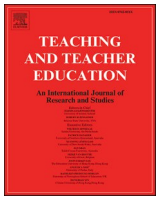
Teaching and Teacher Education 144 (2024) 104599

Contents lists available at ScienceDirect

Teaching and Teacher Education

journal homepage: www.elsevier.com/locate/tate



Research paper

The role of research experiences in developing pre-service teachers' epistemic beliefs

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A B S T R A C T

Persistent concerns about the theory-practice gap and desires for an 'evidence-informed' teaching profession have prompted research into how teachers' epistemic beliefs influence their acceptance or rejection of educational research. This study analyses longitudinal interview data from six pre-service teachers (PSTs) to explore how experiences of conducting research (in the domains of science or education) during initial teacher education (ITE) contribute to epistemological development. These research experiences provided opportunities for ad-hoc epistemological development, even in the absence of intentional efforts. Epistemic beliefs sometimes appeared to be supplanted, counterproductively, from science to education. The implications for teacher education and research are discussed.

1. Introduction

There have been many arguments in recent times within international research literature and policy to support the teaching profession becoming more evidence-informed and research-engaged (e.g., BERA-RSA, 2014; O′ Donoghue et al., 2017; Tripney, Gough, Sharples, Lester, & Bristow, 2018). Such trends come in the context of decades of research about the persistence of a theory-practice or research-practice 'gap' in education (Korthagen & Kessels, 1999; McGarr et al., 2017), often related to negative perceptions of educational theory and research. In advancing the 'research-informed teaching' or 'teacher-as-researcher' agendas, many initial teacher education (ITE) providers have sought to include research projects in their programmes (e.g., Brew & Saunders, 2020; Kitchen & Petrarca, 2016). Some research experiences for both pre-service and in-service teachers have been evaluated or shared through the literature (e.g., Flores, 2016; Hardoim et al., 2014; Lapostolle & Chevaillier, 2011) but it is not often that the research experiences are explicitly rationalised in teacher education literature as a mechanism for developing the individual's beliefs about the nature of knowledge and nature of knowing. Such beliefs are known as epistemic beliefs, or sometimes personal epistemologies (Hofer & Pintrich, 1997).

Epistemic beliefs are generally important because they act as filters for how individuals view information and are therefore vital in learning (Luft & Roehrig, 2007). Epistemic beliefs have been found to influence pre-service teachers' perceptions of educational research (Joram, 2007; Preiser et al., 2022) and support or hinder teachers 'buy-in' to evidence-informed and research-engaged practice (Joram, et al., 2020). It is vital that we begin to understand how learning activities within teacher education can be leveraged for epistemological development.

Student-conducted research projects naturally embed many activities that have been suggested as developmental for epistemic beliefs, such as engaging with contradictory literature, understanding research methods, argumentation, and increasing subject knowledge (Gill et al., 2004; Iordanou, 2010; Walker et al., 2012; Yilmaz-Tuzun & Topcu, 2008). So, research projects in ITE have the potential to develop epistemic beliefs conducive to integrating knowledge from education research but this has yet to be systematically investigated. There are multiple forms of research experiences often already organised in ITE programmes, but we know little about how they foster epistemological development. Our own previously published work suggests that ITE ought to focus on epistemic development of PSTs in both their subject matter discipline and Education Studies (Guilfoyle et al., 2020).

The current study provides an exploration by examining pre-service teachers' (PSTs') experiences of research projects in ITE. It draws on a longitudinal qualitative study of science teachers' epistemological development as they move from pre-service post-primary teacher education to post-qualification employment (Guilfoyle, 2018). The study particularly focuses on the development of PSTs epistemic beliefs as they engaged in research projects during the final year of their ITE programme. Research projects were already a part of the ITE programme and could be conducted in the discipline of science or Education Studies (including science education).

In summary, this paper aims to explore how student research projects in ITE can promote epistemological development. To understand the

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https://doi.org/10.1016/j.tate.2024.104599
Received 3 November 2021; Received in revised form 17 March 2024; Accepted 7 April 2024
Available online 12 April 2024

relevance of this exploration and contextualize the work, this introduction has outlined some key points which will be expanded further in subsequent sections: (1) there is a desire to make the teaching profession more evidence-informed and research engaged, (2) epistemic beliefs play an important role in teachers' perceptions of educational research, and (3) while some ITE courses include research experiences, they often do not explicitly aim to develop epistemic beliefs. This paper will address this question 'How do different research experiences in ITE (in the domains of science and Education Studies) contribute to the development of PSTs' epistemic beliefs that are conducive for their buy-in to educational research?' By identifying potential opportunities and barriers for epistemic belief development in existing ITE practices, this knowledge can inform future research and practice of teacher education.

1.1. Epistemic beliefs and epistemological development in teacher education

Individuals' epistemic beliefs, sometimes also known as personal epistemologies, are vitally important to the process of learning generally (Mason, 2010; Muis, 2007) and learning to teach in particular (Buehl & Fives, 2016; Fives, 2011). With a growing body of evidence, scholars argue that 'it is clear that teacher education programmes must concentrate on the determination and development of PSTs' epistemological beliefs' (Yilmaz-Tuzun & Topcu, 2008, p. 82). In this section, we briefly review how epistemic beliefs have been addressed in relation to the domains of science and Education Studies, before highlighting the dearth of research on the interaction between the beliefs in these two domains. In doing so, we argue the importance of epistemic beliefs and epistemological development in teacher education.

It has long been argued that it is essential for teachers, and ultimately students, to learn not just the substantive content knowledge of their disciplines but also the syntactic knowledge of the discipline, that is how these disciplines operate procedurally and epistemically (Schwab, 1962; Ball & McDiarmid, 1990). This agenda has been pursued in several different ways in different disciplines. In science education, for example, there have been at least two strong lines of research with this agenda (Elby et al., 2016). One of these lines of research has been in advocating for students' understanding of the Nature of Science (NOS) which typically refers to the epistemology of science (Lederman, 2007) or, at least, the epistemology and epistemic practices of science are positioned as part of a wider conceptualisation of NOS (Erduran & Dagher, 2014). The second line of research has been in the application of personal epistemology, and related constructs from psychology to science education. In a review of 37 papers in this line of research, Yang and Tsai (2012) found that personal epistemology had been shown to effect science learning across the cognitive, psychomotor, and affective domains.

Teachers' epistemic beliefs in the domain of 'Education Studies' has been the focus of far less research. This, in part, may be due to the extent to which this domain is so contextually variable. In a volume edited by Whitty and Furlong (2017) contributors from various countries articulate how educational knowledge and the traditions of educational research are exceptionally different, nuanced by the particular history and features of their contexts. This means that drawing the boundaries of the discipline, (see Furlong, 2013 for discussion of Education Studies as a discipline) is remarkably difficult. However, some studies have nevertheless sought to understand teachers' epistemic beliefs about educational research and the implications of these beliefs. For example, Joram (2007) found that the epistemic beliefs of pre-service teachers, practicing teachers, and teacher education professors about education research differed in ways that appeared to have implications for their acceptance or rejection of the validity of such research. In this case, that PSTs believed educational knowledge was highly particularistic and not falsifiable. Similarly, Bondy et al. (2007) demonstrate, through the use of particularly illustrative cases, how epistemic beliefs of pre-service teachers mediate their engagement with knowledge in their teacher education. Later work by Joram et al. (2020) found that epistemic beliefs, particularly about generalizability/transferability, and the need for certainty, were important factors in teacher 'buy-in' to use educational research. Merk et al. (2017) also found epistemic beliefs about what they term 'general pedagogical knowledge' may play a role in pre-service teachers' devaluation of such knowledge.

One major challenge in teacher education is that teachers are expected to navigate knowledge both their subject discipline and the field of Education Studies or educational research simultaneously. This means they must grapple with knowledge rooted in quite different epistemologies (e.g., the theories in education are quite different to those in science). While the struggle for teachers to engage with educational research has been studied extensively for many years (Korthagen & Kessels, 1999; McGarr et al., 2017), only recently have teacher educators begun to recognise the impact of teachers' beliefs about their subject discipline on how they perceive other professional knowledgebases such as educational theory and research (Löfström & Pursiainen, 2015). For example, the study reported in Guilfoyle et al. (2020) illuminated how PSTs appeared to reject knowledge from Education Studies both when it was believed to be extremely epistemically different to science (e.g., less robust therefore not trustworthy) and when it was believed to be extremely epistemically similar (e.g., producing universal knowledge claims that are not perceived as useful when classrooms are so context-specific). In that study, PSTs with a more nuanced understanding of epistemic comparisons between the domains appeared to show critical engagement with educational research for practice. This navigation between disciplines is complicated by tensions of identity, for example, between seeing oneself as a teacher or disciplinary expert such as a scientist, historian, mathematician, etc. (Jorde & Tellefsen, 2017), and by the finding that one's multiple identities may result in what Gottlieb and Wineburg (2012) term 'epistemic switching', where different epistemic standards are applied depending on the aspect of one's identity that is invoked in a given context.

Given the emerging importance of epistemic beliefs in learning to teach, teacher educators may wish to put particular effort into supporting epistemological development during teacher education. There are many ways in which epistemic beliefs might be developed in teacher education. For example, Walker et al. (2012) suggested that teaching experience on school placement, increasing subject knowledge, engaging in reflective practice, and encountering contradictions in theory or opinion in their ITE programme may all 'play a role' in epistemological development. In this paper, we consider the role of research experiences in epistemological development.

1.2. Research experience in initial teacher education

Many ITE programmes include research experiences as part of the curriculum, but with a wide variety of intentions and forms of implementation (Flores, 2016). Across the globe, teacher educators are recognising that quality teacher education programmes involve some element of research experience (Darling-Hammond, 2006, 2010). The presence of research experiences in Finnish teacher education is considered to be a key component of their successful educational outcomes at school level (Hökkä & Eteläpelto, 2013; Sahlberg, 2011) and research experiences are considered to be strongly valued components of teacher education in France (Lapostolle & Chevaillier, 2011), Portugal (Flores, 2016), and Brazil (Hardoim et al., 2014).

In many cases, pre-service teachers are found to value the research experiences which they feel promote their development towards evidence-informed practice (Niemi & Nevgi, 2014; Sozbilir, 2007). Other benefits of research, and rationales for its inclusion, include: greater coherence and knowledge integration in the teacher education curriculum (Conway et al., 2009), making apparent the links between theory and practice (Flores, 2016), developing professionals capable of researching their own practice to improve teaching (Medwell & Wray, 2014), and enhancing skills in reading and interpretation of research for practice (Healey & Jenkins, 2009). It is worth noting these experiences

are of educational research, or within the cognate disciplines of 'Education Studies', rather than research in subject disciplines such as science, history, or math (BERA-RSA, 2014).

On other hand, authentic research experiences within the discipline of the pre-service teachers' content area (e.g., science) are thought to be important for developing disciplinary literacies and understanding of the nature of science (Brown & Melear, 2007; Schwartz et al., 2004). Krim et al. (2019) reviewed 307 papers in the STEM education field that reported on students' engagement in research experiences in undergraduate degree programmes, and with in-service teachers. These are research experiences located in subject disciplines. Even the teaching-orientated projects, referred to as Teacher Research Experiences (TREs), are focused on the subject area where the 'outcomes of these experiences include increased STEM knowledge and experience, scientific research practices, career awareness, and STEM self-efficacy and identity' (Krim et al., 2019, p. 3). These subject-specific experiences appear to receive little-to-no attention in the more domain-general teacher education literature (Loughran & Hamilton, 2016), where the research projects discussed are instead educational in focus (Tatto & Furlong, 2015). So it appears while much work has been done to consider the role of research in both science education and teacher education literature bases, there is a disconnect in their foci that perhaps mirrors the tension between the knowledgebases of educational and scientific research that PSTs and in-service teachers are expected to navigate unsupported. Furthermore, while research experiences in science are rationalised by an increased understanding of the epistemic nature of science as an outcome, very rarely are the inclusion of research experiences in teacher education literature explicitly rationalised on the basis of the opportunity for epistemological development or epistemic comparison between one's subject area and educational research.

The empirical study presented in the paper sought to understand how such research projects, as they are currently embedded in a teacher education programme, might have potential for epistemological development, where such development is considered important for supporting an evidence-informed profession. Therefore, the research question that this paper will address is 'How do different research experiences in ITE (in the domains of science and Education Studies) contribute to the development of PSTs' epistemic beliefs that are conducive for their buy-in to educational research?'

1.3. Conceptualisation of epistemic beliefs

The theoretical model of epistemic beliefs used in this study draws primarily on the work of Hofer and Pintrich (1997), though with cognisance of more recent theoretical and empirical contributions (e.g. Chinn et al., 2011; Hofer, 2016). Within this model, epistemic beliefs are considered in terms of a number of 'more or less' independent dimensions, concerning the nature of knowledge and knowing (Hofer, 2016). These dimensions are the certainty, simplicity, and universality of knowledge, where the latter two are sub-elements of the 'structure' of knowledge (Chinn et al., 2011), as well as the source of knowledge and justification for knowing. Aside from the independence of each dimension to develop while others do not, it is also possible for individuals to hold different epistemic beliefs for different domains/disciplines (e.g., in science, psychology, mathematics); that is to say that they can be domain-specific (Hofer, 2000; Urhahne & Kremer, 2023). These dimensions have long been considered as spectra running from 'less developed' to 'more developed', or from 'naïve' to 'sophisticated'. These are value-laden terms which researchers generally defend as necessary when considering uni- or multi-dimensional epistemological development (Schommer-Aikins, 2002). However, as we note in the analysis section, we account for the complexity of these beliefs rather than simply labelling them with such value-laden dichotomous terms. While we are mindful of not imposing our values, as educators, we do acknowledge that certain beliefs, or a combination of beliefs, can be conducive or hinder students in achieving intended learning outcomes (e.g. engaging with knowledge from Education Studies).

This conceptualisation of epistemic beliefs is useful because it theoretically recognises the domain-specific nature of beliefs, while also being sufficiently general to be applied to different domains (in this case science, and Education Studies).

Below is a brief expansion on each of these dimensions in turn, as described for the purposes of this study.

Certainty of knowledge is concerned with the extent to which knowledge is viewed as fixed or fluid. An individual may consider knowledge to be existing with certainty. In such cases, knowledge would not be doubted, all experts would come up with the same answer to a question, and that answer would not change over time. At the other end of the spectrum, individuals would be open to the idea that theories are modified over time as more information is gathered, and that knowledge is not certain or absolute. A nuanced position might recognise that in any domain or discipline there is some knowledge that is core, fundamental and well established, while knowledge at the fringes of discovery might be more tentative and open to revision.

Structure of knowledge can include several features. See Chinn et al. (2011) for a brief elucidation of these. For the purposes of this study, we consider two: simplicity and universality of knowledge. *Simplicity* is concerned with beliefs about knowledge as an accumulation of facts or as highly interrelated concepts. On one side of the spectrum one might consider answers to be straightforward and knowledge to be discrete, concrete and easily knowable. On the other side, the knowledge is understood as complex and relative to other concepts. A nuanced position is quite close to the Polar End 2, understanding knowledge as more complex and inter-related. *Universality* is concerned with the extent to which knowledge is universally applicable across contexts (Polar End 1), or highly context specific (Polar End 2). A nuanced middle ground position might acknowledge that knowledge can be generated in context but can be useful in other contexts – what is often called 'transferability' by qualitative researchers (e.g., Lincoln & Guba, 1985; Tracy, 2010) or that it might be generalised to different degrees.

Justification for knowing is concerned with how individuals evaluate knowledge, how they use or evaluate evidence, authority, and expertise. One polar end of this dimension would include belief in knowledge as justified by expert opinion alone, while the other end of the spectrum would involve a belief in knowledge justified by personal experience and intuition. A more nuanced position might acknowledge this need to rely on testimony, but balance it with a recognition of the need for evaluation of this testimony for plausibility, whether there is consensus, and how it integrates with what is already known (Bråten et al., 2011).

Source of knowledge is concerned with beliefs about knowledge as residing outside the self, which is transmitted from expert/authority to the learner and should not be questioned. Individuals might, alternatively, consider knowledge as constructed in interaction with others. An individual would move from being a spectator to being an active participant in constructing knowledge, using logic and evidence. A nuanced view might strike a balance by acknowledging that multiple sources, including personal experience, can be used to support a claim.

2. Methods

2.1. Research context

The research reported in this paper is situated in the context of a larger project that traced epistemological development of PSTs, in science and Education Studies, over an 18-month period spanning their final year of ITE and first year post-qualification. The project was undertaken in a University in the Republic of Ireland which was the largest provider of post-primary teacher education in the country (O' Doherty, 2016). Two routes of teacher education are offered by the university: a 4-year concurrent bachelors programme and a 2-year Professional Master of Education (PME) in a range of subject areas (e.g., science,

technology, math, languages, physical education). The curriculum of teacher education in Ireland is broadly regulated by the Teaching Council (2017; 2020), but with some local control about how to meet these requirements, subject to approval. While programmes must consist of particular proportions of various elements (i.e., 50% subject discipline, 25% Foundation and Professional Studies, 25% school placement), developing 'The Teacher as … Researcher' was listed as a mandatory element of all programmes, but without specific time requirements (2017, p. 14). This paper focuses only on PSTs in the 4-year concurrent programme (i.e., where students engage in both scientific education and teacher education concurrently) who had a research project embedded into their final year of studies spread across both semesters. This was a mandatory element and amounted to about 5% of the programme (12 credits of 240). Table 2 presents extracts from the module outline for each of the two modules, indicating the syllabus and learning outcomes. A more complete account of the curriculum of the programme is published elsewhere (Guilfoyle et al., 2020). Learning experiences, while a standard heading of the university module outline, are not stated in either case. This is perhaps indicative of the personal supervision approach that was adopted, where each student was supervised by an academic staff member in the university relevant to their project topic, rather than receiving whole-group instruction. What can be seen from this table is that while capacity for disciplinary procedures such as literature reviews, data collection, analysis, and critical discussion were all intended learning outcomes, there were no specific outcomes to develop an explicit understanding of the epistemologies of the disciplines. These learning outcomes are broadly similar to those for FYPs from other undergraduate programmes in different subject areas both within and beyond the institution.

Table 1
Dimensions of Epistemic Beliefs (Synthesis, adapted from Guilfoyle, 2018).

Dimension	Indicators		
	Polar End (1)	Nuanced Position (3)	Polar End (2)
Certainty [C]	Certain: Fixed, stable, concrete, unchanging, undoubted, everyone would have the same answer.	Certain to varying degrees, depending on the discipline and area. Core and peripheral knowledge.	Uncertain: Fluid, tentative, evolving, changing, best we know at the time.
Structure [St]	Simple: Discrete, straight-forward, concrete facts. Isolated, unrelated, accumulated.	Generally, beliefs about knowledge as more complex than simple are preferable.	Complex: Relative and contingent on other concepts. Inter-related and connected.
	Universal [U]: Knowledge is (or aims to be) applicable globally regardless of context.	Knowledge is generated in context, but can be generalised by various means, including transferability to similar contexts.	Particularistic: Knowledge is (or aims to be) specific to the context in which it was generated.
Justification [J]	Authority/ expertise: 'Because an expert said so' - Unwavering trust in authority.	Evaluation and integration of expert views and evidence.	Personal experience: Because of personal experience, intuition, or evaluation of evidence.
Source [So]	Outside the self: From expert, authority source – e.g., teacher, scientist, book etc.	Recognising multiple sources can support a claim.	Within the Self: From experience, intuition, own investigation

2.2. Participants

Six PSTs, from a cohort of 72, participated in the full longitudinal study (Saldana, 2003). These participants are referred to by pseudonyms; Bruce, Monica, Harvey, Lisa, Haley, and Lana. In their course, they could specialise in biology and chemistry or biology and physics. Only Haley was on the biology and physics route. Ethical approval was sought and granted from the institutional ethics committee where the research was conducted. Participation was entirely voluntary and self-selecting by responding to an open invitation to the whole cohort. While there were 12 participants at the beginning of the study, participants were informed of their right to withdraw at any stage, and only 6 chose to continue to participate throughout the full 18-months to provide a full data set for analysis.

All PSTs in this study conducted a research project as part of their final year of ITE. This research could be conducted in their subject area of science, or in Education Studies (which included topics specifically on science education). However, the experience of conducting research was unique for each of the participants, and their subsequent learning was quite different. It is important to note that the participants did not engage in any research methods modules but rather learned methods by engaging with a supervisor.

Table 3 shows a summary brief description of the research project foci and experiences for each participant. These are intentionally vague because the individual nature of the projects would mean that even rather limited details could identify a participant. Harvey and Lisa did their research in the biological sciences, Bruce and Monica did their research in Education Studies, and Lana's was focused on science education. Haley also did her FYP in the biological sciences and went on to pursue further research in this area. While Haley's engagement with further scientific research lies outside the ITE structure, some reflections on this experience are included to further illustrate the potential influence of research experiences.

2.3. Data collection

Each participant engaged in an in-depth interview at the beginning of their final year of the bachelors' programme (Data Point 1; DP1), at the end of their final year (DP2), and one year after the programme (DP3). The key data points for this study are DP1 and DP2, as pre-post interviews for the final year research project, but DP3 data is also considered because reflections on the research project are also given here. Explicit reflections on the FYP experience are included in the DP2 interview schedule, however, epistemic beliefs were being investigated at all three datapoints. It is understandable that participants would draw on or reflect upon their FYP experience when responding to questions about the nature of knowledge and knowing, or useful knowledge from ITE, during the DP3 Interview. Accordingly, it is expected, that a larger volume of comments surrounding the FYP would be noted in DP2. The interview schedule is provided in the Appendix, showing variations in components for all three data points.

The interviews were multicomponent in nature so as to elicit epistemic beliefs in different ways, because individuals often find it difficult to articulate their epistemic beliefs (Guilfoyle, 2022; Joram, 2007). The different components offered a range of opportunities to demonstrate or reveal beliefs (e.g., by discussing learning experiences and aspirations for teaching), to consider alternative perspectives through concept cartoons (Naylor et al., 2007) or to respond to very direct questions on epistemic issues (Tsai, 2002). The interview also utilised cognitive interviewing strategies (Greene et al., 2010) with Hofer's (2000) Discipline-Focused Epistemic Belief Questionnaire (DFEBQ) to gain deeper understanding about PSTs' epistemic beliefs with respect to the theoretical dimensions of epistemic beliefs (Hofer, 2000). The DFEBQ contains 21 Likert scale items for each discipline with statements such as 'Truth is unchanging in this subject' and 'Correct answers in this field are more a matter of opinion than fact'. The

Table 2
Extracts from university module outlines.

Module Heading	Semester 7 – Final Year Project 1	Semester 8 – Final Year Project 2
Syllabus:	Introduction to the project; definition of its purpose, scope, requisites. Introduction to methodologies for undertaking primary and secondary research. Development of initial thesis and research design; directives for refining the initial research idea and for conducting research.	Collection and analysis of primary data, as required. Guidance on the formats available for the final report, on the analytical approaches required, and on the methodology and documentation.
Learning Outcomes:	- Identify literature relevant to the selected research project. - Define a research topic. - Interpret and review the literature relevant to the research question. - Value the significance of the contribution of research to solving problems. - Deliver analysis of refereed research papers to peers. - Organise and present in written format the secondary data and research findings relevant to the research question.	- Arrange, collect and examine published literature on a selected research topic - Clarify, defend and interpret the literature and data available on the research topic - Apply the available information relevant to the research topic to solve the research questions and problems - Summarise and synthesise the findings of the research effort - Analyse the outcomes and draw conclusions from the findings of the relevant primary and secondary data available - Evaluate the findings and recommend further action/directions of study. - Acknowledge the contribution of the research work to furthering knowledge and understanding, skills and attitudes as these relate to the research project - Undertake primary data collection, as required. - Compile the total research process into a dissertation reflective of the prescribed requirements.
Learning Experiences	Not Stated	Not Stated
Credits (of 240 Total)	6	6

participants responded to each statement, but only selected responses were probed further. Responses were selected if they were particularly notable, such as responding on opposite ends of the scale for science vs Education Studies. In addition to the full questions provided in the appendix, Table 4 outlines the different components of the interview, their purpose, content, and changes across datapoints.

2.4. Analysis

We approached this research question in a qualitative manner which sought to understand the connections and changes in a holistic and multifaceted way in the context of participants experiences (Pettigrew, 1995). Underpinned by a critical realist philosophical stance, causation in this study is considered differently from the standard Humean approach of 'If A happens, then B will happen' (Sayer, 2010). Rather, there is a recognition that social causation can be considered as 'processes' and where a 'well-constructed story can satisfy us as an explanation of an event' such that it is 'reasonable to see' how one thing leads to another (Becker, 1994, pp.188-189). The goal is 'to describe credibly, vividly, and persuasively for readers through appropriate narrative the processes of participant change through time' (Saldana, p.46). We therefore used individual narrative profiles in both the analysis and presentation of findings (Seidman, 2006).

The analysis followed the following steps:

(1) ***Coding:*** First, all transcripts were subject to both inductive and deductive coding for the perceptions and beliefs of interest, focusing on both latent and semantic meanings (Clarke & Braun, 2014). All instances of epistemic beliefs were identified using an expanded version of Table 1. Statements would be coded depending on the dimension (e.g., Certainty of knowledge, abbreviation [C], see Table 1) and domain (e.g., science or Education Studies) to which they were relevant. For example, the statement *'in science there is an end. There is a right answer',* would be coded as relevant to the dimension of 'certainty' in the domain of science. We did not seek to reduce the beliefs to 'naïve' or 'sophisticated' that we recognise is traditionally the case in epistemic beliefs research, because we know that beliefs are more complex than this (Sinatra, 2016). We endeavoured to capture and represent this complexity. Therefore, we discuss development not in terms of movement from a category of 'naïve' to 'sophisticated' but a change in particular beliefs (e.g., from believing that all knowledge in science is certain, to believing that there is some knowledge that is more certain than others).

(2) ***Generating Profiles:*** Using the coded elements for each participant, individual belief profiles (in narrative form) were produced to capture a holistic view of the participants' thoughts, including contradictory/contrasting beliefs and the context for their beliefs (e.g., if talking about their own teaching or learning, or in reference to particular experiences such as school placement or research projects).

(3) ***Considering Change:*** These profiles also captured how some beliefs changed over time. These changes in beliefs are recognised in two ways, first by noting the presence of different beliefs in subsequent time points and the second is by noting the individual's statements about how their thinking has changed. Segments of data pertaining to participants' research experiences were drawn out to generate some descriptive accounts of such experiences. Again, we consider both how these experiences coexist with any relative change in epistemic beliefs (e.g., DP1 statement, vs DP2 statement), but we also specifically consider how participants themselves note their beliefs changing as a result of, or while engaging in, particular activities (e.g., I used to think … now I think …).

(4) ***Manageable and meaningful reporting:*** Full profiles consisted about 12 pages of text per participant per time point, including quotations and interpretations. These require further reduction to make them manageable and meaningful (Luker, 2009); therefore, what is presented in this paper are demonstrative extracts and summaries rather than full profiles for each individual.

For this paper, we focused our attention only on discussion which could be related to their experience of engaging in research. We acknowledge that many other experiences in ITE could be influential for participants, however discussion of their engagement in research projects generated rich reflection of their epistemic beliefs worthy of further analysis.

Table 3
Summary of research projects.

Pseudonym	Discipline of Project	Brief Description of Project	Notes on the experience
Harvey	Science – Biology	Identification of organisms in urban ecosystems to draw conclusions about environmental health/quality.	Largely independent field-based work. Guidance provided by supervisor, particularly for asking questions of methods and interpreting results.
Lisa	Science – Biology	Analysis of soil content to draw conclusions about environmental health/quality.	Both field and lab-based work. Working alongside masters and PhD students in the lab, who provide some guidance and training. Supervisor support was available. But there was still a feeling that independence and that personal initiative was necessary.
Haley	Science – Biochemistry + Further Research Post ITE	Molecular cloning to produce a particular protein.	Working as part of a group, continuing from previous students' work. Support for methods and skills provided through the research group and the supervisor.
Bruce	Education Studies	Psychology-informed mixed method study of teachers' perceptions and use of particular educational equipment.	Largely independent field work, though with support from supervisor in developing methodology and exploring the relevant literature.
Monica	Education Studies	Qualitative study on teacher attitudes and preparedness for a given social issue in the school context.	Largely independent field work, though with support from supervisor in developing methodology and exploring the relevant literature.
Lana	Science Education	Designing research-informed educational resources for a particular science topic. Gathering pre-service teachers' understanding and beliefs on the topic and perceptions of the resources.	Largely independent desk research in developing resources and field work in higher education setting for surveys with pre-service teachers. Did not emphasise any specific supervisor support.

2.5. Quality criteria

We subscribed to a vision of quality criteria for qualitative research as articulated by Tracy (2010). This vision builds on the shift in attention away from concepts of reliability, validity, and generalizability (from quantitative research) to criteria of credibility, transferability, and dependability for qualitative research (Lincoln & Guba, 1985). Rather than inter-rater reliability, which generates a measure of how often we agree on the application of a particular coding label, we focused on interrogating the appropriateness of the inferences at each step but particularly at the point of producing individual belief profiles (asking whether the evidence presented was sufficient to make such claims about the participant). Throughout this process, the second and third authors acted as 'critical friends' who question, critique, and probe in an effort to attain 'interpretive agreement' (Tappan, 1997) and check inferences/connections being drawn (Stieha, 2014).

Table 4
Interview components, purposes, content and changes over time.

Component	Purpose	Content (See Appendix)	Changes DP1-2-3
Prior Experiences	Opening the interview. Inferring beliefs through their accounts of impactful or influential experiences in encountering knowledge.	1 primary question 3-6 probing questions e.g., tell me about your time as a student in school, or about your school placement?	DP1 focused on their school experience as a student. DP2 focused on their school placement experience. DP3 focused in-service teaching experience or further education.
Teaching	Inferring beliefs through their approach to and aspirations for teaching, and perceptions of what teacher need to know.	6 questions e.g., describe "best" science, or "ideal" classroom. What do you think teachers need to know? How do they come to know?	No changes: same questions at each timepoint.
Learning	Inferring beliefs through approaches to learning, knowledge use and generation.	3-4 primary questions	DP1: During ITE DP2: Placement and FYP DP3: In-service teaching or further study
Explicit Epistemic Questions	Directed questions about the nature of knowledge and knowing in the disciplines. Inferring beliefs from explicit statements.	1 concept cartoon – nature of theories in science and Education Studies. 4 questions per discipline – e.g., characteristics of scientific knowledge or knowledge in Education Studies.	No changes: same questions at each timepoint.
Probing Prior Stances	Using responses to the DFEBQ instrument to explore divergent or unexpected beliefs.	Probing 3–5 responses on the instrument which was completed before the interview.	Re-sequenced to the beginning in DP3, where instruments were complete in person before the start of the interview.

3. Results

The findings of this paper are presented with respect to the different types of research experiences in which the participants engaged; these are research experiences in science, in Education Studies (including science education), and further scientific research beyond ITE. Finally, we reflect on the absence of explicit epistemological development during the research experiences and in ITE more generally. As outlined in the analysis section, we present the results in a narrative form to 'describe credibly, vividly, and persuasively for readers' (Saldana, 2003, p. 46) such that it is 'reasonable to see' the impact of the various experiences for these participants (Becker, 1994, pp.188-189). Accordingly, each participant's experience is summarised as interpreted by the researchers, with supportive and illustrative quotes. Rather than claiming that particular experiences will regularly cause particular outcomes, these narrative profiles explore plausible possibilities for the role these research experiences can play in PSTs' epistemological development.

3.1. Research experiences in science

When conducting a research study in science in this programme, PSTs would be supervised by an academic member of staff in a science department who was generally actively engaged in scientific research. Sometimes, the PST would come up with their own idea for scientific study and the academic would support them to investigate these (even if there was little desire for such work in the field), but in many instances PSTs would select from a range of 'titles' that academic staff proposed as being of particular interest to them and their research agenda. In this way, many PSTs experienced being a part of a wider team of research students and scientists working on a particular scientific issue that was of current interest to the scientific community.

Harvey and Lisa's research in the sciences appeared to have differing influences on them. Lisa, appeared to develop her understanding of the nature of knowledge and nature of knowing in the area of her research. During the process of reading research and conducting her own lab work with field samples, she began to feel that science was more fallible than what she had previously believed. She said of her own research:

> There was a high source of error in what I was doing. Even though I did try to minimise it, obviously … but there was a high source of error … That kind of thing I just wouldn't have taken into account (before) [C/J] [*DP2 Lisa*]

From her reading she started to see that the body of scientific knowledge still contained many unanswered questions and many unknowns ('*They know less than I thought they knew*' [C/So] - *DP2 Lisa*). There was a noticeable increase in her belief about the tentative and interpretative nature of science:

> You can say it is a fact and you use your evidence, but then at the same time, you could be looking at it the wrong way. So, it could change as well … I would like to think what I am learning now or what I am teaching is fact. And 90% of me probably thinks that it is. But 10% of me is saying 'well they thought this was fact before.' [C/J] [*DP2 Lisa*]

These comments stand in stark contrast to the high level of certainty she attributed to science in her first interview where she said *'in science there is an end. There is a right answer'* [C], *'your answer is your answer, it is a fact'* [C], and it *'is a fact across the board'* [C/U] *[DP1 Lisa]*. She described science as *'concrete', 'proven',* and *'set in stone'* [C] *[DP1 Lisa]*. As time progressed, Lisa moved to a point where she viewed science as working with knowledge that is essentially 'operationally true' at present, but it could be subject to re-evaluation and change. (*'Like nothing in science is set in stone, it is just because it worked out this way most of the time and we are* ***using this as a fact***' [C] - *DP3 Lisa* [emphasis added]). She also differentiates between ongoing current research and foundations of science such that there would be a spectrum from very certain (core) knowledge to more contentious (peripheral) knowledge (*'I know in research there are different opinions, but I feel like in the foundations of science, everyone would have the same answer.'* [C] - *DP3 Lisa*).

Harvey's experience of research was also influential, but not to the same extent as Lisa. The experiences did not appear to cause pervasive change. He also gained a deeper understanding of conducting scientific research, in particular how experiments are planned and conducted. He said that prior to his FYP research, he *'had a very simplistic idea about what an experiment was and what it needed to be' [DP2 Harvey]* and that such knowledge had been *'neglected before'* because his experience of conducting experiments in university was to *'go in on the day [with] your lab manual, you carry it out and get your result. It is either right or wrong and nowhere in between'* [C/J/So] *[DP2 Harvey]*. His research experience encouraged him to be *'more critical of the steps [he] was using'* [So] *[DP2 Harvey]*. He no longer viewed scientific investigation as a simple matter of *'I will do the experiment and get a result'* [J/So], but rather:

> I will get a result, I will think about the result, I will do research on the result, I will see how the research fits in with other things and then I will see how that goes and I will do the experiment again. [J/So] [*DP2 Harvey*]

Harvey's FYP project primarily involved biological identification methods. Such observational scientific work seemed to take a primary role in his understanding of science as *'Observations and experiments of the phenomena of the world, and drawing conclusions from those based on our understanding at a certain point in time'* [J/So] *[DP2 Harvey]*. However, this understanding of science as observational also seemed to help reaffirm his image of science as certain and non-argumentative (*'in science it is very much 'this is it''* [C] - *DP2 Harvey*). The examples Harvey provides for such certainty are all centred on observation, identification, and classification: '*you can't argue that a cat is a dog because looking at the traits of it, it is very clearly a cat'* [C/J] *[DP2 Harvey]*, '*when identifying something like linchins … you can't argue that a folios is a crustos because they look different*' [C/J] *[DP2 Harvey]*. Even when acknowledging that classifications can change, he does not appear to recognise these as human endeavours but advancement in technologies which unveil the true nature of reality.

> within some areas, understanding developed so we are able to better classify stuff. Some plants are in different groups because we looked at the genes and said 'okay, they don't fit in here, they fit in here.' [C/J] [*DP2 Harvey*]

So, while there is evidence that Harvey's experience of research coincided with some developments in his understanding of the nature of knowledge and knowing in science, the changes that occurred did not seem as fundamental as with Lisa. In fact, some of his experience reaffirmed ideas of certainty and lack of argument. A notable distinction between the two was that Harvey's work appeared to be more field-based identification work, while Lisa's involved experimental lab work. Their development of their beliefs appeared to be relevant to their particular experiences. Perhaps this raises a question as to whether opportunities for epistemological development are often more ad-hoc than intentional within these research experiences.

3.2. Research experiences in Education Studies

Bruce and Monica both engaged in research projects with a focus on Education Studies. This means that their research focus was rooted in an educational issue and did not need to be science related. PSTs who conduct a research project in 'Education', as they would term it, would generally be supervised by an academic staff member who would research and teach courses that centre around cognate disciplines of Education Studies, such as sociology, psychology, philosophy, etc. PSTs might focus, for example, on student or teacher perceptions, action research, or on any range of issues with relevance to education.

Bruce and Monica's research in Education Studies appeared to help them gain a more complex and nuanced understanding of the nature of knowledge and nature of knowing in Education Studies (similar to Lisa in the case of science).

At DP1, Bruce believed that knowledge in Education Studies was highly contested where '*there are experts in education that have completely divergent views'* [C] and this was connected to a sense that the *'evidence is weak, sometimes'* [J] and the nature of knowledge was quite different to science, saying *'some of it is empirical … some of it is based on political beliefs'* [J] and *'I have seen very few things where I would say it is anywhere near the standard of scientific knowledge'* [C/J].

At the same time, Monica described Education Studies as highly context specific; *'If you do something in education here and you do something in education somewhere else, the results could be completely different'* [U]. This emphasised the need for her to play an active role in interpreting and evaluating knowledge in Education Studies through her own experience: *'every situation that you come across in education is different …*

for that reason we are strongly encouraged to question.' [U/So].

In both instances, they are communicating beliefs that knowledge in Education Studies is less certain, and perhaps of a lesser standard, than science. The perceived variability and lack of certainty in Education Studies underscores why their own experience is an important source of knowing: knowledge in Education Studies provide *'nice frameworks for understanding'*, *'a wider view'* [DP1 Bruce], or helps you to become *'more self-aware'* [DP1 Monica] rather than certain answers.

Following their engagement with the research projects in Education Studies, both Bruce and Monica could speak in more detail about the methods used in educational research but also a heightened value in such data. Instead of seeing knowledge in Education Studies as weak and not at the standard of scientific knowledge, Bruce said *'I see the value in qualitative data more. I would have thought of it as 'nice' but … I found the stuff that came out of this was maybe even a little bit better … there is certainly something there, there is a truth there'* [J]. Monica said, *'Since I have actually done it, I have a* ***lot more respect*** *for the research that is actually there.'* [DP2].

Both Bruce and Monica highlighted the subjectivity of the researcher as an important consideration, but also indicated a level of comfort with this that perhaps counters earlier discomfort of evidence as 'weak': *'The person doing the research has a huge say in how it turns out … so in a lot of ways, it is kind of subjective, but that is okay too, I think.'* [J/So – DP2 Monica], *'You get a richer discourse from it … it depends on the skills of the researcher'* [J/So – DP2 Bruce].

Both Bruce and Monica began to think about the limits to the use of research that might be small scale and qualitative. For example, Monica recognised that the research could not be generalised but that the knowledge could still be useful by seeing the similarities between contexts: *'[it] is not the same context as the context I am in, but it is quite similar and they found this thing, that this would be helpful … At least you could try it'* [U/J] *[DP2 Monica]*. Bruce also felt that the purpose or use of knowledge was important. He felt that researchers need to keep knowledge claims within the boundaries or limitations of their data, and that they should not oversell their claims as more certain than the data could allow:

> I think it comes down to **what it is being used for**. If it is being used to make qualitative statements, then that is fine. If it is used to make statements that **acknowledge where it comes from**, that is fine. Where the researcher or the person acknowledges that look **'this is based on the views of some people, filtered through me, and within a paradigm within which only certain things will be discussed' that is grand**. I think where it becomes **dangerous** is where someone tries to say 'I interviewed a [number] of people and did a discourse analysis, and that is **kind of quantativey and this is therefore the truth** of what is valuable and what is useful [C/J/So] [*DP3 Bruce*] [emphasis added]

In summary, having engaged in research projects in Education Studies, Bruce and Monica considered the value of different types of evidence, the methods of generating such evidence, and the sorts of claims that various types of evidence could legitimately support. They also considered the limitations to this type of research, such as researcher subjectivity, bias in interpretations, the value laden nature of educational research. Furthermore, they demonstrated comfort with these limitations and a sustained sense of their own role in the interpretation and evaluation of knowledge from educational research.

3.3. Research experiences in science education

Some PSTs would engage in research that was in Education Studies, but rather than pertaining to general topic to education, they would specifically focus on teaching and learning of science. These could be supervised by a range of academics, from educationalists with a specific subject background in science to scientists with an interest in education. Quite often these research projects would be pedagogical in focus, such as the trialling of particular interventions or production of evidence-based resources.

Lana's research was of this nature. While she did conduct some data collection by means of a survey of her peers, her primary goal of the project was the creation of teaching resources for a particular aspect of the science curriculum. As such, she did not feel she was constructing knowledge (*'So, I basically just made a handbook … It was a resource book' … 'There was no ground-breaking results' - DP2 Lana*), but rather she was exploring the international literature to inform the creation of this resource (*'I just looked up how [topic] is taught in different countries, what are the main difficulties with teaching [the topic]' - DP2 Lana*). Lana did not seem to reflect the same extent or degree of learning that her peers did about the nature of knowledge and its generation, in either science or Education Studies. But the experience was still influential for at least some of her epistemic beliefs. For example, her reading of literature seemed to suggest to her that there were similar findings across numerous educational contexts and this was important for validity of research in education.

> … most of the research that I found about [the topic] were in the same line of thinking, they got the same results even though they are in different countries. So, I think there was Sweden, Germany, whatever the other countries were, the same results were found. I think the same survey was given. Even when they repeated it, a few different things stayed the same. So, I think the research methods were the same, the results were the same. Similar let's say. [U/J] *[DP2 Lana]*

Lana inferred from this that truth in educational research was established by repeating findings across a range of global contexts: *'I suppose it is validating their research. That many different researchers did it so it must be true … '* [J] [*DP2 Lana*]. While this is a development from justification by authority in her first interview (*'theorists have looked it up … [I would be] veering on just accepting that it is true'* [J/So]- *DP1 Lana*), it also continues her view that science and Education Studies knowledge are justified in the same way. There seems to be a reaffirmation of her belief that, in order to be valid or trustworthy, educational research must mimic the justification criteria of repeated measures and the methods that she believes science uses. Thus, she said for both science and Education Studies, *'repetition infers validity'* [J] [*DP2 Lana*] and

> You would have to have repetition; they both have the same research methods that are very similar … The way the information is achieved in both of them is the same. The same methods anyway. [J] [*DP2 Lana*]

So, for Lana, her experience of research in ITE was one which perhaps brought the interface of scientific research and educational research into greater focus than those studying in just a single content area. However, it is not clear that it provided more clarity. In fact, there may even have been some emerging tensions in the contrast between her beliefs in science and education. For example, it was observed that her belief of justification by 'scientific repeatability' conflicted with her belief about high contextual variability in classrooms, posing challenges for her in placing trust in educational research for practice ('*even though there has been research done, not necessarily will the ideas presented in the textbook work in the particular scenario that you will be in, in education*' [C/U] – [*DP3 Lana*]).

3.4. Further experiences with scientific research after ITE

Finally, Haley had a unique set of research experiences. She did an FYP, in science, in her final year of teacher education, like her peers, but she also continued into further study including scientific research as part of a master's degree. This experience helped her to develop a more complex understanding of science, both in terms of the practices of science and its epistemic nature. There was even a sense of a stepwise development between the two research experiences. For example,

following her FYP, Haley spoke about scientific knowledge as changing and containing contradictions. Her reading of scientific literature exposed her to articles which appeared to be contradictory. However, at this stage she believed these contradictions were merely a function of time, that knowledge changed with time and one needed to be careful of the date on the literature being read *('one of them could be dated 10 years previous and that is why it is contradicting because there is more research since'* [C] *[DP2 Haley]*). At DP2, she also indicated that she had begun to learn the language of reporting scientific results, which she had not recognised before. She noticed, then, that scientific results were often reported more tentatively than she had previously thought:

> And even from having to read through so many articles, you kind of pick up on little phrases and stuff that are their ways of saying 'we don't actually know if this is right or not'. Whereas if you were to have given it to me two years ago, I would have been saying 'yeah, that is right'. [C/J/So] [*DP2 Haley*]

Later, after more extensive experience in research and with time exploring scientific literature, she felt better able to evaluate knowledge claims made in science. She moved from thinking that incorrect information in scientific literature was because it was outdated, to thinking that researchers were fallible; they could be wrong: *'books have been just wrong … not just wrong over time but wrong from the outset'* [C/So] *[DP3 Haley]*. She felt she was able to read scientific literature more accurately and with a higher level of critique, where she previously would have accepted knowledge as absolute (*'gospel'*) from an authority source: *'Before, in my undergrad, if I were to read a scientific paper, that is gospel. Whereas, now I am way more critical, and I will nit-pick and stuff … because I can read'* [C/J/So] *[DP3 Haley]*.

However, while Haley changed in terms of believing in authority sources whole heartedly and without question, she also understood that there was a role of testimony in science. She also felt she would need to put her faith in the testimony of experts at some points:

> If I am thinking about physics and they are talking about antimatter and black matter and all of that, I have an interest in that stuff, I think it is cool. But I don't understand it. I don't know how it works, so I am putting my faith into them that that is the right thing. Because there is that level of knowledge that I am never going to have [So] [*DP3 Haley*]

These examples provide just a brief glimpse into the development of Haley's epistemic beliefs in science. It is clear that her experiences of research were influential in generating a more nuanced understanding of the nature of knowledge and the nature of knowing. Her views of Education Studies did not develop, *per se*, but did change somewhat. Rather than seeing this as starkly different as she did before, she seemed to substitute her beliefs about science into epistemic questions in Education Studies (*'I am assuming it [Education Studies] is the same as science'* [J] - *DP3 Haley*). This might be explained by the absence of any experiences relating to Education Studies after her Initial Teacher Education. This concept of 'absence' of opportunities for development of epistemic beliefs in Education Studies emerged from more than just Haley, however. It is thus explored in more detail next.

3.5. Absence of explicit epistemological development

Some participants pointed towards an absence of experiences that could ground their understanding or ability to grasp some of the questions being posed during the interviews. There were indications that participants had not been exposed to experiences which would give them any direction or reference point for thinking about knowledge and knowing, particularly in Education Studies. Some of these indications were implicit, while others were clearly articulated as absences of experience. There were statements from many participants to the effect of: *'I have never thought about this before'* and *'we have never been asked questions like this'*. The two specific cases described below show evidence that some participants, in the absence of any confident beliefs about the epistemic nature of Education Studies, resorted to substituting their epistemic beliefs about science into Education Studies in order to fill the void.

In the case of Haley, she was seen to regularly substitute her understanding of the epistemic nature of science into her gaps in understanding of Education Studies – assuming that Education Studies 'should' be able to operate in a manner like science:

> Because as I think about it more, you know, if you are putting out a paper, I am **assuming it is the same as science** and it is peer-reviewed and it is critiqued, and it is fully accepted, and **it has to be repeatable.** I think if you are doing something in Ireland with Irish kids, but it is **repeatable in India** with Indian kids, and lots of different cultures and things, rather than 'we are going to do a study and we are going to carry it out on white children from middle class families in big cities in Ireland' … like, **if you are sticking with the one group, it is an opinion** you are forming then because you are not taking into account the full picture. Whereas if you then go to open it up and if everything is saying the same thing then, well you have … like if you were to do **statistics, your t-tests would tell you**, yeah that is true or not true, or statistically significant, which helps to **solidify that it is a fact** rather than a matter of opinion [U/J] [*DP3 Haley*]

There are a number of assumptions that Haley makes here that appear to be borrowed from her understanding of science, not least that the goal of the endeavour is always to say something as universal and generalisable as possible, but also that it would be justified by statistical analysis. To make a claim about a particular group, rather than all people, is considered by her to be little more than a matter of opinion. However, she did often surround such comments with caveats such as: *'I don't know', 'I don't have enough experience', 'I am not looking up education stuff', 'I am not a psychologist and I haven't read the papers or anything' [DP3 Haley]*.

Lisa also noted this sense of absence in ITE more clearly. As a general remark about her difficulties in articulating beliefs about Educations Studies she stated that *'I am undereducated in this department though, that is the problem'* [*DP3 Lisa]*. More specifically, Lisa stated she had not received any instruction in Education Studies surrounding the nature of knowledge in the same way as she felt that she did in science.

> I know a theory is below a principle, but … it is like a hypothesis, in both cases. Then it is proven over a period of time, that is a theory in science anyway, I think. Then, in education, it is tried and tested and proven over time as well, maybe … is it? They don't teach us this in education! [C/J] [*DP3 Lisa*]

The quote above illustrates how Lisa tentatively inserts her epistemic beliefs about science into the case of Education Studies in the absence of any other more strongly held beliefs.

This absence of epistemological development is important to note for at least two reasons. First, it highlights a need for more explicit attention to be paid to issues of epistemological development in ITE. Second, those who have engaged in an FYP in science were most explicit about their sense of absence of epistemic understanding in Education Studies, while those who conducted FYPs in education (Bruce and Monica) appeared to have more opportunity to consider epistemic issues in Education Studies. This raises the concern that experiences of epistemological development are ad-hoc experiences rather than intentionally integrated and an opportunity might be missed to support PSTs comparative understanding of, or navigation between, the different knowledge domains in their ITE.

4. Discussion

Bearing in mind that the research study reported in the paper uses qualitative methods with a small number of participants, we do not

suggest a definite causal link between particular types of research projects and a certain degree of epistemological development. However, the strength of this study is in exploring these pre-existing experiences with a new lens and providing illustrative examples of potential opportunities and barriers for research projects to be developmental experiences. The importance of epistemic beliefs in teaching and learning has been clearly identified in many studies and the need to focus on epistemological development in teacher education has been strongly argued (Yilmaz-Tuzun & Topcu, 2008; Brownlee et al., 2011; Guilfoyle et al., 2020; Peiser et al., 2022). Given the importance, it is useful to have a more detailed understanding of how teacher education can address these issues through learning experiences already in place in many ITE programmes.

Research experiences were clearly valuable to participants, though their influence on the PSTs' epistemic beliefs varied from reaffirming previously held beliefs to developing epistemic beliefs in one or both domains. It was clear that these research experiences could be powerful for changing PSTs' perspectives about the process of knowledge development in a particular field, as it forces them to consider what sort of evidence they require to support a claim in that field, through their own inquiry processes and through closer engagement with the literature of that field. It could also be noted that their experiences not only varied between domains but could be even more contextualised to the research methods and questions the PSTs were pursuing. However, it would not be reasonable to speculate at this point that some methods or questions are more conducive to development than others.

The most obvious reason for variety is that these experiences were not designed with an intention of epistemological development; research projects in ITE programmes are not generally included for this particular purpose (Feiman-Nemser, 2012; Flores, 2016; Munthe et al., 2011; Sahlberg, 2011). Some participants in this study encountered developmental incidents through these experiences on what appeared to be an ad-hoc basis, and this is an important finding. While the study itself was not interventionist in nature, and these PSTs did not experience concerted efforts in their ITE programme to develop their epistemic beliefs, we can reasonably trace some epistemological development to particular incidents and experiences. Therefore, it is within reason that if these PSTs were to encounter these experiences by design, with support and direction, they would experience developments in their epistemic understandings (Bråten, 2016).

The absence of experiences to help PSTs to grapple with the nature of knowledge and knowing in Education Studies in particular, leaves them to merely fill this absence with ill-fitting ideas of similarity with science – though they appear to feel the tension of the probable inaccuracy of these ill-fitting beliefs. This supplanting of science beliefs into the case of Education Studies is consistent with other empirical and theoretical work (Drever & Cope, 1999; Hordern, 2017; Sjølie, 2014) but also generates issues for accepting Education Studies as useful for practice (Guilfoyle et al., 2020). The rationale for inclusion of research projects in ITE has previously been to achieve greater coherence and knowledge integration in the teacher education curriculum (Conway et al., 2009), so that graduate teachers might become potential collaborators, consumers, and creators of educational research knowledge (Cochran-Smith & Lytle, 2009), and ultimately 'as a way of moving beyond the theory-practice divide in ITE' (Flores, 2016, p. 212). These are all admirable goals in themselves, but if experiences of conducting research projects in Education Studies or subject matter are to be included on ITE programmes for these purposes, as they are in the University of this study, then it may be a learning experience which can be utilised for the purposes of epistemological development too.

The evidence generated in this study can point to potential ways to capitalise on the affordances of student research projects in ITE. At the most basic level, we argue for explicitly considering it a learning outcome of the experience that PSTs would learn more about the epistemic nature of the field in which they are investigating. From this point alone, project supervisors could plan within their unique context to ensure that PSTs engage with epistemic issues relevant to the field of study. Further interventionist research studies would need to be carried out to investigate the impact of particular practices, though existing literature can support some of the embedded activities within research projects for epistemological development (see Brownlee et al., 2016 for a review). For example, encountering contradictory literature was a feature of Haley's experience which appeared particularly developmental, providing an increased understanding about the nuances of tentative and argumentative language used with research papers. There is a sufficient evidence base in different contexts to support that this embedded activity would be helpful for epistemological development, if scaffolded (e.g., Gill et al., 2004). Engaging in the construction of arguments within the discipline through the PSTs research theses, using evidence they had themselves collected, appeared to support the development of a more nuanced understanding of the nature of claims and evidence, as in the case of Bruce and Monica. Similarly, utilising argumentation as a vehicle for epistemological development also has empirical support (e.g., Iordanou, 2010; Iordanou & Constantinou, 2014).

The cases presented in this paper also illustrate how in the absence of explicit scaffolding of epistemological development some students are left to re-affirm beliefs they previously held (e.g., Harvey) or generate new beliefs that may be less helpful (e.g., Lana). The need for scaffolding and support in the epistemological development is made clear by Bråten (2016) as he notes that while much research on epistemological development focuses on inducing cognitive dissonance and epistemic doubt through contradictory perspectives, actually navigating this requires rather advanced cognitive flexibility (Jacobson & Spiro, 1995). Engaging in these tasks 'requires adaptive epistemic cognition at least as much as it promotes it' (Bråten, 2016, p. 362). Thus, if left to their own devices when engaging in epistemological development activities, it may be the case that only those with already advanced epistemic beliefs will be able to reap the benefits; metaphorically, only the rich get richer (Bråten et al., 2011; Stanovich, 1986).

Returning to the issue of teachers navigating the epistemic boundaries between their subject area discipline and disciplines of their other professional knowledge bases (i.e., Education Studies/educational research), there are a number of questions that emerge from the observations of this study when placed in the context of the wider literature on research in teacher education. We have noted in the literature review how the rationale for including research experiences in teacher education differs whether it is scientific research (e.g., Krim et al., 2019) or educational research (e.g., BERA-RSA, 2014), and that these literature bases do not often appear to overlap. This disconnect in the literature on the nature of research experiences to be included in teacher education is noteworthy and prompts the question: How can we expect learner teachers to navigate the boundaries between the disciplines if we are not navigating these ourselves as science educators, science teacher educators, or teacher educators more generally? This study reports on a programme that allowed students, who are studying science and education concurrently, to choose in which discipline they conduct their Final Year Research project. Explicit epistemological development within that discipline of choice could be supported but because epistemic beliefs are discipline-specific (Hofer, 2000), the epistemological development in the other discipline and the comparison between them would still need to be considered. The study presented examples of individuals, such as Lisa and Haley, who showed epistemological development in science and yet continued to find it difficult to relate to the nature of educational research. In another paper, we've explored more deeply the implications of epistemic comparisons of PSTs between the disciplines of science and Education Studies (Guilfoyle et al., 2020), demonstrating how a variety of different belief profiles generate challenges for PSTs. In this case, epistemological development in one discipline alone would not be sufficient to resolve these challenges and simultaneous epistemological development in both disciplines needs to be a concern for teacher educators.

It deserves reiteration here in the final comments that this paper did not seek to establish generalisable claims about the epistemic beliefs of PSTs or about the impact of research projects as interventions on epistemological development. Given the observational and non-interventionist nature of the study, our claims are more nuanced. The spectrum of possibilities is not exhaustive, but they are sufficient to understand ways in which PSTs might encounter research projects in their teacher education and how these encounters might be differently experienced in terms of epistemological development. This paper, then, raises the issue for recognition and attention by shining a light on the experiences of students as viewed through the particular lens of epistemic beliefs. It affords an opportunity to focus more closely on the learning experiences we might wish PSTs to have in ITE, while also being cognisant of the many other ways in which PSTs are expected to develop. Teacher educators may wish to engage in similar qualitative research to understand the experiences of PSTs as they fine tune their planning. Once such defining and refining has been completed, quantitative work on measuring impact of these experiences as interventions would become more useful.

As such, the primary outcome of this paper is not a roadmap for practice, but a support for teacher educators to think about their ITE programmes and how some of the experiences they provide could be leveraged for epistemological development.

CRediT authorship contribution statement

Liam Guilfoyle: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **O. McCormack:** Writing – review & editing, Validation, Supervision. **S. Erduran:** Writing – review & editing, Validation, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Acknowledgements

Funding: This work was supported by the Irish Research Council. [GOIPG/2016/1071].

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tate.2024.104599.

References

Ball, D. L., & McDiarmid, G. W. (1990). The subject-matter preparation of teachers. In W. R. Houston, M. Haberman, & J. Sikula (Eds.), *Handbook of research on teacher education* (pp. 437–449). New York: Macmillian.

Becker, H. S. (1994). "Foi por Acaso": Conceptualizing Coincidence. *The Sociological Quarterly, 35*(2), 183–194.

BERA-RSA. (2014). Research and the Teaching Profession: Building the capacity for a self-improving education system. In *Final report of the BERA-RSA inquiry into the role of research in teacher education*. London: BERA.

Bondy, E., Ross, D., Adams, A., Nowak, R., Brownell, M., Hoppey, D., … Stafford, L. (2007). Personal epistemologies and learning to teach. In *Teacher education and special education: The Journal of the teacher education Division of the Council for exceptional children* (Vol. 30, pp. 67–82), 2.

Bråten, I. (2016). Epistemic cognition interventions: Issues, challenges, and directions. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 360–371). New York: Routledge.

Bråten, I., Britt, M. A., Strømsø, H. I., & Rouet, J. F. (2011). The role of epistemic beliefs in the comprehension of multiple expository texts: Toward an integrated model. *Educational Psychologist, 46*(1), 48–70. https://doi.org/10.1080/00461520.2011.538647

Brew, A., & Saunders, C. (2020). Making sense of research-based learning in teacher education. *Teaching and Teacher Education, 87*, Article 102935. https://doi.org/10.1016/j.tate.2019.102935

Brown, S., & Melear, C. (2007). Preservice teachers' research experiences in scientists' laboratories. *Journal of Science Teacher Education, 18*(4), 573–597. https://doi.org/10.1007/s10972-007-9044-9

Brownlee, J., Schraw, G., & Berthelsen, D. (2011). *Personal epistemology and teacher education*. New York: Taylor & Francis.

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*. New York: Routledge.

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: Routledge.

Chinn, C. A., Buckland, L. A., & Samarapungavan, A. (2011). Expanding the dimensions of epistemic cognition: Arguments from philosophy and psychology. *Educational Psychologist, 46*(3), 141–167. https://doi.org/10.1080/00461520.2011.587722

Clarke, V., & Braun, V. (2014). Thematic analysis. In T. Teo (Ed.), *Encyclopedia of critical psychology* (pp. 1947–1952). New York: Springer.

Cochran-Smith, M., & Lytle, S. L. (2009). *Inquiry as stance: Practitioner research for the next generation*. New York: Teachers College Press.

Conway, P. F., Murphy, R., Rath, A., & Hall, K. (2009). *Learning to teach and its implications for the continuum of teacher education: A nine-country cross-national study*. Retrieved from Maynooth.

Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education, 57*(3), 300–314. https://doi.org/10.1177/0022487105285962

Darling-Hammond, L. (2010). Teacher education and the American future. *Journal of Teacher Education, 61*(1–2), 35–47. https://doi.org/10.1177/0022487109348024

Drever, E., & Cope, P. (1999). Students' use of theory in an initial teacher education programme. *Journal of Education for Teaching, 25*(2), 97–109. https://doi.org/10.1080/02607479919574

Elby, A., Macrander, C., & Hammer, D. (2016). Epistemic cognition in science. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 113–127). Routledge.

Erduran, S., & Dagher, Z. R. (2014). *Reconceptualizing the nature of science for science education: Scientific knowledge, practices and other family Categories*. Springer.

Feiman-Nemser, S. (2012). *Teachers as learners*. Cambridge, MA: Harvard Education Press.

Fives, H. (2011). One preservice teacher's developing personal epistemology about teaching and the explicit connection of those beliefs to future practice. In J. Brownlee, G. Schraw, & D. Berthelsen (Eds.), *Personal epistemology and teacher education* (pp. 114–128). New York: Routledge.

Flores, M. A. (2016). Teacher education curriculum. In J. Loughran, & M. L. Hamilton (Eds.), *International handbook of teacher education* (Vol. 1, pp. 187–230). Singapore: Springer.

Furlong, J. (2013). *Education-an anatomy of the discipline: Rescuing the university project?* Abingdon: Routledge.

Furlong, J., & Whitty, G. (2017). Knowledge traditions in the study of education. In G. Whitty, & J. Furlong (Eds.), *Knowledge and the study of education: An international exploration* (pp. 13–58). Oxford: Symposium Books.

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*(2), 164–185. https://doi.org/10.1016/j.cedpsych.2004.01.003

Gottlieb, E., & Wineburg, S. (2012). Between veritas and communitas: Epistemic switching in the reading of academic and sacred history. *The Journal of the Learning Sciences, 21*(1), 84–129.

Greene, J. A., Torney-Purta, J., Azevedo, R., & Robertson, J. (2010). Using cognitive interviewing to explore elementary and secondary school students' epistemic and ontological cognition. In L. D. Bendixen, & F. C. Feucht (Eds.), *Personal epistemology in the classroom: Theory, research, and implications for practice* (pp. 368–406). New York: Cambridge University Press.

Guilfoyle, L. (2018). *A longitudinal study exploring the influence of epistemic beliefs on pre-service science teachers' perceptions of education studies (unpublished doctoral dissertation)*. Limerick: University of Limerick.

Guilfoyle, L. (2022). Cognitive and multicomponent interviewing. In T. Delahuny, & M. Ni Riordain (Eds.), *Perspectives and approaches in contemporary STEM education research*. Routledge.

Guilfoyle, L., McCormack, O., & Erduran, S. (2020). The "tipping point" for educational research: The role of pre-service science teachers' epistemic beliefs in evaluating the professional utility of educational research. *Teaching and Teacher Education, 90* (April).

Hardoim, R. L. A., da Pessôa, T. L., & Chaves, I. M. B. (2014). Narrativas de iniciação à docência na relação universidade-escola. In M. A. Flores, C. Coutinho, & J. A. Lencastre (Eds.), *Proceedings of the international conference Formação e trabalho docente na sociedade da aprendizagem, organized within the context of International Study Association on Teachers and Teaching (ISATT) and Research Centre on Child Studies* (pp. 145–153). Braga, Portugal: CIEC, UMinho.

Healey, M., & Jenkins, A. (2009). Developing undergraduate research and inquiry. *The higher education academy*.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology, 25*(4), 378–405. https://doi.org/10.1006/ceps.1999.1026

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: Routledge.

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*(1), 88–140. https://doi.org/10.3102/00346543067001088

Hökkä, P., & Eteläpelto, A. (2013). Seeking new perspectives on the development of teacher education: A study of the Finnish context. *Journal of Teacher Education, 65*(1), 39–52. https://doi.org/10.1177/0022487113504220

Hordern, J. (2017). Berstein's sociology of knowledge and educational(al) studies. In G. Whitty, & J. Furlong (Eds.), *Knowledge and the study of education: An international exploration* (pp. 191–210). Oxford: Symposium Books.

Iordanou, K. (2010). Developing argument skills across scientific and social domains. *Journal of Cognition and Development, 11*(3), 293–327.

Iordanou, K., & Constantinou, C. P. (2014). Developing pre-service teachers' evidence-based argumentation skills on socio-scientific issues. *Learning and Instruction, 34*, 42–57.

Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research, 12*(4), 301–333.

Joram, E. (2007). Clashing epistemologies: Aspiring teachers', practicing teachers', and professors' beliefs about knowledge and research in education. *Teaching and Teacher Education, 23*(2), 123–135. https://doi.org/10.1016/j.tate.2006.04.032

Joram, E., Gabriele, A. J., & Walton, K. (2020). What influences teachers' "buy-in" of research? Teachers' beliefs about the applicability of educational research to their practice. *Teaching and Teacher Education, 88*, Article 102980.

Jorde, D., & Tellefsen, C. W. (2017). Building science teacher identity within an integrated teacher education program at the University of Oslo. In *12th nordic research symposium on science education, trondheim, Norway*.

Kitchen, J., & Petrarca, D. (2016). Approaches to teacher education. In J. Loughran, & M. L. Hamilton (Eds.), *International handbook of teacher education* (Vol. 1, pp. 127–186). Springer.

Korthagen, F., & Kessels, J. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational Researcher, 28*(4), 4–17.

Krim, J. S., Coté, L. E., Schwartz, R. S., Stone, E. M., Cleeves, J. J., Barry, K. J., Burgess, W., Buxner, S. R., Gerton, J. M., Horvath, L., Keller, J. M., Lee, S. C., Locke, S. M., & Rebar, B. M. (2019). Models and impacts of science research experiences: A review of the literature of CUREs, UREs, and TREs. *CBE-Life Sciences Education, 18*(4), ar65.

Lapostolle, G., & Chevaillier, T. (2011). Teacher training in France in the early 2010s. *Journal of Education for Teaching, 37*(4), 451–459. https://doi.org/10.1080/02607476.2011.611014

Lederman, N. G. (2007). Nature of science: Past, present, future. In S. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 831–879). Mahwah, NJ: Lawrence Erlbaum.

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Beverly Hills, CA: SAGE.

Löfström, E., & Pursiainen, T. (2015). Knowledge and knowing in mathematics and pedagogy: A case study of mathematics student teachers epistemological beliefs. *Teachers and Teaching: Theory and Practice, 21*(5), 527–542.

Loughran, J., & Hamilton, M. L. (2016). *International handbook of teacher education*. Springer Singapore.

Luft, J. A., & Roehrig, G. H. (2007). Capturing science teachers' epistemological beliefs: The development of the teacher beliefs interview. *Electronic Journal of Science Education, 11*(2), 38–63.

Luker, K. (2009). *Salsa dancing into the social sciences*. Cambridge, MA: Harvard University Press.

Mason, L. (2010). Beliefs about knowledge and revision of knowledge: On the importance of epistemic beliefs for intentional conceptual change in elementary and middle school students. In L. D. Bendixen, & F. C. Feucht (Eds.), *Personal epistemology in the classroom: Theory, research, and implications for practice* (pp. 258–291). New York: Cambridge University Press.

McGarr, O., O'Grady, E., & Guilfoyle, L. (2017). Exploring the theory-practice gap in initial teacher education: Moving beyond questions of relevance to issues of power and authority. *Journal of Education for Teaching, 43*(1), 48–60.

Medwell, J., & Wray, D. (2014). Pre-service teachers undertaking classroom research: Developing reflection and enquiry skills. *Journal of Education for Teaching, 40*(1), 65–77. https://doi.org/10.1080/02607476.2013.864018

Merk, S., Rosman, T., Rueß, J., Syring, M., & Schneider, J. (2017). Pre-service teachers' perceived value of general pedagogical knowledge for practice: Relations with epistemic beliefs and source beliefs. *PLoS One, 12*(9), 1–25. https://doi.org/10.1371/journal.pone.0184971

Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist, 42*(3), 173–190. https://doi.org/10.1080/00461520701416306

Munthe, E., Malmo, K.-A. S., & Rogne, M. (2011). Teacher education reform and challenges in Norway. *Journal of Education for Teaching, 37*(4), 441–450. https://doi.org/10.1080/02607476.2011.611012

Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and primary science. *Research in Science Education, 37*(1), 17–39. https://doi.org/10.1007/s11165-005-9002-5

Niemi, H., & Nevgi, A. (2014). Research studies and active learning promoting professional competences in Finnish teacher education. *Teaching and Teacher Education, 43*, 131–142. https://doi.org/10.1016/j.tate.2014.07.006

O' Doherty, T. (2016). Teacher education in the republic of Ireland: A challenging and changing landscape. In G. Beauchamp, L. Clarke, M. Hulme, M. Jephcote, A. Kennedy, G. Magennis, I. Menter, J. Murray, T. Mutton, T. O'Doherty, & G. Peiser (Eds.), *Teacher education in times of change* (pp. 125–140). Bristol: Policy Press.

Peiser, G., Pratt, A., & Putwain, D. (2022). Student teachers' views about the university's research contribution to professional knowledge development. *Teaching and Teacher Education, 112*, Article 103647. https://doi.org/10.1016/j.tate.2022.103647

Pettigrew, A. M. (1995). Longitudinal field research on change: Theory and practice. In G. P. Huber, & A. H. Van de Ven (Eds.), *Longitudinal field research methods* (pp. 91–125). Thousand Oaks, CA: Sage.

Sahlberg, P. (2011). *Finnish lessons: What can the world learn from educational change in Finland?* New York: Teachers College Press.

Saldana, J. (2003). *Longitudinal qualitative research: Analyzing change through time*. Walnut Creek, CA: AltaMira Press.

Sayer, A. (2010). *Method in social science: A realist approach* (Revised 2nd ed.). London: Routledge.

Schommer-Aikins, M. (2002). An evolving theoretical framework for an epistemological belief system. In B. Hofer, & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 103–118). Lawerence Erlbaum.

Schwab, J. (1962). The teaching of science as enquiry. In J. J. Schwab, & P. F. Brandwein (Eds.), *The teaching of science* (pp. 1–103). New York: Simon and Schuster.

Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education, 88*(4), 610–645. https://doi.org/10.1002/sce.10128

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and the social sciences* (3rd ed.). New York, N.Y. London: Teachers College Press.

Sinatra, G. (2016). Thoughts on knowledge about thinking about knowledge. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 479–491). New York: Routledge.

Sjølie, E. (2014). The role of theory in teacher education: Reconsidered from a student teacher perspective. *Journal of Curriculum Studies, 46*(6), 729–750. https://doi.org/10.1080/00220272.2013.871754

Sozbilir, M. (2007). First steps in educational research: The views of Turkish chemistry and biology student teachers. *European Journal of Teacher Education, 30*(1), 41–61. https://doi.org/10.1080/02619760601120072

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21*, 360–407.

Stieha, V. (2014). Critical friend. In D. Coghlan, & M. Brydon-Miller (Eds.), *The SAGE encyclopedia of action research* (pp. 206–208). London: SAGE.

Tappan, M. B. (1997). Interpretive psychology: Stories, circles, and understanding lived experience. *Journal of Social Issues, 53*(4), 645–656.

Tatto, M. T., & Furlong, J. (2015). Research and teacher education: Papers from the BERA-RSA inquiry. *Oxford Review of Education, 41*(2), 145–153.

Teaching Council. (2017). Initial teacher education: Criteria and guidelines for programme providers. *Maynooth: Teaching Council*.

Teaching Council. (2020). *Céim: Standards for initial teacher education. Maynooth: Teaching Council*.

Tracy, S. J. (2010). Qualitative quality: Eight "Big-Tent" criteria for excellent qualitative research. *Qualitative Inquiry, 16*(10), 837–851.

Tripney, J., Gough, D., Sharples, J., Lester, S., & Bristow, D. (2018). Promoting teacher engagement with research evidence. https://www.wcpp.org.uk/wp-content/uploads/2018/11/WCPP-Promoting-Teacher-Engagement-with-Research-Evidence-October-2018.pdf.

Tsai, C.-C. (2002). Nested epistemologies: Science teachers' beliefs of teaching, learning and science. *International Journal of Science Education, 24*(8), 771–783. https://doi.org/10.1080/09500690110049132

Urhahne, D., & Kremer, K. (2023). Specificity of epistemic beliefs across school subject domains. *Educational Psychology, 43*(2–3), 99–118. https://doi.org/10.1080/01443410.2023.2179605

Walker, S., Brownlee, J., Whiteford, C., Exely, B., & Woods, A. (2012). A longitudinal study of change in preservice teachers' personal epistemologies. *Australian Journal of Teacher Education, 37*(5). https://doi.org/10.14221/ajte.2012v37n5.1

Yilmaz-Tuzun, O., & Topcu, M. S. (2008). Relationships among preservice science teachers' epistemological beliefs, epistemological world views, and self-efficacy beliefs. *International Journal of Science Education, 30*(1), 65–85. https://doi.org/10.1080/09500690601185113