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A conversational journey for professional development through an epistemically insightful lens.

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Abstract
Previous research in Epistemic Insight (EI) has focused on the foundational knowledge of individual disciplines. This reflective piece offers new perspectives on how cross-disciplinary discussions about EI can challenge participants to interrogate their fundamental beliefs about the nature of knowledge in their field, in ways that do not occur during professional conversations between experts in the same discipline. As teacher educators in primary mathematics (Nic) and science (Rob), we use Borton's three stage reflective process, What-So-what-Now-what, to explore how our positioning within our respective communities of practice evolved during conversations prompted by critical incidents which arose during our teaching collaboration. Our interrogation of disciplinary similarities and differences allowed us to recognise and find a way through the limitations of communities of practice which unilaterally frame definitions of expertise within a field. We emphasise the value of developing communities which are both multi-disciplinary and deliberately focused on the nature of knowledge rather than addressing issues of performativity. We have not written a traditional research report, instead, this article is structured to follow our developing conversations and awareness because these conversations prompted reflection about and critical interrogation of our practice as teacher educators. As well as highlighting the power of EI to promote conversations about disciplinary knowledge, this conversational journey also shows that developing epistemic awareness can offer a counter-narrative to the instrumentalization of mathematics and science teaching.

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Introduction

Our conversational journey begins with the preparation of a lecture introducing the Epistemic Insight (EI) project to first-year undergraduate students on a work-based route degree in primary education. Rob, a teacher educator in secondary science, was responsible for embedding EI into the university's curriculum provision. The aim of the EI project was to support students' examination of the unique nature of knowledge in individual disciplines and to experience how blending different disciplinary voices provides holistic answers to real world questions. Consequently, Nic, a teacher educator in primary mathematics, felt that it would constitute a useful conclusion to a module studying how mathematical understandings are developed. Our original intention was to write a research paper on how the lecture had influenced the ideas and practice of the students involved. During the writing process, however, the value of the reflective journey we had engaged in through conversation, revealed itself to be of greater importance for us than our original focus. This paper, therefore, does not follow a conventional structure and we have deliberately avoided the use of terminology such as 'findings', preferring instead to use Borton's (1970) reflective framework to explore how our conversational journey led to a number of realisations which have significantly altered our teaching and research practice. This evolution is, in our eyes, the definition of transformational professional development.

The purpose of most teacher professional development is to improve student outcomes (Borko, Jacobs and Koellner, 2010; Van der Klink, et al., 2017). Even when the focus is to prompt change in teaching practice or teacher subject-knowledge, evaluation generally occurs through student-based measures (Garet, et al., 2001; Hill, Beisiegel and Jacob, 2013). Whilst research into professional development is almost exclusively focused on planned, structured interventions (Colling and Smith, 2021), we argue that these structures provide a limited view of how, and what, teachers learn (Webster-Wright, 2009). Our journey demonstrates that collegial interaction can often provide the impetus for sustained changes in thinking and, consequently, practice, which more formalised programmes measuring the quality of teaching based on student attainment and student satisfaction often fail to achieve (Kitchen, Ciuffetelli Parker and Gallagher, 2008; Selkrig and Keamy, 2015).

Borton's (1970) 'What, so what, now what?' framework, designed to support learning from critical incidents, reflects our individual and joint learning journeys so well, that we have used it to provide the structure for this article. The critical incidents which launched this, now two-year long, conversational journey have led to a series of realisations that reflect the transformative power for practice of cross disciplinary conversations. We suggest that positioning disciplinary knowledge as boundary objects and using it to interrogate the similarities and differences between subjects, highlights epistemic distinctiveness more effectively than intra-disciplinary inquiry which does not automatically involve consideration of the nature of disciplinary knowledge. This debate about the epistemic distinctiveness of an individual discipline has highlighted the limitations of communities of practice in framing definitions of expertise in a field and the value of developing communities which are both multi-disciplinary and deliberately focused on the nature of knowledge rather than addressing issues of performativity. Finding a way through these limitations has allowed for critical exploration of our positions within our disciplinary communities of practice and heightened awareness of our own positionality in research. These conversations have offered us a counter-narrative to the increasingly instrumentalised nature of mathematics and science teaching by forcing recognition of the humanness of knowledge creation and application. As such, EI has proven to offer far more than originally intended or anticipated. Last, but not least, we hope to show how a cross-disciplinary conversational journey can engender critical professional reflection and ongoing professional development.

We aim to take the reader on a journey through our discussions about our practice and subsequent reflexivity. To do so, our writing adopts a conversational style that deviates from

dual-authored research publications. We reflect on how our conversations constructed new communities of practice. Although we resist constructing a theoretical framework for our research, some level of background is required to provide the reader sufficient guidance to follow the themes that emerge. We will then explore our individual stories about how it has reframed our practice and research before concluding with ongoing actions we are undertaking.

Background: Why is it important to discuss disciplinary knowledge?

From the outset, it is imperative to highlight our individual positionality within these our conversations. Nic is a senior lecturer in primary mathematics, thus she is working with preservice teachers who will be required to teach a range of disciplines in an individual classroom. Many of the preservice teachers Nic works with will not hold a qualification in mathematics beyond a general certificate in secondary education (GCSE) which students sit, aged 16, in England. By contrast Rob is a senior lecturer in science education and leads the Secondary science post graduate certificate in education (PGCE) with qualified teacher status, (QTS) course. The preservice teachers Rob works with hold degrees in science or related fields and will almost certainly have studied at least one of the three sciences (biology, chemistry or physics) to A-level standard or equivalent.

Initially one might therefore assume that Nic holds a stronger justification for discussing the unique facets of mathematical knowledge with her students, as the science preservice teachers Rob supports may have previously interrogated the distinctive features of scientific knowledge as part of their degree. However, extensive research (Abd-El-Khalick, 2012; Lederman, N.G. and Lederman, 2019; Lederman, N.G., Lederman and Antink, 2013) suggests that learners rarely have opportunities to reflect upon their beliefs about scientific knowledge, how it is constructed or how such knowledge is distinctive from other forms of disciplinary knowledge. Indeed, recognising that learners, irrespective of their level of expertise, struggle to articulate how scientific knowledge is unique, aligns with Russ' (2014) contention that epistemology of science is fluid, personal and challenging to define. Although some work highlights that specific interventions focussed on investigating how scientific knowledge is distinctive can develop expert and defendable beliefs about the distinctiveness of science (Lederman, N. G., et al., 2001), these courses are often labour and time intensive. Consequently, the preservice teachers Rob works with are unlikely to have studied the epistemic foundations of scientific knowledge.

The EI project, which defines Epistemic Insight as "knowledge about knowledge" (Billingsley, et al., 2018, p.1121), seeks to empower teachers and teacher educators to explore big questions through a multidisciplinary lens. Adopting an epistemically insightful approach to teaching can support school children (Billingsley, et al., 2018), preservice teachers (Billingsley, Campbell and Dell, 2020) and teacher educators (Billingsley, et al., 2023) to appreciate the types of questions that are amenable to individual disciplines alongside "bigger" questions that require a wide range of disciplines to work in unison to construct an answer. Therefore, EI provided a valuable framework for Nic to reflect upon how she supported primary preservice teachers to articulate the distinctiveness of mathematics.

Lave and Wenger's (1991) concept of communities of practice was central to how we saw fundamental changes in our positionality. Wenger's (1998) conceptualisation of learning as a trajectory through, across and around a community of practice provides way to consider less structured forms of professional development, in particular those that arise from encounters with people external to existing communities of practice (foreign competencies), aka Rob, (Wenger, 1998, p.211). We argue that, as teacher educators working within a power structure imposed by a recent governmental review of teacher education (Department for Education, 2019; Hordern and Brooks, 2023), which compartmentalises teacher education into subject specialisms, the limited potential for cross-disciplinary and cross-phase collaboration stifles a rich source of reflexive professional development. Cross-disciplinary conversations about

knowledge challenge the limitations of intra-disciplinary communities of practice, allowing more critical examination of the reasons and motivations behind our instructional decisions and how they influenced the development of our practice.

What? Two critical incidents

In England, both primary and secondary initial teacher education is taught by discipline-specific experts, in ways which fail to highlight epistemic distinctiveness. Consequently, conversations about the uniqueness of disciplinary knowledge have little occasion to occur and epistemic assumptions about the nature of knowledge often remain unchallenged across all levels of education (Billingsley and Hazeldine, 2020). Whilst EI supports students in developing awareness of the nature of knowledge in individual disciplines, it does not force the educator to critically examine their own epistemic beliefs. As such, a multi-disciplinary EI project could be implemented by a group of teachers, each within their own discipline, without them engaging with their own ideas about disciplinary knowledge, even while encouraging their students to do so (Billingsley, et al., 2023). In contrast, the collaborative development of our cross-disciplinary lecture about epistemic distinctiveness provided fertile ground for refining our perceptions of the nature of our disciplines and our positionality within them. Intrinsic to this learning journey were our respective critical incidents, described in this section, which acted as catalysts for ongoing professional learning through conversation. These incidents began the shift in focus from our original research plan to reflection on how moving beyond EI proved more impactful on our practice.

Critical Incident #1 – So Nic, what's distinctive about mathematics?

In our first meeting to prepare for the lecture, Rob asked me to define what was distinctive about mathematical knowledge and ways of knowing. Given our aim of prompting preservice teachers to consider the purpose, nature and unique powers of mathematics in the lecture, the unexpected difficulty I faced in formulating a clear definition provided the first reflexive step in dialogical professional development.

As educators, we sit within multiple communities of practice (Cyrino, 2020; Lave and Wenger, 1991; Wenger, 1998). We participate fully in some and sit further towards the fringes of others. Our position in each community of practice is fluid, evolving as we gain competence in the practices which characterise membership (Wenger, 1998). Also in a state of evolution, however, is our perception of what constitutes competence within a community of practice. As teacher educators, we recognise that the perceptions of competence acquired during our own initial teacher education were quickly replaced by greater expectations after qualifying and gaining more comprehensive experience in the classroom. If greater interest was taken in a particular subject, the characterisation of a successful teacher developed further, encompassing an awareness of deeper, relational understandings and pedagogical content knowledge (Ball, Thames and Phelps, 2008; Shulman, 1986). The ability to articulate the knowledge and skills particular to this community of practice is, therefore, indissociable from developing competence (Lave and Wenger, 1991). The ability to articulate disciplinary distinctiveness, in contrast, is not.

Whilst mathematics as a significant and distinctive form of human knowledge (Ernest, 1991) is implied in the purpose of study outlined in the National Curriculum (Department for Education, 2013a), it is noticeably absent from the curriculum aims and content. This instrumentalization of mathematics is not exclusive to England (Murgatroyd and Sahlberg, 2016; Sahlberg, 2023) and a delivery approach to teaching mathematics, characterised by task propensity (Gravemeijer, et al., 2016), has developed widely, promoting in students an image of mathematics as a disconnected collection of facts and algorithms, rigid and irrelevant to daily life (Ziegler and Loos, 2017). Just as the broader vision of the English mathematics curriculum intent is overshadowed by the technical focus of the curriculum content (Department for Education, 2013a), competence in teaching is primarily recognised for the practitioner's technical ability: the way they engage in teaching and interact with students, the

instructional decisions they tend to make, the repertoire of routines, examples and experiences on which they draw (Ball, et al., 2008; Shulman, 1986). In contrast, the development of an epistemically insightful approach to teaching requires the articulation of a philosophy for mathematics, encompassing how it constructs a view of social reality, what can be known about social phenomena in that reality and how that knowledge is acceptably explained (Pring, 2015). It also requires an understanding of how those beliefs about the nature of mathematics impact on teaching practices (Tanase and Wang, 2010) and yet teachers are rarely asked to consider what they believe mathematics to be (White-Fredette, 2009).

Our conversations highlighted the extent to which our practice was influenced by preservice teachers', in particular primary preservice teachers', focus on self-efficacy (Geddis and Wood, 1997; Palmer, 2006) and subject-knowledge development (Bowie, Venkat and Askew, 2019; Verdugo-Perona, Solaz-Portolés and López, 2016). Consequently, already limited disciplinary understandings remain under-developed. Within our teacher education system, which prioritises school-based placements, we suggest that there is a strong need to develop the capacity to reflexively consider the epistemic foundations of individual disciplines (Hamed, et al., 2020) in order for educators at all levels to critically consider the implications these foundations have for their practice and beyond. In mathematics, for example, the lack of reflection about what mathematics is and does has helped to fuel, or rather left unchallenged, a pedagogical approach based within an exercise paradigm which fails to prepare critically active citizens (Skovsmose, 2014; 2023). The lack of critique is not a fault of the teachers, but rather a consequence of an education system where space for dialogue and critique is increasingly circumscribed.

Critical incident #2 – Labels do not equate to identity

I was the "expert" on EI responsible for introducing EI to the teaching curricula at St Mary's University. One of the activities we introduced in preparation for the cross disciplinary lecture was the big questions activity (see Table 1 below). In preparation for the EI session on the primary mathematics module, we discussed a range of 'big questions' (requiring insight from multiple disciplines), alongside questions with a single disciplinary focus. Up to this point, I assumed a significant level of epistemological overlap between mathematical and scientific knowledge. On reflection, this assumption was based upon my belief that scientific knowledge is explained using mathematical language rather than mathematics playing a more active role in constructing scientific understanding. Furthermore, this view of mathematics as a tool, common amongst scientists and other technologists (Ernest, 1991), rather than a construction, led to an assumption that only science utilised falsification as a mechanism to generate theory (Popper, 2014). Any question that could be falsified was a priori a scientific question. I consequently expected Nic to agree with me on how science and mathematics can be interwoven to answer big questions and which questions were exclusively amenable to science. Table 1 outlines the questions discussed and how we individually allocated them to one or more disciplines, whilst Figure 1 highlights the relative weighting we gave each discipline in providing an answer to the question.

	Question	**Rob (Science)**	**Nic (Mathematics)**
1	How do you know that plants photosynthesise?	Science alone	Science, informed by maths
2	How do I know you have a toothache? (Big question)	Multidisciplinary	Multidisciplinary, including maths
3	How do you know that I am in love? (Big question)	Multidisciplinary	Multidisciplinary, including maths
4	How do you know the sun will rise tomorrow?	Science alone	Maths, informed by science
5	How is the SARS-CoV-2 virus transmitted?	Science alone	Science, informed by maths

6	How do we know global warming is causing climate change? (Big question)	Multidisciplinary	Multidisciplinary, including maths

Table 1 Big questions

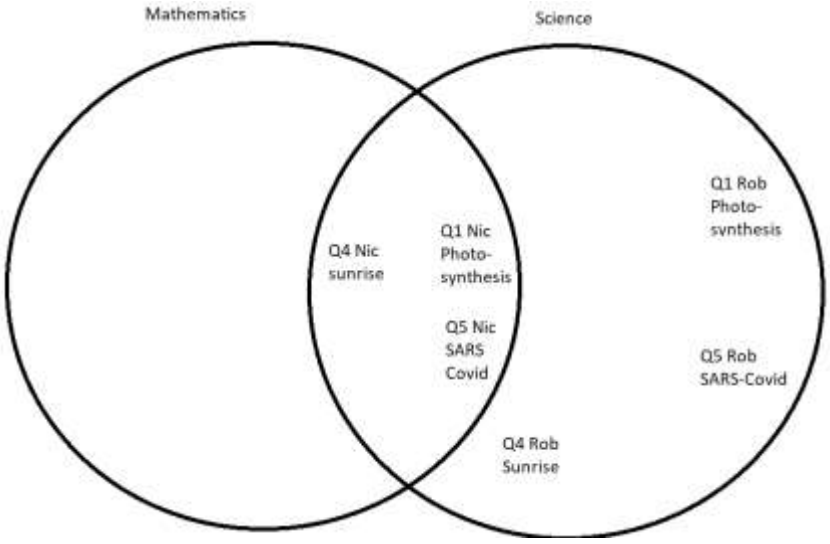

Figure 1 Positioning of responses to big questions

Realising that two teacher educators from different fields can each identify the same question as more amenable to their individual discipline, utilising the same explanation and data set, problematised my epistemic beliefs about how scientific knowledge is distinctive. Moreover, I had the troubling revelation that despite being a key member of the EI team, a multidisciplinary community of practice, I had not previously been challenged to defend my beliefs about how scientific knowledge is constructed. I recognised that the label of the person responsible for embedding EI into a curriculum offer did not, in isolation, guarantee I had a secure understanding of how individual disciplines are distinctive. Upon reviewing available literature, I have come to realise that although there is extensive research on suggested teaching methods for secondary science (Allen, 2016; Harlen and Qualter, 2014; Nag Chowdhuri, King and Archer, 2021), and initial teacher education (ITE) for primary science specialists, (Appleton and Kindt, 2002; Hume, 2012), there is less available on how the epistemic beliefs about science frames teachers' and teacher educators' definition of the distinctive features of scientific knowledge. Given the understanding that scientific knowledge is framed by cognitive, epistemic and sociocultural foundations (Dagher and Erduran, 2014), this appears surprising, suggesting the assumptions about the distinctiveness of scientific knowledge held by science teachers and teacher educators warrants further investigation.

So what? Reframing practice and research

This cross-disciplinary and cross-phase collaboration highlighted the need to develop a common language to work together effectively (Nevin, Thousand and Villa, 2009) and the unexpected challenge of articulating disciplinary distinctiveness to someone outside of one's field. The stimulus for reviewing professional practice, whether mandated or self-directed, is often technical or cognitive discomfort (Borko, et al., 2010). Nic's early discomfort at the difficulty in constructing a satisfactory response which encapsulated how a mathematician thinks beyond habits of mind and technical practices, stemmed from a new awareness that the purpose and nature of mathematics and mathematical knowledge had not previously been considered. Furthermore, this lack of consideration had not impacted any evaluation of competence within Nic's community of practice. Rob's discomfort arose across the course of our conversations with the recognition that whilst the introduction of EI into our primary ITE provision had prompted conversations within the science team, these conversations had not forced him to articulate his definition of science as they took place with colleagues from the same disciplinary background. By expanding the Epistemic Project to include other disciplines

such as mathematics, conversational spaces with teacher educators with different disciplinary expertise were opened. Conversations began to call into question our definitions of successful education and educators in our respective subject areas.

Nic's story

My difficulty articulating the epistemic distinctiveness of mathematics led me to explore different philosophies of mathematics and the consequences of those beliefs for mathematics teaching. It also led to a recognition of the disjunct between the educational aims I value and those my mathematics teaching practice has promoted.

The ambivalent relationship the UK population maintains with mathematics is not a newly discovered phenomenon (Mathematical Futures Board of the Advisory Committee on Mathematics Education, 2023; Williams, 2008). Ziegler and Loos (2017) suggest that the lack of engagement with mathematics, particularly in post-18 education, can be directly attributed to the pedagogical approaches adopted in schools. Student disengagement from mathematics (Boaler, 2002), in particular, is attributed to traditional, didactic, instrumentalist approaches. Ziegler and Loos (2017) suggest that a notable absence in mathematics education is a reflective element that considers what mathematics is, the roles it performs in society and how the subject is relevant to daily life. Advocates for critical mathematics education suggest that this reflection should go further and include a critique of mathematics in action (Skovsmose, 2010a; b; 2014; Skovsmose and Nielsen, 1996). Lack of reflection notwithstanding, the politically recognised economic importance of a numerate workforce, in particular since the publication of the Cockcroft Report in 1982 (Boylan, Adams and Birkhead, 2023), has ensured that mathematics has maintained its privileged position within school curricula and eclipsed any focus on considering the ontological and epistemic foundations of mathematics or mathematics education. It is perhaps, therefore, unsurprising that epistemic reflexivity is not a component of teacher education or evaluation.

Nevertheless, conversations about philosophies of mathematics education provided the opportunity to uncover and challenge the implicit assumptions and ideologies (Ernest, et al., 2016) that we unconsciously champion through our teaching practices. Such conversations also allow us to imagine alternatives (Ernest, 1991). The conversations with Rob during the lecture development helped to transform my perception of competence as a mathematics teacher and teacher educator. Competency moved beyond the acquisition of deep, connected mathematical knowledge (Boylan, et al., 2023; Schoenfeld, 2020; Skemp, 1976), and beyond helping learners acquire the tools, knowledge and habits of thought which enable them to work mathematically (for example, Mason, Burton and Stacey, 2010; Mason and Johnston-Wilder, 2004). It incorporated the ability to situate mathematical learning and knowledge within wider contexts of human activity and culture (Ernest, 1991; Skovsmose, 2010b). My view of mathematics education had grown to incorporate the goal of helping students see how mathematics can be used to explain and construct reality (Skovsmose, 2010a; b). Recognising my teaching practice as consistent with descriptions of a multiplistic absolutist philosophy of mathematics (Ernest, 1991) allowed me to see how I maintained a discourse of mathematics as objective, culture-free and somehow above ethical considerations (Yasukawa, Skovsmose and Ravn, 2011), a sharp contrast to my practice when teaching in other subject areas. Whilst I continue to teach the importance of modelling structures, uncovering relationships, respecting properties, finding patterns, setting or uncovering parameters and generalising rules as the basic tools of working mathematically, these are now framed as crucial to developing an ability to understand situations from a mathematical perspective. And whilst making sense of the world mathematically requires an understanding of the principles underpinning what is accepted as mathematically true (Shulman, 1986), the question for me has become true for who and to what end? (Walkerdine, 1990)

The conversations with Rob and the subsequent self-initiated study reframed my conversations with the preservice teachers on our courses. As a result of the EI lecture, three

particular themes became more frequent. First, how a burgeoning epistemic awareness of mathematical knowledge altered personal beliefs about mathematics as a subject of study. Second, a recognition of the power of understanding mathematics for creating more informed and critical citizens. Third, the nature of multidisciplinary learning and the barriers to its implementation.

The first two conversational themes, which fall within areas of interest for critical mathematics education (Skovsmose and Borba, 2004), are closely connected. Conversations made it clear that the preservice teachers' perceptions of mathematics were mostly influenced by their personal experiences as mathematics learners (Ziegler and Loos, 2017) and that they felt their professional practice was framed principally by their individual experiential filters. However, it was evident that shifts were occurring in how they worked on mathematics themselves and how they supported mathematical learning. These students are all employed as teaching assistants or unqualified teachers in primary education, so their views of what it means to be competent in doing and teaching mathematics are shaped, therefore, not only by personal, but also by professional, experiences (Lave and Wenger, 1991; Wenger, 1998). These conversations had significant implications for my practice as a teacher educator.

When imagining teaching alternatives which encouraged an epistemological consideration of mathematical knowledge (Skovsmose and Borba, 2004), I re-evaluated the experiences I provide for preservice teachers as learners, rather than teachers, of mathematics. My goal was to counteract the double discontinuity effect (Kilpatrick, 2019; Ziegler, 2010) whereby teachers, once in the classroom, revert to the, often instrumentalised, teaching style they experienced in school, rather than draw on the ways of working mathematically learned later on. In other words, somewhat counterintuitively, to improve my practice as a teacher educator, I needed to focus as much on how I teach mathematics, as what I teach about teaching and learning mathematics. In order for my ITE students to develop their understanding and use of mathematics to become active, critical citizens (Freire, 1970 / 2017), it is not enough to work on activities or talk about how mathematics shapes our lives. I needed to maintain a constantly reflexive attitude towards how I promoted, and made space for students to prompt, dialogue in the classroom (Skovsmose and Alrø, 2002), how the language I used positions students vis-à-vis mathematics (Wagner, 2007) and how consistently mathematics was presented as a human construct (Gutstein, 2006). Only by ensuring that my teaching practices centre on enabling my students to become mathematically critical and active participants in society, can I hope to encourage similar practices in their classrooms.

The third most common theme, the nature of multi-disciplinary learning and the barriers to its implementation in particular, mirrored a point of sustained discussion with Rob around the meaning of multidisciplinarity and how primary and secondary teachers are positioned to use multi-disciplinary learning in their classrooms. Although primary teachers are trained and teach across a range of disciplines, that does not in and of itself guarantee an understanding of the unique nature of each discipline, its methods of enquiry or norms of thought (Andersson and Gullberg, 2014; Bolden and Newton, 2008). Even the frequently multi-disciplinary nature of primary teaching, using Drake and Burns (2004) definition of an interwoven range of disciplines applied to a particular theme, does not require practitioners to be aware of the epistemic foundations of knowledge in each discipline (Mård and Hill, 2020). Furthermore, even EI's recommendation of the important distinction that should be drawn between cross-disciplinary and multi-disciplinary teaching does not in itself guarantee teachers question their own epistemic beliefs.

It was the realization that, despite our experience as teachers, and previous experience using Epistemic Insight to promote multi-disciplinary thinking (Billingsley, et al., 2020), we were not as able to clearly define the distinctive features of mathematical and scientific knowledge as we had assumed which provided the source of Rob's discomfort.

Rob's story

Looking back, I now recognise that my epistemic beliefs on falsification, framed by my interrogation of research literature, were insufficient to predict the types of questions that are exclusively answerable through scientific enquiry. Research within the secondary science education community of practice largely resides within the positivist paradigm (Bianchi and Turford, 2022). As the practitioner introducing EI to colleagues, I considered my understanding of the distinctiveness of scientific knowledge to be well-established. Thus, initially, I did not interrogate the assumptions that underpin research within science education, or differences between how I labelled questions as amenable to my discipline, compared to a primary mathematics teacher educator. Consequently, my initial assumptions remained unchallenged, and I missed an opportunity to adapt my practice reflexively. Conversations with Nic were invaluable in reframing my perspective and challenging my initial epistemic assumptions. These collegial conversations across disciplinary boundaries were prerequisite to understanding that the reason I identified questions such as 'How do we know the sun will rise tomorrow?' as scientific was based upon curricular awareness of the seasons taught in the KS2 and KS3 (Department for Education, 2013b), rather than the types of knowledge required to answer that question. Until this point, my conversations about Epistemic Insight were restricted to fellow science teacher educators.

Consequently, my underlying assumptions about scientific epistemology and my resultant classification of which questions were answered by science alone remained unchallenged (Applebee, 1994; Craig, Lerner and Poe, 2008). Therefore, I anticipated a top-down process of introducing EI to colleagues in other disciplines, as the expert in the room. The realisation that colleagues outside of my field held differing opinions on the disciplinary categorisation of questions led me back to my community of practice with queries about the security of our definition of the epistemology of science (Oborn and Dawson, 2010). In contrast to my previous experiences with EI, the joint lecture with Nic began a dialogic and dialectical process which has involved reframing the joint enterprise and terms of mutual engagement in my community of practice through a revised repertoire of language and understandings (Wenger, 1998). My emphasis on shattering subject silos in teaching (Billingsley and Hazeldine, 2020) is no longer focused on supporting preservice secondary science teachers to understand how science links to other disciplines, but rather based on a realisation that the epistemic distinctiveness of an individual discipline can only be uncovered when you interrogate the similarities and differences between disciplines and provide an opportunity to converse with experts outside of your specialism.

Although my knowledge of the science curriculum was sufficient to afford critical interrogation of its contents, it is, on reflection, evident that my community of practice was focused on debating the politics of educational policy rather than how scientific knowledge is constructed and by whom it is validated. As a result of cross-disciplinary conversations and resultant encounters with foreign competence (aka Nic) (Lave and Wenger, 1991), I have repositioned myself in relation to my science teacher educator community of practice. In my ongoing research I have begun to critically interrogate my epistemological and ontological perspectives of what science encompasses (Akerson, Cullen and Hanson, 2009; Akerson, et al., 2012), challenging my initial beliefs that science alone is based on falsification. These changes in my positionality mean I also adopt new research methodologies to examine my practice as an early career researcher and ensure the focus of my research is on myself. My research interests have shifted away from developing epistemological awareness among preservice teachers through an integrated teaching approach, instead gravitating toward my developing epistemological awareness, following inter-disciplinary conversations. In contrast to Nic, I would argue that the primary value of our multi-disciplinary conversations has been to refocus my ongoing practice as a researcher rather than a teacher educator.

Both our stories demonstrate that these conversations only came about by trying to work in a multidisciplinary way using the EI framework. The value of this experience has therefore not

been about how to construct a joint lecture with a multidisciplinary focus, but rather how these conversations (which resulted from using the EI framework) allowed us to each gain a deeper epistemic understanding of our disciplinary specialisms and to realise how our assumptions or lack of critique had shaped our pedagogical practices. Our initial individual communities of practice had not offered the opportunity to have conversations like this which provoked a reframing of practice and research.

Now what? Ongoing actions

Our conversational journey has highlighted the need to incorporate a broader purpose for studying individual subjects into teacher education and later professional development. Whilst mathematics represents a 'distinctive form of *human* knowledge' (Haylock, 2024, p.20. our emphasis), it is also a tool at the service of other disciplines. The dominance of its service role in beliefs about why we study mathematics (Ziegler and Loos, 2017), combined with the invisibility of the mathematics present in our everyday lives (Gravemeijer, et al., 2017; Nunes and Bryant, 2022), has led to a narrowed conception of the curriculum, driven by task propensity (Gravemeijer, et al., 2016), and thence to growing rejection of the role mathematics can have in developing connections with other disciplines (Skovsmose, 2010b). This perception of mathematics necessarily limits the professional learning trajectories that teachers follow within their communities of practice. Both primary and secondary preservice teachers tend to demonstrate a focus on subject content knowledge during initial teacher education (Ball, 1990; Bowie, et al., 2019; Verdugo-Perona, et al., 2016). In schools, subject-based professional development is focused almost exclusively on improving children's outcomes (Borko, et al., 2010), leading inevitably to a preponderance of technical initiatives. Our conversational journey has foregrounded an opportunity, and a responsibility, for teachers to emphasise, to learners of all ages, the power and limitations of different disciplines to explain reality.

Valuing substantive knowledge over other forms of knowing is not restricted to mathematics ITE (Davis, Debra and Julie, 2006). Within secondary science ITE, fostering opportunities to work collaboratively with preservice teachers from other disciplines would provide a platform for reflection on the epistemic beliefs on which their view of knowledge is based. Developing collaborative lectures that critically interrogate the purpose of mathematics and science as core subjects can foster valuable conversations that move beyond an instrumentalised approach and therefore reframe a community of practice as multidisciplinary (Kensington-Miller, 2018).

As teacher educators, conversations will continue with each other, with our colleagues and with preservice teachers where we seek to identify subconscious assumptions about the nature of knowledge and illuminate the epistemic foundations on which views of knowledge are based. Our stories manifest a need to return to our initial disciplinary communities of practice to challenge and critically interrogate epistemic assumptions and how these assumptions frame our practice as teacher educators. The hope is that this will influence the type of knowledge we, colleagues and preservice teachers, seek to develop through professional development. This realisation only occurred through cross-disciplinary conversations which interrogated our epistemic beliefs. Membership of a multi-disciplinary community of practice, in and of itself, may not suffice to challenge epistemic awareness.

As research practitioners, the conversation will also continue within our communities of practice. From a mathematical perspective, we believe an examination of what preservice teachers believe the purpose of mathematics to be and to uncover the voices which influence those beliefs (Ernest, et al., 2016) merits further investigation. We recognise that rehabilitating the general perception of mathematics, which has been stubbornly unappreciative in the UK for many years (Mathematical Futures Board of the Advisory Committee on Mathematics Education, 2023; Williams, 2008), is not a short-term endeavour, but the roots for this transformation undoubtedly lie in teacher education and professional development, so that a

different view of mathematics is instilled from the earliest stages of school. Rob's research utilises our ongoing conversations to critically examine his beliefs about the nature of science and investigate how these beliefs frame his practice as a science teacher educator. We propose that cross-disciplinary conversations open opportunities to then examine our own practice within our disciplinary silos and the extent to which we acknowledge the multifaceted nature of our disciplines in our subject specific teaching. Consequently, our interest diverges from the initial aims of the Epistemic Insight Initiative that sought to deconstruct subject silos in the curriculum (Billingsley and Hazeldine, 2020). Instead, we used EI as a springboard to reflexively review our practice as teacher educators and recognise that even expert teacher educators' can hold limited and novice epistemic beliefs (Billingsley, et al., 2023).

Takeaways

In line with our untraditional structure, we are not presenting any findings or conclusions, but rather some points to take away for reflection. The temporal definition of a community of practice is 'sustaining enough mutual engagement in pursuing an enterprise together to share some significant learning' (Wenger, 1998, p.86). The cross-disciplinary nature of our conversations has traced a pathway through the limitations of an intra-disciplinary communities of practice approach by providing a source of external professional development. This development allows not only the formation of new cross-disciplinary communities of practice but, returning from an encounter with foreign competence prompts critical interrogation of practice.

Our conversational journey represents a trajectory through our own community of practice and has resulted in significant changes to our teaching and research interests. In the busy lives of educators, making time for conversations which are not directly about improving practice in terms of student outcomes seems an almost frivolous endeavour. However, very few conversations over the past two years have not produced some new insight. Taking part in academic cross-disciplinary discussions about the purpose or nature of a discipline is to examine the very basis of what we teach, how we teach it and why we teach it. It is to reframe the curriculum content with intentions which will traverse key stages and, more importantly, be applicable beyond school. In this respect, the EI project has offered more than it originally set out to do.

EI inspired conversations offer a counter-narrative to the instrumentalization of mathematics and science teaching by forcing recognition of the humanness of knowledge creation and application. Whilst EI asks pre and in-service teachers to consider their disciplinary knowledge, it is cross-disciplinary conversations which offer an opportunity to critique practice, to consider how to support pre-service teachers to develop criticality within their own disciplines. The learning from these conversations has the potential to outstrip the learning intended by the EI project. And yet, conversations alone will not guarantee a change in practice. It is the continual reflections prompted by those conversations which may cause an evolution of both teaching practice and research endeavours. Thus, this paper which tracks our story exposes how deliberate action to move outside existing communities of practice, and subsequent reflective writing, can transform practice and scholarly activity for teacher educators in England and beyond.

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