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Teachers' perspectives on the relationship between secondary school departments of science and religious education: Independence or mutual enrichment?

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Abstract

There is a gap in the research on the relationship between secondary school subject departments, particularly where, as in the case of science and religious education (RE), there is not the traditional relationship that may be seen in science and maths or across humanities subjects. More awareness of content taught in other departments is important for pupils' coherent experience of curriculum and schooling. This article reports on data from 10 focus groups with 50 participants from six universities, where student teachers of science and RE revealed a complex picture of relationships between the two departments in their placement schools. Furthermore, this article reports findings from a survey where 244 teachers and student teachers of science and RE shared their perspectives on the relationship between the two school departments. The measure was adapted from Barbour's typology, a classification describing the nature of the relationship between science and religion in a range of literature. The terms 'conflict', 'independence', 'dialogue', 'collaboration' and 'integration' were presented to teachers of both subjects. Little evidence was found of conflict between science and RE departments, but more 'independence' than 'dialogue' between the two departments was reported.

In the light of these findings, the benefits of boundary crossing are explored alongside the role teachers should play in boundary crossing.

KEYWORDS
Barbour's typology, boundary crossing, interdisciplinary learning (IDL), religious education, science education

INTRODUCTION

In recent years, subject departments in English secondary schools have tended to work independently and discretely. The National Curriculum (Department for Education [DfE], 2014) implemented by the coalition government saw a move away from emphasis on connections between subjects, explicitly encouraged under the previous iteration (QCA, 2007). However, many substantial topics such as climate change or the origins of the universe cross disciplinary and subject boundaries. In considering pupils' holistic understanding of such topics, it is important to consider the awareness departments have of what is being taught on similar topics in other subject lessons. This article is, therefore, important, as it reveals the limited nature of the relationship between two subject departments which can both cover the same substantial topics, science and RE. Pupils' connections between topics taught in different lessons can be left to chance, or they can be more deliberately supported and guided by teachers. Under the terms of the National Curriculum, since its inception in the 1988 Education Act, the study of both science and religious education (RE) is compulsory to 16. However, the details of the RE curriculum are set out locally, through Standing Advisory Councils for Religious Education (SACRE). Considering how topics are taught across the two subjects is therefore not a simple comparison of National Curriculum documentation. Interdisciplinary learning can come not only from fully integrated lessons, but can also be seen in a simpler form when pupils are encouraged to make connections between the knowledge taught in discrete subject lessons. If pupils are not encouraged to make connections across curriculum boundaries, then there is a danger they can walk away with limited perspectives on complex topics. It is our contention that positive relationships between subject departments of science and RE are necessary to build teachers' awareness of boundary crossing opportunities.

This article provides a comparison between two relationships. The first is the historic relationship between the two fundamental concepts of religion and science, on which much has been written over many decades (see McGrath, 2020), and where different forms of that relationship have famously been categorised into a typology by Barbour (1966). The second, at an embodied level, is the relationship between secondary school departments of science and religious education (RE) where less has been written. The authors suggest that there are some revealing parallels worth exploring within this comparison. There can be doubts about using a simplified model to explain complex epistemologies and the detailed relationships that occur at school level. Barbour's work on the relationship between science and religion was seminal (McGrath, 2020), and is referred to in much of the literature on teaching science and religion in schools (Pearce et al., 2021). The combination of focus group and survey data in this article seeks to use Barbour's typology as a point from which more nuanced relationships can be explored. While we acknowledge that Religious Education is not the only subject where pupils learn about religion, and that Religious Education extends beyond the study of religions, the data in this article only comes from teachers and student teachers of science and RE.

The relationship between school curriculum subjects has been a focus of recent interest (Chan & Erduran, 2022; OECD, 2019); revised national curriculum documentation has encouraged interdisciplinary learning (Scottish Government, 2008) or integrated approaches to learning and teaching (Welsh Government, 2022). We argue that building dialogue between school subject departments is a necessary precondition to meaningful interdisciplinarity on the school curriculum. Using the language of Barbour's typology on science and religion with the parallel relationship between school departments of science and RE reveals nuances and gradations in existing relationships. Furthermore, using Barbour's justification of his typology can provide a new way of thinking about relationships between school departments, a need to encourage dialogue between teachers of different subjects. There are critical debates on the purported value of interdisciplinary education and we are not seeking to make a case for one or other side of those arguments. Rather, we see that there is legitimacy in investigating the nature of interdisciplinary connection between these subject departments because there is a unique cultural interest in science and religion and a general desire to see how learning is organised in schools to serve the best interests of pupils.

There is little empirical work that directly explores the current relationship between school departments of science and RE in English schools. This relationship is of particular interest as, historically, the language of war or conflict has been used to describe the relationship between science and religion (McGrath, 2020) and it is therefore reasonable to suggest that tensions may have existed between the ideas taught in school RE lessons and the ideas taught in school science lessons. More recent academic work suggests there is now less perception of conflict between these two ways of thinking about the world, particularly in England (Spencer & Waite, 2022). When recent empirical work has implicitly touched upon the relationship between departments of science and RE, findings differ. Where some describe compartmentalised subjects (Billingsley et al., 2018), others develop research projects dependent on collaboration between the two departments (Erduran et al., 2019; Pearce et al., 2021). Erduran et al. (2022) have suggested that collaboration between science and RE teachers is 'rare' and that there is 'typically minimal interaction between science and RE teachers internationally' (p. 668). Understanding the current relationship between departments would appear to be a necessary precondition to facilitating boundary crossing, whether as part of an intentional interdisciplinary curriculum (as in Wales) or an understanding of pupils' experience of a coherent curriculum (as in England).

This article builds on research from a large-scale project funded by Templeton World Charity Foundation exploring teachers' confidence and competence in science/religion encounters in the classroom (Bowie et al., 2023, Riordan et al., 2021). (A science/religion encounter was defined as when scientific topics creep into the RE classroom or religion or ethics creep into the science classroom). The findings of the wider project identified some of the processes necessary to effect meaningful boundary crossing, a particular precondition being the need for teachers to understand the purpose of the 'other' curriculum subject before collaboration (Woolley et al., 2022). This article sets out a justification for a second precondition to interdisciplinarity: The need for dialogue between subject departments.

In the following sections, we explore aspects of interdisciplinarity, particularly in relation to boundary crossing, powerful knowledge, the role of the teacher and the need for teacher-to-teacher dialogue beyond curriculum discipline boundaries. We then set out Barbour's (Barbour, 1966) typology on the relationship between science and religion and some of the critique on his work. Our methods are explained and justified, particularly the decision to adapt and share Barbour's typology within a broader online survey for teachers of science and RE. Two sets of empirical data are then explored against this context. Following Barbour, we argue that a relationship of independence between school departments of RE and science is not sufficient; dialogue between departments and teachers of science and RE needs to be explicitly encouraged for mutual enrichment.

LITERATURE REVIEW

Two sets of literature are considered here. First, the concept of interdisciplinarity is explored, with particular reference to boundary crossing and the role of the teacher in order to show the importance of building relationships between school subject departments. Second, Barbour's (1966) work is considered, along with some critique in order to justify the use of his typology as a survey item.

Curriculum boundary crossing between science and RE

Interdisciplinarity can be difficult to not only define, 'a concept of wide appeal', but also 'wide confusion' (Klein, 1990, p. 11). Klein (2021) has suggested that interdisciplinarity connotes an integration of concepts, methods and theories from multiple disciplines in order 'to answer a question, to solve a problem or to address a topic or theme that is too broad or complex to be dealt with by one discipline' (p. 17). She distinguishes between narrow interdisciplinarity, which occurs between disciplines with compatible methods, paradigms and epistemologies, and broad interdisciplinarity which occurs between disciplines with different epistemologies and methods. Relationships between school departments of science and RE therefore demand broad interdisciplinarity due to the contrast in epistemologies and methods. Darbellay (2015) identified two different discourses about interdisciplinarity which are also worth detailing here as they exemplify some of the debate over interdisciplinarity in schools. He distinguished between an 'epistemological theoretical orientation that transcends disciplinary boundaries and a pragmatic, participative orientation to problem solving' (cited in Klein, 2021, p. 27). Klein explains that 'the epistemic approach is philosophical, raising questions about the nature of knowledge amplified by ontological questions about the nature of reality. In contrast, problem solving is oriented to instrumental needs' (p. 27). This distinction between two academic lines of argument relating to interdisciplinarity proves useful when the quality of relationship between school departments is considered.

In schooling, interdisciplinary approaches are distinct from the broader, content-led, cross-curricular approaches involving 'removing subject boundaries' that came to dominate some secondary schools in England after the inception of the 2007 National Curriculum (Oates, 2011, p. 128). In their three educational scenarios for the future, Young and Muller (2010) wrote 'the end of boundaries' in a particular 'Future 2' of their three possible futures. In this 'Future 2' model, school subjects might be integrated as 'boundaries between subjects and between school knowledge and everyday knowledge are weakened' (p. 18). Niemelä (2021), however, has argued that curriculum boundaries can be drawn and crossed to support the development of powerful knowledge through a coherent curriculum design. Hu (2022) argues that interdisciplinary efforts do not necessarily involve diminishing disciplinary boundaries, but suggests the need for a connection to the disciplinary core that provides stable internal norms, for example, established procedures for judging truth claims.

The National Curriculum in England (DfE, 2014), in defining learning in terms of subjects, delineates clear boundaries between subject disciplines. However, there are arguments for making the connections between subjects explicit so that pupils can benefit from boundary crossing. Boundary crossing is a geographical term by origin, pointing to a distinctive line between one land and another (Akkerman & Van Eijck, 2013). Boundaries can, however, be seen as permeable and contingent; boundaries can be crossed or bridged; interacting, integrating and collaborating can occur at boundaries (Klein, 2021). Essentially, boundaries carry potential for learning (Akkerman & Bakker, 2011). Thomson et al. (2021) have suggested 'those who cross boundaries will cross and return, share and cooperate… benefit mutually and eventually transform' (p. 58). They stress, building on the work of Giroux (1992)

and Akkerman and Bakker, that 'difference creates an opportunity for learning and should therefore be considered positively rather than as a problem to be overcome' (p. 59).

The authors of this article see that interdisciplinary learning in schools can be carefully constructed, where teachers work closely to bring subjects together, or can occur by chance, when pupils are taught the same topic in different lessons and are expected to make connections for themselves. However, the authors argue that pupils' boundary crossing may be left to chance if teachers are not willing to engage in their own boundary work. This can be daunting, perhaps particularly for teachers, who are more established in certain disciplines through their academic qualifications. As Akkerman and Van Eijck (2013) put it, 'when people cross boundaries their position is one of belonging to multiple worlds, but also one of being a marginal stranger to each of these worlds (63). Suchman (1994) suggested that professionals at work, in boundary crossing, enter "unfamiliar territory" and may feel "unqualified" (p. 25). While Niemelä (2021) has argued that boundary crossing should be considered at the level of the written curriculum, therefore placing responsibility in the hands of policymakers, there is an argument for teachers to take a more agentic role in crossing boundaries through dialogue with other teachers, in order to provide a more coherent curriculum for pupils. Fortus and Krajcik (2012) suggest a coherent curriculum is designed to support teachers in understanding the connections between and within subjects and how learning progresses cumulatively.

Far from weakening boundaries between subjects, projects such as the *Oxford Argumentation in Science and Religion* project (Erduran et al., 2019) or *The New Biology* project (Pearce et al., 2021) seek to identify links between the two subjects that can help pupils identify and explore disciplinary boundaries, emphasising and exploring the interfaces between science and religion. These projects show careful, nuanced planning between the school subjects of RE and science that places issues of epistemology centre-stage exploring how knowledge and argumentation work in different disciplines. In both projects, pupils are encouraged to explore the way knowledge is constructed and organised in both science and religion, taking the interdisciplinarity beyond the pragmatic, towards an epistemological approach that necessitates deep dialogue between subject teachers across curriculum boundaries. If such dialogue is to become more commonplace in schools, then it is necessary to explore existing relationships between science and RE departments, from the perspective of the teachers, so that teachers from the different subject disciplines can be supported to initiate and deepen their dialogue.

Barbour's typology

Barbour's (1966) pioneering *Issues in Science and Religion* described the relationship between science and religion in a broad range of literature. This typology, or classification of the literature, consisted of four sections: conflict, independence, dialogue and integration. Barbour reworked and developed the explanation of his typology in a number of publications over ensuing decades (Barbour, 1990, 1997, 2000). In terms of 'conflict', he wrote scientific materialism and biblical literalism, at opposite ends of the theological spectrum but sharing characteristics in that both believed there were 'serious conflicts between contemporary science and classical religious beliefs' (Barbour, 1997, p. 78). Under the title of 'independence', Barbour (1997) suggested that 'one way to avoid conflicts between science and religion is to view the two enterprises as totally independent and autonomous' (p. 84). According to Barbour, proponents of this view say 'there are two jurisdictions and each party must keep off the other's turf' (p. 84). Contrasting methods and differing languages are described. Barbour, however, did not encourage independence, despite acknowledging that 'the possibility of conflict would be avoided' (p. 89). Crucially, he argued that, if independence

between science and religion was encouraged, 'the possibility of constructive dialogue and mutual enrichment would also be ruled out' (p. 89). Barbour placed the term 'dialogue' between 'independence' and 'integration', giving examples such as methodological parallels between science and religion and nature-centred spirituality. He highlighted, for example, environmental ethics as a feature of nature-centred spirituality (Barbour, 1997, p. 97). For 'integration', Barbour suggested there was a final group of authors that held some integration was possible between the 'content of theology and the content of science'. He provided three distinct versions of 'integration', including 'natural theology' where it is claimed that 'the existence of God can be inferred from the evidence of design in nature, of which science has made us more aware' (p. 98). Barbour himself, commenting on the relationship between science and religion, suggested there were reasons for supporting dialogue and 'certain versions of integration' (Barbour, 1990, p. 3).

Barbour's typology has been subject to some critique and attempts have been made to refine or replace his classic categories. Reiss (2007) has pointed out that Barbour did not provide a reason as to the order of his listing. Peters (2018) put forward eight alternative ways of relating science and theology including scientism, hypothetical consonance, ethical overlap and New Age spirituality. Hoven (2013) has suggested this model acts as a corrective of Barbour's approach which did not clearly differentiate between the many non-warfare metaphors. There are, however, arguments to be made in favour of using Barbour's typology with teachers. Jesse (2006), in using the typology to promote discussion among pre-service teachers, justified its use 'because it has shaped our thinking on this topic for so long' (p. 231). Reiss (2008) suggested there is value in student teachers being introduced to 'a range of models as worthy contenders' (p. 164).

Historically, conflict, or warfare, has been a predominating metaphor used to describe the relationship between science and religion (McGrath, 2020). Recently, Theos and The Faraday Trust (Spencer & Waite, 2022) have carried out research to explore contemporary attitudes to science and religion in the United Kingdom. They found a shift in attitude over the last 20 years and suggest that 'the angry hostility towards religion engineered by the New Atheist movement is over' (p. 10). While they report that there is a 'legacy of antagonism' around science and religion (p. 10), they conclude that much of the science and religion 'battle' has been smoke 'but without much real fire' (p. 12). Rather than the 'conflictual' lenses of the Big Bang and evolution, Spencer and Waite suggest there are still tensions around deeper concerns such as epistemology, metaphysics, hermeneutics, anthropology, ethics and politics. This raises important parallels for the areas where science and RE might intersect on the school curriculum; there may be potential for boundary crossing through deeper concerns, rather than the more 'conflictual' lenses of the Big Bang and evolution, but supporting pupils' in such boundary crossing would require deep dialogue between teachers.

MATERIALS AND METHODS

This article draws on data from a larger research project investigating the early career teacher and science/religion encounters in the classroom. The broader research project took an interpretivist, mixed-methods approach to data collection, intended to capture some of the language and experiences of student teachers through focus groups, then explore the generalisable nature of those experiences through an online survey disseminated to a wider set of participants. The research question informing this part of the study was:

- How do secondary teachers of science and RE describe the relationship between the science and RE departments in their schools?

Ten focus groups were carried out with 50 secondary initial teacher education (ITE) student teachers from six universities across England; seven in RE and three in science. (Participants from the different subjects were recruited in the same way, through ITE tutors, with more RE students answering the call, hence the discrepancy in numbers). We were particularly interested in early career teachers, their experiences of science/religion encounters and how they might best be supported in this area. A robust ethical framework was agreed by the university ethics committee in advance of the data collection to ensure informed consent and anonymity of participants alongside appropriate safeguarding of data (BERA, 2018). Three focus groups took place face-to-face; a pandemic led to others being held online. Book vouchers were offered to all focus group participants to attract a wider range of student teachers, including those without prior interest in science/religion encounters in the classroom. A review of the literature and the research questions of the broader project led to a semi-structured protocol including questions about participant's experiences of science/religion encounters, confidence in approaching science/religion encounters and support or barriers to planning for science/religion encounters in the classroom. The focus groups each had between 3 and 8 participants and lasted around an hour. The focus groups were recorded and transcribed. While there are few of the focus groups that have individual participants answering questions from the researcher, most of the data show the student teachers responding to one another and building on or reacting to examples. Most of the focus groups with secondary student teachers took place towards the end of the PGCE year so that participants were able to describe their experiences across different placement schools. The focus groups were almost all conducted by two of the authors of this article, with a third author joining for one of the focus groups. Each of these authors has extensive experience working in ITE and in conducting focus groups.

The authors have experience of accessing 'hard-to-measure' areas by using focus groups first to explore an area of interest, then using analysis of the focus group data to inform items and language in a survey. Focus group data was first analysed inductively through thematic analysis, establishing initial codes and then forming those codes into themes (Braun & Clarke, 2022). Results from this data are reported elsewhere (e.g. Woolley et al., 2022). The semi-structured focus group protocol did not include a specific question on the relationship between science departments and RE departments in schools. However, analysis showed frequent comments that described such relationships. Codes with more than one item included 'collaboration', 'comparison science and religion', 'dialogue science religion', 'dichotomy science or religion', 'religion in science classroom', 'science in RE' and 'separate subjects'. In this methodology, responsive to findings at each stage, the overlap in language between these codes and Barbour's (1966) typology was enough to convince us to include an item on the online survey using Barbour's typology to explore the relationship between science and RE departments from the perspective of teachers. As we were seeking to research the relationship between school departments, based on this initial analysis of the focus group data, we decided to slightly adapt Barbour's typology by including the term 'collaboration' alongside his four original terms. Once the online survey data was analysed, we wanted to know more about what participants might mean when they used the terms 'independence' or 'dialogue' to describe the relationship between the two departments, so we returned to the data from the focus groups and completed a deductive analysis, specifically against the terms from the typology, with 'collaboration' included. Examples from this analysis are included in the focus group findings below.

An online survey, with over 70 items devised from analysis of focus group data, was shared with ITE providers across England between March 2021 and June 2021. It was also disseminated to practicing teachers through alumnae networks and social media. The survey was aimed at early career teachers of science and RE, defined as either in pre-service training or in their first 2 years post-qualification. Sixty-five early career secondary science

teachers and 76 early career secondary RE completed over 50% of the survey including the particular item on departmental relationships, which it was decided was the appropriate level to be included in the analyses for this article. As the survey was advertised through professional contacts and social media groups, a number of experienced teachers, with more than 2 years teaching post-qualification, also completed the survey. We include data from 85 experienced RE teachers and 18 experienced science teachers below. However, as the number of experienced science teachers is comparatively low, only tentative claims are made from this second set of data. Online survey participants agreed they had read an information sheet about how data would be used, stored and reported. On completion of the online survey, participants could choose to be entered into a draw to win vouchers, an incentive intended to publicise the survey in a period when teachers were under pressure due to the pandemic lockdown. One item, towards the end of the survey, asked participants to describe the relationship between the science and RE departments in their school. Five choices were provided in alphabetical order so as not to suggest a hierarchy: collaboration, conflict, dialogue, independence and integration.

There are methodological limitations to this approach. Student teachers in the focus groups were not asked directly about the relationship between science and RE departments. It is possible that early career teachers would not know the full details of the relationship between science and RE departments in their school. Higher numbers of participants would have contributed to stronger claims, but the pandemic limited initial plans for recruitment of survey participants. The participants in the online survey were not given the opportunity to explain what they meant when selecting the terms 'independent', 'dialogue' or 'integrated' and so data on this is extrapolated from a different sample of pre-service teachers in the focus groups. The two sets of data, however, used together, do suggest different levels of relationship and claims are adjusted for these limitations. Through the analysis we came to realise that student teachers in the focus groups could be reporting on both what they had observed in lessons taught by others and their own experiences in the schools. As all student teachers would have access to both observations and experiences, this limitation was outweighed by the breadth of experience provided. The English school system has many layers of complexity, with faith schools, independent schools, science specialist schools and more. It is possible that some of these differences in mission and purpose could have had an impact on the relationship between the science and RE departments in the schools, but due to the complexity of the context, the authors of this article have chosen to group the schools together rather than focus on potential differences in the relationship in different types of school.

FINDINGS

Focus group findings

Examples of conflict

For the purpose of this analysis, a broad definition of conflict has been utilised. There were no examples given of arguments or explicit disagreements between subject departments or teachers, however, there were a few examples of tension. Two participants in the focus groups reported a tension between the scientific ideas pupils were bringing to the lessons and the intentions of RE lessons:

> I get it all the time, it's a very atheist school, my school and I get it all the time in my lessons, "Oh no, science says this. It can't be true". [student RE teacher, FG9]

It is possible that the pupils described brought these particular scientific ideas from outside school, and that these ideas of science and religion being in conflict were not represented within the school. However, as the teacher does not describe the differences being resolved, the example does suggest some challenges in the relationship between science and RE departments in the school. Two further student RE teachers described tensions between themselves and particular student science teachers that they approached for joint-planning linked to university course requirements. Although these examples do not suggest conflict between departments, they are indicative of some tensions between a small number of science and RE student teachers.

Examples of independence

This section describes three scenarios where the relationship between science and RE department could be described as one of 'independence'. The first is where there was no contact between teachers of science and RE. The second is where student teachers perceived there was no overlap in content between the two subjects. The third is where similar content was taught, at times, in science and RE, but the two departments did not communicate about that shared content.

When asked if there was any conversation between science and RE teachers in a placement school, one RE student teacher replied, 'our departments are nowhere near each other, so no' (student RE teacher, FG1). A teacher from another focus group in a different part of the country supported this experience:

> the school that I've worked in recently and my first placement, there didn't appear to be any dialogue between different departments. And I find that quite strange. [student RE teacher, FG4]

This lack of contact between the two departments could be a particular problem for student teachers:

> Never actually seen an RE lesson unfortunately. [student science teacher, FG7]

Three focus group participants spoke specifically of school placements where they were not aware of any overlapping content between science lessons and RE lessons, although complete knowledge of curriculum content may have been affected by the global pandemic during some school placements. These examples suggest that, in these schools, there was no planned discussion of scientific issues in RE unless a pupil raised a particular question and the teacher had the time and knowledge to answer appropriately.

More common than the lack of content crossover described above, however, were descriptions of content taught in both science and RE, but with no knowledge of what details the other department was teaching or when they were teaching it:

> There's certain content crossover if that's something that I can bring up. Like the origins of the universe is taught in both and it's obviously taught in very different kind of viewpoints. We've talked about things like euthanasia, abortions. A lot of abortion talk is you're setting up with the scientific fact of when the foetus is a person and deciding that. So there's certain content crossover that needs to be there and needs to be established from the science. [student RE teacher, FG5]

Such examples of each separate department teaching content which overlapped the content of the other, science or RE department, were given frequently by student teachers, supporting the quantitative evidence below, that 'independence' commonly describes the relationship between science and RE departments.

Examples of dialogue

'Dialogue' might involve ongoing conversations between teachers of RE and science or discussions about related topics that teachers from each subject were covering. No examples of such dialogue were reported by the student teachers in the focus groups. However, there was one science teacher who approached an RE teacher for support in subject knowledge development and there were some examples of planned synchronous teaching of certain overlapping topics. Each of these were coded as 'dialogue' as they involved conversations between staff members. They also involve something more than 'independence' and something less than 'collaboration'.

The one example of a student science teacher seeking out support from a teacher of 'Religion' [sic] related to his fear that his lack of knowledge might cause misconceptions among pupils:

> The kid that was doing the dissection was Muslim. So there was a conflict between religious belief and science with that student. And she didn't want to go against her religion which is completely understandable. But the rest of the kids who weren't Muslim didn't understand that. And for me it was trying to present information to the rest of the kids that had never encountered this before so they could understand… rather than give out incorrect information. I went and asked one of the Religion [*sic*] teachers if they'd anything about it and then I went through that the first thing the following day with those kids. So they understood why. [student science teacher, FG7]

Here, the student science teacher had a very particular question to ask, but he also knew who to approach in the RE department and his request for support resulted in better-informed pupils.

In a further example of 'dialogue', two student teachers described a form of cooperative planning in their placement schools where certain topics in RE were taught in parallel to the same topics in science lessons:

> I know my school, when they're teaching about creation, they plan and work with the science department so that it's being covered at the same time. So the students are able to get a more in-depth understanding of it than maybe what we'd be able to deliver them as RE specialists. [student RE teacher, FG6]

These are examples, given by student teachers, of dialogue between teachers across subject boundaries. Student teachers did not report regular dialogue between science and RE departments in their placement schools.

Examples of collaboration

Examples of collaboration included science teachers going into RE lessons to support teaching or student teachers working across subject boundaries on university-led

assignments. Two student RE teachers described science teachers coming into RE lessons to support or deliver part of the lesson, bringing expert scientific knowledge to the lesson:

> We did creation and we aimed it at Year 8. It was actually really helpful working with this [science] teacher. [student RE teacher, FG1]

> For the Polkinghorne [science and religion debate] in Year 13, we do get a physics teacher to come in and sort of give them a bit of background. And I think there's a topic in Year 8 about humanism as well and environmental ethics where a science teacher might come in and just do a bit of a lesson with us. [student RE teacher, FG1]

A small number of the student teachers who took part in the focus groups had studied modules on teacher education programmes that encouraged them to collaborate with teachers from another subject:

> We were looking at stem cell research and I designed a lesson with the biology student at our school. We never actually taught the lesson but just to design it… Where my assumption of what the ethical conflict would have been in stem cell research would have been based on incomplete knowledge of the science and where you can get stem cells from. [student RE teacher, FG2]

These examples show it was possible to take a collaborative approach to planning overlapping topics.

Examples of integration

There were no examples from the student teachers of rich, sustained cooperation that might be described as integration. There were no examples of a series of lessons being planned together, for example, or drop-down days, or subject boundaries being broken down with the specific intention of integrating subjects under shared topics or competences.

Aspirations for dialogue

The student teachers interviewed may not have given many examples of dialogue and collaboration between science and RE departments, but many aspired to build a better relationship in their future schools.

> I want to know when they're learning about evolution so I can talk about it in my lessons. [Student RE teacher, FG4]

The student science teachers in the focus groups showed more aspiration to engage with RE teachers than vice versa:

> I would be very keen to speak to one of our RE teachers and say, “Look, how would you incorporate this in terms of the ethical side of things?” And, “Can you educate me a little bit more in terms of what different religions might think of this?” [Student science teacher, FG10]

One science student suggested that science and maths departments often have a framework to know what is taught when in the other subjects. He suggested that:

> A similar thing could be done with RE… What have you taught so far? I think an understanding that they can be aligned would be sufficient. [student science teacher, FG7]

Another student science teacher supported this, identifying topics such as 'Space' in Key Stage 3, and 'IVF and blood transfusions' in Key Stages 4 and 5. He asked whether science and RE teachers might come together on making resources for such topics. The student RE teachers took a rather different approach in their aspirations with one talking about the limitations of the current curriculum and how she would prefer to see 'a more holistic view of where a lot of these subjects are coming from' (student RE teacher, FG8). Others identified a need to have more philosophy on the curriculum from a younger age, also aspiring to more freedom to 'deconstruct' 'more in-depth scientific viewpoints' and to 'explain the way scientific judgements are made in the RE classroom' (student science teacher, FG8).

Online survey findings

The online survey findings are separated into two parts. Table 1 and Figure 1 report findings from 'beginning teachers', those in training or in their first 2 years of teaching. Table 2 and Figure 2 report findings from 'experienced teachers', those with more than 2 years post-qualification experience in teaching. Participants were asked to describe the relationship between science and RE departments in their schools by selecting one of the five terms:

For each group of teachers, 'Independence' was the most popular way of describing relationship between science and RE departments. Beginning RE teachers referred to dialogue between the two departments (26.3%) more than secondary science teachers (20%). There were small numbers for collaboration (6.6% for RE and 7.7% for science). The very small numbers that chose conflict (2.6%) came only from the student RE teachers. Two RE teachers and three science teachers chose the word 'integration' to describe the relationship between the two departments.

The second set of quantitative results reports on experienced teachers. These results should be treated with caution as only 18 experienced science teachers responded to the survey. However, the similarity in outcome to the beginning teachers supports the finding that 'independence' is the predominant relationship between science and RE departments in English secondary schools.

TABLE 1 Percentages of beginning teachers using different terms to describe the relationship between science and RE departments in their school.

	Secondary RE ($n=76$)		Secondary science ($n=65$)	
	N	Percentage	*N*	Percentage
Collaboration	5	6.6	5	7.7
Conflict	2	2.6	0	0
Dialogue	20	26.3	13	20
Independence	47	61.8	44	67.7
Integration	2	2.6	3	4.6
	76	100	65	100

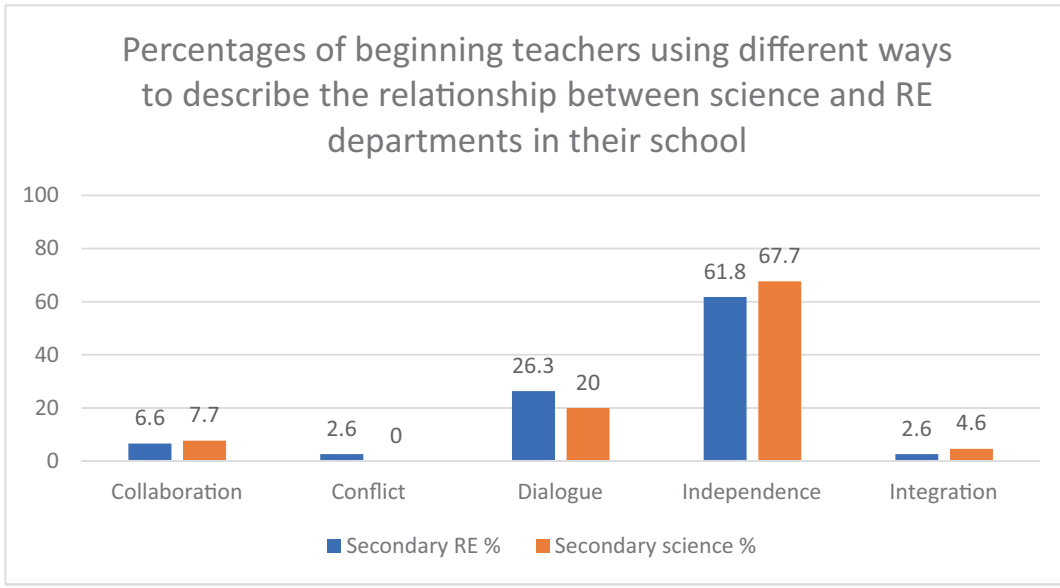

FIGURE 1 Percentages of beginning teachers using different ways of describing science and RE relationships.

TABLE 2 Percentages of experienced teachers using different ways to describe the relationship between science and RE departments in their school.

	Secondary RE ($n=85$)		Secondary science ($n=18$)	
	N	**Percentage**	***N***	**Percentage**
Collaboration	13	15.3	1	5.6
Conflict	1	1.2	0	0
Dialogue	27	31.8	6	33.3
Independence	44	51.8	11	61.1
Integration	0	0	0	0
	85	100	18	100

While the experienced teachers do report more dialogue (31.8% > 26.3% for RE teachers and 33.3% > 20.0% for science teachers) and slightly more collaboration is reported by experienced RE teachers (15.3% > 6.6%), the majority of both beginning and experienced teachers report a relationship of 'independence' between the science and RE departments in their school. No experienced teachers reported a relationship of integration. From the whole data set, only three teachers reported a relationship of 'conflict' between the two departments and each of those were RE teachers.

DISCUSSION

The findings of the focus groups and the survey reported above both suggest there is little conflict between departments of science and RE in English schools. While there may be some tensions, there is no evidence in this research of 'angry hostility' (Spencer & Waite, 2022, p. 10) that characterised the relationship between science and religion 20 years ago (See

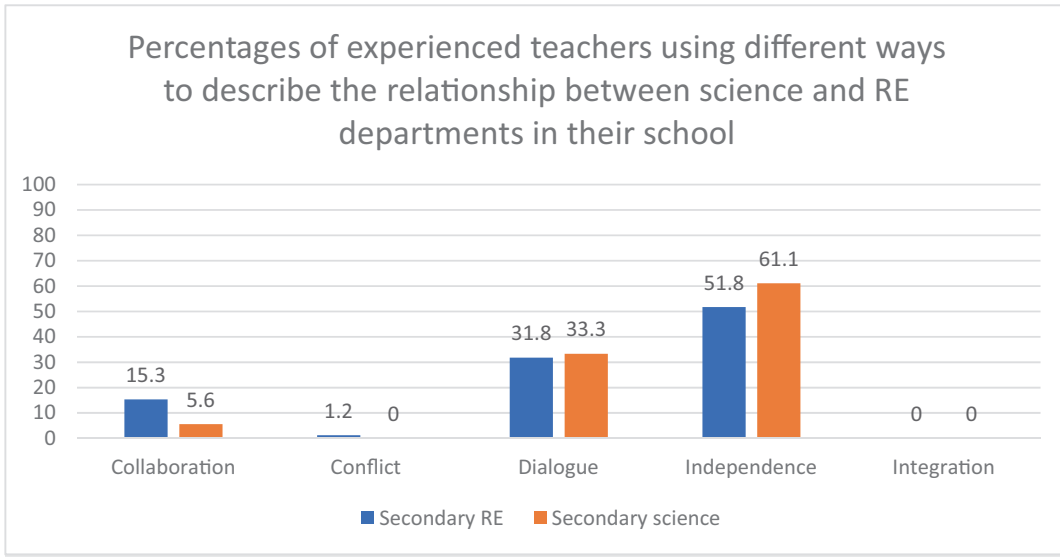

FIGURE 2 Percentages of experienced teachers using different ways to describe the relationship between science and RE departments in their school.

also McGrath, 2020). However, the findings reported above suggest many science and RE departments in English schools work completely independently, with the majority of both beginning and experienced teachers selecting 'independence' to describe the relationship between the two departments. Although this may be expected as they are discrete subjects in a disciplinary curriculum, there are times when the two departments teach overlapping content with little or no knowledge of the contributions and limitations of the other subject. We therefore see 'independence' as a negative description of the relationship between the two departments, as pupils could benefit in their epistemological understanding from more awareness, connection and dialogue between the subjects. Barbour, writing on science and religion, suggested that 'one way to avoid conflicts between science and religion is to view the two enterprises as totally independent and autonomous' (Barbour, 1997, p. 84). However, Barbour suggested a relationship of independence between science and religion could lead to a lack of 'constructive dialogue and mutual enrichment' (p. 89). This compares well to school departments of science and RE where both teachers and pupils could benefit from constructive dialogue and mutual enrichment between departments. McGrath (2020), in explaining the work of Barbour, argues that 'the independence model inevitably compartmentalizes reality' (p. 10). Indeed, further parallels can be drawn with the literature on boundary crossing, where Thomson et al. (2021), for example, suggested that those who cross boundaries will 'benefit mutually and eventually transform'. (p. 58). It is our contention that, for pupils to experience such enriching and transformative experiences, teachers need support in developing the relationship between the two departments, and in particular, an awareness and understanding of what is being taught in the other department.

The findings show some evidence of dialogue between school departments of science and RE, but that dialogue might tend towards the pragmatic rather than the philosophical. Experienced teachers reported a little more dialogue between departments than early career teachers. Focus group data suggested dialogue between teachers of different subjects was not a significant part of the student teacher experience and that when it did occur, it was often about seeking help. One student teacher gave a very specific example of how, when both departments teach about creation or origins of the universe, the teachers ensured that the topic was being taught at the same time in both subjects. As the student teacher justified

it, 'students are able to get a more in-depth understanding'. Yet, in this example, the pupils were left to cross the boundary between two subjects independently and connections between the subjects appear to be left to chance. This contemporaneous teaching of the topics has the potential to help pupils focus on the deeper concerns that Spencer and Waite (2022) or Darbellay (2015) highlight, such as epistemological or methodological differences between the subjects. Indeed, this need for depth can be linked back to Barbour who, in finding examples of dialogue between science and religion, highlighted methodological parallels. McGrath (2020) cites Pope John Paul II on science and religion, 'Each can draw the other into a wider world, a world in which both can flourish' (p. 10). McGrath goes on to write of the need to enhance the 'intellectual rigour of Christian theology through an extended dialogue with the natural sciences'. As schools move towards using more academic scholarship in framing how subjects are taught, they could also learn from the interdisciplinary dialogue that takes place between academic disciplines.

Questions remain over responsibility for boundary crossing. While Niemelä (2021) has argued that boundary crossing should be considered at the level of the written curriculum, therefore placing responsibility in the hands of policymakers, there is also an argument for teachers to take a more agentic role in crossing boundaries through dialogue with other teachers, in order to provide a more coherent curriculum for pupils. Fortus and Krajcik (2012) suggest a coherent curriculum is designed to support teachers in understanding the connections between and within subjects and how learning progresses cumulatively, but teachers still need to be offered the time, space and motivation to develop an understanding of such connections. Lefstein et al. (2020) have found, through a systematic literature review, that there is limited research on teacher collaborative discourse, but that teacher professional conversations can play a critical role in teacher learning. Findings showed student teachers aspiring to more connection with teachers from the other department. It is noticeable that the student science teachers aspired to more pragmatic connections, whereas the student RE teachers sometimes aspired to more philosophical connections. This may be a reason for senior leaders and ITE tutors to guide initial dialogue between teachers coming from different disciplines. The authors support Barbour, in suggesting dialogue is an appropriate way forward, both for science and religion, and departments of science and RE, but suggest that teachers, senior leaders and policymakers all have a role to play in ensuring that encouragement is given for teachers to engage in and deepen dialogue across subject boundaries.

It is our contention that the term 'interdisciplinarity' is broad when used in relation to the school curriculum and that practice in this curriculum area would benefit from more nuanced language. Klein (2021), writing of interdisciplinary research, identified degrees of interaction between disciplines and identified the processes of interacting, integrating or collaborating at boundaries. Focus group data showed that there are many levels of relationship that may fall between Barbour's broad terms. Student teachers revealed experience of observation, knowledge of one another's planning, knowing who to go to for more developed subject knowledge, invited expert speakers from other departments and more. In the absence of nuanced language to describe the different gradations of interdisciplinarity, two scenarios are possible. Either departments jump at collaboration opportunities but lack a shared understanding of what they are trying to achieve, running a risk of resulting in Young and Muller's (2010) Future 2 scenario where either subject or both is dependent on everyday rather than disciplinary knowledge. Alternatively, genuine, mutually beneficial collaboration opportunities could be missed as teachers seek to avoid potential tension or remain in ignorance of significant overlap in taught content. A more nuanced language to discuss interdisciplinary opportunities could avoid either scenario and lead to a more coherent curriculum experience for pupils.

Indeed, to follow Barbour, it is our contention that encouraging teacher-to-teacher dialogue beyond traditional subject boundaries could be a necessary precondition of either

a coherent disciplinary curriculum with border crossing acknowledged, or an explicitly interdisciplinary curriculum. The term 'dialogue' is of course worthy of further consideration. While we suggest dialogue should form an essential pre-cursor to effective collaboration (or a decision not to collaborate), we do not underestimate the challenges involved. Support for structured dialogue between teachers across the curriculum would seem a sensible ambition for curriculum leaders, to ensure a coherent curriculum experience for pupils. Indeed, following Spencer and Waite (2022), if we are to get to the deeper end of the debates between science and religion, then not only is dialogue necessary, but it needs to be dialogue about substantial issues such as epistemology and hermeneutics. Teachers of science and RE may need support to have meaningful and respectful dialogue about such issues, but an understanding of what the other subject is teaching in these areas would lead to a deeper understanding for pupils of the very boundary lines of these curriculum subjects. We argue that such dialogue across subject boundaries would not lead to a weakening of boundaries between subjects, in the way Young and Muller feared, but an exploration and clarification of subject or disciplinary boundaries.

CONCLUSION

This research project borrowed a typology used in academic research to describe the range of relationships between science and religion as two conceptual fields. During focus group analysis, the authors noticed parallels between the conceptual relationships described in the typology and the reality of embodied relationship between subject departments described by student teachers of science and RE. The online survey used the language of the typology, slightly adapted, to explore how a broader set of teachers might describe the relationship between the two subject departments, and applied that typology to the relationship between departments of science and RE in English secondary schools.

Findings suggest that the majority of these school science and RE departments are independent from one another, with little dialogue or collaboration between teachers. We follow Barbour's insight from science and religion in suggesting a relationship of independence avoids the opportunities for dialogue and mutual enrichment afforded between the two subjects. Insights around the conceptual relationship of subjects find legitimate parallels in data about the embodied relationships in schools. The adapted typology used to collect data in this article provides a simple, but effective framework for collecting data on gradations of relationship between science and RE departments in schools and might be used effectively beyond these two subjects. For those countries, such as Wales or Scotland, where interdisciplinarity is encouraged, this framework could be developed further to identify current and aspirational levels of interdisciplinarity. For those of us in England, where the current focus is on disciplinary learning, the findings of this article suggest there is much to be gained from a more nuanced understanding of the relationship between subject departments. There is much for secondary teachers to learn from other curriculum subjects; beyond independence, opportunities for constructive dialogue and mutual enrichment abound. We suggest dialogue should form an essential and explicit precursor to collaboration, although we do not underestimate the challenges involved in meaningful, deep and respectful dialogue.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

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.

ETHICS STATEMENT

This research was granted ethical approval by Canterbury Christ Church University Faculty of Education Research Ethics Committee (Ref: 19/EDU/015).

GEOLOCATION INFORMATION

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.

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REFERENCES

Akkerman, S. F., & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research*, *81*(2), 1–5. https://doi.org/10.3102/0034654311404435

Akkerman, S. F., & Van Eijck, M. (2013). Re-theorising the student dialogically across and between boundaries of multiple communities. *British Education Research Journal*, *39*(1), 60–72. https://www.jstor.org/stable/24464802

Barbour, I. G. (1966). *Issues in science and religion*. Prentice-Hall.

Barbour, I. G. (1990). *Religion in an age of science: The Gifford lectures 1989–1991* (Vol. *1*). Harper and Row.

Barbour, I. G. (1997). *Religion and science: Historical and contemporary issues*. HarperSanFrancisco.

Barbour, I. G. (2000). *When science meets religion: Enemies, strangers or partners*. HarperSanFrancisco.

Billingsley, B., Nassaji, M., & Fraser, S. (2018). A framework for teaching epistemic insight in schools. *Research in Science Education*, *48*, 1115–1131. https://doi.org/10.1007/s11165-018-9788-6

Bowie, R. A., Aantjes, R., Woolley, M., Hulbert, S., Thomas, C., Revell, L., & Riordan, J.-P. (2023). Science religion encounters, epistemic trespass, neighbourliness and overlapping domains: theorisation and quantitative evidence of extent. *Journal of Religious Education, published online.*, https://doi.org/10.1007/s40839-023-00209-w.

Braun, V., & Clarke, V. (2022). *Thematic analysis: A practical guide*. SAGE.

British Educational Research Association [BERA] (2018) Ethical Guidelines for Educational Research, fourth edition, London. https://www.bera.ac.uk/researchers-resources/publications/ethicalguidelines-for-educational-research-2018

Chan, J., & Erduran, S. (2022). The impact of collaboration between science and religious education teachers on their understanding and view of argumentation. *Research in Science Education*, *53*, 121 – 17. https://doi.org/10.1007/s11165-022-10041-1

Darbellay, F. (2015). Rethinking inter- and transdisciplinarity, undisciplined knowledge and the emergence of a new thought style. *Futures*, *65*, 163–174.

Department for Education. (2014), *National curriculum*. https://www.gov.uk/government/collections/national-curriculum.

Erduran, S., Guilfoyle, L., & Fancourt, N. (2019). Argumentation and interdisciplinarity: Reflections from the Oxford argumentation in religion and science project. *Disciplinary and Interdisciplinary Science Education Research*, *1*, 8. https://doi.org/10.1186/s43031-019-0006-9

Erduran, S., Guilfoyle, L., & Park, W. (2022). Science and religious education Teachers' views of argumentation and its teaching. *Research in Science Education*, *52*, 655–673. https://doi.org/10.1007/s11165-020-09966-2

Fortus, D., & Krajcik, J. (2012). Curriculum coherence and learning progressions. In B. Fraser, K. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 783–798). Springer. https://doi.org/10.1007/978-1-4020-9041-7

Giroux, H. A. (1992). *Border crossings: Cultural workers and the politics of education*. Routledge. https://doi.org/10.1177/002205749217400110

Hoven, M. (2013). A critical guide to resources in religion and science. *Religious Education*, *108*(3), 280–297. https://doi.org/10.1080/00344087.2013.783361

Hu, X. (2022). Powerful disciplinary boundary crossing: Bernsteinian explorations of the problem of knowledge in interdisciplinarity. *Curriculum Journal*, *34*(3), 472–486. https://doi.org/10.1002/curj.195

Jesse, J. G. (2006). Mapping the "unmappable geography": Teaching religion and science. *American Journal of Theology & Philosophy*, *27*(2/3), 225–246. http://www.jstor.org/stable/27944381

Klein, J. T. (1990). *Interdisciplinarity: History, theory and practice*. Wayne State University Press.

Klein, J. T. (2021). *Beyond Interdisciplinarity: Boundary work, communication and collaboration*. OUP.

Lefstein, A., Louise, N., Segal, A., & Becher, A. (2020). Taking stock of research on teacher collaborative discourse: Theory and method in a nascent field. *Teaching and Teacher Education*, *88*, 3–13. https://doi.org/10.1016/j.tate.2019.102954

McGrath, A. (2020). *Science and religion: A new introduction* (3rd ed.). WileyBlackwell.

Niemelä, M. (2021). Crossing curricular boundaries for powerful knowledge. *The Curriculum Journal*, *32*(2), 359–375. https://doi.org/10.1002/curj.77

Oates, T. (2011). Could do better: Using international comparisons to refine the National Curriculum in England. *Curriculum Journal*, *22*(2), 121–150. https://doi.org/10.1080/09585176.2011.578908

OECD. (2019). OECD Future of Education and Skills 20130: OECD Learning Compass: A series of concept notes OECD. https://www.oecd.org/education/2030-project/teaching-and-learning/learning/learning-compass-2030/OECD_Learning_Compass_2030_concept_note.pdf

Pearce, J., Stones, A., Reiss, M. J., & Mujtaba, T. (2021). Science is purely about the truth so I don't think you could compare it to non-truth versus the truth.' Students' perceptions of religion and science, and the relationship(s) between them: Religious education and the need for epistemic literacy. *British Journal of Religious Education*, *43*(2), 174–189. https://doi.org/10.1080/01416200.2019.1635434

Peters, T. (2018). Science and religion: Ten models of war, truce, and partnership. *Theology and Science*, *16*(1), 11–53. https://doi.org/10.1080/14746700.2017.1402163

QCA. (2007). *The national curriculum, qualifications and curriculum authority*. HMSO.

Reiss, M. J. (2007). Imagining the world: The significance of religious worldviews for science education. In M. R. Matthews (Ed.), *Science, worldviews and education*. Springer. https://doi.org/10.1007/978-90-481-2779-5_7

Reiss, M. J. (2008). Should science educators deal with the science/religion issue? *Studies in Science Education*, *44*(2), 157–186. https://doi.org/10.1080/03057260802264214

Riordan, J. P., Revell, L., Bowie, B., Woolley, M., Hulbert, S., & Thomas, C. (2021). Understanding and explaining pedagogical problem solving: A video-based grounded theory study of classroom pedagogy. *Research in Science & Technological Education*, https://doi.org/10.1080/02635143.2021.2001450.

Scottish Government. (2008). *Building the curriculum 3: A framework for learning and teaching*. Scottish Government.

Spencer, N., & Waite, H. (2022). *'Science and religion': Moving away from the shallow end*. Theos.

Suchman, L. (1994). Working relations of technology production and use. *Computer Supported Cooperative Work*, *2*, 21–39.

Thomson, S., Cornelius, S., Kopp, E. amd van Lakerveld, J. (2021) Boundary crossing in teacher education, *Pedagógusképzés*, *20*(10), 54-75. https://doi.org/10.37205/TEL-hun.2021.1.03

Welsh Government. (2022). *Curriculum for Wales*. https://hwb.gov.wales/curriculum-for-wales

Woolley, M., Bowie, R. A., Hulbert, S., Thomas, C., Riordan, J.-P., & Revell, L. (2022). Science and RE teachers' perspectives on the purpose of RE on the secondary school curriculum in England. *Curriculum Journal*, *34*(3), 487 – 504. https://doi.org/10.1002/curj.191

Young, M., & Muller, J. (2010). Three educational scenarios for the future: Lessons from the sociology of knowledge. *European Journal of Education*, *45*, 11–27. https://doi.org/10.1111/j.1465-3435.2009.01413.x

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