



# Changing Teachers' Epistemic Cognition: A New Conceptual Framework for Epistemic Reflexivity

Jo Lunn Brownlee,<sup>1</sup> Leila E. Ferguson,<sup>2</sup> and Mary Ryan<sup>3</sup>

<sup>1</sup>*Faculty of Education, Queensland University of Technology, Brisbane, Australia*

<sup>2</sup>*Department of Education, University of Oslo, Norway*

<sup>3</sup>*Department of Educational Studies, Faculty of Human Sciences, Macquarie University, Sydney, Australia*

There is increasing evidence to show that teachers' epistemic cognition is related to how they conceive of and engage in teaching; therefore it is important that teachers develop adaptive epistemic cognition. This article provides an overview of the different ways of theorizing and investigating changes in epistemic cognition for teaching and learning. A growing body of research shows that explicit reflection on epistemic cognition may be a useful way to promote change. Drawing on the work of Lunn Brownlee and Schraw and the Advanced Study Colloquium group described in the introduction to this special issue, we extend the concept of explicit reflection to encompass reflexive thinking. Reflexivity involves critical thinking that evaluates multiple perspectives in context and leads to specific action in the classroom. The 3R-EC Framework (*Reflection, Reflexivity and Resolved Action for Epistemic Cognition*) for theorizing change in epistemic cognition is described and exemplified in the contexts of classroom practice and teachers' professional learning.

The role of epistemological beliefs is likely to be subtle, yet ubiquitous. These beliefs are likely to influence how students learn, how teachers instruct, and subsequently, how teachers knowingly or unknowingly modify students' epistemological beliefs. Schommer-Aikins (2004, p. 27)

In the dozen years since Schommer-Aikins made this (cautious) statement, research has flourished, nomenclature varied, and implications have been drawn about the role of epistemic cognition in students' learning and teachers' instruction. There is growing evidence of relations between epistemic cognition and disciplinary learning, comprehension, critical thinking, and teaching approaches (e.g., see Greene, Sandoval, & Bråten, 2016; Kuhn, 2016; Lunn Brownlee, Johansson, Walker, & Scholes, 2017). Given that these are crucial aspects of learning, teaching, and

education, the pertinence of epistemic matters in educational systems has become a focus of research attention. Notably, there is growing evidence to suggest that teachers' epistemic cognition mediates how they conceive of and engage in teaching. Likewise, student teachers' epistemic cognition may influence their understanding of teacher education courses and their depth and use of teaching knowledge (Buehl & Fives, 2016; Ferguson & Lunn Brownlee, 2016; Yadav & Koehler, 2007).

In light of the importance of epistemic cognition in teaching and learning, as well as research focusing on developing individuals' conceptions and use of knowledge and research (Bendixen, 2002; Kienhues, Ferguson, & Stahl, 2016), this article introduces and explores the role of reflection and reflexivity for changing practicing and student teachers' epistemic cognition. Specifically, we are interested in how to improve (student) teachers' views of and interactions with knowledge, enabling them to engage with complex problem-solving and reliable processes of knowledge production. In the first section, we present a review of educational psychology research on epistemic cognition with a focus on teaching and teacher education, followed by a review of research on changing teachers' epistemic cognition. Finally, we propose a framework for changing teachers' epistemic cognition that draws on theories of teacher reflection and reflexivity.

---

© Jo Lunn Brownlee, Leila E. Ferguson, and Mary Ryan

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Correspondence should be addressed to Jo Lunn Brownlee, Faculty of Education, Queensland University of Technology, Victoria Park Road, Kelvin Grove, Brisbane, Queensland, 4059, Australia. E-mail: [j.lunn@qut.edu.au](mailto:j.lunn@qut.edu.au)

Color versions of one or more of the figures in the article can be found online at [www.tandfonline.com/hedp](http://www.tandfonline.com/hedp).

## RESEARCH ON EPISTEMIC COGNITION

Although the historical development of the construct of epistemic cognition are described in detail elsewhere (Greene, Azevedo, & Torney-Purta, 2008; Hofer & Pintrich, 1997), we use *epistemic cognition* as an umbrella term for epistemic beliefs, epistemic development, epistemological beliefs, and personal epistemologies (Greene et al., 2008). Since its inception in the 1970s, research on epistemic cognition has experienced substantial growth (Greene et al., 2016). Earlier described as layperson's folk epistemologies, unexamined understandings or commonsense theories and "untutored views about the nature of knowledge" (Kitchener, 2002, p. 89), the use of the term *epistemic cognition* now reflects "how people acquire, understand, justify, change, and use knowledge in formal and informal contexts" (Greene et al., 2016, p. 1). To concretize further, we draw on two working definitions of epistemic cognition in this article. First, Greene and Yu (2016) described "a process involving dispositions, beliefs, and skills regarding how individuals determine what they actually know, versus what they believe, doubt or distrust" (p. 2). Second, Chinn and colleagues' definition is directed at cognitions about a network of interrelated epistemic topics including knowledge, its sources and justification, belief, evidence, truth, understanding, and explanation (Chinn, Buckland, & Samarapungavan, 2011). Both of these conceptualizations focus on a broad range of aspects of epistemic cognition rather than on underlying beliefs that formed the basis of earlier research in this domain (see Hofer, 2016; Hofer & Pintrich, 1997). Drawing on a recent review by Hofer (2016), we now provide a brief overview of the movements that have shaped the study of epistemic cognition in educational psychology research since 1970.

The first era of research pertains to developmental models of epistemic cognition, initiated by Perry (1970) and followed up by Belenky, Clinchy, Goldberger, and Tarule (1986) and by Baxter Magolda (1992; see Hofer, 2016). Within this tradition, Kuhn and Weinstock (2002) proposed qualitatively different levels of epistemological understanding. Young children initially view knowledge as a direct copy of reality before experiencing ensuing stages of *absolutism*, which represents a categorical, right-or-wrong view of knowledge representations. *Multiplism* involves the notion that all ideas are equal, as knowledge claims represent people's equally valid opinions. Finally, *evaluativism* occurs when the veracity of claims are judged according to standards such as available evidence and argumentation. Typical for this way of viewing individuals' epistemic cognition is that each stage of thinking is characterized by a different degree of "certain knowledge," which in turn relates to the standards of justification processes and critical thinking that will be deemed necessary or "correct" at that stage of epistemic cognition (Kuhn & Weinstock, 2002).

The beginning of a new era of epistemic cognition research occurred when Schommer (1990) investigated more or less independently developing epistemic dimensions (Hofer, 2016). Schommer labeled these continuous dimensions structure, stability, source of knowledge, ability, and speed of learning. However, factor analyses based on Schommer's work typically yield four factors relating to beliefs about

1. fixed ability, ranging from the idea that intelligence is given and fixed to views of intelligence as something that can be improved;
2. the speed of learning, reflecting views that learning may occur quickly or not at all, to the idea that learning occurs at a gradual pace;
3. simple knowledge, varying from regarding knowledge as consisting of isolated facts to interrelated webs of knowledge; and
4. certain knowledge, with views of knowledge ranging from absolute and fixed to tentative and evolving.

In response to Schommer's work and contemporary research programs, Hofer and Pintrich (1997) referred to laypersons' epistemological theories concerning the nature of knowledge (how one defines knowledge) and the nature of knowing (how one comes to know). Further, they proposed that each of these systems of beliefs could be further divided in two dimensions that build on and develop the foregone research. The two dimensions concerning the nature of knowledge are

1. certainty of knowledge, ranging from viewing knowledge as absolute, fixed, and unchanging to viewing knowledge as tentative and evolving, and
2. simplicity of knowledge, ranging from viewing knowledge as consisting of an accumulation of facts to viewing knowledge as a web of interrelated concepts.

The two dimensions concerning the nature of knowing are

1. source of knowledge, ranging from conceiving knowledge as originating outside the self and residing in external authority from which it should be transmitted to conceiving knowledge as actively constructed by the individual in interaction with others, and
2. justification for knowing, which ranges from justification of knowledge claims via observation and confirmation by authority, or on the basis of what feels right, to the use of rules of inquiry and the evaluation and integration of different sources of evidence.

Hofer and Pintrich proposed that each of the separate but likely related dimensions of beliefs could be considered to

reflect a continuum from naïve to more advanced beliefs, thus reflecting the development of beliefs as portrayed by models such as Kuhn and Weinstock's (2002). However, this classification has been criticized for dichotomizing beliefs as better or worse, as well as for the negative connotations that are associated with the term *naïve*. Thus, Muis (2004) proposed the terms *availing* and *nonavailing* to replace advanced and naïve, where *availing* beliefs are those associated with better learning outcomes and *nonavailing* beliefs have no influence or are negatively associated with learning outcomes. This avoids the connotations associated with advanced and naïve beliefs. Further, in light of mixed findings concerning relations between so-called naïve or advanced epistemic cognition and educational outcomes (for discussions, see, e.g., Bromme, Kienhues, & Stahl, 2008; Ferguson & Bråten, 2013), Bromme and colleagues suggested that such relations might be context sensitive. They argued that sophisticated (i.e., *advanced* or *availing*) epistemic cognition might be reflected in a type of *flexibility* in one's epistemic thinking, that is, an ability or tendency to apply different epistemic standards or practices in different contexts (Bromme et al., 2008; Kienhues & Bromme, 2011). This notion is linked to the third movement in epistemic cognition research, described next.

The third movement is characterized by expansion of the epistemic cognition construct on several fronts (Hofer, 2016). Stemming from discussions about such matters as context sensitivity, specificity, dimensionality, and methodologies used, developments have been made that are of special interest for the new framework described in this article. First, disciplinary studies have offered insight into the situated nature of epistemic cognition (Elby & Hammer, 2010). Specifically, they give credence to the idea that epistemic cognition may be even more fine-grained than what occurs at a domain level, for example, that it occurs at a topic-specific level as well (Bråten, Strømsø, & Samuelstuen, 2008). Second, intervention studies have provided preliminary evidence that epistemic cognition can be changed, at least in the short term, by having students grapple with diverging views (Kienhues et al., 2016).

Third, researchers have argued that one way of enriching educational research on epistemic cognition is to take a closer look at philosophical literature (Hofer, 2016), which has several implications for expansion of the construct (Chinn et al., 2011). Building on an extensive review of educational and philosophical literature (Chinn et al., 2011), Chinn and colleagues developed the AIR framework with a specific focus on epistemic Aims, Ideals, and Reliable processes (Chinn & Rinehart, 2016; Chinn, Rinehart, & Buckland, 2014). The first component, *epistemic aims and values*, draws attention to the idea that people can have different epistemic aims other than ascertaining knowledge, such as developing true beliefs, understanding, or wisdom. As such, epistemic cognition widens the scope of the use of the term *epistemic* (Chinn & Rinehart, 2016). According to

Chinn and Rinehart (2016), knowledge, understanding, and explanation are all encompassed in the study of epistemology, with explanation and understanding falling under the headings of "other epistemic aims and products" (p. 463). These form subsets of epistemic aims and values in the AIR model. As Chinn and Rinehart noted, people also attach different values to different kinds of knowledge and other epistemic aims. For example, knowledge about cognitive development may be viewed as more valuable than knowledge about individual differences by some teachers.

Next, epistemic *ideals* are the "criteria or standards that must be met for [people] to judge that their epistemic aims have been achieved" (Chinn et al., 2014, p. 433). For example, ideals can include standards that must be met if one is to rely on the testimony of others, sufficient complexity in an argument or piece of evidence or well-articulated explanations. Finally, the model includes *reliable processes* for achieving epistemic aims, such as argumentation or (in) formal logical reasoning (Chinn & Rinehart, 2016). Regarding the reliability of processes of knowledge production, Chinn and his colleagues focus on strategies, procedures, and activities for achieving knowledge, understanding, and other epistemic aims (Chinn et al., 2011). Each of these dimensions is exemplified later in this article when Chinn's model is reexplored as a part of the 3R-EC Framework.

## EPISTEMIC COGNITION IN TEACHING AND TEACHER EDUCATION

Recently, the idea that teachers' epistemic cognition might provide insight into their development as teachers and into their teaching practices has been identified (e.g., Lunn Brownlee, Schraw, & Berthelsen, 2011; Lunn Brownlee, Schraw, Walker, & Ryan, 2016). We frame our review here by referring to research related to personal epistemology and epistemic cognition, which emerges typically from the field of educational psychology. Epistemic cognition influences the extent to which individuals make meaning of and engage with complex problem solving (Hofer, 2002). Therefore, it should be of critical importance for teachers given that the core business of teaching is managing complex learning environments with multiple stakeholders. Practicing teachers' epistemic cognition has been shown to influence their teaching approach, the strategies they employ in the classroom, and their expectations for students (Buehl & Fives, 2009; Lunn Brownlee et al., 2011). Student teachers' epistemic cognition is thought to impact the depth of understanding achieved during teacher education courses and teachers' decision making, planning, orchestrating, and assessment in subsequent practice (Buehl & Fives, 2016; Yadav & Koehler, 2007). Moreover, teachers continue to learn throughout their teacher education programs. They are required to engage in continuous professional learning

to develop their practice, and they facilitate the learning of others (Buehl & Fives, 2016). In this section, therefore, we review epistemic cognition literature that relates specifically to teaching and teacher education, that is, teachers as practitioners and teachers as learners. We argue that availing epistemic cognition should be a goal of teaching and teacher education. We view teaching knowledge as a domain-specific example of epistemic cognition, as knowledge about teaching is a recognized and institutionalized body of knowledge (Fives & Buehl, 2008).

### Epistemic Cognition and Teaching Practice

Concerning teachers as practitioners, Feucht and Muis both conducted a number of studies investigating aspects of knowledge representation and use in the classroom, termed the “epistemic climate” (Bendixen & Rule, 2004; Feucht, 2010; Muis & Duffy, 2013). According to Feucht, the epistemic climate in a learning environment can foster or limit student learning, with the epistemic climate being shaped and influenced by teachers’ epistemic cognition and pedagogical practices. Epistemic climate refers to facets of knowledge and knowing that are salient in the classroom context. For example, the educational model of personal epistemology highlights the personal epistemologies of students and their teachers, the epistemic underpinnings of classroom practices, and instructional artifacts as the defining factors of epistemic climate in the classroom context (Feucht, 2010). Based on this framework, Feucht explored the epistemic underpinnings of different classrooms, including teachers’ instruction and knowledge representation and their implications for students’ epistemologies (Feucht, 2010). Feucht concluded that teachers’ epistemic cognition can be classified according to different developmental levels but that it is also subject to change. He further proposed that teachers with availing epistemic cognition are “receptive to epistemic development” and “less resistant to educational reform” (Feucht, 2010, p. 69), which in turn influences teaching practices, students’ epistemic cognition, and the epistemic climate of the classroom. In a follow-up investigation, Feucht (2011) showed specific links between teachers’ epistemic cognition and practice, such as absolutist views of knowledge as true and stable resulting in “step-by-step recipe” instruction and asking questions to determine “correct understanding” (p. 236).

Our review has so far documented research showing relations between epistemic cognition and teaching practice, but there is also evidence of inconsistency between teachers’ self-reports of epistemic cognition and their practice (Lunn Brownlee et al., 2011). Thus, it is important to bear in mind that other factors influence teaching practice and learning, for example, social influences such as teacher professional standards and standardized testing regimes. Analyses of teacher professional standards from around the world (Bourke, Ryan, & Lloyd, 2016;

Cochran-Smith, 2005; Evans, 2011; Ryan & Bourke, 2013) show that such standards promulgate an anti-intellectual discourse that is based on achieving behavioral competences. Within this prevailing discourse, and evident in case study research with teacher educators in Australia (Bourke et al., 2016), teachers are positioned as technicians who should demonstrate minimum standards of behavior rather than intellectual and emotional professionals who evaluate appropriate action according to contextual conditions, personal concerns, and epistemic aims. Research also has shown that standardized testing leads to reductionist practices (Comber, 2012; Ryan & Barton, 2014), whereby teaching goals relate to test preparation rather than to epistemic aims.

### Epistemic Cognition and Teacher Education

Moving to a specific focus on teacher education, Lunn Brownlee et al. (2011) reviewed research showing that although student teachers’ personal epistemologies are considered to be important for their understanding of students’ approaches to learning and learning outcomes, this is still an emerging field of research. Yadav, Herron, and Samarapungavan (2011) considered the ways in which student teachers’ epistemic cognition was important for teacher preparation. The authors surmised that student teachers’ epistemic cognition played a role in their perceptions and attention when observing other teachers, and in the teaching goals that they developed. Specifically, regarding student teachers’ epistemic cognition and teaching goals, Kang (2008) reported that preservice science teachers who viewed science knowledge as consisting of facts, set the goal of having students utilize science knowledge, whereas those who viewed science knowledge as evolving in nature were more likely to aim to have students develop thinking skills necessary to conduct scientific inquiry.

Yadav et al. (2011) further noted that student teachers’ epistemic cognition was related to their approaches to learning. With reference to a study by Chan (2003), Yadav et al. reported that beliefs about the source of knowledge predict different learning approaches in student teachers. Although beliefs about knowledge stemming from external authorities were positively related to surface learning approaches and negatively related to deeper learning approaches, the belief that learning entails effort and understanding was positively related to “deep and achieving approaches” to learning (p. 31). Similarly, in a study of epistemic cognition focusing on different knowledge sources and relations to motivation to learn from different aspects of a teacher preparation course, Bråten and Ferguson (2015) found that student teachers who trusted teacher educators and textbooks as sources of teaching knowledge were motivated to learn from formal teacher training courses. Students who placed more trust in other teachers and students as sources of teaching knowledge were more

motivated to learn from the practical part of the teacher education course.

On the basis of this review, we suggest that epistemic cognition should be an important focus for research on teaching practice and teacher education alike because of its potential influence on instructional practices and approaches to (student and teacher) learning. However, research exploring ways of addressing teachers' epistemic cognition is somewhat underdeveloped, and suggestions are often made in ways that do not provide specific guidance. We attempt to shed light on this complex endeavor in the next sections.

## CHANGING TEACHERS' EPISTEMIC COGNITION

Given the connections between teachers' epistemic cognition, the strategies they employ in the classroom (Buehl & Fives, 2009; Lunn Brownlee et al., 2011), and their expectations for students (Buehl & Fives, 2009), we argue that it is important to find ways to develop epistemic cognition in the context of teaching and teacher education programs. Lunn Brownlee et al.'s (2016) review identified two main ways in which changes to epistemic beliefs might take place: as a result of engagement in higher order thinking (as described by conceptual change theory) and explicit reflection on epistemic beliefs (see also Parkinson & Maggioni, in press).

### Higher Order Thinking and Conceptual Change Theory

Conceptual change theory involves the process of resolving cognitive conflict (Bendixen, 2002; Lunn Brownlee et al., 2016). To illustrate, Bendixen's (2002) interview study identified doubt or conflict as a key lever for belief change. The process of conceptual change requires first that students experience doubt about their beliefs, followed by engaging in new experiences that enable them to understand, enact and experience success with their newfound ideas. This process essentially involves higher order thinking.

The trigger for doubt or cognitive conflict in teacher education programs might involve exposure to conflicting theoretical perspectives (Parkinson & Maggioni, in press). In support of this notion, a number of long-term (longitudinal) and short-term interventions demonstrate that cognitive conflict may promote epistemic belief change for student teachers (for a review, see Lunn Brownlee et al., 2016). Longitudinal studies have explored changes in student teachers as they progress through their teacher education programs. These studies suggest cognitive conflict induced by constructivist approaches to learning (Rodríguez & Cano, 2007), or exposure to conflicting theories (Sosu & Gray, 2012; Walker, Brownlee, Whiteford, Exley, & Woods, 2012), may promote belief change (Lunn Brownlee

et al., 2016). Such belief change has also been shown to take place in relatively short-term interventions (Gill, Ashton, & Algina, 2004; Kienhues, Bromme, & Stahl, 2008; Lunn Brownlee et al., 2016). These interventions involve the use of what is known as refutational texts, which serve as a mechanism to induce cognitive conflict by making the reader question previously held conceptions and become dissatisfied with them. Further, this intervention strategy always includes factual information in the texts, "because conceptual change encompasses not only a reorganization of pre-existing knowledge but also an integration of new knowledge." (Kienhues et al., 2008, p. 549).

### Explicit Reflection on Epistemic Beliefs

Although a growing body of research suggests that teachers' epistemic beliefs might be challenged and changed by way of cognitive conflict and higher order thinking, there is also evidence to suggest a role for explicit reflection in changing epistemic beliefs (see Lunn Brownlee et al., 2016, for a review). Specifically, metacognitive reflection on one's epistemic beliefs about the nature of knowledge and the process of knowing can support changes in epistemic cognition (Lunn Brownlee et al., 2011; Lunn Brownlee et al., 2016; Muis, 2007). Deniz (2011) and Güven, Sülün, and Çam (2014) asked student teachers to engage in reflection on their epistemic beliefs as they participated in science units. Both studies reported changes in student teachers' epistemic beliefs: Denez noted changes in certainty and simplicity, justification, source, and attainability of truth, and Güven et al. noted changes in quick learning, innate ability, source of knowledge, and simple knowledge. Other studies by Charalambous, Panaoura, and Phillippou (2009); Valanides and Angeli (2005); and Tsai (2006) also point to a metacognitive process of explicit reflection in promoting change in teachers' epistemic beliefs.

However, although this research is instructive in helping us to consider how best to promote changes in epistemic beliefs, there is growing evidence that such explicit reflections need to take place in the context of teaching practices in the classroom. Adibelli and Bailey (in press) suggested that in addition to having preservice teachers reflect on their epistemic beliefs, they also need to engage in or observe teaching practices that actually mirror those epistemic beliefs. Similarly, Fives and Buehl (in press) argued that having teachers reflect on their epistemic beliefs, needs to take place in conjunction with teaching experiences that are supportive of such epistemic beliefs. These studies point to the idea that epistemic beliefs might evolve by embedding explicit reflection on such beliefs within the contexts of actual teaching practice that is constructivist in nature. In other words, teaching experiences need to be accompanied by explicit reflections on how epistemic cognition might be related to one's actual teaching practice (Lunn Brownlee

et al., 2016). This process can be described as enacted epistemic cognition and forms the basis for the 3R-EC (Epistemic Cognition) Framework. This framework includes a focus on epistemic reflexivity as a process that promotes change in epistemic cognition. The framework and the specific notion of epistemic reflexivity are described in more detail in the following sections.

## EPISTEMIC REFLEXIVITY

Much of the extant literature that refers to the role of explicit reflection in promoting epistemic cognition has not been clear about how this should take place. One way in which the role of reflection in epistemic belief change might be developed is to clarify what we mean by reflection and how we might extend this notion to include reflection as enacted epistemic cognition. Drawing on the work of Lunn Brownlee et al. (2016), we propose that the concept of explicit reflection can be extended to encompass what is known as epistemic reflexivity as described in the 3R-EC Framework.

### What Is Reflexivity?

Ryan (2015) argued that reflexivity is often used interchangeably with other terms such as critical or transformative reflection (Ryan & Bourke, 2013). We view reflection as a necessary component of reflexivity, the latter characterized by internal dialogue and deliberative action following reflective thought. Although some forms of reflective learning rely on metacognitive thinking strategies (Dahl, 2004), that is, thinking about thinking, these alone fail to account for changes in learning behavior. In contrast to reflection, reflexivity is characterized by an internal dialogue that takes place in order to understand and evaluate multiple perspectives (the individual's and those situated in the broader social context, e.g., those based on school policies, curriculum expectations, social justice agendas) and maintain or change courses of action based on this dialogue (Archer, 2010). We argue that thinking about epistemic cognition in the context of teaching practice can be considered as reflexive in nature and is the main conceptual focus of the 3R-EC Framework.

Building on work by Archer (2012), Ryan and Bourke (2013) argued that to promote changes in teaching practices, teachers need to not only reflect on epistemic goals but also engage in a process of reflexivity through which they consider their personal values and motivations in relation to the immediate context but also the broader political and social context. "The distinguishing feature of reflexivity is that it has the self-referential characteristic of 'bending-back' some thought upon self, such that it takes the form of *subject-object-subject*" (Archer, 2012, p. 2). Here "subject" and "object" are not specific epistemic dimensions but refer to self, and the context and structures that influence, and

are influenced by, the reflection that is happening, respectively. As such, reflexivity is characterized as an internal conversation that includes *discernment* (reflecting on a key issue or aim for them as a teacher or person, e.g., student well-being), *deliberation* (reflexively weighing personal and contextual concerns including motivations, priorities, and the impact of potential subversion of expected practices such as teaching to the test), and *dedication* (resolved action, e.g., not following school leadership expectations of testing drills in order to maintain the goal of student well-being; Archer, 2012). Ryan and Bourke (2013) explained that reflexivity is always situated and potentially transformative in nature and thus is more likely to impact on teaching and learning directly.

### Epistemic Reflexivity and the 3R-EC Framework

In recent theorizing, Lunn Brownlee et al. (2016) adapted Ryan and Bourke's (2013) work by focusing on reflexivity as a process that leads to change in teachers' epistemic cognition. This framework, known as the *3R Framework of Reflexivity*, was refined further through discussions with the Cyprus ASC group (see the introduction in this special issue; Cyprus ASC, 2015). Based on these discussions, the framework became known as the 3R-EC Framework to reflect better the alignment with current theory in the field of epistemic cognition (Chinn et al., 2011; Chinn et al., 2014). Epistemic cognition within this framework needs to be examined in specific teaching and learning contexts, rather than more broadly as epistemic beliefs. This context sensitivity is important for understanding how objective, contextual demands (such as the nature of the discipline, the school community expectations or government accountability agendas) impact teachers' motivations; understandings; and, most important, subsequent actions.

The 3R-EC Framework for epistemic reflexivity focuses on making the epistemic aims and reliable processes explicit (Lunn Brownlee et al., 2016; Ryan, 2015). It draws specifically on Chinn and colleagues' AIR model (Chinn et al., 2011; Chinn et al., 2014) to relate such epistemic cognition to reflexivity in specific teaching and learning contexts. The value of using the AIR model is that the identification of specific epistemic aims, ideals, and reliable processes embeds the "epistemic" in everyday teaching interactions. The steps of the framework are represented visually in Figure 1 and described next. We argue that the reflection-reflexive distinctions have much to offer to the field of epistemic cognition change in teaching and teacher education (Lunn Brownlee et al., 2016).

#### *Step 1: Reflections on Classroom Practice (Discernment)*

When considering teachers as practitioners in classrooms, the first step in the framework involves teachers

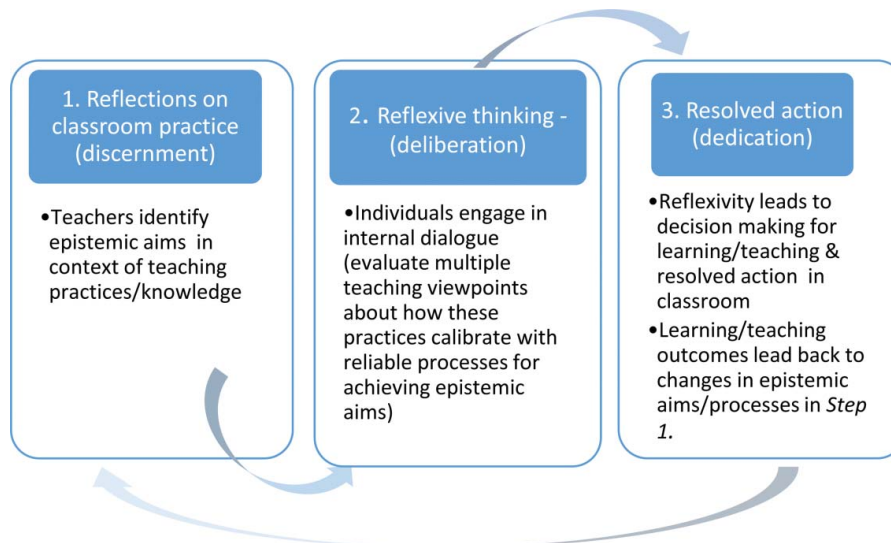


FIGURE 1 The 3R-EC Framework of Epistemic Reflexivity. Adapted from “Reflection and Reflexivity: Higher Order Thinking in Teachers’ Personal Epistemologies,” by J. Lunn Brownlee & G. Schraw, in press, *Teachers’ Personal Epistemologies: Evolving Models for Transforming Practice*, edited by G. Schraw, J. Brownlee, J., L. Olafson, and M. VanderVeldt, Charlotte, NC: Information Age. © IAP – Information Age Publishing Inc. Adapted by permission of IAP – Information Age Publishing Inc. Permission to reuse must be obtained from the rightsholder.

discerning classroom issues and then identifying specific teaching practices that might address such issues (see Figure 1). Here, teachers might reflect on a teaching/learning issue of individual or group concern. The 3R-EC Framework, however, argues that in addition to reflection on teaching practices, it is important to identify epistemic aims that might be associated with such practices.

According to Chinn et al. (2011), epistemic aims are considered to be central to epistemic cognition. One important epistemic aim relates to *knowledge*, which involves developing justified true beliefs. These are “beliefs that accurately represent a particular aspect of the world (at least approximately) and that are supported by accurate reasons” (Chinn et al., 2011, p. 147). Other epistemic aims include *understanding* and *explanations*. Chinn, Duncan, Dianovsky, and Rinehart (2013) argued that unlike an aim of developing justified true beliefs (knowledge), individuals who aim to understand or provide explanations are more likely to learn differently by seeking reasons and explanations for why things happen the way they do. Teachers can focus on a range of epistemic aims for classroom teaching practices that include a focus on knowledge, understanding, or explanations. These epistemic aims may also be related to epistemic values, which, Chinn and colleagues (Chinn et al., 2011; Chinn et al., 2014) argued, are a significant feature of epistemic cognition. For example, the value that teachers place on developing knowledge in the classroom will influence epistemic aims for children’s learning and the use of reliable processes to develop knowledge and/or explanations about teaching practices (epistemic ends).

Teachers may have both epistemic and nonepistemic aims for children in their classrooms. It is important for teachers to be able to distinguish between these aims as


they engage in teaching practice (Chinn et al., 2014). For example, a nonepistemic aim of promoting social inclusion in the classroom, which takes account of multiple cultural diversities, might influence the epistemic aim to develop understanding and explanation of injustice. This would take place by evaluating a range of perspectives about diversity and inclusion through examining relevant research, cultural values in the school, of parents and those of their fellow teachers. It is important in the 3R-EC Framework that research explores how both epistemic and nonepistemic aims work together to achieve epistemic ends.

The reflective process in Step 1 of the 3R-EC Framework is illustrated using teaching for active citizenship as an example. This first step supports teachers to reflect on what teaching practices might help children to understand active citizenship in the classroom. As indicated by the linking & arrow in Table 1, we argue that teachers also need to identify clearly the epistemic aims embedded in such practices.

### *Step 2: Reflexive Thinking—Deliberation*

Once teachers have reflected on epistemic aims and teaching practices, the next step in the framework is to engage in reflexive deliberation or internal dialogue that involves a process of considering “What does this mean for me?” This is what Archer (2012) and Ryan (2015) described as bending back thinking processes (see also Lunn Brownlee et al., 2016). Bending back in the context of the 3R-EC Framework means that teachers deliberate on the extent to which the self-identified classroom practices from Step 1 might prove to be reliable processes for achieving such aims.

TABLE 1  
Step 1: Reflection and Exemplar

<i>Step 1: Reflection on . . .</i>	<i>Description and Example</i>
Teaching practices	Teachers reflect on teaching practices that support children to achieve understanding about active citizenship for example, providing scenarios or provocations to which children respond.
	
Epistemic aims	Teachers might agree that a social justice agenda for active citizenship requires epistemic aims of understanding and explanation (reasoning) about injustice and exclusion to promote critical moral pedagogy—this helps children to engage in critical reflection on moral values for active citizenship.

Chinn et al. (2014) described reliable processes as the third component of the AIR model of epistemic cognition. They are “schemas specifying the reliable processes by which epistemic products (such as knowledge, understanding, explanations or models) are produced” (p. 436). In the example of the epistemic aims of promoting understanding and explanation, a reliable process would be one which ensures that children are engaged in listening to others’ ideas in the classroom and then using such perspectives to come to an informed opinion. We argue that in the context of the 3R-EC Framework, such reliable processes may include teaching practices that support children to engage in argumentation that accesses many points of view. Conversely, an unreliable process for achieving the epistemic aim of understanding and explanation might be to engage children through direct teaching instruction about a certain topic. Understanding reliable processes also means explicating the conditions in which processes may be considered to be reliable. This focus on conditions is not present in other EC frameworks. For example, argumentation may not be a reliable process if the discussion becomes aggressive

and lacks clear argument or if people do not feel comfortable about contributing to the discussion.

Extending the example of teaching for active citizenship, we now exemplify the reflexive thinking process that extends Step 1 into Step 2. Reflexivity is a more complex process than reflection alone because it involves internal negotiations and action cycles. In these cycles, the teacher is required to connect back to self through the process of calibrating their own teaching practices with reliable processes for achieving epistemic aims (see Table 2). Once again the & arrow in Table 2 highlights the needs to consider both the “epistemic” and teaching practices together.

In Step 2, reflexivity involves teachers evaluating a range of teaching practices in tandem with their identified epistemic aims for those approaches to teaching. It is such epistemic reflexivity, grounded in teaching practices, that we argue can lead to changes in teachers’ epistemic cognition. Ryan (2015) made a strong case for ensuring that reflexivity forms an explicit component of all teaching and learning, whereby action and re-action are built into the cycle of deliberation. The focus of the previously described Step 1 was on teachers reflecting on their epistemic aims. We argue that changes in epistemic cognition are more likely to take place through a process of reflexivity (Steps 1 and 2), which requires internal negotiations about how epistemic aims calibrate with actual teaching practices and lead to reliable processes for classroom practices. Maggioni and Parkinson (2008) also argued that teachers could be supported in the process of calibrating their epistemic beliefs with their teaching practices by providing them with help to understand the variations between their beliefs and practices.

*Step 3: Resolved Action (Dedication)*

Finally, in Step 3, *resolved action*, teachers engage in decision making and subsequent enactment of this decision

TABLE 2  
Step 2: Reflexivity and Exemplar



<i>Step 2: Reflexivity About . . .</i>	<i>Description and Example</i>
Teaching practices	Teachers are encouraged to reflexively evaluate (internal dialogue) alternative perspectives and ideas about teaching. This leads teachers to evaluate a range of teaching practices based on research and practice. This range of viewpoints might include those expressed by parents, children, the research, and colleagues with regard to promoting social justice in the classroom.
	
Reliable processes for achieving epistemic aims	Teachers engage in internal dialogue about how teaching practices engage children in the epistemic aims of understanding and explanation and how they might need to modify their practices to achieve these aims. This is a type of calibration of epistemic aims with teaching practices. Chinn et al. (2013) described practices (i.e., reliable processes) for promoting understanding and explanation which might include accountable talk, argumentation, scaffolds (supporting language like “disagree with . . .”), epistemic categories (ways to distinguish between evidence and opinions, standards used to evaluate knowledge), establishing norms in classroom and holding children accountable (e.g., shared commitment to reasoned argumentation—children can get goals and evaluate performance against these). In the example of active citizenship, scenarios can allow for these processes in reasoning about what constitutes injustice or exclusion, what might be argued as inclusion and how this might differ from an acknowledgment of diversity.



TABLE 3  
Step 3: Resolved Action and Exemplars

<i>Step 3: Resolved Action Regarding . . .</i>	<i>Description and Example</i>
Teaching practices	Using the example of teaching for active citizenship, resolved action involves teachers deciding on a course of action. This involves enacting teaching practices for active citizenship in the classroom that support children epistemically to understand and explain (reason) as they recognise and engage with social inequality and oppression in the classroom. Such dedication is a critical aspect of reflexivity.
	
Achieving epistemic aims	Outcomes, which are perceived by teachers to be successful (i.e., epistemic aims achieved) may then lead to further changes in teachers' epistemic aims (leading back to step 1 and discernment of other aims). For example, were the scenarios powerful enough to prompt different viewpoints about inclusion, exclusion and injustice? Did the opportunities to respond to the scenarios lead students to adopt the same beliefs as the teacher or did they prompt critical argumentation processes and the use of evidence to advance a point of view? Do the scenarios need to change? Do the processes of responding to the scenarios need to be recalibrated to be more dialogic?

making in the classroom (also known as dedication) based on epistemic reflexivity described in Step 2. Table 3 provides a description and exemplar of this final step.

## CONCLUSION AND IMPLICATIONS

Reflection has been noted as a key way to change epistemic cognition, but we have argued in this article that this needs to be extended to take account of epistemic reflexivity. Epistemic reflexivity involves calibrating epistemic aims with reliable processes for teaching and then enacting this in one's practice. The 3R-EC Framework introduced in this article addresses explicit epistemic reflexivity in the contexts of classroom practice. We do not suggest that this framework would form the basis of every classroom interaction or lesson. Sometimes the aim in a particular lesson is to practice skills, to learn basic "rules" of grammar or number, for example, or to consolidate previous understandings. The framework's focus on action-oriented reflexivity for teachers to interrogate and potentially change their epistemic cognition for teaching practice is very useful for teaching contested forms of knowledge, or complex concepts that rely on interactions between subject and object for meaning to emerge. An example of the latter would be consideration of government policy concerning asylum seekers, which deals with emotive (subjective) issues within objective structures of human rights, border protection, child protection, the law, and so on. As such, the 3R-EC Framework provides a new way forward, perhaps a "fourth wave" in epistemic cognition research.

Thirteen years after Schommer-Aikins's (2004) suggestion that epistemic cognition might play a subtle role in education, the idea seems to be more established through a sparse but growing body of research. The complexity of issues to be solved and the multiplicity of knowledge production and representation in modern society mean that a focus on availing knowledge and beliefs is imperative for teachers. The influence of teachers' epistemic cognition on their teaching practices has been documented in the

literature (Buehl & Fives, 2016; Lunn Brownlee et al., 2011) and therefore deserves more attention in teacher education and professional learning. Although several researchers have put forward the idea that (student) teachers need to reflect on their beliefs and practices, few have provided a framework for how this might occur.

We posit that changes in epistemic cognition may take place through reflexivity, not just reflection about teaching practice. Such reflexivity demands internal dialogues that evaluate a range of approaches to teaching, with explicit consideration of how they constitute reliable processes for achieving epistemic aims. We believe that this epistemic reflexivity, grounded in both teaching practice and epistemic cognition, provides a mechanism for changing teachers' epistemic cognition.

This reflexive approach to teaching may also help to reposition "teachers as professionals, working with the cognitive dimensions of knowledge and the emotional dimensions of teaching, for the greater good of the teaching profession," rather than as technicians addressing standards (Bourke et al., 2016, p. 3). Reflexive, intellectual, and emotional professionals who weigh appropriate action with contextual conditions, personal concerns, and epistemic aims are more likely to move beyond a focus on test preparation in their classrooms, to engage with epistemic aims that relate to knowledge, understanding, and explanation. Our framework rests on a host of existing educational and philosophical literature on epistemic cognition, yet its strength can be tested only through further empirical work such as longitudinal classroom interventions and formal evaluations of teaching and learning.

## ACKNOWLEDGMENTS

This article was initiated by a working group attending the EARLI (European Association for Research on Learning and Instruction) Cyprus Advanced Study Colloquium 2015: Changing Personal Epistemologies in Teaching and Teacher Education: A Focus on Reflection and Reflexivity, August 2015, Limassol, Cyprus.

## REFERENCES

- Adebelli, E., & Bailey, J. (in press). Exploring the factors contributing to preservice elementary teachers' epistemological worldviews about teaching science. In G. Schraw, J. Lunn Brownlee, L. Olafson, & M. VanderVeldt (Eds.), *Teachers' personal epistemologies: Evolving models for transforming practice*. Charlotte, NC: Information Age Press.
- Archer, M. (2010). Introduction: The reflexive re-turn. In M. Archer (Ed.), *Conversations about reflexivity* (pp. 1–14). London, UK: Routledge.
- Archer, M. (2012). *The reflexive imperative in late modernity*. Cambridge, UK: Cambridge University Press.
- Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.
- Belenky, M., Clinchy, B., Goldberger, N. R., & Tarule, J. (1986). *Women's ways of knowing: The development of self, mind, and voice*. New York, NY: Basic Books.
- Bendixen, L. D. (2002). A process model of epistemic belief change. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 191–208). Mahwah, NJ: Erlbaum.
- Bendixen, L. D., & Rule, D. C. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist*, 39, 69–80.
- Bourke, T., Ryan, M., & Lloyd, M. (2016). The discursive positioning of graduating teachers in accreditation of teacher education programs. *Teaching and Teacher Education*, 53, 1–9.
- Bråten, I., & Ferguson, L. E. (2015). Beliefs about sources of knowledge predict motivation for learning in teacher education. *Teaching and Teacher Education: An International Journal of Research and Studies*, 50, 13–23. <https://doi.org/10.1016/j.tate.2015.04.003>
- Bråten, I., Strømso, H. I., & Samuelstuen, M. S. (2008). Are sophisticated students always better? The role of topic-specific personal epistemology in the understanding of multiple expository texts. *Contemporary Educational Psychology*, 33, 814–840. <https://doi.org/10.1016/j.cedpsych.2008.02.001>
- Bromme, R., Kienhues, D., & Stahl, E. (2008). Knowledge and epistemological beliefs: An intimate but complicate relationship. In M. S. Khine (Ed.), *Knowing, knowledge, and beliefs: Epistemological studies across diverse cultures* (pp. 423–441). New York, NY: Springer.
- Buehl, M. M., & Fives, H. (2009). Exploring teachers' beliefs about teaching knowledge: Where does it come from? Does it change? *The Journal of Experimental Education*, 77, 367–407.
- Buehl, M. M., & Fives, H. (2016). The role of epistemic cognition in teacher learning and praxis. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 247–264). New York, NY: Routledge.
- Chan, K. W. (2003). Hong Kong teacher education students' epistemological beliefs and approaches to learning: Cultural implications for research in teacher education. *Australian Journal of Teacher Education*, 29, 1–13.
- Charalambous, C. Y., Panaoura, A., & Phillippou, G. (2009). Using the history of mathematics to induce changes in preservice teachers' beliefs and attitudes: Insights from evaluating a teacher education program. *Educational Studies of Mathematics*, 71, 161–180. <https://doi.org/10.1007/s10649-008-9170-0>
- Chinn, C., Buckland, L., & Samarapungavan, A. (2011). Expanding dimensions of epistemic cognition: Arguments from philosophy and psychology. *Educational Psychologist*, 46, 141–167. <https://doi.org/10.1080/00461520.2011.587722>
- Chinn, C., Duncan, R., Dianovsky, M., & Rinehart, R. (2013). Promoting conceptual change through inquiry. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 539–557). Florence, Italy: Taylor & Francis.
- Chinn, C., & Rinehart, R. W. (2016). Epistemic cognition and philosophy: Developing a new framework for epistemic cognition. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 460–478). New York, NY: Routledge.
- Chinn, C. A., Rinehart, R. W., & Buckland, L. A. (2014). Epistemic cognition and evaluating information: Applying the AIR model of epistemic cognition. In D. Rapp & J. Braasch (Eds.), *Processing inaccurate information: Theoretical and applied perspectives from cognitive science and the educational sciences* (pp. 425–453). Cambridge, MA: MIT Press.
- Cochran-Smith, M. (2005). The new teacher education: For better or for worse? *Educational Researcher*, 34, 3–17.
- Comber, B. (2012). Mandated literacy assessment and the reorganisation of teachers' work: Federal policy, local effects. *Critical Studies in Education*, 53, 119–136.
- Cyprus Advanced Study Colloquium. (2015). *Changing personal epistemologies in teaching and teacher education: A focus on reflection and reflexivity*. Limassol, Cyprus: EARLI Advanced Study Colloquium.
- Dahl, B. (2004). Analysing cognitive learning processes through group interviews of successful high school pupils: Development and use of a model. *Educational Studies in Mathematics*, 56, 129–155.
- Deniz, H. (2011). Examination of changes in prospective elementary teachers' epistemological beliefs in science and exploration of factors mediating that change. *Journal of Science Education and Technology*, 20, 750–760. <https://doi.org/10.1007/s10956-010-9268-x>
- Elby, A., & Hammer, D. (2010). Epistemological resources and framing: A cognitive framework for helping teachers interpret and respond to their students' epistemologies. In L. D. Bendixen & F. C. Feucht (Eds.), *Personal epistemology in the classroom: Theory, research, and implications for practice* (pp. 409–434). Cambridge, UK: Cambridge University Press.
- Evans, L. (2011). The 'shape' of teacher professionalism in England: Professional standards, performance management, professional development and the changes proposed in the 2010 White Paper. *British Educational Research Journal*, 37, 851–870.
- Ferguson, L. E., & Bråten, I. (2013). Student profiles of knowledge and epistemic beliefs: Changes and relations to multiple-text comprehension. *Learning and Instruction*, 25, 49–61. <https://doi.org/10.1016/j.learninstruc.2012.11.003>
- Ferguson, L. E., & Lunn Brownlee, J. (2016). *Preservice teachers' beliefs about the certainty of teaching knowledge*. Manuscript submitted for publication.
- Feucht, F. C. (2010). Epistemic climate in elementary classrooms. In L. D. Bendixen & F. C. Feucht (Eds.), *Personal epistemology in the classroom: Theory, research, and educational implications* (pp. 55–93). New York, NY: Cambridge University Press.
- Feucht, F. C. (2011). The epistemic underpinnings of Mrs. M's reading lesson on drawing conclusions: A classroom-based research study. In J. Lunn Brownlee, G. Schraw, & D. Berthelsen (Eds.), *Personal epistemology and teacher education* (pp. 3–21). New York, NY: Routledge.
- Fives, H., & Buehl, M. (in press). The functions of beliefs: Teachers' personal epistemology on the pinning block. In G. Schraw, J. Lunn Brownlee, L. Olafson, & M. VanderVeldt (Eds.), *Teachers' personal epistemologies: Evolving models for transforming practice*. Charlotte, NC: Information Age Press.
- Fives, H., & Buehl, M. (2008). What do teachers believe? Developing a framework for examining beliefs about teachers' knowledge and ability. *Contemporary Educational Psychology*, 33, 134–176.
- Gill, M. G., Ashton, P. T., & Algina, J. (2004). Changing preservice teachers' epistemological beliefs about teaching and learning in mathematics: An intervention study. *Contemporary Educational Psychology*, 29, 164–185. <https://doi.org/10.1016/j.cedpsych.2004.01.003>
- Greene, J. A., Azevedo, R., & Torney-Purta, J. (2008). Modelling epistemic and ontological cognition: Philosophical perspectives and methodological directions. *Educational Psychologist*, 43, 142–160. <https://doi.org/10.1080/00461520802178458>

- Greene, J. A., Sandoval, W. A., & Bråten, I. (2016). *Handbook of epistemic cognition*. New York, NY: Routledge.
- Greene, J. A., & Yu, S. B. (2016). Educating critical thinkers: The role of epistemic cognition. *Policy Insights from the Behavioral and Brain Sciences*, 3(1), 45–53. <https://doi.org/10.1177/2372732215622223>
- Güven, G., Sülün, Y., & Çam, A. (2014). The examination of elementary preservice teachers' reflective diaries and epistemological beliefs in science laboratory. *Teaching in Higher Education*, 19, 895–907. <https://doi.org/10.1080/13562517.2014.934350>
- Hofer, B. K. (2016). Epistemic cognition as a psychological construct: Advancements and challenges. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 19–38). New York, NY: Routledge.
- Hofer, B. (2002). Personal epistemology as a psychological and educational construct: An introduction. In B. Hofer & P. Pintrich (Eds.), *Personal epistemology: The psychological beliefs about knowledge and knowing* (pp. 3–14). Mahwah, NJ: Erlbaum.
- Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.
- Kang, N. (2008). Learning to teach science: Personal epistemology, teaching goals, and practices of teaching. *Teaching and Teacher Education*, 24, 478–498. <https://doi.org/10.1016/j.tate.2017.01.002>
- Kienhues, D., & Bromme, R. (2011). Beliefs about abilities and epistemic beliefs - aspects of cognitive flexibility in information rich environments. In J. Elen, E. Stahl, R. Bromme, & G. Clarebout (Eds.), *Links between beliefs and cognitive flexibility: Lessons learned* (pp. 105–124). New York, NY: Springer. [https://doi.org/10.1007/978-94-007-1793-0\\_6](https://doi.org/10.1007/978-94-007-1793-0_6)
- Kienhues, D., Bromme, R., & Stahl, E. (2008). Changing epistemological beliefs: The unexpected impact of a short-term intervention. *British Journal of Educational Psychology*, 78, 545–565. <https://doi.org/10.1348/000709907x268589>
- Kienhues, D., Ferguson, L. E., & Stahl, E. (2016). Diverging information and epistemic change. In J. Greene, W. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 318–330). New York, NY: Routledge.
- Kitchener, R. F. (2002). Folk epistemology: An introduction. *New Ideas in Psychology*, 20, 89–105.
- Kuhn, D. (2016). A role for reasoning in a dialogical approach to critical thinking. *Topoi*, pp. 1–8. <https://doi.org/10.1007/s11245-016-9373-4>
- Kuhn, D., & Weinstock, M. (2002). What is epistemological thinking and why does it matter? In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 121–144). Mahwah, NJ: Erlbaum.
- Lunn Brownlee, J., Johansson, E., Walker, S., & Scholes, L. (Eds.). (2017). *Teaching for active citizenship: Personal epistemology and practices in early education classrooms*. New York, NY: Routledge.
- Lunn Brownlee, J., & Schraw, G. (in press). Reflection and reflexivity: Higher order thinking in teachers' personal epistemologies. In G. Schraw, J. Brownlee, J. L. Olafson, & M. VanderVeldt. *Teachers' personal epistemologies: Evolving models for transforming practice*. Charlotte, NC: Information Age Press.
- Lunn Brownlee, J., Schraw, G., Berthelsen, D. (2011). Personal epistemology and teacher education: An emerging field of research. In J. Brownlee, G. Schraw, & D. Berthelsen (Eds.), *Personal epistemology and teacher education* (pp. 3–21). New York, NY: Routledge.
- Lunn Brownlee, J., Schraw, G., Walker, S., & Ryan, M. (2016). Changes in preservice teachers' personal epistemologies. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 300–317). New York, NY: Routledge.
- Maggioni, L., & Parkinson, M. (2008). The role of teacher epistemic cognition, epistemic beliefs, and calibration in instruction. *Educational Psychology Review*, 20, 445–461.
- Muis, K. R. (2004). Personal epistemology and mathematics: A critical review and synthesis of research. *Review of Educational Research*, 74, 317–377.
- Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist*, 42, 173–190. <https://doi.org/10.1080/00461520701416306>
- Muis, K. R., & Duffy, M. C. (2013). Epistemic climate and epistemic change: Instruction designed to change students' epistemic beliefs and learning strategies and improve achievement. *Journal of Educational Psychology*, 105, 213–225.
- Parkinson, M., & Maggioni, L. (in press). *The potential of course interventions to change preservice teachers' epistemological beliefs*. In G. Schraw, J. Lunn Brownlee, L. Olafson, & M. VanderVeldt (Eds.), *Teachers' personal epistemologies: Evolving models for transforming practice*. Charlotte, NC: Information Age Press.
- Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years*. New York: Holt, Rinehart and Winston.
- Rodríguez, L., & Cano, F. (2007). The learning approaches and epistemological beliefs of university students: A cross-sectional and longitudinal study. *Studies in Higher Education*, 32, 647–667. <https://doi.org/10.1080/03075070701573807>
- Ryan, M. (2015). Introduction: Reflective and reflexive approaches in higher education: A warrant for lifelong learning? In M. E. Ryan (Ed.), *Teaching reflective learning in higher education: A systematic approach using pedagogic patterns* (pp. 1–13). Sydney, Australia: Springer. [https://doi.org/10.1007/978-3-319-09271-3\\_1](https://doi.org/10.1007/978-3-319-09271-3_1)
- Ryan, M., & Barton, G. (2014). The spatialized practices of teaching writing in elementary schools: Diverse students shaping discursive selves. *Research in the Teaching of English*, 48, 303–328.
- Ryan, M., & Bourke, T. (2013). The teacher as reflexive professional: Making visible the excluded discourse in teacher standards. *Discourse: Studies in the Cultural Politics of Education*, 34, 411–423.
- Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504. <https://doi.org/10.1037/0022-0663.82.3.498>
- Schommer-Aikins, M. (2004). Explaining the epistemological belief system: Introducing the embedded systemic model and coordinated research approach. *Educational Psychologist*, 39, 19–29. [https://doi.org/10.1207/s15326985ep3901\\_3](https://doi.org/10.1207/s15326985ep3901_3)
- Sosu, E. M., & Gray, D. S. (2012). Investigating change in epistemic beliefs: An evaluation of the impact of student teachers' beliefs on instructional preference and teaching competence. *International Journal of Educational Research*, 53, 80–92. <https://doi.org/10.1016/j.ijer.2012.02.002>
- Tsai, C. (2006). Re-interpreting and reconstructing science: Teachers' view changes towards the nature of science by courses of science education. *Teaching and Teacher Education*, 22, 363–375. <https://doi.org/10.1016/j.tate.2004.06.010>
- Valanides, N., & Angeli, C. (2005). Effects of instruction on changes in epistemological beliefs. *Contemporary Educational Psychology*, 30, 314–330. <https://doi.org/10.1016/j.cedpsych.2005.01.001>
- Walker, S., Brownlee, J., Whiteford, C., Exley, B., & Woods, A. (2012). A longitudinal study of change in preservice teachers' personal epistemologies. *Australian Journal of Teacher Education*, 37(5), 24–35. <https://doi.org/10.14221/ajte.2012v37n5.1>
- Yadav, A., Herron, M., & Samarapungavan, A. (2011). Personal epistemology in preservice teacher education. In J. Lunn Brownlee, G. Schraw, & D. Berthelsen (Eds.), *Personal epistemology and teacher education* (pp. 25–39). New York, NY: Routledge.
- Yadav, A., & Koehler, M. (2007). The role of epistemological beliefs in preservice teachers' interpretation of video cases of early-grade literacy instruction. *Journal of Technology and Teacher Education*, 15, 335–361.