottermann, B., Aeschbacher, U., & Huber, E. (2010). Alltagsvorstellungen über den Treibhauseffekt und die globale Erwärmung verändern - eine Voraussetzung für Bildung für nachhaltige Entwicklung. *Schweizerische Zeitschrift für Bildungswissenschaften, 32*(2), 251-273.

Reinfried, S., Tempelmann, S. & Aeschbacher, U. (2012). Addressing secondary school students' everyday ideas about freshwater springs in order to develop an instructional tool to promote conceptual reconstruction. Hydrology and Earth System Science, 16, 1365-1377. http://www.hydrol-earth-syst-sci.net/16/1365/2012/hess-16-1365-2012.html

Reinfried, S., Aeschbacher, U., Kienzler, P. M. & Tempelmann, S. (2015). The model of educational reconstruction – a powerful strategy to teach for conceptual development in physical geography: The case of water springs. International Research in Geographical and Environmental Education, 24(3), 237-257, http://dx.doi.org/10.1080/10382046.2015.1034459

Reinfried, S. (2006). Conceptual change in physical geography and environmental sciences through mental model building – the example of groundwater. International Research in Geographical and Environmental Education, 15(1), 41-61.

Riegel, U. (2013). Einleitung. In U. Riegel & K. Macha (Eds.), *Videobasierte Komptenzforschung in den Fachdidaktiken* (pp. 9-24). Münster: Waxmann.

Rosenberger, K. (2016). Fall-Vignetten: Ein methodisches Instrumeent in der Bildungsforschung. In C. Fridrich, R. Klinger, R. Potzmann, W. Greller & R. Petz (Eds.), *Forschungsperspektiven 7*. Wien: Lit.

Ruszek, M. (2016). Earth System Science in a Nutshell. Science Education Ressource Center, Carlton College. Retrieved from http://serc.carleton.edu/introgeo/earthsystem/nutshell/index.html (12.1.2017)

Saddler, P. M. & Sonnert, G. (2016). Understanding misconceptions. Teaching and learning in middle school physical science. American educator, Spring 2016, p. 26-32. Retrieved from https://www.aft.org/ae/spring2016/sadler-and-sonnert (8.8.2017)

Schnotz, W. et al., 2014. Focus of attention and choice of text modality in multimedia learning. *European Journal of Psychology of Education*, pp.1–19.

Schratz, M., Schwarz, J. F., & Westfall-Greiter, T. (2012). *Lernen als bildende Erfahrung: Vignetten in der Praxisforschung*. Innsbruck: Studienverlag.

Schultz, H.-D. (2014). Fach unter Fächern oder was sonst? Eine disziplinhistorische Skizze zur deutschen Geographie. *Geographische Revue, 2014(1)*, 20-54.

Sherin, M. G. (2004). New Perspectives on the Role of Video in Teacher Education. In J. Brophy (Ed.), *Using Video in Teacher Education* (Vol. 10, pp. 1-27). Amsterdam: Elsevier.

Sherin, M. G., Jacobs, V., & Philipp, R. (Eds.). (2011). *Mathematics teacher noticing: Seeing through teachers' eyes*. New York: Routledge.

Shulman, L.S. 1987. Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review* 57(1):1-22.

Siegenthaler, D. (2016). Zur Geschichte des Schulfachs Geographie. Bericht aus einem Forschungsprojekt. *GeoAgenda, 2016(1)*, 17-21.

Solem, M. & Boehm, R.G. 2018. Research in geography education: moving from declarations and road maps to actions. International Research in Geographical and Environmental Education, 27(3): 191-198.

Solem, M., Stoltman, J., Lane, R., Bourke, T., Chang, C.H., & Viehrig, K. (2018). An assessment framework and methodology for a Trends in International Geography Assessment Study (TIGAS). *Geographical Education*. 31. pp. 7-15 (peer-reviewed)

Taylor, L. (2008). *Think piece: Concepts in Geography.* From www.geography.org.uk

TPACK, & Koehler, M. J. (2012). Using the TPACK Image. Retrieved from http://tpack.org/

The Millennium Projekt (2009). Global Challenges for Humanity. Retrieved from http://www.millennium-project.org/millennium/challeng.html (21.8.2017).

Ullrich, M. et al., 2012. Kognitionspsychologische Aspekte eines Kompetenzmodells zur Bild-Text-Integration. *Psychologische Rundschau*, 63(1), pp.11–17. Available at: http://psycontent.metapress.com/openurl.asp?genre=article&id=doi:10.1026/0033-3042/a000105 [Accessed September 29, 2014].

Urban, M. & Rhoads, B. (2003). Conceptions of nature: implications for an integrated geography. In S. Trudgill & A. Rov (Eds.), Contemporary Meanings in Physical Geography. From What to Why? (p. 211-231). London: Arnold.

Van der Schee, J. (2000). Helping children tot analyse a changing world: looking for patterns and relationships in space. In Robertson, & R. Gerber, *The Child's World. Triggers for learning* (pp. 214-231). Melbourne: Acer Press.

VGD-CH. (2013). Rahmenvorgaben für die Lehrerinnen- und Lehrerausbildung im Fach Geographie an Universitäten und Pädagogischen Hochschule der Schweiz. Retrieved from http://www.vgd.ch/files/Rahmenvorgaben_VGD-CH_2013_d.pdf

Viehrig, K. (2015). *Exploring the effects of GIS use on students' achievement in geography.* (Dissertation Dissertation), Heidelberg University of Education, Heidelberg. Retrieved from http://opus.ph-heidelberg.de/frontdoor/index/index/docId/71

Viehrig, K. (2017). Pre-service geography teachers' voices on the choice of spatial examples. Results from the first year of an educational design research study. J-reading, 1, 29-44.

Viehrig, K., Siegenthaler, D., & Burri, S. (2016). Presentation of the conference and outlook. *GeoAgenda, 2016*(5), 8-9.

Vosniadou, S., Ed. (2008). *International handbook of research on conceptual change*. New York, London: Routledge.

Wardenga, U. (2013). Writing the history of geography: What we have learnt - and where to go next. *Geographica Helvetica, 2013(1)*, 27-35.

Weinert, F.E. (Hg.) (2001). Leistungsmessungen in Schulen. Weinheim, Basel: Beltz.

Williams, G. (2010). Subject benchmarking in the UK. In D. Dill & M. Beerkens (Eds.), *Public policy for academic quality: Analyses of innovative policy instruments* (pp. 157-181). New York: Springer.

Williams, D., & Coles, L. (2003). The Use of Research by Teachers: information literacy, access and attitudes. Final Report on a study funded by the ESRC: Department of Information Management. The Aberdeen Business School. The Robert Gordon University.

Young, M. (2008b). From constructivism to realism in the sociology of the curriculum. *Review of Research in Education, 32,* 1-28.

Ziener, G. (2013). Bildungsstandards in der Praxis: Kompetenzorientiert unterrichten. Seelze-Velber: Kallmeyer.

List of Presentations

Keynotes

Blankman, M. (2016). Content knowledge and pedagogical content knowledge of geography teachers: challenges and constraints.

Bourke, T. (2016) Standards in Teacher Education – Mirage or miracle cure?

Kerski, J. J. (2016). Benefits, challenges, and lessons learned in professional development for educators using GIS and other geospatial technologies. https://sway.com/J3zhkb2fLa9M27nU

Kisser, T. (speaker), Siegmund, A. (2016). In-service teachers', teacher trainers' and government stakeholders' views on competence based education.

Reinfried, S. (2016a). Earth Science and Geography – more than just collecting rocks and knowing the countries of the world.

Solem, M. (2016). A Research Coordination Network for Transformative Research in Geography Education.

Stoltman, J. (2016). Geography's role in developing a worldview: Teachers and students.

Other presentations

Behnke, Y. (2016). Learning-Related Challenges Presented by Graphic Visualisations in Geography Textbooks.

Lane, R. (2016). Promoting conceptual change and deep understanding in the Earth Sciences: an online approach.

Lupatini, M. (2016). Which role does public space play in geography teaching?

Scholten, N., Sprenger, S. (speaker) (2016). The Missing Link between Competence and Performance – Introducing Noticing into Geography Teacher Education.

Reinfried, S. (2016b). "Wherever spring water is released, there must be caves" – An analysis of students' knowledge construction and reasoning about complex and abstract geoscience concepts and how they can be changed through instruction.

Viehrig, K. (2016). Pre-service teachers' voices on the choice of spatial examples.