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Science religion encounters, epistemic trespass, neighbourliness and overlapping domains: theorisation and quantitative evidence of extent

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Abstract
This study advances a concept of science religion encounter (SRE), with preliminary theorisation and shares findings on the extent and nature of such encounters reported by secondary religious education and science teachers. SREs are interdisciplinary engagements in classrooms involving subject knowledge from more than one subject. The researchers hypothesised they may arise unexpectedly, when a pupil asks a question, or be teacher-planned and intended. This article further elaborates the concept of SRE with reference to the concepts of 'epistemic trespassing' (ET), epistemic neighbourliness, and overlapping domains, introducing these to the field of education. The study is contextualised in the school classroom with quantitative data gathered among beginning and experienced teachers measuring whether this ET in SRE topics enter the classroom via 'spontaneity' or via a 'deliberateness'. This clarifies the different roles a teacher may play and offers considerations for teacher development when navigating an SRE in ways that potentially reduce lost learning.

Keywords Science religion encounter · Religious education · Science education · Epistemic trespass

1 Introduction

This article also conceptualizes 'science religion encounters' (SREs) with reference to epistemic trespass (ET) (Ballantyne, 2019a), a concept born out of the experience of *limelight scientists* commenting on fields beyond their own. This article relates ET to new data on teacher reported SREs in the classroom suggesting that ET has relevance to teachers. The data comes from focus groups and an online survey and shows topic areas where

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secondary school teachers find themselves handling knowledge from another discipline in the classroom. Concept analysis research and empirical data methods are both necessary for a specific and a general reason. The specific reason is that the basic concepts within the investigation are composed of two, science and religion, which themselves are conceptually constructed (Spencer, 2023). The general reason is the critical observation that language is never exclusively propositional, always containing metaphors conveying meanings and actions (Austin, 1962; Lakoff & Johnson, 1980).

Encounters between different kinds of knowledge, developed through subject disciplines following discrete epistemological frameworks, are inevitable and relentless in human experience. At all levels of education and knowledge production, degrees of mingling between knowledges occur. Literature in higher education teaching and research characterises the significant place of interdisciplinary education even within monodisciplinary education cultures (not just multidisciplinary cultures), important as this article is focused on the English education jurisdiction which is monodisciplinary (Klaassen, 2018; Lindvig et al., 2019; Nikitina, 2006; Pountney & McPhail, 2019; Schijf et al., 2022). Top scientific research cites scholarship from other disciplines (Chen et al., 2015) although the correct measurement of interdisciplinary scientific research is an ongoing project (Wagner et al., 2011).

Literature on school curricula confidently emphasizes the value and integrity of separate subjects (Graham et al., 2017/2023) as well as the reliance some subjects have on others. For example, the centrality of language development such as English (literacy, reading and writing) for accessing the curriculum as a whole; and, albeit with a complex relationship map, the sciences' dependencies on mathematics (Penrose, 2004, 2016). Any notion of subject boundary is qualified to the extent to which boundaries are absolute, agreed or whether some territories straddle different domains, or whether multiple subjects hold competing claims regarding those territories.

If 'multidisciplinary' study is significant even in monodisciplinary education cultures which emphasize separate subjects, can we better understand the sites of interaction between the different disciplines at school level? At the more granular level of day-to-day lessons in schools, much less is known. Secondary school pupils pass from subject lesson to subject lesson. They encounter topics that also feature in other subject lessons, or a knowledge kind that belongs to a different subject. This may be intended or planned by the teacher, unplanned and accidental, and may arise initiated by the pupil. The specialist teacher may quickly find themselves in unfamiliar territory needing to engage with knowledge produced through a different epistemological process.

2 The enquiry and the conceptual frames

2.1 An enquiry into science religion encounters

Science religion encounters (SREs) in this article are engagements in religious education (RE) or in science lessons. They occur when something pertaining to religion, ethics or values occur in science classrooms or something pertaining to scientific knowledge or concepts in RE. This study captures teachers' experience of this intersection in their classroom. This curriculum subject area of RE has traditionally included ethics issues and ideas from religion and non-religious philosophical perspectives. Religious and ethical education occur in subjects framed as RE (England) or in some continental countries as religion and

worldviews (R&W), religious and moral education (Scotland) or religion values and education (Wales). For simplicity here RE is used.

An SRE can enter the classroom in the form of:

1) A question asked unexpectedly by a pupil or
2) Something deliberately planned by a teacher, or
3) Something a teacher aspires to teach.

The beginning teacher in the science/religion encounter was a three-phase study investigating the 'encounter' between science and religion in schools as perceived by beginning teachers, commonly known as early career teachers, but in this study combining these with student/trainee/preservice teachers. The first phase used a video research technique that uses clips of recorded interactions in the classroom as reported here (Riordan et al., 2021). The second phase researched the, as yet little-known, science religion understanding and classroom experience of primary and secondary beginning teachers of RE and science in six universities using group interviews and quantitative surveys to generate a comprehensive understanding of where student teachers find themselves at the beginning of their school professional lives (Woolley et al., 2022 and under review). The third phase produced teacher education resources for use to support beginning teachers in this area (https://nicer.org.uk/science-religion-encounters). The project was funded by TWCF and part of a broad programme of research (https://www.templetonworldcharity.org/our-priorities/big-questions-classrooms).

This paper comes out of this project investigating the beginning teacher (the student teacher and early career teacher (ECT)) and the science religion encounter in the classroom. It was an empirical, mixed-methods research project (by NICER, a Canterbury Christ Church University Research Centre that contributes to the university's Anglican foundational purpose to pursue educational research). The project focus on beginning teachers sought to draw on the experiences of new teachers, and provide a snapshot of actual experiences, as well as intentions, of these teachers, aiming to discover the nature and extent of science religion encounters.

This article seeks to establish what is happening in English school classrooms. What are the occurrences where knowledge from one subject is drawn on in another subject area, in the context where the teacher is likely a specialist in one field but not the other. This gains significance in the conceptualisation part of this article where the teacher is considered to be a trespasser. To know more about these engagements is an appropriate precondition to discussions about inter or multidisciplinary matters.

2.2 Science religion

A secondary school-based science religion encounter involves subjects that have a turbulent relationship history (science and religion) in a context where there is concern about the integrity of subject disciplines, with questions about the value of interdisciplinary working, and where a teacher is required or choose to move beyond one subject area, into another.

The idea of the science religion encounter builds on prior literature which has referred to the 'religion-science interface' or encounter in the context of education, learning and teaching (Astley, 2005; Brickhouse et al., 2000; Bunkers, 2001; Wertheim, 1995) and studies such as those involving pre-service elementary teachers (Bickmore et al., 2009). Science and religion present an additional factor in that the history of these two concepts, and

the emergence of one in relation to the other, is marked as an extensive subject field in its own right (Woolley et al., 2022). 'Entangled' histories of historic and ongoing grapplings of questions of what is a human and who gets to decide (Brooke, 1999; Spencer, 2023) may be joined to recent studies in theological and social scientific research that try to make sense of the relationship between the two and how they may contribute to human flourishing (Briggs & Reiss, 2021; Jones et al., 2019; Messer, 2020). A significant element in these entangled histories is the question of magisterial authority (Spencer, 2023), the nature and solidity of the boundaries and the related terms of reference.

2.3 Mono/multi/inter disciplinary

The school-based picture in the English school context can be defined as *monodisciplinary* in that the English curriculum emphasizes discreet subjects with their integrities over cross curricular working. Some literature is wary of multi disciplinarity in curricula, with concern that the boundaries between subjects should be protected and preserved—good boundaries make for good neighbours not least because of a lack of theoretical underpinning and a lack of respect for epistemological distinctness that can emerge in cross curricular working (Niemelä, 2021; Rached & Grangeat, 2021; Standish, 2012). Some have argued schools should teach and assess epistemic insight (Billingsley et al., 2018) and scholarship has identified the development of epistemic gaze and stance taking among children to determine who knows best when two subjects offer an account (Heller, 2018). Logical sequencing within subject has become a particular focus of English school policy, albeit controversially so owing to a lack of empirical evidence (Davis, 2023) but work has also been done to identify the interplay of different subject sequencing in classroom settings. For example, to understand how interdisciplinary processes that enable the synergistic interweaving of mathematics and science content and processes can be effectively framed and enacted (Tytler et al., 2021). This article is not commenting on the relative value claims about interdisciplinary cross curricular learning or mono disciplinary learning but its interpretation may be affected by implicit association with such value claims.

2.4 Epistemic trespass

Science religion encounters strongly relate to the concept of 'epistemic trespassing' and elements of Ballantyne's (2019a, 2019b) theorisation cross over the research design of the SRE project. 'Epistemic trespassing' in the classroom context can be quantitatively measured through the presence of topics that are sites of SRE, entering the classroom via 'spontaneity' or via 'deliberateness'. We are retroactively linking ET to the SRE project as we have seen a conceptual convergence. The sense of encounter with the other (the other epistemology and knowledge it produces) is the threshold to trespass.

The boundary crossing nature of an SRE, raises questions about what Ballantyne calls 'epistemic trespassing' (Ballantyne, 2019a) a concept not yet applied to school education and not known to the researchers at the time of the data collection.

Teachers may be 'trespassers' on a regular basis albeit in ways that differ from Ballantyne's conception, which is based around a person with field leading expertise. They have to transmit knowledge from the 'epistemological family' that is 'centred on the testimony of others' (O'Brien & Noy, 2015), and sometimes this knowledge is 'controversial' (Hand, 2008) as well as in areas where they are not experts themselves. This varies from subjects where there are settled understandings, for example in the methods

to be followed in solving mathematical problems, and those subjects which must manage degrees of disagreement, uncertainty and plurality of answers, more common in the arts and humanities (McCreery, 2005).

'Epistemic trespassing' (Ballantyne, 2019a) is conceptualised as an encounter where a boundary crossing movement occurs across or between subject boundaries. Important is that these boundary lines are 'highly-visible', and that the person is expert in one field, but a relative novice in the other. These experts find the trespassing impossible to avoid. In this regard, Ballantyne observes this often occurs to 'scholars in the limelight', but he argues it happens to other scholars as well. Epistemic trespassers, according to Ballantyne, often intentionally enter a field in which they are not expert themselves. Here Ballantyne distinguishes between (1) trespassers who hold 'confident opinions', versus (2) trespassers who 'investigate questions in another field' (370). With regard to the first category, Ballantyne quite negatively portrays these epistemic trespassers as 'immodest, dogmatic, or arrogant' (370) in areas in which they are not expert themselves. Ballantyne attributes this to a lack of intellectual and epistemic humility. Despite such negativity, he considers it 'epistemically appropriate' to investigate questions that cross into other fields.

ET is a helpful concept for education, in school curricula, and specifically in terms of teachers and science and religion in classrooms. ET helps to operationalise a concept of Science Religion Encounter. Secondary teachers must be viewed as experts in their very own fields whether in science or in religious or ethical studies (Anderson & Taner, 2023). For example, a secondary school science teacher is not expected to have in-depth expertise in topics in RE such as religious ethics or how religious people read creation narratives. Secondary RE teachers are not expected to have in-depth expertise in topics in science such as a comprehensive understanding of vaccination. Both have mastering expertise in their own fields. Thus, a Science Religion Encounter (SRE) relates to a subject topic or a question related to science that is encountered in a RE lesson and treated by the RE teacher, or a subject topic or a question related to RE that is encountered in a science lesson and treated by the science teacher. For example, the moral question of how public authorities decide the level of compulsion around vaccination draws both on the science of vaccination and the ethics and politics of public health.

One element of ET in the context of the classroom, is that teachers do not necessarily intentionally seek to cross subject boundaries. Often, teachers do not seek to fulfil an expert role in another area or may not hold explicitly strong opinions about topics in the other field. Rather, teachers will often fall in Ballantyne's second category of 'investigating questions in another field'. The question investigated may lead a teacher to enter a situation of ET by accident, unintentionally, and as such, may experience a *lack* of confidence and competence. This necessitates some intellectual humility as Ballantyne (2019a) promotes, to make ET 'permissible' when some easement is permitted to allow access into the other territory. Both may be more likely to occur in a more discursive subject such as RE, if dialogue and discussion feature in the lessons.

Overall, ET is associated with both competence and confidence as it requires both care in navigating a careful movement, and a willingness to stray. However, Ballantyne's conceptualisation shows a primary focus on competence and a consequential focus on confidence. Confidence isolated from competence is dangerous, whilst competence accompanied by confidence is desirable, especially among beginning teachers confronted with SREs. It would be desirable to teachers to have an appropriate level of self-awareness about their relative degrees of confidence and competence about their levels of knowledge.

2.5 Neighbourliness, shared domains and trust

ET is a helpful concept metaphor but it has received critique and development from Watson (2022) who has observed that the idea of a shared or overlapping domain also has its uses, using trust and epistemic neighbourliness as metaphors to explore boundary crossing. He draws on ideas of farmer reliant on trusting relationships to manage boundary crossing over each other's land. Watson also suggests that there may be neutral or shared spaces. Shared use of access can occur where there is an overlapping access right. Watson's suggestion is that neighbourliness is also a metaphor that could help navigate, building on the ET concept, especially when there are shared domains, when territory is not solely within one or other's exclusive ownership. However, this is reliant on the relative relationship between the domains, and whether that is weaker or stronger. Watson concludes "My hypothesis is that epistemic neighbourliness is the norm rather than the exception for cases of boundary crossing" (p. 408, 2022).

Watson also drew on the concept of a council of trust to navigate these territories, conceptualising this where there are relationship links between domains, such as different aspects of medical sciences. He considers trust to be key here to mitigate the loss of trust arising from cases of direct deception leading to harm, as in the case of the allegations about the MMR vaccine (Watson, 2022). This is not an undue comparator for education where matters of trust remain around the teaching of science in religious schools that on occasion are found by government inspectorate to be acting inappropriately regarding the teaching of science. In a recent (very small) private school Ofsted inspection, the inspectorate found "the Christian worldview is presented as more important than scientific fact" in a curriculum suggested to present the Bible as an overarching focus in the curriculum, above history and science. This led to serious censoring by the inspectorate following which the school closed (Ofsted, 2023).

There remain sensitivities around religion and science in education settings and part of those sensitivities have epistemic dimensions. It is not clear that all SREs are necessarily movements of trespass as some of the topic areas exist in spaces of overlapping domain interest. This is particularly the case in matters of ethics. An ethical question about a science process or issue is arguably between domains. Explanations for the origins of the universe might be more contentious to locate as 'between domains' however given issues around creationism in science (Reiss, 2011).

2.6 Measuring the extent and nature of SREs

This article seeks to provide empirical insights around the nature and extent of SREs in English school settings, illuminating the topic areas which constitute sites of SRE, where ET might occur, which in turn raises questions about the boundaries and sharedness of subject domains at school level and the sensitivity of the areas in which neighbourliness, and trust, and effective negotiation is required of teachers.

3 Method

This method has been more fully detailed in Woolley et al. (2022) but the following also identifies specific aspects relevant to the focus of this paper which have not yet been published.

3.1 Focus groups

Ten focus groups were recruited through tutors from six universities across England. They were carried out with 50 secondary initial teacher education (ITE) students; seven groups had student RE teachers and three groups had student science teachers. The university ethics committee approved a robust ethical framework prior to data collection, including consent, anonymity and safeguarding of data (BERA, 2018). In addition, focus group participants were required to agree not to disclose contributions from other participants. Lockdown impacted the mode of focus group so that with three taking place face to face and the rest online. The focus group protocol explored different aspects of science/religion encounters in the classroom including the different subject topic areas that participants identified as related to science religion encounters, what might be interpreted as SRE sites.

3.2 The online survey instrument

Participants were recruited through the same six universities, but also through use of social media, subject associations and other teacher education contacts. The survey was accessed in total by 949 participants over a period of 13 weeks, from 12 to 2021 to 14 June 2021. There was variation with respect to the percentage of completion reached. Of the 949 responses recorded, 584 had a completion response of 100%, 68 completed between 100% and 50% of the questionnaire, and 297 had less than 50% completion. It was decided to include only participants who completed at least 50% of the survey (N = 652) to avoid systematic missing cases and completion bias.

Of these 652, 154 participants were, in fact, experienced teachers because they had been qualified for more than two years. They had been, on average, teaching for M = 13.25 years, s.d.= 8.39, min = 2 years and max = 39 years. The number of those who could be referred to as beginning teachers, that is the participants who were currently studying to be teachers or within their first two years since qualification, was 486. In this sample, 82 beginning teachers (17.7%) identified as secondary RE teachers and 76 (15.6%) secondary science teachers and 324 (66.7%) primary school teachers.

This paper is concerned with early career secondary teachers of science and RE. These were defined as either in pre-service training or in their first two years post-qualification and the paper reports findings from 76 secondary science beginning teachers and 86 secondary RE beginning teachers.

Additionally, since the survey was shared through a range of networks 154 unexpected responses from experienced teachers with over two years since qualification were received including 96 secondary RE and 18 secondary science. Though outside the initial boundaries of the project the findings are included for comparative purposes. Experienced respondents were not originally sought out but came about due to the changes in data collection required to continue the project through COVID-19. Strong links into RE networks elicited significant numbers and including that data does show responses over time. However, experienced science teacher responders were far fewer.

The subject areas (extracted from the focus group data set) were listed in survey questions, in the following way:

> *Teachers have shared with us the following topics as possible sites for "Science Religion Encounters" (SRE). Mark the ones you have planned for, the ones where students have raised the topic in a lesson and/or the ones you would like to teach in the future. If you are not interested in teaching some of these topics as an SRE, leave that row unticked.*

The intention was to capture what was going on in terms of beginning planning, which may combine both content on ITE courses and curricula in the classroom, moments of SRE that were pupil generated, and something of beginning teacher interest in a topic.

The methodological limitations to this approach are noted in detail elsewhere (Woolley et al., 2022) but in summary, higher participant numbers would have strengthened the claims. The questions used required responses to a pre-defined list of topics, which has limitations. The sample may have been skewed away from teachers less likely to complete a survey and take interest in educational research. Nonetheless the findings retain validity and raise interesting and significant points.

4 Findings

For the purposes of this article, we select and report here the topics identified by focus group participants, and then in survey data, that are sites of SRE which are the likely sites of ET and the locations of curricula which will require neighborliness and trust, and therefore sensitivity. This constitutes a depiction of the curriculum identified through the perception of teachers.

A wide range of topic areas were identified as sites of SRE. Some are traditionally associated with classic science and religion topics and debates including Origins (big bang, creation stories, evolution), and also ultimate existential questions (death, design arguments, philosophy of science) but additionally present were some 'traditional' ethical matters (abortion, animal rights, blood transfusions, designer babies, stem cells), some ethical matters of global and public health significance (climate change, care for the environment, COVID-19, mass vaccination) and also gender identity.

Pertinent here is the presence of some topics around which there are specific government education policies that explicitly state the value of multi-subject contribution. These topics include relationships and sex education (DfE, 2021) and sustainable development (DfE, 2022) which are areas of educational priority, pupil sensitivity (Schrader, 2004) and sometimes intellectual controversy (Hand, 2008).

The proportions of beginning teachers participants who said "yes" they have planned for this encounter in a lesson, are presented in Table 1. Four observations are made.

First the most popular SRE topics which secondary RE beginning teachers have already planned for are:

- Creation stories (84.88%)
- Design argument for the existence of God (82.56%)
- Death (81.40%).

Table 1 Topic sites of science/religion encounters identified in the focus groups

Abortion	Designer babies
Animal antibodies	Euthanasia
Big bang	Care for the environment
Climate change	Philosophy of science
Creation stories	Stem cell research
Death	Evolution
Design argument existence God	Experiences COVID-19
Blood transfusions	Mass vaccination
	Gender identity

Second the most popular SRE topics which secondary science beginning teachers have already planned for are:

- Climate change (69.74%)
- Evolution (68.42%)
- Stem cell research (68.42%).

Each type of teacher has clearly and unsurprisingly planned to teach topics which sit more comfortably within their own subject specialism. The results show that secondary RE teachers are more likely to report planning for SRE than secondary science teachers and show higher percentages of engagement with the planning of SRE topics. This is the case for the majority but not all topics.

Third, the biggest difference in planned SRE lessons topics was for "Big bang" and "Euthanasia".

Fourth, in every topic experienced RE teachers reported higher values than beginning teachers and higher response rates across more topic areas. SRE teaching increases with experience for RE teachers:

- Stem cell research (from 32.6 to 68.8%)
- Designer babies (32.6–77.1%)
- Blood transfusions (24.4–52.1%)
- Care for the environment (66.3–96.9%)
- Euthanasia (73.3-93.8%).

Science teacher responses cannot be compared in this way due to a low number of experienced respondents.

The proportion of participants who said "yes" they would like to teach this as an SRE in future, are presented in Table 2. Four things are observed here:

First, secondary RE teachers prioritised these topics for future teaching, perhaps suggesting that they had not already had an opportunity to teach them. One could consider these choices stereotypically part of the domain of a science curriculum:

- Philosophy of science (56.98%)
- Mass vaccination (50%)
- Animal antibodies (46.51%)
- Stem cell research (43.02%).

Table 2 Beginning and experienced teachers' planned 'SRE' topics

	Beginning secondary RE teachers %	Beginning secondary science teachers %	Exp secondary RE teachers %	Exp secondary science teachers %
Abortion	72.1	32.9	93.8	27.8
Animal antibodies	8.1	36.8	14.6	44.4
Big bang	77.9	48.7	99.0	77.8
Creation stories	84.9	14.5	97.9	33.3
Death	81.4	30.3	95.8	27.8
Design argument existence God	82.6	13.2	96.9	16.7
Blood transfusions	24.4	27.6	52.1	27.8
Designer babies	32.6	50.0	77.1	61.1
Euthanasia	73.3	18.4	93.8	22.2
Care for the environment	66.3	63.2	96.9	72.2
Philosophy of science	24.4	36.8	49.0	50.0
Stem cell research	32.6	68.4	68.8	83.3
Evolution	72.1	68.4	96.9	77.8
Experiences COVID-19	25.6	55.3	34.4	38.9
Mass vaccination	5.8	53.9	8.3	55.6
Gender identity	48.8	27.6	54.2	22.2

Second, secondary science teachers prioritised different topics for future teaching, which could also be considered the stereotypical domain of RE curriculum. Together with the previous results, this might be a sign that SREs are seen as more appropriate when dealing with a topic that the teachers may know less about because counter-stereotypical of their own subject.

- Euthanasia (43.42%)
- Death (36.84%).

Secondary science teachers were, in general, selecting fewer topics, showing overall less interest in teaching SRE in future.

Third, the biggest differences in percentages can be observed for the following topics and in each case these differences favoured RE teacher interest.

- Animal antibodies (17.6% difference)
- Stem cell research (20.6% difference)
- Philosophy of science (25.4% difference)
- Experiences of COVID-19 (23.7 difference)
- Mass vaccination (25.7% difference).

In general terms beginning RE teachers gave higher response rates to the question of aspiration to SRE topics (Table 3). Beginning RE teachers express a much stronger

Table 3 A table showing beginning and experienced teachers' aspirations to teach SRE topics

Theme	Beginning secondary RE teachers %	Beginning secondary science teachers %	Experienced secondary RE teachers %	Experienced secondary science teachers %
Abortion	24.4	31.6	8.3	5.6
Animal antibodies	46.5	28.9	27.1	11.1
Big bang	22.1	30.3	13.5	11.1
Climate change	26.7	25.0	13.5	5.6
Creation stories	22.1	21.1	11.5	5.6
Death	25.6	36.8	11.5	11.1
Design argument existence God	23.3	23.7	13.5	16.7
Blood transfusions	39.5	31.6	18.8	11.1
Designer babies	39.5	31.6	14.6	5.6
Euthanasia	26.7	43.4	11.5	5.6
Care for the environment	26.7	23.7	8.3	5.6
Philosophy of science	57	31.6	26	22.2
Stem cell research	43	22.4	21.9	5.6
Evolution	27.9	25	13.5	11.1
Experiences COVID-19	34.9	9.2	16.7	11.1
Mass vaccination	50	26.3	37.5	11.1
Gender identity	34.9	31.6	22.9	27.8

aspiration to teach a number of topics that would require high levels of technical knowledge than their science counterparts.

The proportions of participants who said "yes" students raised this topic in a lesson, are presented in Table 4. Three things are observed here:

First, that the SRE topics which RE teachers report pupils raising the most in a lesson are:

- Experiences of Covid-19 (41.86%)
- Death (38.37%)
- Abortion (37.21%)
- Big bang (37.21%).

Second, that the SRE topics which secondary science teachers report pupils raising the most in a lesson are:

- Gender identity (39.47%)
- Experiences of Covid-19 (34.21%)
- Mass vaccination (34.21%).

Table 4 Teachers responding yes to pupils' raising SRE topics

Theme	Beginning secondary RE teachers %	Beginning secondary science teachers %	Experienced secondary RE teachers %	Experienced secondary science teachers %
Abortion	37.2	32.9	20.8	38.9
Animal antibodies	4.7	10.5	10.4	5.6
Big bang	37.2	32.9	17.7	27.8
Climate change	33.7	26.3	28.1	27.8
Creation stories	30.2	21.1	17.7	33.3
Death	38.4	32.9	20.8	27.8
Design argument existence God	31.4	25	16.7	50
Blood transfusions	15.1	17.1	27.1	22.2
Designer babies	17.4	19.7	21.9	16.7
Euthanasia	27.9	17.1	24	38.9
Care for the environment	25.6	30.3	19.8	16.7
Philosophy of science	15.1	17.1	16.7	33.3
Stem cell research	12.8	26.3	16.7	27.8
Evolution	36	25	19.8	22.2
Experiences COVID-19	41.9	34.2	34.4	38.9
Mass vaccination	22.1	34.2	25	22.2
Gender identity	36	39.5	36.5	27.8

Third, the experiences of Covid-19 and death are the topics, between those listed, that pupils seem to be most interested in asking about which is hardly surprising given the circumstances of the research data collection which was during the Covid-19 pandemic.

Fourth, the relative response rates between science teachers and RE teachers show less divergence than planned or aspirational. There were differences of which these 5 show the greatest level of difference.

- Creation stories (9.1% in favour of RE teachers)
- Euthanasia (10.8% in favour of RE teachers)
- Stem cell research (13.5% in favour of science teachers)
- Evolution (11% in favour of RE teachers)
- Mass vaccination (12.1% in favour of science teachers).

There is no consistent pattern of difference between experienced and beginning RE teachers (where response rates for each group are both strong) suggesting comparable experiences over time. Pupils raising SRE topics is a shared experience among secondary science and RE teachers.

5 Discussion

5.1 SRE, ET and the secondary RE teacher

Whether by choice or inclination, RE teachers encounter science in their *trespassing* more significantly than their science teacher counterparts perhaps because of the discursive nature of RE and its curriculum range, particularly in applied ethics. This requires intellectual humility and care around the handling of knowledge from another discipline. Teachers have a greater responsibility to take due care in any trespass, to respect the integrity of the subject that has produced the knowledge. RE teachers also report more highly a requirement to field questions from pupils about the theoretical foundations of the sciences. Considered discussion about science's philosophical foundations was less clearly reported in science teacher experience.

There are both important and also sensitive topic areas that are sites of SRE and therefore the significance of ET in those areas deserve significant consideration. First, this research reveals that sites of science religion encounters are reported in a number of important areas of the curriculum by significant minorities and sometimes majorities of early career teachers. RE teachers on balance report higher responses to SRE topic experiences. Experience of pupils raising SRE topics is something secondary science and RE teachers share. It is noticeable that some subject topics relate to sustainable development and environmental ethics.

Second, RE teachers also report SREs in areas of high sensitivity, specifically in matters of relationships and sex education where there exist English government policy ambitions noting the value of multiple subject contribution. There are many questions that could be asked about the navigation of that topic in RE, given the socially conservative position many religious communities have on matters of sex, gender and ethics.

RE teachers report higher responses to their ambition to teach SRE topics. They report a willingness to intentionally cross boundaries or trespass into other epistemic territories to a greater level than science teachers. It is not obvious that RE teachers are choosing to trespass. They may be required to do it. Some of these are topic areas commonly found in RE curricula due to their bearing on ultimate issues and ethics, raising questions about domain agreement and boundary. A subject concerning ethics inevitably draws on knowledge sets from other subjects as soon as it engages practical or applied ethical topics. Ambition is therefore not necessarily an expression of teacher autonomy but curriculum requirement and, surprising as this may seem, it appears that some subject matter is more likely engaged in RE curricula, such as the philosophy of science. The encounter or act of trespass may be necessary as much as chosen as a requirement of curricula that require scientific knowledge or it may be *apparent* trespass.

Perhaps the philosophical foundation of knowledge is more properly 'outwith' the science curriculum, however surprising this might seem. RE does not have the same solidity of disciplinary boundary as is present in science given its inheritances from theology, philosophy and the social sciences. The sciences have discreet disciplinary identities with theoretical and practical distinctions, but the range of values in the subject knowing structures of the disciplines that contribute to RE are extensive and sometimes contradictory. Consider analytical philosophy and Zen contradictory though; mystical and experiential encounters and evidence based social scientific research.

It may also be that, given that RE teachers teaching ethics find themselves in other subject areas, they have a legitimate disposition to explore different subject areas and

the subject itself might attract teachers with that disposition precisely because it wanders widely into human experience.

5.2 Blurred lines

These findings suggest science religion encounters are not an obscure or minor area of interest, but rather a significant budgie in the coal mine for the extent to which students are supported in learning to make sense of topics treated by different epistemological frameworks.

Epistemic trespassing is likely taking place but the outcomes (intended or otherwise) of that trespassing is unclear. Sometimes the SRE occurs in a shared or overlapping domain space and so it is not so much an example of ET. But many topics debated in RE require knowledge from science and therefore will contain a component of ET.

These areas can be viewed as shared domains where the organisation of topics can legitimately be structured through different epistemological frameworks, such as those concerning matters of right or wrong, and how such positions are established, and those providing indications on the impact of human activity on global conditions, for instance, and how that evidence is held to be secure.

Beyond the question of trespass and subject boundary, the concept of an overlap within these subjects requires further attention. How are plural axiologies negotiated? How should a teacher move from scientific evidence about global warming to moral responses to that, given the historic philosophical debates around moving from 'is' to 'ought'? It is not clear that all SREs are necessarily movements of trespass as some of the topic areas exist in spaces of overlapping domain interest. Explanations for the origins of the universe might be more contentious to locate as 'between domains' given issues around creationism in science (Reiss, 2011).

5.3 Supporting pupils with curriculum planning

We do not know anything about the nature of teacher responses to those occasions and movements, but see that they are in areas of sensitivity and social and personal significance. Epistemic trespass or shared domain navigation is required by pupils for teachers to respond to these unplanned encounters and teachers are in a similar position to the public figures Ballantyne speaks of.

Irrespective of arguments for or against mono disciplinary or multidisciplinary curricula, encounters between subjects are inevitable, and likely necessary at some basic minimal level so some provision must be made for navigating them. Is it to be left to individual pupils and teachers to navigate these? If so, what support is given? Is it something that can be left to school ethos of leadership to direct? In which case what are the limits of such direction?

Pupils are agents of science religion encounters, raising questions with teachers and placing demands on teachers to respond, possibly in territories outside their specialist area of knowledge. There is no data on the motivation for these questions but given they are being asked we can speculate on several possible motives: wondering in the mind of the pupil questioner; curiosity or distraction desire provoking a teacher to trespass beyond their subject into another subject area; and necessity of understanding as a related knowledge area to that which is studied. Whatever the motive, given the topic list, it would appear that students are asking teachers to provide help in navigating these areas.

Science religion encounters may be sites of boundary crossing and epistemic trespass which present questions about effective navigation. There is a risk that a pupil may be confused about two kinds of knowledge, especially if there is no navigation assistance. There are risks that teachers may reach beyond the area of specialism to draw on knowledge and misrepresent knowledge from outside their specialist area of confidence and competence. Some coordination and support across the two department/subject areas is recommended on the basis of these findings.

It would be important to know that topics covered by each subject had appropriate comparability in terms of knowledge to assure accuracy and also identify potential points where some explicit intervention is necessary, even in a monodisciplinary subject curriculum. Schools would be encouraged to take note of curriculum sequence of the relevant knowledge and how it appears in the two subjects to optimise learning and avoid confusion.

Epistemic trespass does have limits as a metaphor concept because at the point that there are ethical questions about matters involving scientific knowledge, this may more properly be understood as a shared domain, although that would be far more sensitive in subject topics related to matters of origins. Could curricula be constructed to show more clearly where the subject domains are, where there is necessary respectful boundary crossing, and where there are spaces that have overlapping domain interest? Might Watson's (2022) idea of an epistemic council of trust be helpfully translated into school contexts to provide clarity and advice for teachers tending the curriculum and pupils' navigation of it?

5.4 Further work

Given these considerations, further work is recommended around: (1) how students navigate these different ways of knowing (aided or otherwise by teachers); (2) how effectively schools manage cooperation across curriculum areas whether between similar or different epistemologically framed subjects; (3) what the impact is of unguarded poorly navigated epistemic trespass, such as over reach from one subject into another subject's domain or in territories where there is an overlap between the domains, such as in matters of ethics and science.

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Data availability The data that support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions. The data for this research were collected from a series of focus groups held either face-to-face or online with university students across England and an online survey advertised through universities, subject associations and teacher social media in England.

Declarations

Conflict of interest The authors have no conflicts of interest to disclose.

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