



# Working with Students' Ideas in Physical Geography: A Model of Knowledge Development and Application

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## Abstract

Researchers in science education have for some time recognised the need for teachers to develop an awareness of students' common alternative conceptions – a key element of pedagogical content knowledge (PCK) – and use this knowledge to develop student understanding (Morrison & Lederman, 2003). Less attention, however, has been devoted to the investigation of geography teachers' awareness of and work with students' ideas. This paper outlines what is currently known about the nature of alternative conceptions in physical geography, teachers' knowledge of these ideas and their use of this knowledge to inform instruction. The paper proposes a framework to explain the factors affecting the development of geography teachers' knowledge in this area and their application of this knowledge in the classroom. Implications of the framework for pre-service training, and the accreditation and ongoing professional learning of geography teachers, are discussed along with directions for future research.

**Keywords:** pedagogical content knowledge, alternative conceptions, geography

## Introduction

It is now well understood that students construct robust mental models or conceptions of phenomena in an attempt to make sense of their everyday experiences and that these beliefs have a significant impact on learning (Clough & Driver, 1986; Duit, Widodo, & Wodzinski, 2007; Greca & Moreira, 2000). Awareness of these conceptions has led to a long tradition of research in science education exploring the nature of students' intuitive mental models and the processes and mechanisms of conceptual change (Vosniadou, Vamvakoussi, & Skopeliti, 2008). Researchers in science education have also explored the implications of these findings for the knowledge requirements of teachers. Following from Shulman's (1986) seminal work, numerous

studies have investigated science teachers' understandings of students' common alternative conceptions and their use of this knowledge to inform instruction (Berg & Brouwer, 1991; Halim & Meerah, 2002; Morrison & Lederman, 2003). This research has shaped the nature and content of pre-service and in-service teacher education for mathematics and science teachers. Most teachers trained in these disciplines over the past 20 years will have been likely introduced to approaches for diagnosing students' alternative conceptions of core concepts and strategies for promoting conceptual change (Duit et al., 2007).

Like researchers in mathematics and science, scholars in geographical education have for some time acknowledged the need to first diagnose, then address alternative conceptions through instruction (Dove, 1999, 2014; Ghaye & Robinson, 1989; Harrison & Purnell, 2012; Lambert & Balderstone, 2010; Leat & Chandler, 1996). Researchers have investigated the nature of students' alternative conceptions in many areas of physical geography, which is logical given the close alignment between the epistemologies of physical geography and the natural sciences. Both hold a world view that rests on consensus-based understandings and logical positivism (Peet, 1998 cited by Hutchinson, 2013). A comprehensive overview of the research in this area is provided in *The Ludwigsburg-Lucerne bibliography of misconception research in the geosciences* (Reinfried & Schuler, 2009). The bibliography includes studies of teachers' and students' alternative conceptions of the Coriolis effect (Nelson, Aron, & Francek, 1992), greenhouse effect (Reinfried, Aeschbacher, & Rottermann, 2012), mass wasting (Nelson et al., 1992), groundwater (Dickerson, Callahan, Van Sickle, & Hay, 2005; Reinfried, 2006a), Arctic environments (Dove, 2014), weather (Dove, 1998a), pollution (Boyes & Stanisstreet, 1997), tropical storms (Lee, 1999), rock types (Dove, 1996), weathering and erosion (Dove, 1997), tropical rainforests (Dove, 2012) and rivers (Dove, Everett, & Preece, 2000).

In contrast to researchers in mathematics and science, however, geographical educators have rarely taken the next step of considering the implications of this work with students for research exploring geography teachers' knowledge. One consequence of this has been a lack of attention directed to the investigation of geography teachers' knowledge of students' ideas – an important component of pedagogical content knowledge (PCK) – and the factors influencing the development of this knowledge base. Likewise, little is known about the ways in which experienced geography teachers use their knowledge of students' world views – their views about the nature of reality and being (Olafson, Schraw, & Vander Veldt, 2010) – and intuitive mental models to inform their classroom practice. An understanding of geography teachers' knowledge and practice in this area would provide a useful guide for research and for the planning of professional learning initiatives to enhance the effectiveness of conceptual change instruction in geography classrooms.

This paper aims to start a conversation around the development of a framework to better understand geography teachers' knowledge of students' ideas in physical geography and the use of this knowledge to inform instruction. The paper is divided into two sections. The first section provides an overview of what we currently know about the nature of alternative conceptions and the implications for the development of geography teachers' PCK. The purpose of this section is to highlight the current state of research in this area. In the second section, a framework is proposed to explain the process of development of geography teachers' knowledge of students' common preconceptions in physical geography and their use of this knowledge to inform instruction.

## **Section 1: What We Know About the Nature of Students' Alternative Conceptions and Geography Teachers' Awareness of These Ideas**

### **The Nature of Alternative Conceptions**

The literature exploring the nature of students' alternative conceptions highlights several important features of these ideas. Firstly, alternative conceptions tend to be widely held by both school aged students and adults and are neither idiosyncratic nor culturally dependent (Driver, Squires, Ruchworth, & Wood-Robinson, 1994).

Secondly, while students' intuitive beliefs may appear to be incomplete or theoretically incorrect to a discipline expert they are often perceived as functional, plausible and evidence-based to the

learner (Posner, Strike, Hewson, & Gertzog, 1982; Reinfried, 2006b). These ideas have a significant influence on the learning process because they act as a lens through which learners interpret and decode information in order to construct meaning (Driver et al., 1994).

Dove (1998b, 1999) and Reinfried (2004) cite a number of possible sources of alternative conceptions in science and geography, including the use of everyday language in domain-specific contexts, changing definitions, the oversimplification of concepts, overlapping similar concepts, rote learning, students' preconceptions from private world experiences, stereotyping and incorrect information in textbooks, myths, and inadequate prerequisite knowledge. Lee (1999) highlights the importance of the discourses or voices that children encounter in social and cultural contexts and the role they play in shaping students' beliefs. He argues that students make meaning from various information sources, including family, teachers, school, friends and the media. When examining the possible origins of students' conceptions in both science and geography it is important to remember the role of social interaction in the process of knowledge construction. Common sayings such as *the dew is falling, the force be with you* and *shut the door to keep the cold out* can provide students with overly simplified and incorrect analogies about the operation of physical processes, resulting in the reinforcement of alternative conceptions (Driver et al., 1994).

Finally, students' alternative conceptions tend to be both robust and resistant to change because they have been constructed from learners' personal experiences and continue to be confirmed and reinforced by their everyday interactions (Ozdemir & Clark, 2007). Vosniadou et al. (2008, p. 4) maintain that students' intuitive views of the world are "not fragmented observations but form a coherent whole [or] framework theory." These theories are constructed from learners' "interpretations of . . . common everyday experiences in the context of lay culture" (p. 15) and are used by learners to make predictions and to provide explanations of phenomena. Individual mental models are shaped by students' ontological and epistemological beliefs – their beliefs about reality and the nature and purpose of knowledge. These beliefs are stored in schemas or mental models and are often substantially different from both the ideas to be taught and from the established views of experts in particular subject domains (Driver, 1989; Vosniadou et al., 2008). Recently, the term powerful knowledge has been used to refer to these established expert views (Young & Muller, 2010). Powerful knowledge or disciplinary knowledge differs from intuitive, everyday

knowledge in that it is evidence-based, abstract and theoretical (conceptual), reliable (consistent and testable) and open to challenge. Children and young people are unlikely to acquire powerful knowledge through their everyday experiences at home or in the workplace as this knowledge is often counterintuitive and exists outside the direct experience of the learner (Lambert & Hopkin, 2014).

The relationship between powerful knowledge and alternative conceptions can be seen in the example of the greenhouse effect. According to Reinfried, Aeschbacher, and Rotterman (2012) students commonly believe that the human induced greenhouse effect is a result of the ozone hole – “a hole in the atmosphere allows more rays of sunlight to enter; they are then reflected by the earth’s surface but cannot find the hole (i.e. “the exit”) to escape resulting in a warming of the atmosphere” (p. 157). This belief is clearly inconsistent with the established scientific consensus communicated by the Intergovernmental Panel on Climate Change. According to leading climate scientists, ozone depletion is not the mechanism of global warming. Ultraviolet radiation represents a small percentage (less than one percent) of the energy from the sun which is not enough to cause a significant heating of the earth’s surface. The main cause of global warming is the release of carbon into the atmosphere caused by the burning of coal, gas, and oil. These gases spread around the planet and capture solar heat that would otherwise be radiated out into space (Royal Meteorological Society & National Centre for Atmospheric Science, 2014). Despite being inconsistent with the current scientific consensus, however, these intuitive beliefs are plausible to the individual and therefore highly resistant to change.

The concept of alternative conceptions in human geography is more problematic as this sub-discipline draws its ontological and epistemological foundations from the social sciences and humanities. In many areas of human geography it is possible to have multiple truths, as the key concepts are values and perspective-based in contrast to the consensus-based understandings of physical geography. It makes little sense, for example, to talk about alternative conceptions of *place*, *community* or *the future*. The model discussed in this paper adopts the ontological and epistemological assumptions of the physical sciences as it focuses on teachers’ knowledge of and work with students’ ideas about weather and climate and the causes and impacts of tropical cyclones.

## **The Implications of Alternative Conceptions for Geography Teachers’ Knowledge**

Research across a number of domains (especially science) suggests that teachers require an awareness of students’ common alternative conceptions in key topic areas if they are to help students build depth of understanding (Morrison & Lederman, 2003). The importance of this knowledge base is clearly articulated in Shulman’s conceptualisation of pedagogical content knowledge. Shulman (1986) defines PCK as “expert content-knowledge of subject matter and curricular knowledge linked to effective teaching strategies within a content area” (p. 9). His initial conceptualisation of PCK consisted of two components, (a) knowledge of multiple methods for representing and organising subject content to make it comprehensible to students and (b) knowledge of what makes the learning of particular content easy or difficult for students including an understanding of students’ *common alternative conceptions in key topic areas*. According to Shulman (1986), an understanding of the alternative conceptions that students develop prior to formal instruction, and the instructional conditions necessary for overcoming these beliefs, should be “at the heart of our definition of needed pedagogical knowledge” (p. 10). It is argued that teachers require knowledge of common alternative conceptions so that they can recognise these ideas during instruction and develop strategies for helping students articulate, compare, analyse, evaluate and, where necessary, restructure these ideas (Arnold, Sarge, & Worrall, 1995). Knowledge of students’ alternative conceptions is also important for the development of valid and reliable assessments to diagnose and address learning problems in schools. Building teacher awareness of these ideas is, therefore, seen as an essential first step in the development of pedagogies for improving geographic literacy (Reinfried, 2006b).

## **What Do We Know About Science and Geography Teachers’ Knowledge of Student Ideas?**

Shulman’s (1986, 1987) suggestion that teachers need strong PCK to develop student understanding has resulted in a number of studies exploring pre-service and in-service primary and secondary science teachers’ knowledge of, and work with, students’ ideas (Berg & Brouwer, 1991; Halim & Meerah, 2002; Morrison & Lederman, 2003). The results of this research suggest that teachers of science often pay a “striking lack of attention to children’s ideas, predictions [and] explanations” (Smith & Neale, 1989, p. 12), are insensitive to students’ viewpoints (Osborne, Bell, & Gilbert, 1983), and lack an awareness of the potential for

alternative conceptions to interfere with science learning (Hollon & Anderson, 1987). Jones, Carter, and Rua (1999) note that experienced teachers of primary and secondary science are often *shocked, surprised* and *intrigued* (p. 554) when made aware of the alternative conceptions held by some of their students. Teachers often respond by either ignoring students' ideas or assuming that these conceptions can be easily changed through instruction, for example, teacher exposition (Hollon & Anderson, 1987). When teachers are aware of students' preconceptions, their knowledge is often either general in nature or restricted to a narrow range of topics (Berg & Brouwer, 1991; Morrison & Lederman, 2003).

In contrast to the research in science education there are few studies exploring pre-service or in-service geography teachers' knowledge of student ideas. A recent study examined 16 experienced geography teachers' epistemological beliefs, knowledge of students' intuitive ideas (about tropical cyclone causes and processes) and use of this knowledge to inform instruction (Lane, 2015). To be classified as experienced a teacher needed to have taught geography for at least five years. This, according to Berliner (2001), is the minimum classroom experience required before a teacher can move to a more expert level of functioning. The results of this study indicate that the knowledge of experienced geography teachers in this area is both complex and varied. Even amongst these experienced geography teachers, the awareness of students' conceptions was uneven. Some teachers demonstrated a very limited knowledge of students' ideas. They were able to outline broad areas of difficulty commonly experienced by students but not specific alternative conceptions. These teachers lacked an understanding of the constructed and robust nature of alternative conceptions and tended to view these beliefs as errors/mistakes or a lack of knowledge. In contrast, other teachers with similar levels of experience were able to provide detailed and specific examples of students' commonly held alternative conceptions. These teachers also understood that alternative conceptions are constructed from students' everyday experiences and that they are based on students' developing (naïve) theories of how the world works.

### **How Do Geography Teachers Use Their Knowledge of Students' Ideas to Inform Practice?**

Research on geography teachers' work with students' ideas suggests that experienced geography teachers use their knowledge of students' ideas in diverse ways in their classrooms. In emerging work with experienced geography teachers, five different uses of this

knowledge were identified (Lane, 2015). The teachers used their knowledge of alternative conceptions to: (1) work closely with individuals and groups of students to identify their common alternative conceptions – adopting a constructivist/conceptual change approach to instruction; (2) identify “errors” and address them by “adding content” to their lessons and “build understanding from scratch”; (3) reflect on and evaluate their own content knowledge, epistemological beliefs and pedagogical approach; (4) limit the focus of lessons, script delivery of content, and minimise opportunities for lessons to go “off track”; and (5) prioritise the “covering of content” and avoid any engagement with students' “incorrect” ideas. Some of the teachers in the study adopted a combination of the above approaches.

While this research represents an important first step in our understanding of geography teachers' work with student preconceptions, further research is required to better understand the factors affecting the development of teachers' knowledge in this area. The following section proposes a framework to explain differences in experienced geography teachers' knowledge of, and work with, students' ideas.

## **Section 2: Model for the Development and Enactment of Geography Teachers' Knowledge of Students' Ideas**

The literature in both science and geographical education suggests there is a process to the development and enactment of teachers' knowledge of student ideas and that a range of factors including teachers' content knowledge, epistemological beliefs, knowledge of evidence-based strategies and topic-specific self-efficacy affect this process (see Figure 1).

Emerging research with experienced geography teachers suggests these factors do not operate in a deterministic way but more like a series of filters or barriers affecting the development and enactment of this element of PCK. Each of the filters is of equal importance and their order of application is not important.

In this section, we propose a framework to explain the development of teachers' knowledge of students' ideas and their use of this knowledge in the classroom. Although models of PCK development and enactment in science education have been proposed in the past (e.g. Park & Oliver, 2008), the model proposed here focuses specifically on experienced *geography teachers'* and their *knowledge of and work with students' ideas*.

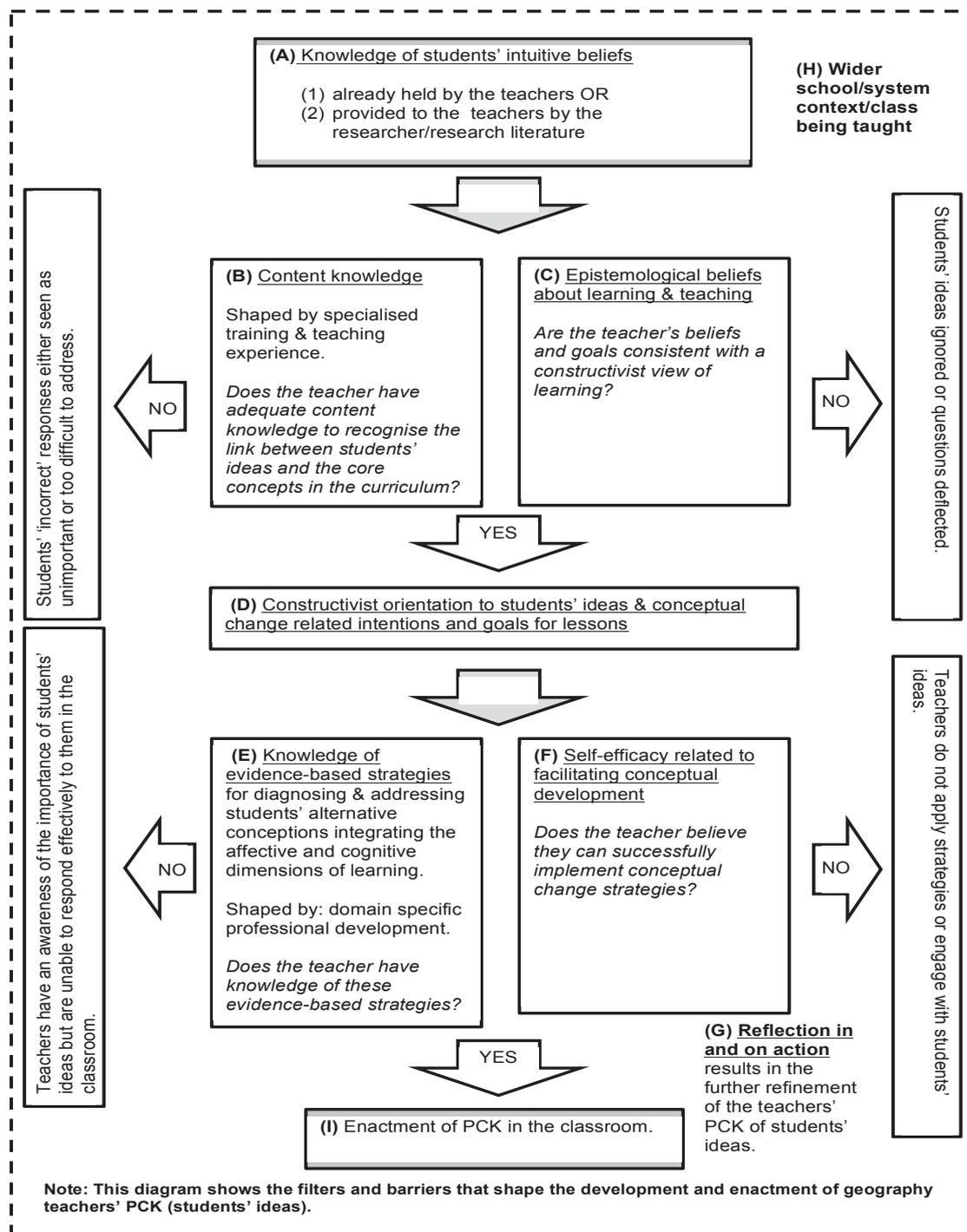
## Elements of the Model

Figure 1 shows how experienced geography teachers build on their existing knowledge of students' intuitive beliefs and apply this knowledge in the classroom. As discussed in Section 1, the research suggests that experienced geography teachers vary in their initial knowledge of student ideas (as represented by Box A in Figure 1). Some teachers hold knowledge that is fragmented or uni-structural (Biggs & Collis, 1982) i.e. they can list some ideas but not explain the connections between them. Others hold

detailed and relational understandings of students' ideas, their construction and development. It is hypothesised that experienced geography teachers use a combination of sources to develop this initial knowledge base. These sources include their own classroom experiences, information obtained from other teachers, studies reported in textbooks and (to a lesser extent) the research literature (Lane, 2009).

The available research with geography teachers indicates that the further development and enactment of this knowledge base involves a

**Figure 1 – Factors affecting the enactment and further development of geography teachers' knowledge of students' ideas.**



two-stage process with four specific filters or barriers. Stage 1 [the planning stage] involves teachers developing an understanding of the role of alternative conceptions in the learning process and setting the reconstruction of these ideas as a key goal of instruction (see Figure 1 – Boxes A to D). There are two filters or potential barriers that affect the development of these instructional intentions. These filters include the teachers' depth of content knowledge and their epistemological beliefs about learning and teaching.

Stage 2 of the model considers the factors affecting the application/enactment of this knowledge in the classroom (see Figure 1 – Boxes E to I). Geography teachers with constructivist goals and relational content knowledge may be prevented from enacting their intentions by either a lack of knowledge of evidence-based conceptual change strategies or by a lack of confidence in their ability to successfully implement these strategies in the geography classroom (topic-specific self-efficacy). A teacher's ability to reflect in/on action and their teaching context also plays an important role here (Lane, 2009). The role of these filters/barriers in shaping geography teachers' work with students' ideas is discussed in further detail below.

## **Stage 1 – Factors affecting teachers' instructional intentions and orientations to students' ideas**

### **(1) Depth and Accuracy of Content Knowledge**

More than 30 years of PCK research in science education indicates that teachers' awareness of, and ability to diagnose, alternative conceptions is related to their depth of subject content knowledge (Box B, Figure 1). A number of researchers have noted, for example, that it is unlikely that teachers will be able to recognise, diagnose and address students' alternative conceptions if they themselves possess similar incorrect and imprecise mental models (Dahl, Anderson, & Libarkin, 2005; Hoz, Tomer, & Tamir, 1990; Schoon, 1995; Smith & Neale, 1989). Similarly, researchers in geographical education including Lambert and Hopkin (2014) and Firth (2014) argue that subject-based knowledge is essential if teachers are to be able to recognise alternative conceptions during instruction and develop strategies to help students articulate, compare, analyse, evaluate and where necessary, restructure these ideas. Lane (2011, 2015) in a study involving experienced geography teachers found that participants without a threshold level of knowledge of tropical cyclone causes and processes either failed to recognise alternative

conceptions during lessons or avoided engaging with comments and questions from students they were unsure about. A relational understanding (Biggs & Collis, 1982) of atmospheric processes was required before the teachers could identify students' common alternative conceptions during instruction and explain the significance of these beliefs for student learning.

### **(2) Beliefs About Knowledge, Learning and Teaching**

Another key factor affecting teachers' knowledge of and work with students' ideas is their epistemological beliefs (beliefs about knowledge and knowing) and their related beliefs about learning and teaching (Duit et al., 2007; Magnusson, Krajcik, & Borko, 1999). Research across a number of domains suggests that a constructivist orientation to learning and teaching is required before teachers are likely to set the diagnosis and addressing of alternative conceptions as key goals of instruction (Duit et al., 2007; Hashweh, 1996b; Pinnegar, 1989). The importance of teachers' epistemological beliefs in the development and enactment of PCK is represented by Box C in Figure 1. Research in both science and geographical education indicates that teachers' beliefs about knowledge and learning influence their sensitivity towards students' views and their willingness to consider students' preconceptions in their planning and classroom practice. As Schraw and Olafson (2003) note, the different epistemological world views of teachers influence the way they think and make important decisions about teaching and assessment practices. Teachers with a clear understanding of the constructed and intransigent nature of students' preconceptions are more likely to value students' ideas and develop strategies for exploring, extending and, where necessary, challenging these beliefs (Hashweh, 1996a; Lane, 2015).

Recent research with experienced geography teachers (Lane, 2015) demonstrates the important link between teachers' epistemological beliefs and their orientations towards students' ideas. The findings of this study with 16 experienced geography teachers indicate that teachers with constructivist beliefs are more likely to view students' ideas as resources for improving student understanding and sources for reflection and professional growth. The teachers with predominately non-constructivist views of knowledge and learning interpret students' alternative conceptions as signs of knowledge gaps; indicators of failure in the learning/teaching process; or distractions from the key goals of instruction. These contrasting beliefs about learning and teaching shape the way individual teachers use their knowledge of students' ideas

to inform instruction. The research suggests that teachers without an understanding of the constructed nature of students' ideas are unlikely to recognise the importance of supporting students to articulate, compare, analyse, evaluate and where necessary restructure their intuitive mental models. As a result, students' alternative conceptions may be overlooked or ignored during instruction. Inquiry-based learning approaches, such as those advocated in the Australian Curriculum: Geography, may not be adopted (see the arrow to the right of Box C).

## Stage 2– Factors Affecting Teachers' Work With Students' Ideas

### (1) Knowledge of Evidence-Based Strategies for Diagnosing and Working With Students' Alternative Conceptions and an Ability to Reflect on Practice

While constructivist goals and intentions help teachers recognise the importance of students' ideas, they alone are not sufficient. To work productively with students' ideas (Box I), teachers also require knowledge of evidence-based strategies for diagnosing students' preconceptions and for promoting conceptual development (Box E).

Although there is no singular agreement among researchers regarding the mechanisms of conceptual change (Clement, 2008), a number of possible approaches for improving the conceptual understanding of students can be identified from the literature. These strategies require teachers to consider the epistemological (views of knowledge and learning), ontological (worldviews or views about the nature of reality and being) and affective dimensions (emotions, motivation and social aspects) of learning (Duit, Treagust, & Widodo, 2008). Examples of evidence-based conceptual change approaches include the following:

- regularly assessing and monitoring the validity of students' conceptions (Ozturk & Alkis, 2010);
- engaging students in a variety of rich tasks where they are encouraged to explore and evaluate a range of explanations for geographical phenomena including their personal beliefs and theories;
- promoting the expression of intuitive conceptions in class and using students' ideas as the starting point for instruction;
- encouraging students to identify the key characteristics of concepts and to differentiate between related ideas – e.g. boiling and evaporation (Carey, 1991);
- designing curricula so that students from early years onwards are exposed to learning

experiences that help them build the required prior knowledge for understanding more complex concepts in the curriculum (Vosniadou, 2008). An example of this is the progressive building of students' understanding of key weather and climate processes within the Australian Curriculum: Geography and Science (F–10);

- building students' reflective and metacognitive skills so they are more aware of their beliefs and assumptions and are able to identify and monitor inconsistencies in these beliefs (Inagaki & Hatano, 2003);
- promoting substantive discussions in class where students feel comfortable expressing their beliefs and are given the opportunity to identify and reflect upon inconsistencies in their explanations – e.g. using *Thinking through geography* strategies and other similar approaches (Leat, 2001);
- promoting argument and debate rather than consensus in the classroom. Dove (1999) suggests a number of strategies for achieving this in physical geography;
- modelling the application of processes and principles in real world contexts – e.g. through the use of simulations and hypotheticals;
- breaking down complex phenomena, such as the processes of a tropical cyclone, and providing opportunities for students to explore the individual processes and principles in a range of contexts<sup>11</sup>; and
- building students' critical literacy skills so they can question the accuracy of representations of geographical processes depicted in popular culture and differentiate these ideas from established scientific understandings (Luke, 1999). The dominance of images/representations of natural hazards in popular culture, for example, makes these critical literacy skills particularly important in physical geography. An awareness of the multiple purposes of texts can also assist students to decipher scientific fact from entertainment.

Without a repertoire of effective instructional approaches, geography teachers may struggle to translate the intention of working with students' ideas and building depth of understanding into action (see the arrow to the left of Box E in Figure 1).

Teachers most responsive to students' ideas also have a capacity to reflect on their practice both during and after lessons (Jones et al., 1999; Lane, 2011, 2015; Loughran, Mulhall, & Berry, 2008; Sperandio-Mineo, Fazio, & Tarantino, 2006; Wang, 2004). These teachers are attentive to students' ideas and use the information collected from diagnostic/formative assessment to

identify alternative conceptions, monitor student understanding, and make ongoing adjustments to their practice (Box G).

Without an awareness of evidence-based strategies and an ability to effectively reflect on practice, geography teachers are unlikely to apply their knowledge of students' ideas in the classroom and further develop their understanding of students' common alternative conceptions.

## **(2) Teacher Self-Efficacy Related To the Application of Conceptual Change Strategies in Physical Geography**

There is considerable evidence over many years of the importance of self-efficacy in shaping teaching practice (Dembo & Gibson, 1985; Guskey, 1988; Schunk, 1990). Self-efficacy, according to Bandura (1977, 1986), refers to an individual's belief in their competence to complete a task or meet a goal. In this case, the key factor is the teachers' confidence in their ability to effectively apply conceptual change strategies in specific topic areas. According to Park and Oliver (2008) ". . . when teachers believe in their capacity to execute their PCK effectively, the PCK will be more likely to be enacted in actual classrooms" (p. 270). They also note that greater teacher self-efficacy promotes the development of "worthier professional goals and manifests as a willingness to try new teaching strategies" (Park & Oliver, 2008, p. 271). Without this confidence, teachers of geography are unlikely to effectively employ topic-specific conceptual change strategies in the classroom (Appleton, 2006; Park & Oliver, 2008).

These findings suggest that self-efficacy related to facilitating conceptual change/development (represented by Box F in Figure 1) is likely to be important for the growth and enactment of geography teachers' PCK.

## **(3) Teaching Context**

In addition to the above factors, the conceptual change research suggests that teaching context can play an important role in either encouraging or inhibiting teachers' work with students' ideas. Lane (2009) and Morrison and Lederman (2003) outline a number of elements of the teaching context which affect teachers' work with students' ideas. These include the perceived pressure to cover content for external examinations, time constraints, conflicting school/system priorities and lack of professional development focused on strategies for working with students' ideas. These pressures have a significant impact on teachers' priorities and are often cited by experienced geography teachers as reasons for not supporting students to articulate and evaluate their

intuitive ideas (Lane, 2009). Box H in Figure 1 emphasises the likely importance of these factors in influencing geography teachers' work with students' ideas – an important component of PCK.

Further research using semi-structured interviews, lesson observations and video stimulated recall sessions may also help identify additional factors/filters shaping geography teachers' knowledge of common alternative conceptions and the use of this knowledge to inform instruction. It is likely, for example, that teachers' own school experiences and ontological worldviews – collective beliefs about the nature of reality and being – play a role in shaping their practice in this area (Hutchinson, 2013). Data collected from the exploration of these factors could be used to further refine the model of PCK development and enactment.

## **Discussion/Conclusion**

The model presented above suggests it is insufficient for both research and professional development to focus solely on investigating and enhancing teachers' knowledge of new curriculum content or strategies for promoting geographical understanding. In particular it highlights the importance of adopting a holistic approach to the development of geography teachers' PCK. This has implications for the pre-service training, accreditation and ongoing professional development of geography teachers. Constructing and supporting the PCK of geography teachers is a complex task. To enhance teachers' work with students' ideas, we need to focus on building their knowledge and skills in each of the six areas (Boxes A-F) identified in Figure 1. Firstly, pre-service teachers need to develop a relational understanding of core geographical concepts and develop an understanding of the role of knowledge reconstruction in the learning process. Secondly, it is vital that geography teachers continue to consolidate their understanding of *the foundational concepts and processes* of physical geography throughout their careers and refine their ability to reflect on practice. Finally, it is important that teachers receive adequate system and school-level support to develop their knowledge of evidence-based strategies and to foster a strong sense of teacher self-efficacy (belief in their ability to affect learning outcomes).

A key message from Figure 1 and the literature is the need to ensure that teachers of geography have sound content knowledge. This presents a challenge for both pre-service teacher training and ongoing professional learning. According to the National Professional Standards for Teachers (Australian Institute for Teaching and School Leadership [AITSL], 2011, p. 10), graduate teachers should be able to "demonstrate

knowledge and understanding of the concepts, substance and structure of the content and teaching strategies of [their] teaching area". For geography teachers, it is important that this includes sound knowledge of the underlying processes and principles of both human and physical geography. The results of recent studies (Lane, 2009, 2011, 2015; Lane & Coutts, 2012) indicate that teachers without a background in core geographical processes find it most difficult to identify and work with students' alternative conceptions. This is likely to be more evident with pre-service and early career teachers since the research has shown they are more likely to be driven by self-efficacy concerns and a preoccupation with the procedural and practical aspects of day-to-day teaching (Evans & Tribble, 1986).

Minimum subject content requirements for accreditation play an important role in shaping the content knowledge of graduate teachers. The minimum discipline specific study requirements for teachers in Australia are mandated by AITSL. Students wishing to teach geography as a first teaching subject are required to complete at least six units of study in the discipline with no more than two units at a first year level. There is no specific requirement, however, for pre-service teachers to study a combination of units in physical and human geography. The model presented above and the literature on which it is based suggest that an academic major in geography, with a balance of units across human and physical geography, may provide graduating teachers with a better understanding of the key underlying processes for teaching secondary geography. Whilst it is not possible for pre-service teachers to complete undergraduate studies in all aspects of the curriculum, foundational studies in physical and human geography would appear to be essential (Lane, 2011). Indeed, it would make good sense for those advising pre-service teachers in geography to have a balance between the two as both are required in the teaching of geography in schools.

Once within the school system, there is a need to encourage geography teachers to continue to update and consolidate their content knowledge by engaging in ongoing professional learning. It is insufficient for professional learning to focus exclusively on new curriculum content, teaching approaches and support resources. It is vital that professional learning reinforces teachers' understanding of the foundational concepts and processes of physical geography. The Professional Standards for Accomplished Teaching of School Geography (University of Melbourne, Australian Geography Teachers' Association, Geography Teachers' Association of Victoria, & Victorian Institute of Teaching, 2010)

state that accomplished teachers of geography should be able to "promote understandings of physical and human processes, structures and patterns and their interdependence in place, space and time" (p.4). This involves recognising alternative conceptions during instruction and developing strategies to help students articulate, compare, analyse, evaluate and where necessary, restructure these ideas. To achieve this, teachers need to "know the breadth and depth of the academic discipline including its concepts, skills, values and understandings" (p.3). Lane (2011) discusses a number of approaches for improving the accuracy and depth of geography teachers' content knowledge. These strategies include engaging teachers in reflection and discussions to promote cognitive conflict and promoting wider involvement with professional associations. Reflexivity can be strengthened through peer interactions and social media interactions between practitioners. These networks provide invaluable opportunities for critical reflection with colleagues and can help build motivation for lifelong learning. The resources provided by professional associations, including journals, conferences and workshops, can also provide important content knowledge support.

The literature and model (Figure 1) also suggest that working with students' ideas requires that teachers hold beliefs about learning and teaching that are consistent with conceptual change approaches to instruction. We cannot assume that all experienced geography teachers are aware of the impact of their beliefs on classroom instruction. Of the 16 experienced geography teachers in Lane's study (2015), none of the teachers with transmissionist or partly-constructivist beliefs (n=13) communicated any concerns about the implications of their beliefs about learning for classroom instruction. The first challenge, therefore, is to raise geography teachers' awareness of their beliefs about learning and teaching and the impact of these beliefs on classroom practice.

Raising awareness of epistemological beliefs and challenging them is a difficult process. Recent research (Reinfried, 2006b, 2007; Reinfried et al., 2012) using the model of educational reconstruction (Duit, Gropengiesser, Kattmann, Komorek, & Parchmann, 2012) and 5Es approach (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook, & Landes, 2006) suggests that a mental model-building approach may be effective in challenging and reconstructing geography teachers' beliefs. These approaches provide teachers with an opportunity to experience conceptual change first-hand so they can gain a better understanding of the nature of students' intuitive beliefs and the importance of these ideas in the learning process. It should be noted,

however, that there is a paucity of literature investigating the nature of geography teachers' epistemological beliefs and the implications for instruction. This is, therefore, an important area for further research.

Having relational content knowledge and constructivist beliefs is, however, not sufficient for teachers to successfully implement conceptual change strategies in the classroom. Working effectively with students' ideas also requires knowledge of evidence-based strategies for facilitating conceptual development (Box E). A key feature of these strategies is that they encourage students to articulate, elaborate on and share their preconceptions about core ideas in the curriculum. It is vital that professional learning for geography teachers focuses not only on general approaches for learning new syllabus content but also on concept specific strategies for helping reconstruct common alternative conceptions in physical geography.

The developmental model outlined in Figure 1 also highlights the need for both systems and schools to build teachers' self-efficacy or confidence in their ability to promote student learning (Hoy, 2000). Research across a number of domains highlights the relationship between topic-specific self-efficacy and teachers' general feelings of self-efficacy. It can be hypothesised that having a strong sense of self-efficacy is a necessary precondition for the development of confidence in the use of topic-specific conceptual change strategies in physical geography. Jerald (2007), in his review of the research in this area, argues that teachers with a stronger sense of self-efficacy are more open to new ideas and are more willing to experiment with methods to better meet the needs of their students (such as the conceptual change strategies outlined earlier). In contrast, teachers with weak sense of self-efficacy are unlikely to engage with students' ideas because of a fear that student comments and questions might derail their lesson or that they may not be able to adequately respond to students' questions (Lane, 2009). While it is clear that teacher self-efficacy plays an important role in the process of PCK development, further research is required to better understand the individual elements of topic-specific self-efficacy and their impact on teachers' work with students' ideas.

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## Endnote

- 1 Australian Meteorological and Oceanographic Society (2014, p. 188) notes in its Submission to the Review of the Australian Curriculum (p. 188), for example, that “It is not clear how students are supposed to understand or appreciate the mechanisms that drive meteorological or oceanographic hazards (e.g. tropical cyclones) without having prior and scaffolded exposure to the geophysical variables (e.g. ocean heat content, wind shear, earth’s rotational effects) and the dynamical and thermodynamical principles which drive them.”