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An Investigation of Preservice Teachers' Beliefs About the Certainty of Teaching Knowledge

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Abstract: Beliefs about the certainty of teaching knowledge may influence how preservice teachers engage with and learn from knowledge sources in teacher education, and their subsequent practice. In light of inconsistencies in prior findings that mainly employ epistemic questionnaires, we extended research focusing on a contextual analysis. Sixty-six elementary and lower-secondary preservice teachers in Norway responded to the Beliefs about the Certainty of Teaching Knowledge (BECK) scale in the first and second year of study, respectively. Participants believed knowledge about teaching and learning was more tentative and evolving at T2 than at T1 ($t(65) = 2.0, p = .049, \text{Cohen's } d = .23$). We uncovered beliefs about the ways knowledge and practice will change, reasons for change, and the rate of change in teaching knowledge. The results suggest preservice teachers hold specific beliefs about the certainty of teaching knowledge that should be addressed by teacher educators.

Introduction

The beliefs preservice teachers hold about knowledge and knowing (epistemic beliefs) play a role in their learning and engagement throughout their teacher education programmes (Brownlee, Schraw & Berthelsen, 2011; Ravindran, Greene, & Debacker, 2005). For example, epistemic beliefs influence preservice teachers' ability to evaluate different types of teaching knowledge (cf. Greene & Yu, 2016), as well as their motivation to learn from these sources (Bråten & Ferguson, 2015). Moreover, epistemic beliefs influence learners' problem-solving and learning and understanding of complex information (Strømsø & Kammerer, 2016; Valinides & Angeli, 2008), which are vital for future teachers who will be responsible for planning, instructing and evaluating learning in others, as well as for continuing to develop their own knowledge bases (Buehl & Fives, 2016). The beliefs preservice teachers hold about knowledge and knowing will likely have important consequences for the nature and content of their future classrooms (Feucht, 2010; Schommer-Aikins, 2004) and practice (Brownlee et al., 2011; Lunn Brownlee, Ferguson & Ryan, 2017). It is therefore important that teacher educators understand the kinds of epistemic beliefs that preservice teachers are likely to hold and how these might influence learning and teaching in teacher education programmes.

In this paper, we focus on preservice teachers' beliefs about the certainty of teaching knowledge, because these are considered to be core epistemic beliefs (Trautwein & Ludtke, 2007b). Knowledge about preservice teachers' epistemic beliefs should be compelling for teacher educators because it can help them to help their students understand more about the nature of teaching knowledge and to motivate them to value and engage with different knowledge sources. It will also aid them in facilitating preservice teachers' higher order

thinking about changes that may occur in teaching and how this fits with their existing beliefs and practice. In the next section, we develop a theoretical background from research on epistemic beliefs, including the development and structure of epistemic beliefs, and their complex relation to learning and teaching, before detailing our study.

Epistemic Belief Research

Epistemic belief research focuses on individuals' views and understandings of knowledge and the process of knowing (Chinn, Buckland, & Samarapungavan, 2011; Hofer & Pintrich, 1997, 2002). Of this research, certainty of knowledge beliefs are considered foundational (Trautwein & Ludtke, 2007b): The tentativeness of knowledge is a foundation of scientific thinking (Popper, 2002), and the certainty dimension is a 'core component of almost all conceptions of epistemological reasoning' (Trautwein & Ludtke, 2007a, p. 350).

There are three main approaches to understanding people's epistemic beliefs, including general developmental approaches (King & Kitchener, 1994; Kuhn, Cheney & Weinstock, 2000; Perry, 1970), multidimensional systems of beliefs research, (Ferguson, Bråten & Strømsø, 2012; Chinn et al., 2011; Greene, Azevedo, & Torney-Purta, 2008; Hofer & Pintrich, 1997; Schommer, 1990) and a situated view of epistemic cognition (Chinn et al., 2011; Hammer & Elby, 2002). The first approach is represented by the works of Perry (1970), King and Kitchener (1994) and Kuhn and Weinstock (2002). These authors have proposed central theories that involve general stage-like changes in views of knowledge that occur throughout a lifetime in response to educational and sociocultural interactions (Hofer, 2016). For example, Kuhn and Weinstock (2002) proposed that young children initially view the world and its knowledge as direct copies of reality, before tending to go through ensuing stages of *absolutism*, which represents a categorical, right-or-wrong view of knowledge representations; *multiplism*, where all ideas are equal, since knowledge claims represent people's equally valid opinions; and *evaluativism*, where the veracity of claims are judged according to standards such as available evidence and argumentation. These developmental positions reflect progressive changes in beliefs about the certainty of knowledge from viewing knowledge as certain (absolutism), to personal opinions where knowledge is uncertain (multiplism) and finally to knowledge as tentative but evidence-based (evaluativism). Developmental researchers have generally made use of interviews that they interpret to "assign respondents to a general epistemic level" (Mason, 2016, p. 277).

The second approach involves *systems of beliefs*, initiated by Schommer (1990), who proposed that, rather than being unidimensional and developing in a stage-like manner, beliefs about knowledge and knowing were likely multi-dimensional systems of more-or-less independently developing beliefs. With this suggestion Schommer also introduced the possibility of measuring epistemic beliefs with pencil and paper questionnaires that could be filled out by research participants. Schommer (1990) proposed a system of beliefs consisting of beliefs about knowledge, knowing and learning that each exist on a continuum, including "the structure, certainty, and source of knowledge, and the control and speed of knowledge acquisition" (Schommer, 1990, p. 498). However, these five dimensions proved difficult to capture in factor analyses, resulting in four factors relating to "innate ability, simple knowledge, quick learning, and certain knowledge" in Schommer's own work (1990, p. 498); here expressed at the least sophisticated end of each continuum.

Beliefs in the certainty of knowledge also featured in Hofer and Pintrich's (1997) seminal belief system which comprised the nature of knowledge (certainty & simplicity of knowledge) and the nature of knowing (justification & source of knowledge). In the first sub-system, the two dimensions concerning the nature of knowledge are certainty of knowledge

(ranging from viewing knowledge as absolute, fixed and unchanging to viewing knowledge as tentative and evolving) and simplicity of knowledge (from viewing knowledge as consisting of an accumulation of facts to viewing knowledge as a web of interrelated concepts). In the second sub-system about the nature of knowing, the two dimensions include the source of knowledge and justification for knowing. Beliefs about sources of knowledge range from conceiving of knowledge as originating outside the self and residing in external authority to conceiving of knowledge as actively constructed by the individual in interaction with others. Justification for knowing beliefs range from validation of knowledge claims via observation and confirmation by authority, or validation based on what feels right, through to the use of rules of inquiry, evaluation and corroboration of different sources of evidence.

Third, joining a growing body of knowledge focusing on a more situated understanding of epistemic beliefs, Chinn et al. (2011; Chinn & Rinehart, 2016) have built on and expanded Hofer and Pintrich's framework for understanding epistemic beliefs by further incorporating philosophical scholarship. Essentially, Chinn and colleagues specify five components. The first, epistemic aims and values, refers to inquiry goals that individuals set for themselves (e.g., knowledge or understanding) and the value they attach to achieving them. The structure of knowledge and other epistemic achievements component of Chinn et al.'s framework builds on Hofer and Pintrich's simplicity dimension, also encompassing other dimensions, such as topic-specific epistemic structures. The third component, epistemic virtues and vices, has been the focus of earlier psychological investigations, and relates to praiseworthy or detrimental dispositions of character and mind. The fourth component, (un)reliable processes for achieving epistemic aims, concerns the processes by which epistemic aims can be achieved. The final and most relevant component for our focus on certainty, is the component associated with sources, justification and related epistemic stances, which incorporates the source, justification and certainty dimensions, respectively, from earlier models. Particularly, certainty is '...characterized as one of a number of different stances that one can take towards knowledge claims' (Chinn et al., 2011, 156). Research from this perspective has underscored the importance of contextual analysis (Mason, 2016).

Certainty of Knowledge Beliefs and Learning

There are links between beliefs about certainty of knowledge and aspects of learning that have implications for preservice teachers' own learning, as well as their considerations about their students' learning (Bråten, Britt, Strømsø, & Rouet, 2011; Muis, 2007; Tabak & Weinstock, 2005): Typically, studies have demonstrated that individuals holding more constructivist views of knowledge (e.g., knowledge is tentative) outperform those who believe that knowledge is certain and fixed (Muis, 2007). For example, a belief in the tentative nature of knowledge reflects the idea that knowledge is dynamic and changes over time in light of advances in theoretical frameworks, which may be conducive to learning (cf. Tabak & Weinstock, 2005). Whereas, a strong belief in the certainty of knowledge 'indicates that a student believes scientific theories and results to be certain, and is considered to reflect an unsophisticated view of the nature and boundaries of human knowledge with "negative consequences for learning (e.g., low-level processing)" (Trautwein & Lüdtke, 2007a, p. 350). That is, those who believe knowledge is more certain than tentative may view learning and comprehension as something that occurs once and for all, and fail to recognize the importance of knowledge revisions or deep-processing. Moreover, theoretical (Bråten et al., 2011) and empirical (Schommer, 1990) links have been made between certainty beliefs and successful comprehension of complex information, such as comprehending multiple sources, which is a typical task in modern teacher education programmes. Furthermore, beliefs in certain

knowledge have been linked to less propensity to engage in conceptual change (Qian & Alvermann, 1995), which is also an important component of higher education. In sum, these findings are particularly pertinent for teacher educators faced with the challenge of changing preservice teachers' intuitive, experience-based understandings of complex concepts such as teaching, learning and motivation to more research-based discernments, and helping preservice teachers to engage with multiple sources of complex written information in a way that leads to deep-learning.

Certainty beliefs are also presumed to influence school achievement and choice of college major (Trautwein & Lüdtke, 2007a). For example, in two large-scale studies in Germany, Trautwein and Ludtke (2007a) found negative associations between certainty beliefs and school achievement in upper secondary students, while choice of college major ('hard' vs. 'soft' fields) was a predictor of certainty beliefs. Especially in a Norwegian context (as is the case for this study), where there is a pending national teacher shortage (Norwegian Statistics, 2012) and entry requirements to teacher education are relatively low, these findings might suggest that preservice teachers may not hold particularly sophisticated beliefs about the certainty of teaching knowledge.

However, research investigating the relationship between certainty beliefs and learning outcomes is not unequivocal (Bromme, Kienhues, & Stahl, 2008). For example, as Bromme and colleagues discussed, individuals with little knowledge about a domain will tend to rely on categorical assumptions from 'world' knowledge, and may then state that knowledge is uncertain, thus seeming to reflect advanced views (particularly in response to epistemic questionnaires). As an example, we might apply this notion to knowledge about motivation; gaining more knowledge might also include learning more established motivational theories, and the resulting reflection of less adaptive (i.e., more 'naïve') views of knowledge about the domain as certain. Depending on ontological features of the field in question, gaining further knowledge might again lead to the realisation that the truthfulness of claims is dependent on factors such as measures used and underlying assumptions. This involves an understanding of the context-sensitive nature of knowledge and the need to verify claims considering existing theories that are represented by adaptive (also called sophisticated or advanced) epistemic beliefs.

Certainty of Knowledge Beliefs and Teaching

In considering preservice teachers' beliefs about the certainty of teaching knowledge, we refer to the domain of teaching knowledge as "all knowledge relevant to the practice of teaching" (Buehl & Fives, 2009, p.370). And while there is a large body of research about teacher beliefs in general, there is a lack of research examining epistemic beliefs and teaching (Hofer, 2010), and this is particularly true of beliefs about the certainty of teaching knowledge and teacher education (Buehl & Fives, 2009). Importantly, Buehl and Fives (2009) argued for more extensive investigation of teachers' beliefs about the certainty of knowledge in light of inconsistencies in previous findings in comparison to researcher expectations (Ravindran et al., 2005) and confounding results (Hofer, 2000). They reported that Ravindran and colleagues "unexpectedly" found a positive relation between "preservice teachers' beliefs about certainty of knowledge [and] meaningful cognitive engagement in an applied learning situation" (Buehl & Fives, 2009, p. 372). Also, certainty beliefs are sometimes combined into one factor with other epistemic belief dimensions and studied in relation to outcome variables (Hofer, 2000) so that the nature and role of certainty beliefs remains unclear. Therefore, Buehl and Fives (2009) examined preservice and inservice teachers' beliefs about the certainty of teaching knowledge by posing two questions: 'In the next twenty years, how much do you

think the knowledge needed for effective teaching will change?’ and ‘...in what way(s) do you think the knowledge needed for teaching will change?’ In their study, they identified three themes relating to the certainty of teaching knowledge (which they labelled stability), specifically: amount (how much knowledge would change, ranging from no change, through little, a lot, to drastic changes), direction (whether knowledge needed to teach would increase or decrease), and quality of change (the rate of change and qualitative shifts in the nature of knowledge). Buehl and Fives’ research (2009; Fives & Buehl, 2008) explored teachers’ epistemic beliefs about the certainty knowledge using a fine-grained, contextual analysis of epistemic beliefs, which is in keeping with recent suggestions for research (Kienhues, Ferguson & Stahl, 2016; Chinn, et al., 2011; Greene & Yu, 2014).

The Study

Following Buehl and Fives (2009), we explored beliefs about the certainty of knowledge in the context of teacher education and teaching knowledge. This research contributes new understandings about preservice teachers’ assessment of the degree to which they believe in the certainty of knowledge and the potential development of such certainty beliefs. It also continues a line of investigation that focuses on the contextual analysis of epistemic beliefs. Using a mixed-methods approach, our research investigated:

- a) whether preservice teachers’ beliefs about the certainty of teaching knowledge changed during the first year of a teacher education programme, according to a quantitative measure, and;
- b) how preservice teachers’ beliefs about the certainty of teaching knowledge could be characterized on the basis of a qualitative examination of their responses to open-ended questions.

Participants

Sixty-six preservice teachers (62% female) in their first year (at T1) of a teacher education programme at a university-college in south-east Norway participated in the study. The mean age of the participants was 21.1 years (*SD* 4.3, min. 18, max. 43). Participants were attending a four-year teacher education programme to qualify for teaching grade levels one through to seven ($N = 25$) or five through to 10 ($N = 41$). The questionnaire was part of a larger study on preservice teachers’ beliefs that was administered in regular class time. Participation was voluntary and all participants were entered in a prize draw with two prizes of gift cards for a local shopping centre worth 500NOK each (approximately 80AUS\$). At the first data collection time point (T1), the preservice teachers had been studying teacher education for approximately 12 weeks and at the second data collection time point (T2) they had an additional year of study experience.

Measures

Quantitative measures may have difficulties capturing what Bromme and colleagues define as epistemological ‘sophisticatedness’ (p. 433). We therefore chose to supplement a quantitative scale with a graphic task, as well as a qualitative measure that required participants to explain their answers, thus allowing more insight into potential ‘sophisticatedness’. Moreover, the use of multiple or mixed methods of assessment designed to capture epistemic beliefs can potentially improve reliability “through triangulation of

multiple data sources” (Barzilai & Weinstock, 2015, p. 142). Thus, not only is our quantitative assessment framed in the context of teacher education and teaching knowledge, but the qualitative assessment has the potential to provide a detailed account of the participants’ epistemic thinking (Barzilai & Weinstock, 2015). In line with recent arguments (Chinn et al., 2011; Greene & Yu, 2014; Mason, 2016), we also propose that the complexity of epistemic beliefs might better be captured by several measures that tap separate aspects of beliefs (Chinn et al., 2011), and further that our findings might contribute to theories of epistemic beliefs that are influenced by what people (teachers) actually think.

A three-part instrument, the Beliefs about the Certainty of Teaching Knowledge (BECK), was developed based on Buehl and Fives’ (2009) Open-Ended Teaching Belief Questionnaire (OTBQ). In collaboration with a senior (Norwegian) researcher, the first author (English speaking and fluent in Norwegian) translated and adapted the OTBQ (from English to Norwegian). The adaption included the inclusion of a graphic/ numeric visual aid, on which the participants had to answer question 1 (see below), as well as tailoring the original question (about the teaching knowledge needed for “effective teaching”, Buehl & Fives, 2009, p. 375) to the context of teacher education (see also Question 1 below). Participants received the following instruction and questions:

Instruction: ‘You shall now answer two questions. We are not looking for the correct answer, but we are interested in your views.

Question 1. [Graphic/ numeric assessment of degree of change in teaching knowledge, where the horizontal line was marked at 10% intervals from 0 to 100%.]:

a) Please indicate how much you think knowledge about teaching and students’ learning (that one studies in [this class]) will change during the next 20 years. Please mark a cross on the line to indicate your answer.

b) Please write a short reason for your response to part (a).

Question 2. In what ways do you believe this knowledge will change?’

Question 1a was designed to capture participants’ beliefs about the degree of (un)certainty of teaching knowledge. Thus, the higher the participants rated this item, the more they considered knowledge about teaching and learning to be tentative and changing. While Buehl and Fives posed a similar question, the participants in that study provided written answers to open-ended questions that were subsequently coded by the authors, whereas we assessed this question in a quantitative manner. We did this for two reasons: 1) we wanted to be able to carry out a comparison of preservice teacher responses from T1 to T2 and we found this to be a more precise method of comparison; 2) we placed the onus on the participants to specify their answer, rather than leaving it open to researcher interpretation and coding. We believed that the graphic aid would help the pre-service teachers in their expression of this somewhat abstract task. Although we acknowledge that use of single item measures is not ideal, Wanous, Reichers and Hudy (1997) argue convincingly, based on evidence from a meta-analysis of psychological literature for the acceptability of single-item measures. We further argue that this is a suitable measure for the present research in view of the use of multiple data sources, and interpretation of the quantitative response considering qualitative data.

Question 1b was intended to further investigate the nature of beliefs about the certainty of teaching knowledge, specifically addressing participants’ reasoning about the phenomenon and Question 2 addressed the ways knowledge about teaching might change (rather than Buehl and Fives’ changes in the knowledge needed to be “an effective teacher”, 2009, p. 75). These qualitative written responses were expected to provide more insight into

the nature of certainty beliefs, particularly regarding reasons for change and ways knowledge might change.

Recruitment

Participants were recruited in an education class “pedagogy and pupil-related skills”, a compulsory class that covers 60 European Credit Transfer and Accumulation system (ECTS) credits (the entire teacher education course consists of 240 ECTS credits) and focuses on topics such as instructional methods for diverse students and theories of student learning. The first author wrote an information letter and invitation to participate in the study that was distributed by the regular class teacher and participants had to complete a consent form at T1 (participation rate > 90%). Neither of the authors were affiliated with the university-college where the study took place. Questionnaires were administered by the first author during normal class time. The invitation to participate was repeated one year later, with a Professor from the university-college department of teacher education (who was not the class’ regular teacher) completing the data collection. At that time participation was slightly lower (69%). Only participants that were present at both data collection points were included in the analyses.

Data Analysis

Regarding the quantitative data, we performed a paired sample *t*-test to identify change in pre-service teachers’ beliefs over time. Next, we inductively analysed the qualitative data in the written responses to Question 1b and Question 2 in several iterative steps (Creswell, 2005). Such an inductive approach enabled in-depth explorations of beliefs that are not possible using survey measurements (Greene & Yu, 2014) because the themes emerged from, rather than were imposed on, the data. During the first steps, the first author read and reread the participant responses with the goals of 1) getting an overall impression of the data, 2) sensitising herself to the intricacies of the data (Brownlee et al., 2012), 3) identifying relevant segments of responses, 4) identifying important and salient themes in the data, and 5) identifying categories and subcategories of responses at a more fine-grained level of analysis than the overarching themes. After multiple readings of the participants’ responses as well as comparing response segments among their initial groupings, the first author noted that no new subcategories of responses were emerging and each response received an initial code.

Next, a peer review process of the data analysis took place using dialogic reliability checks (Åkerlind, 2005). This involved the first author translating the responses (from Norwegian to English) so that the second author could complete a detailed examination of the data, including the preliminary suggestions for themes and subcategories. Both authors have research experience from the fields of teacher beliefs and epistemic beliefs. The second author agreed with the coding developed by the first author, but also added some supplementary subcategories. By analysing the responses in this way, the second author not only ‘acted as a peer debriefer for the first author... [but] [t]he iterative process allowed both researchers to question their understanding ... in general, as well as the data collected from the participants’ (Greene & Yu, 2014, p. 17). After these initial steps, the authors discussed the data and the proposed themes and sub-categories of responses frequently, until agreement was attained (Buehl and Fives, 2009).

Based on this careful examination of the data, three overarching themes emerged: 1) ways teaching knowledge (and practice) will change; 2) reasons for change in teaching

knowledge; and 3) rate of change in teaching knowledge. Finally, following feedback from a thoughtful reviewer, we decided to focus on the broad themes and categories of responses that had emerged, rather than narrow subcategories, thus enabling us to provide more detailed descriptions and clear examples from the categories (see Results section).

It is important to note that while question 1b and 2 were posed separately, we discerned that some of the participants either confounded or confused the two aspects of knowledge change and reasons. Therefore, we were careful to pay attention to the actual participant responses (rather than the question that elicited the response) in the analysis.

Results

In this section, we present the results from question 1a, the graphic/ numeric assessment of degree of change in teaching knowledge, before presenting the thematic results from questions 2 participants' reasons for changes in teaching knowledge; and 1b, ways this knowledge will change.

Quantitative Results: Change in Beliefs about Teaching Knowledge

Descriptive statistics (means and standard deviations) for the participants' estimations of how much teaching knowledge will change in the next 20 years are presented in Table 1 (below). A paired sample *t*-test showed that participants scored statistically significantly higher on the measure at T2 ($M = 45$, 95% CIs [37.2, 45.2]) than at T1 ($M = 41$, 95% CIs [40.9, 49.3]), with $t(65) = 2.0$, $p = .049$, Cohen's $d = .23$. The results indicate that, as a group, the participants believed that a larger proportion, or amount, of teaching knowledge was likely to change over the next 20 years at T2 than at T1. This may be interpreted as a general strengthening of the participants' belief that teaching knowledge is tentative (Bromme et al., 2008). A change in this direction is generally conceived as evidence of development towards more 'advanced' beliefs. Further, it should be noted that, although this effect size is small, it is still a significant finding. Given the proposed deep-set, experience-based nature of preservice teachers' beliefs (Levin, 2015) and the research which suggests that epistemic beliefs develop over a prolonged period of time (Kuhn et al., 2000), we believe this finding warrants further investigation.

	<i>M</i>	<i>SD</i>
Time 1	41.2	16.7
Time 2	45.1	17.3

Table 1: Descriptive statistics for estimations of knowledge change

Qualitative Results: Examination of Participants' Written Responses

Thematic analysis enabled beliefs about the certainty of teaching knowledge to be explored in a more fine-grained, nuanced manner than is typically possible through use of questionnaires (Barzilai & Weinstock, 2015; Chinn & Rinehart, 2016). As was the case for the study by Buehl and Fives (2009), the participants' written responses provided much richer data than we had anticipated. The themes identified included beliefs about 1) the *ways* teaching knowledge (and practice) will change; 2) the *reasons* for change in teaching knowledge (Table 3); and 3) the *rate* of change in teaching knowledge. We now present and discuss each of the themes. Please note that *n* refers to number of responses corresponding to

each theme in total, with the number of responses at each time point being denoted as ‘T1’ and ‘T2’.

Theme 1: Ways Teaching Knowledge (and Practice) Will Change

We identified two main categories pertaining to this theme, as identified in Table 3. The first category included epistemic/ knowledge changes *per se*; the second was more practical in nature, referring to knowledge about changes in teaching practice.

Category	Examples
<i>Epistemic/ knowledge</i>	Knowledge base Student qualities/characteristics/ learning
<i>Teaching practice</i>	More constructivist, less ‘traditional’ teaching Focus on individual/ adapted/ special education/ multicultural teaching New methods in general Teacher qualities Unspecified shift in focus of teaching / schools/ subject Teaching resources
<i>Don’t know</i>	Don’t know/ no idea

Table 2: Ways teaching knowledge and practice will change

Epistemic/ knowledge changes ($n = 23$, T1 = 12, T2 = 11). In this category, the participants detailed ways that knowledge and other epistemic aims (Chinn & Rinehart, 2016) would change, for example ‘Research studies and experiences will lead to changes in knowledge around this subject’ [S51, T1], ‘Our understanding of that which is important to learn will be better’ [S24, T1].

Knowledge specifically relating to teaching practice ($n = 165$, T1= 87, T2= 78). This category reflected a focus on the ways knowledge about teaching practices and teachers would change. Some preservice teachers ($n = 16$, T1 = 7, T2 = 9) described a focus on more constructivist views/ less ‘traditional’ teaching, for example, ‘...less material things like textbooks, and possibly less teaching in traditional classrooms’ [S29, T2]). Other responses ($n = 30$, T1 = 18, T2 = 12) reflected a focus on adapted multicultural teaching, for example, ‘...focus even more on adapting teaching, not just for the weakest students, but also for the [academically] strong ones’ [S43, T1]. Some described new teaching methods in general. There were also responses that referred to changes in the teacher, such as teacher qualities, for example, teachers being ‘More relation-oriented’ [S9, T1], and preservice teachers reflected on teaching resources, (digital) tools and ICT as a way knowledge about teaching practice would change, for example ‘More digital teaching’ [S30, T1]. Finally, there were 16 (T1=5, T2=9) incidences of non-responses, with preservice teachers indicating most often that they ‘did not know’ ways in which teaching knowledge would change.

As a whole, participants’ responses describing ways knowledge would change were outweighed by answers relating to knowledge about teaching practices, indicating a focus on practice, rather than a focus on knowledge *per se*.

Theme 2: Reasons for Changes in Teaching Knowledge

The responses in this theme addressed the issue of *why* knowledge will change over the next twenty years. From the 66 participants’ responses at Time 1 and 2, we identified

three categories that represented the reasons for changes in teaching knowledge (plus one incidence of ‘don’t know’). These reasons were categorized as ‘social’, ‘individual’ and ‘epistemic’.

Reasons	Examples
Social	Societal changes ICT
Individual	People/ teachers change Diversity in pupils and schools
Epistemic	New research/ knowledge/ theories

Table 3. Reasons for change in teaching knowledge

Social reasons. Preservice teachers ($n = 53$, $T1 = 33$, $T2 = 20$) described reasons for change in teaching knowledge based on the belief that because society, in general, changes, teaching knowledge will also change, this also included technological reasons. For example, ‘It will change because society changes’ [S13, T1], ‘Society is changing and what they thought was correct and most effective till now can change during the next 20years’ [S40, T1], ‘Society changes. Technology and school are developing’ [S33, T1], ‘Changes in use of technology’ [S21, T1].

Individual reasons. Preservice teachers ($n=27$, $T1=11$, $T2=16$) also described how changes and differences in people (teachers and students) cause changes in teaching knowledge for example, ‘Ways of doing things change, because people change’ [S33, T1]. ‘We become aware of different types of behavior, and the (school) environment and people change’ [S22, T1], and ‘... no students are completely similar when it comes to learning. That’s why we already have different learning theories’ [S17, T1].

Epistemic reasons. Many preservice teachers stated that the production or discovery of new research, knowledge, or theories ($n = 61$, $T1=30$, $T2=31$) would be the reason for changes in teaching knowledge, for example that ‘New methods and research will change what we know today ...’ [S10, T2], or ‘...there are always new reports about what we should be working with’ [S27, T2]. For some it seemed that new knowledge is simply better than old: ‘We hold onto old theories and so on, but it is important to be “recent” [up to date] all the time’ [S34, T2]. Others commented that school-based subject (education/ pedagogics) would change because of new knowledge, ‘New knowledge can lead to small changes in the [knowledge base of the] subject pedagogics...’ [S51, T2].

Overall the preservice teachers reported that knowledge changes because it is driven by changes in society, individual characteristics (or how the knowledge is, or needs to be, applied) and because new knowledge is “produced” (epistemic).

Theme 3: Rate of Change in Teaching Knowledge

The third theme that we identified was not one that we had envisioned. Interestingly, it seems to represent the response type that lies closest to the traditional way of considering certainty of knowledge beliefs, because it is specifically related to the changing nature of knowledge. Participants wrote responses about the rate of change in teaching knowledge that seemed to fall along a continuous dimension (cf. systems of beliefs research on epistemic beliefs, Hofer & Pintrich, 1997) ranging from *things/ knowledge change(s) all the time*, through to the idea that there is a *fixed base of knowledge, but some things will always change*, to the view that there is *no room for change*.

Things/ knowledge ‘change(s) all the time’ ($n = 45$, $T1 = 20$, $T2 = 25$). Responses suggested a view that knowledge was always changing, for example ‘School is always changing

and there are always new reports about what we should be working with' [S27, T2]. Interestingly, there were more incidences of reports of this belief at T2 than at T1, which may corroborate our interpretation of the quantitative results (see *Discussion*).

Fixed base of knowledge, but some things will always change ($n = 18$, $T1 = 9$, $T2 = 9$). Perhaps an even more 'sophisticated' belief that was expressed by the participants was the idea that some facts are certain and 'known' (cf. Chinn & Rinehart, 2016), whilst there will always be room for improvement. For example, 'The market is partly saturated with various theories, but as time goes by things will always change...' [S23, T1].

No room for change ($n = 3$, $T1 = 1$, $T2 = 2$). Contrary to the most popular response in this section (knowledge is always changing), a small number of participants expressed the belief that there would be no new knowledge about teaching in the next 20 years, because everything that is worth knowing is already known. One preservice teacher indicated '[I] don't think there will be great changes in the next 20 years when there haven't been drastic changes over the last 20 years' [S38, T2].

Finally, we would like to note a fourth type of response posited by a small number of preservice teachers that related to the changing nature of teaching knowledge, although it stuck out as not fitting along a continuum of beliefs: The *Idea that 'things need to change'* ($n = 5$, $T1 = 2$, $T2 = 3$). The fourth type of belief that preservice teachers was more of a hope (or a lack of hope) that things might change in the future, for example 'Hopefully things will improve, in the way of ...' [S30, T2].

Discussion

In this article, we have identified significant differences in participants' responses to a quantitative measure of expected change in teaching knowledge, after a year of teacher education. We have also explored epistemic beliefs about the certainty of teaching knowledge qualitatively by identifying preservice teachers' beliefs about ways knowledge and practice will change, reasons why knowledge is likely to change and beliefs about the rate of change.

Our results show that preservice teachers hold specific beliefs about the certainty of teaching knowledge, and that these beliefs may develop during teacher education (Lunn Brownlee et al., 2017; Strømsø & Bråten, 2011). The quantitative measure showed that preservice teachers' beliefs about the certainty of teaching knowledge changed from Time 1 to Time 2. That is, they believed that more knowledge was likely to change over the next 20 years, which is usually interpreted as a stronger belief that knowledge is tentative. There was also some evidence of this change in the qualitative data in *Theme 3: Rate of change in teaching knowledge*. Namely, some preservice teachers expressed the belief that things/knowledge 'change(s) all the time' ($n = 45$, $T1 = 20$, $T2 = 25$), and we noted that there were more reports of this belief at T2 than at T1. The expression of the belief that knowledge is constantly changing has previously been interpreted as a sign of epistemic sophistication by researchers exploring epistemic beliefs using Likert type measures (see Bromme et al., 2008; Bråten, Strømsø & Samuelstuen, 2008; Greene & Yu, 2014; Trautwein & Ludtke, 2007a, b). However, Chinn and Rinehart (2016) recently suggested that epistemic sophistication may be more about degrees of certainty in that 'much scientific knowledge... is well-established and beyond reasonable doubt, and ... other scientific knowledge is more open to legitimate doubt' (ref. to Osborne and colleagues in Chinn & Rinehart, 2016). With regards to this way of viewing sophistication, we also found some reports ($n = 18$, $T1 = 9$, $T2 = 9$) of a belief in the existence of a 'fixed base of knowledge, but some things will always change, seeming to reflect Chinn and Rinehart's views. However, these results did not suggest any advances in the preservice teachers' understanding of the nature of knowledge, since the number of

responses reflecting this belief were similar at T1 and T2.

The results of the qualitative data about the *ways* in which the participants thought knowledge would change over time showed that more preservice teachers cited teaching practices rather than changes in knowledge *per se*. This practical, process-oriented interpretation may relate to Chinn et al.'s notion of reliable processes for achieving epistemic aims (Chinn et al., 2011). However, given the lack of a specific focus on knowledge or other epistemic aims in the preservice teachers' responses, we view this finding as more likely to suggest a view that the way knowledge is created and changed is through what teachers do and the qualities they bring to the classroom, which might be described as a *practical epistemology* (Boulton-Lewis, Brownlee, Berthelsen, & Dunbar, 2008). Such a practical epistemology pays attention to teaching practices used in the classroom, rather than considering existing theories and research about teaching. Lunn Brownlee and colleagues (Lunn Brownlee, Johansson, Cobb-Moore, Boulton-Lewis, Walker, & Ailwood, 2015) explored elementary school teachers' epistemic beliefs, by observing teachers' practices, then used stimulated recall interviewing techniques, to get them to reflect on their epistemic beliefs. The teachers described a range of epistemic beliefs, including what the researchers termed *practical evaluativism*, which is about teachers evaluating a range of practical sources (e.g., colleagues teaching practices rather than theory or research) when considering their own and others' teaching practices. This practical epistemology, while potentially adaptive in the context of busy teaching spaces, did not weigh up current research or theorising.

On the other hand, this practical epistemology was not evident when preservice teachers described the most commonly occurring *reasons for perceived changes in teaching knowledge*. Preservice teachers' responses about reasons for change included research, knowledge, theories (including changes in subjects) and ICT at both times, as well as changes in people or society. This apparently anomalous finding may relate to Chinn and colleagues' notions of epistemic aims and value (Chinn et al., 2011, Chinn & Rinehart, 2016). Preservice teachers may have epistemic aims of gaining knowledge, understanding and wisdom about how to teach, but the value they attach to these aims might be less than that attached to their non-epistemic aims of classroom management or carrying out teaching plans.

Finally, the nuances in preservice teachers' epistemic beliefs that were reported in this study may not have been evident through the use of a quantitative measure alone because prescribed statements about knowledge require less reflection and do not enable participants to reveal emergent psychological aspects of constructs (Greene & Yu, 2014).

Theoretical and Methodological Implications

If teacher beliefs about the certainty of knowledge are important for teaching and learning, then a better understanding of what preservice teachers believe, how these beliefs are formed throughout education, and their influence on cognition and practice are essential areas of investigation. However, to understand these constructs it is imperative that they are defined and measured in valid ways (Mason, 2016).

With regard to theoretical definitions, to date, most research on beliefs about certainty have taken place within the broader Hofer and Pintrich (1997) framework which includes the nature of knowledge (how one defines knowledge) and the nature of knowing (how one comes to know). The certainty of knowledge forms part of the nature of knowledge dimension and includes a range of beliefs from viewing knowledge as absolute to viewing knowledge as evolving. However, Chinn et al., (2011) argued for 'a more specific, fine grained analysis ... within several of the dimensions that Hofer and Pintrich discussed' (p. 142), including beliefs about the certainty of knowledge (viewed by Chinn and colleagues as one of several possible

epistemic stances). Our findings have revealed specific beliefs within the dimension of certain knowledge in the context of teacher knowledge. Following Chinn et al. (2011), we have continued to unpack the fine-grained nature of epistemic beliefs. Finer-grained analyses of beliefs about teaching knowledge show that there are nuances within the domain of teaching knowledge. Several researchers have advanced a topic specific analysis of certainty beliefs (Bråten, Gil, Strømsø, & Vidal-Abarca, 2009; Trautwein & Lüdtke, 2007b), yet there are likely contextual differences in certainty beliefs, even at a topic specific level, that should continue to be investigated in the form of cross-contextual research (Mason, 2016).

With regard to valid measurements, our nuanced findings about certain knowledge have emerged, in part, because of a mixed methods approach, which has enabled us to take a fine-grained look at preservice teachers' beliefs about certain knowledge (Greene & Yu, 2014). This can have implications for future studies of epistemic beliefs that focus on developing domain-specific theories and measures. The study of epistemic beliefs continues to be inhibited by questions of construct definition and use of measures with poor psychometric properties (Greene & Yu, 2014; Mason, 2016). Without dealing with such issues at a methodological level, future theory development will be problematic, as well as lacking practical applicability (cf. Chinn et al., 2011; Greene & Yu, 2014). In light of the nuances revealed in our study as well as prior literature, we would suggest that findings from studies based solely on self-reports using Likert-type scales must be interpreted with caution (Mason, 2016).

Limitations

The results from this study have several theoretical and educational implications. However, they are not without limitations. The research is conducted in the context of preservice elementary and lower secondary teachers in Norway, and generalization to a wider population would require more extensive investigations across different cultures. Also, the study focuses on preservice teachers' epistemic *beliefs* or *stances* at two points in time, rather than assessing in-situ cognitions. Thus, there may be discordance between what the participants report and how they cognize, or teach, and we may expect that this would differ over time and contexts. This relates to the likely tacit nature of epistemic beliefs (Chinn et al., 2011) that might limit participants' ability to express them in written form (Chinn et al., 2011). More observational studies such as the use of scenario-based tasks (Ferguson & Bråten, 2017; Mason, 2016) may therefore be required.

Regarding the mixed methods approach in this study, although the qualitative data seemed to corroborate the quantitative data regarding development of beliefs in one regard (i.e., more reports of knowledge as tentative at T2), it did not in another (i.e., number of reports of knowledge consisting of 'a fixed base, but some things will always change' were similar at T1 and T2). Also, due to the brevity of some participants' responses and the fact that we could not probe them for further explanation (as afforded by e.g., cognitive interviews), we were unable to trace signs of development in participants' responses at an individual level. Interview data or probed cognitive interviews (cf. Greene, Torney-Purta, Azevedo, & Robertson, 2010) would be helpful for research seeking to delve further into such questions. When interpreted in light of other recent attempts by the research community to better understand (preservice) teachers' beliefs about knowledge, we view this study, despite its limitations, as having implications for teacher educators, which we outline below.

Implications for Teacher Education

The beliefs that preservice teachers hold about the certainty of teaching knowledge are likely to influence their learning and how they relate to different knowledge sources (Buehl & Fives, 2016; Bråten & Ferguson, 2015), as well as deep-learning and engagement in higher-order thinking, such as reflecting on knowledge and practice (Lunn Brownlee et al., 2017). This has consequences for the evidence-base of preservice teachers' future practice, as well as how they interact with their future students. Therefore, teacher educators need knowledge about epistemic beliefs and how to facilitate their development in preservice teachers (Lunn Brownlee et al., 2017).

First, preservice teachers are not only required to choose and integrate reliable theoretical and practical knowledge sources (Bråten & Ferguson, 2015), they should understand that the evolving nature of knowledge creates a need for updating their knowledge base, also after graduation. So, while preservice teachers are often inclined to place more trust in inservice teachers and their own experience as learners (Bråten & Ferguson, 2015), it is important that teacher educators manage to communicate the value of (new) empirical and theoretical research reports. Contrarily, it is equally important that preservice teachers learn to critically evaluate new knowledge sources and practices, so that they avoid "jumping on the band wagon" every time a new research report or educational product is launched. Thus, while recency of knowledge is one important factor, it is also important that teachers learn to assess other source evaluation factors, such as relevance and the motivations of the author (Bråten, Strømsø, & Andreassen, 2016), before they engage in deep-processing.

Second, exploring preservice teachers' beliefs about the certainty of teacher knowledge assists us in understanding preservice teachers' epistemic stances (Chinn et al., 2011) and the extent to which they might be 'willing to amend those ... [knowledge considerations] in the light of new evidence' (Greene & Yu, 2014 p. 14). Such epistemic stances provide a way in which to understand how preservice teachers might adapt to new knowledge and beliefs, which is an important quality for teachers in the 21st century. With the exponential growth of knowledge and technology nowadays, the need for 'lifelong learning' is greater than ever before. Teacher educators need to equip preservice teachers with the skills to ensure that they continue to learn and adapt to the rapidly changing nature of today's world, also after graduating, but it is equally important that they can facilitate learning of, as yet, unknown skills and competencies in their own students (cf. Buehl & Fives, 2016). Addressing epistemic beliefs in teacher education and fostering adaptive certainty beliefs in pre-service teachers may be one way of facilitating these skills.

Third, the preservice teachers in this study seemed to display some evidence of an understanding that knowledge about teaching changes gradually over time. However, they also seem to hold more practical epistemic beliefs that focused on knowledge enactment in terms of practice. By shedding light on the types of epistemic beliefs held by preservice teachers, it is our hope that we may aid teacher educators in addressing them, and in challenging preservice teachers to further develop them. Teacher educators should also help preservice teachers to develop epistemic goals, such as understanding, explanation and gaining new knowledge in keeping with developments, rather than focusing exclusively on non-epistemic goals. Lunn Brownlee et al. (2017) recently developed a framework for developing teachers' epistemic beliefs through what they referred to as epistemic reflexivity, which involves the critical evaluation of own beliefs and the evaluation of multiple perspectives that leads to specific action in the classroom. Considering the findings in this study regarding the practical nature of preservice teachers' thinking about knowledge, this may be a particularly suitable framework for discussing epistemic beliefs in teacher education. Teacher educators might also introduce discussions about the changing nature of

teaching knowledge (e.g., Alexander, Murphy, & Woods, 1996) and how current theories and practices fit in with previous trends. This, along with guided reflection and consideration of how beliefs calibrate with practices may foster a climate and will for changing beliefs, as well as encouraging preservice teachers to engage with and critically evaluate the knowledge and ideas that they meet in lectures and classrooms (Feucht, Lunn Brownlee & Schraw, 2017, Lunn Brownlee et al., 2017).

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