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How Students View the Boundaries Between Their Science and Religious Education Concerning the Origins of Life and the Universe

BERRY BILLINGSLEY,[1] RICHARD BROCK,[2] KEITH S. TABER,[2] FRAN RIGA[2]
[1]*Institute of Education, University of Reading, London Road Campus, Reading, RG1 5EX, UK;* [2]*Faculty of Education, University of Cambridge, Cambridge, CB2 8PQ, UK*

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ABSTRACT: Internationally in secondary schools, lessons are typically taught by subject specialists, raising the question of how to accommodate teaching which bridges the sciences and humanities. This is the first study to look at how students make sense of the teaching they receive in two subjects (science and religious education [RE]) when one subject's curriculum explicitly refers to cross-disciplinary study and the other does not. Interviews with 61 students in seven schools in England suggested that students perceive a permeable boundary between science and their learning in science lessons and also a permeable boundary between religion and their learning in RE lessons, yet perceive a firm boundary between science lessons and RE lessons. We concluded that it is unreasonable to expect students to transfer instruction about cross-disciplinary perspectives across such impermeable subject boundaries. Finally, we consider the implications of these findings for the successful management of cross-disciplinary education. *Sci Ed* **100:**459–482, 2016

INTRODUCTION

This paper presents a study which looked at how students in secondary schools make sense of their experiences in science and religious education (RE) lessons, two subjects

Correspondence to: Berry Billingsley, e-mail: b.billingsley@reading.ac.uk

which are statutory in schools in England. The study was motivated by an issue which affects education internationally: the capacity of schools to adequately prepare students for some of the cross-disciplinary questions they are likely to encounter as future citizens and scholars (Lederman, Antink, & Bartos, 2014; Ratcliffe & Grace, 2003; Tytler, 2007). There are numerous important questions which in the view of many scholars should not be addressed from the perspective of science alone (McComas, 2002), and schools are under increasing pressure to give students more opportunities to ask and explore questions that bridge the sciences and the humanities (Dodick & Shuchat, 2014; Tytler, 2007). To illustrate why cross-disciplinary thinking is likely to become increasingly important in research and in public forums, we notice that many researchers studying human health and personality are now using cross-disciplinary frameworks to help them capture the range of factors that seem to be important (Rose, 2013). Scholars working in these fields refer not only to genetics and the environment but also to ideas that are traditionally associated with the humanities like agency, self-concept, and autonomy when they attempt to explain how a child's capabilities and personality develop (Karmiloff-Smith & Thomas, 2003; Rose, 2013). These and other advances suggest that thinking in a cross-disciplinary frame is likely to be increasingly important when negotiating the medical and lifestyle choices that students will one day encounter. The significance of these discussions for school education is that if the relationships between science and other disciplines are not discussed, there is a basis to say that some students will suppose that having a scientific view necessarily implies disregarding ideas that are not supported scientifically (Francis & Greer, 2001). This point is central to our discussion and is discussed in detail in later sections. Here we note that although the value of giving students opportunities to consider and examine the capacity of science to provide a complete account of human interests and experiences has been emphasized many times (Harris & Ratcliffe, 2005; Ratcliffe, 2009; Reiss, 2010), it remains the case that this aspect of education is given little attention in schools (Lederman et al., 2014). Some of the barriers that reduce opportunities for cross-disciplinary enquiry are as follows: In secondary schools in England and internationally, students' education is typically delivered through individual subjects each taught by a specialist teacher. Teachers working in different subject departments rarely if ever plan or teach collaboratively across the sciences and humanities (Billingsley, Riga, Taber, & Newdick, 2014; Hart, 2013; Ratcliffe, Harris, & McWhirter, 2005; Smith, 2012). In addition, science teachers typically lack the confidence and enthusiasm to teach about ideas that go beyond the borders of their discipline whereas teachers of other subjects are often reluctant to address questions that relate to science (Ratcliffe, 2009). This points to the need for studies such as this one which seek to identify ways that schools can extend students' understanding of how science relates to nonscientific disciplines.

The focus of the current study is to look at what happens when a theme that has a cross-disciplinary dimension (the origins of the universe and life) is taught in two subjects at school. The case we explore is particularly interesting because the RE Framework in England recommends that students consider how science and religion relate (Religious Education Council of England and Wales [REC], 2013) whereas the science curriculum makes no mention of religion (DfE, 2013b).

This asymmetrical arrangement prompted us to wonder how students interpret their experiences in lessons when topics bridging science and religion are discussed. As such the approach we take in this study is novel. While previous studies have asked students to compare and reason about science and religion, this is the first study to ask students to compare and reason about their experiences in two subjects that teach about topics addressed by science and religion. The findings will tell us some of the consequences of the arrangement that England has in place and the extent to which students' interpretations

of the aims of the teaching seem to align with those in the curriculum documents. It seems reasonable to surmise that some of the inferences that students form for themselves are ones that are unintended by their teachers. As such, this study may reveal more of what has been called the hidden curriculum (Densgombe, 1982) or, in other words, the unintended consequences of some current educational practices.

The aim for this study then is to bring new insights to the question of how schools can best prepare students for some of the cross-disciplinary questions they are likely to encounter as future citizens and scholars. By studying the approach England has adopted, we anticipate that we can inform international debate on where and how to include teaching about topics bridging science and religion. Furthermore, it seems reasonable to suppose that some of the findings of the study will be pertinent more widely when looking at how to teach topics bridging science and the wider humanities in schools.

In the sections that follow, we begin by discussing what scholarship says about the nature and limits of science and about how science and religion relate. We then turn to studies which have discussed how students currently understand the relationship between science and religion. We will examine the curriculum documents in England to discover what students are expected to learn and how the teaching is organized between the subjects. Finally, we will then discuss the findings of our research in which we asked students to explain their perceptions of the teaching and how they understand the roles of the two subjects when they cover topics addressed by science and religion.

BACKGROUND

Scientism

When thinking about questions that bridge science and the humanities, a central issue is how science responds to claims that cannot be investigated scientifically. Scientism is an important idea in this study. Scientism has been defined in a number of ways, one of which is to say it is a commitment to the view that science can one day give a complete explanation of the universe and its habitants (Stenmark, 2001). A commitment to scientism would mean believing that scientific truths are the only valid truths about the world, whereas other accounts are either pseudoknowledge or can be reduced to scientific knowledge so that, "where we thought we had two sets of concepts, entities, laws, explanations, or properties, we in fact have only one, which is most perspicuously characterized in terms of the reducing vocabulary" (Charles & Lennon, 1992, p. 2). Scientism is sometimes confused with science, and one reason for this is that some scientists have defended their positions on the nature of science with authority without explaining that these are metaphysical considerations and not questions that can be resolved within science (Hutchinson, 2011). Indeed, another acceptable and widely held position among scientists is that while science is highly regarded it is not an exclusive path to reliable knowledge (Poole, 2007). As such, scientism is not a necessary commitment for a scientist to hold and, in agreement with many philosophers of science and science educators (see, e.g., Cobern, 2000; Hutchinson, 2011; Stenmark, 2001), we believe that scientism is not a necessary presupposition of science.

Relationships Between Science and Religion

There is a widespread recognition that the task of relating science and religion is not straightforward (Brooke, 1991). One of the reasons for this is that science and religion

themselves are not easy to define, and each can be presented differently by different scholars. Of the two areas of thought, there is more agreement about the nature of science (Reiss, 2010). Science is focused on constructing knowledge about the material world, and there is a high level of consensus among scientists for the validity of established scientific ideas (Brooke, 1991). The scientific community has a tradition of coming to internal agreement over time on the appropriate methodological apparatus and standards of evaluating evidence in its various subfields (Taber, 2009).

Theologian Keith Ward writes that religions have in common that most argue for the existence of a God or gods or supernatural being (Ward, 2011) and that the great religious traditions of the world argue for the importance of transcending the ego to attain true satisfaction (Ward, 1995). Cavanaugh (2009) rejects Ward's attempts to define religion according to the beliefs that religions hold and argues instead for a functionalist definition, which focuses on discerning the tasks that a religion performs for people in a given social, political, or psychological context. When considering how science and religion interact, one of the central questions to address is how truth claims should be gathered, constructed, and evaluated (Reiss, 2010). In the previous section, we noted that scientism is the view that science is the only valid way to construct reliable knowledge. It follows that for someone holding this stance, science and religion are perceived to advocate conflicting positions on how reliable knowledge can be obtained (Barbour, 1988). In their typologies on how science and religion relate, Brooke (1998) and Barbour (1997) both highlight another reason why science and religion are seen by some people to be conflicting. Some religious denominations, including some Baptist traditions, argue for a literalistic interpretation of the Abrahamic creation story a view that is widely labeled as Young Earth Creationism. Young Earth creationists reject the claim by the vast majority of scientists that the Earth is billions of years old and also reject the possibility of "macro" evolution—that is, evolution which leads to completely new forms of living things (Brooke, 1991). The prominence of Young Earth Creationism in public discussions about science and religion has produced widespread awareness that (mainstream) science and this particular religious stance are in vehement opposition on some issues (Poole, 2008). In their review of the ways that the relationships between science and religion have been presented by scholars historically and currently, Brooke and Cantor (1998) identify two other positions. One of these is the view that science and religion are nonoverlapping and mutually independent. The basis for independence is argued to be that science is concerned with the workings of the material world whereas religion is concerned with moral questions and questions about ultimate purpose (Gould, 1999). Independence has become less popular in recent times because it dismisses the possibility of useful dialogue between the disciplines and also because in practice it is difficult to find a religion that makes no claims about the material world (Cantor, Christie, Hodge, & Olby, 2012). Alongside conflict and independence, Brooke and Cantor (1998) present a third view of the relationship which is harmony, the stance that science and religion can each contribute to progress in the other. To illustrate how this stance manifests in scholarly writing, the authors give the example of science historian, Reijer Hooykaas who "argued that biblical theology, especially Reformed theology, was the crucial factor in transforming Greek science into modern science" (p. 67).

What this review highlights is that individuals can have different perceptions of how science and religion relate, in part because there are differences of opinion on the natures of science and religion (Brooke & Cantor, 1998). By studying these debates, young people can, we argue, extend their understanding of the natures of science and religion and also of the challenges involved when attempting to discern boundaries and relationships between them.

School Students' Perceptions of How Science and Religion Relate

A large body of work conducted across several decades shows that among young people, the most widely held view of how science and religion relate is that they conflict (see, e.g., Bauser & Poole, 2002; Billingsley, 2013; Brickhouse, Dagher, Letts, & Shipman, 2000; Francis, Gibson, & Fulljames, 1990; Hanley, 2008; Hokayem & BouJaoude, 2008; Shipman, Brickhouse, Dagher, & Letts, 2002). There is a basis to say that perceptions of conflict are frequently formed without a careful consideration of other views of the relationship (Billingsley et al., 2013). Research that has sought to understand young people's perspectives on how science and religion relate draws attention to the cognitive difficulty of the reasoning that scholars frequently use when they discuss issues of epistemology and emphasizes that it is unlikely that students will achieve the levels of understanding required without effective teaching. This was, for example, a conclusion by Reich (1991) on the basis of an interview study across a 10-year period to look at how young people think about the origins of life and the universe. Other researchers have noted that to understand the nature of science, students need to appreciate that science uses analogies and models to communicate ideas (Podolefsky & Finkelstein, 2006). Similarly explaining the nature of religion "is almost impossible to do without metaphors" (Büttner, 2009, p. 130). The current authors have previously sought to categorize the ways in which young people reason about what science and religion say about the origins of life and the universe beginning with the premise that undergraduate and school students may have initial ideas and strategies which are not evident in scholarly reflections (Billingsley, 2004, 2013; Billingsley et al., 2013). The work included an interview study which led to a typology that included the position of students who say that until the interview they had not appreciated that there is a link between science and religion. Two further views that emerged from the study were "contradictory," which was the view that both accounts could not both be true, and "negotiated," which was the view that science and religion can agree if one or both are modified.

The Influences of School Science Teaching on School Students' Epistemic Reasoning

This study is designed to investigate schools students' perceptions of the teaching that takes place in two subjects at school when they teach about topics that are addressed in both. As we noted in the previous sections, for students to access a range of views of the relationships between science and religion, it would be important for them to appreciate that scholars do not agree on pertinent aspects of the natures of science and religion and in particular hold different views on whether scientism is a requisite of science. As we identify in this section, the style of teaching in science lessons combined with the compartmentalization of science lessons from lessons in other subjects is said in existing research to influence how students perceive the nature of science.

Though the concept of a school subject is difficult to define, each of the individual subject areas has a distinctive culture with defined norms and practices (Stodolsky & Grossman, 1995). School subjects like science and history are not drawn directly from academic disciplines, and there is a range of relationships between the academic disciplines and the subjects at school which share their names (Stengel, 1997). The distinction between "science," the subject studied in school and "science," the professional work of scientists is emphasized in educational research (Deng, 2007), but, while researchers and curriculum planners are wise to this distinction, there is a basis to say that school students are less inclined to question whether the activity that takes place in their science lessons is "science."

Research, for example, by Leach, Hind, and Ryder (2003) observed that students frequently characterize both science the discipline, and science the subject in similar ways. Similarly, Sjøberg and Schreiner (2007) draw on an international study of learners' attitudes toward science and technology in society to notice that students are often not making a distinction between science in school and the professional work that scientists do.

A related and recurrent theme in science education for several decades has been the concern that the experiences students have in science lessons can suggest to them that science is a set of facts that are proved by experiments (Driver, 1989; Gilbert, Osborne, & Fensham, 1982; Leach et al., 2003; Millar & Osborne, 1998; Osborne & Dillon, 2008). This characterization of science arises in large part because a considerable amount of school science time is spent carrying out "recipe" experiments (also called closed enquiry investigations) that produce an outcome that is known prior to the investigation (Dudu & Vhurumuku, 2012; Sullivan-Watts, Nowicki, Shim, & Young, 2013). Byrne and Brodie (2013, p. 28) also draw attention to and criticize the pedagogy that persists in science classrooms saying that the content is all too often "designed mainly to educate a minority of future scientists rather than equipping the majority with the scientific understanding, reasoning and literacy they require to engage as citizens in the twenty-first century." These authors add to their case for reform by pointing to research which shows that students frequently find science at school to be boring and irrelevant to their lives and that the numbers of students choosing to study science is in decline (Byrne & Brodie, 2013). In response to these findings in Europe, Australia and elsewhere curriculum writers have sought ways to encourage students to see science in a more realistic and positive way (Osborne & Dillon, 2008; Tytler, 2007). In Australia, for example, the Curriculum and Standards Framework for the state of Victoria was revised over a decade ago to state that students should be taught to "recognise the limitations of science" (DEET, 2000, p. 5). The science curriculum for England was revised in 2007 to include a similar objective saying that students should know that "there are some questions that science cannot currently answer, and some that science cannot address" (Qualifications and Curriculum Authority, 2007, p. 221). Both the Australian and English curricular have since been revised again and while the emphasis on "How Science Works" in England has shifted, the newly drafted science curriculum for this country states that students should develop an appreciation of "the power and limitations of science" (p. 5). The Next Generation Science Standards (NGSS) in the United States puts an emphasis on developing an understanding of the nature of science with particular reference to the practices that underpin working scientifically such as planning an enquiry (Duschl & Bybee, 2014; Pruitt, 2014). Another aspect is the active nature of science and the idea that "scientific knowledge is open to revision in light of new evidence" Achieve (2013, p. 2) (NGSS, 2013, p. 93). Helping students to consider what kinds of questions science can and cannot address would foreseeably be taught alongside teaching students that "a scientific theory is a substantiated explanation of some aspect of the natural world" (p. 5).

In the years since these reforms began, although teachers have accepted many of the recommendations made, students have continued for the most part to perceive science as composed of facts and teachers have continued to resist calls to teach about the limits of science and how science relates to nonscientific disciplines (Lederman et al., 2014). This is unfortunate as a perception of science as scientistic can lead some young people to form negative attitudes toward science and the possibility of a career in science (Reiss, 2008). Further changing what happens in lessons by, for example, exploring scientific frontiers or allocating time to consider students' questions and interests has a positive effect on students' enthusiasm for studying science (Hagay & Baram-Tsabari, 2015).

The Influences of School Religious Education on School Students' Epistemic Reasoning

The scope of our current discussion is confined to looking at interactions between school teaching and school students' developing knowledge and understanding of science and religion. In the previous section, we discussed the potential of students' experiences in science lessons to affect their perceptions of science. It seems reasonable to suppose that students' experiences in RE lessons are likely to have some influence their perceptions of religion. In the case of RE, however, the situation is made more complex because of a diversity of aims for this subject from country to country. In many countries in Europe, RE is offered in government-run ("public") schools (Schreiner, 2000). In a few of these countries the aim is to nurture pupils into one faith tradition, whereas in the majority of countries RE teaches students about a range of world religions and is also designed to help young people develop their own beliefs and values (Schreiner, 2000). In England, RE is a statutory subject for pupils up to the age of 16, although parents do have an option to withdraw their children. The subject is controlled locally through S.A.C.R.E.s (locally-based Standing Advisory Councils for RE) or, in the cases of faith schools, the relevant faith communities. Academies including free schools can in some cases develop their own RE syllabus while needing to meet certain requirements. In England, a nonstatutory National Framework for RE was published in 2004, which attempted to meet the need for an RE curriculum for schools that is nonconfessional (meaning that a commitment to a particular faith is not openly encouraged) and meets the needs of a multicultural, liberal-democratic society (Barnes, 2014; Jackson, 2004; Schreiner, 2000). The vision was that teachers would help students to critically examine their own beliefs and values while not appearing to favor any one of a plurality of religious and nonreligious positions; however, a report by school inspectors a number of years later revealed that RE teachers are often unclear about what they are trying to achieve in their subject (OFSTED, 2010). This report echoed criticism elsewhere that the Framework failed to adequately explain how students could progress in RE and was unclear about what "understanding" means in this subject (Walshe & Teece, 2013). A more recent review in 2013 summed the position by saying that "successive" government reports have pointed to "significant and well-founded concerns about the uneven quality of learning and teaching in RE across the country" (REC, 2013, p. 8). Despite these criticisms, interviews with students shows that most enjoy RE and feel it is a worthwhile subject (OFSTED, 2010). The 2004 Framework has since been replaced by a new national nonstatutory National Framework (REC, 2013). Many of the aims of the previous version have been transferred to the current guidance and, for example, the new Framework states that students should learn about a pluralism of religious and nonreligious views. Of particular relevance here, both the previous and current Frameworks state that students in lower secondary school (age 11–14) should learn about how science and religion relate. The objective in the current Framework states that "Students develop insight into and understanding of why some people argue that science and religion can be compatible and others argue that they cannot" (REC, 2013, p. 27).

To conclude this and the previous section, we note that it appears that in principle in RE and science lessons in England there are opportunities to help students to become familiar with a range of views of the relationship between science and religion. In particular, current and previous science curricular in England acknowledge the importance of teaching students in science lessons about the limits of science. This could lead to a discussion about the types of questions that science can and cannot investigate and as such could be a conceptual bridge to teaching about the types of questions considered by nonscientific disciplines such as history and religion (Poole, 2007). The RE classroom could then extend this discussion

by looking more closely at the nature of religion and the different types of truth claims that religions make.

Having outlined what students are expected to know about how science and religion relate based on the current curriculum documents, we turn next to what existing research says about the types of barriers that can impede students' capacities to connect the teaching that takes place in different subjects.

The Compartmentalized Curriculum

In light of the curriculum aims discussed in the previous section, it is interesting to note that a number of authors have argued that students are failing to achieve a satisfactory understanding of how scholarship portrays the relationships between science and religion (Astley & Francis, 2010; Hokayem & BouJaoude, 2008). These comments build on research conducted across several decades which shows that among young people in Europe, America, and Australia (to name but a few locations) a majority perceive that scientific and religious accounts of human origins are in conflict (Billingsley, 2004; Hanley, 2008; Hokayem & BouJaoude, 2008). There is also a basis to say that this perception is held without an understanding of other views of the relationship (Billingsley, 2013). The focus for this section is to draw on existing research to present some possible reasons why the teaching students receive may not be achieving its intended aims. The first issue we consider is the extent to which RE and science teachers in practice draw students' attention to the curriculum links between their subjects.

Concurrently with the study we describe here, we conducted a parallel interview study in eight schools of the 11 schools with science and RE teachers, interviewing one teacher of each subject in each school (Billingsley et al., 2014). The findings suggested that the opportunity to make bridges for students between the classrooms is rarely if ever taken up. In this sample, there was only one teacher who said there had been any discussion with a teacher in the other department and none of the teachers said they planned lessons collaboratively or made links in their lesson to the teaching in the other subject (Billingsley et al., 2014). Teachers had mixed opinions on whether collaboration was even desirable. Science teacher, Mr Granite (an assumed name), said he was glad of the physical and social isolation of the science department saying, "We're over here, we're on our own, science, we never see anyone." In contrast, Mrs Acacia (RE) felt the departments "can learn a lot from each other. I think we do need to talk," (Billingsley et al., 2014, p. 11).

We have noted a basis to say that teachers rarely, if ever, make explicit links between the teaching that takes place in science lessons and RE lessons. We consider next whether students are likely to form their own bridges between the ideas they meet in different classrooms. Research on this issue suggests that students are typically poor at transferring skills and concepts even between similar situations (Bassok & Holyoak, 1989). The idea that learning is inextricably linked with the context in which it occurs has been reported for many decades (Sadler, 2009), and situated cognition is the idea that the context of the social environment will influence and constrain the process of learning (Hennessy, 1993; Lave & Wenger, 1991). Indeed, it has been claimed that students' poor success at making meaningful transfers between the learning that takes place in subject compartments is the "most fundamental issue in all of education" (Haskell, 2000, p. 4). Teaching about ideas related to origins occurs in two different social contexts, the science and RE classroom, and it seems reasonable to say that this negatively affects students' learning about how science and religion relate. The extent to which learning might be transferred between these subject classrooms is not straightforward. Some of the factors that have been suggested more generally include the degree of difference between settings, the amount of practice, the number

of shared symbols between the settings, and where attention is directed (Anderson, Reder, & Simon, 1996). In our previous work, we found illustrations of compartmentalization in students' thinking during an interview study with students aged 14 years old. One student explained that questions bridging science and religion are not raised in class because "We don't do science and religion, we don't bond them together; we have two different lessons" (Billingsley et al., 2013, p. 1725).

RESEARCH QUESTIONS

Our review identifies that there are pressures and factors which affect what is taught in RE and science lessons, that students' perceptions of science are influenced by their experiences in science lessons, that students seldom make links between the teaching in each classroom, and that there is evidence that students are struggling to achieve the levels of epistemic insight they need to understand a range of positions on the relationship between science and religion. This picture leads us to propose a hypothesis that students will perceive science as a worldview that excludes other ways of seeing the world and that they will not be well placed to capitalize on the opportunities that the curriculum suggests are available in RE to consider how science relates to religious and nonreligious worldviews.

As such, the research questions for the study were

- What are students' perceptions of the natures of the scientific and religious accounts of origins and of how these accounts relate?
- What are students' perceptions of how teaching about origins is managed in each classroom and what reasoning do they give for why there are differences?

METHOD

Research Design

The research described in this study forms part of a large-scale research project which uses a longitudinal, mixed methods research design, collecting data via surveys, interviews, and workshops with teachers and students in 11 secondary schools in geographically diverse parts of England. Nine of these 11 schools were identified using an educational directory (Tierney, Sinkie, & Gregory, 2005), whereas the remaining were identified through convenience sampling, via networks available to the research team. Seven of these schools agreed to take part in a 3-year interview study to look at students' thinking. The interviews for this study were gathered in the first year of the study with 61 students in these seven schools. Table 1 provides contextual data for the schools participating in this study.

Sample

The students taking part in this study were in Years 7 (age 11–12), 9 (age 13–14), 11 (age 15–16, the final year of compulsory schooling in the United Kingdom), and 12 (age 16–17, first year of noncompulsory schooling in the United Kingdom). Students had initially completed a survey which asked them to select an option to indicate whether or not they saw themselves as having a religious faith and if so which tradition. Students were told that the data they provided on the survey would be anonymized and that the decision whether or not to take part in the study would not affect their grades. The survey included statements which articulated positions on how science and religion relate on a number of topics including the origins of the universe and the origins of life. Examples were "Religious ideas about how

TABLE 1
Information About the Research Schools

Type of School and Assumed Name	Location in England	Number of Students Interviewed
State maintained grammar (Dalesview)	North west	10
Large comprehensive (Eastgate)	North east	7
Comprehensive (Fieldwell)	Midlands	12
Comprehensive (Girlake)	South-south east	7
Village college – comprehensive (Hamlet)	South east	6
Independent (Immaculate)	South east	8
Comprehensive (Julius)	South west	11
	Total	61

TABLE 2
Respondents' Description of Religious or Nonreligious Position

	Participants in Survey of Year Group		Participants in This Interview Study	
	Frequency	Percentage	Frequency	Percentage
Christian	1,052	40.3	29	47.6
Jewish	14	.5	1	1.6
Muslim	138	5.3	1	1.6
Hindu	20f	0.8	0	0
Atheist	669	25.6	13	21.3
Buddhist	25	1.0	1	1.6
Other	582	22.3	13	21.3
Total	2,500	95.7	58	95.0
Missing	113	4.3	3	5.0
Total	2,613	100.0	61	100.0

humans came to be on Earth have been proved wrong by science" and "A good scientist can believe that life was created by God" and "You can believe both science and religion." It also presented statement designed to identify students' own commitments, such as "I believe that God created the Universe" and "I accept the scientific theory of evolution as the explanation for all the different kinds of life on Earth." While the experience of completing the survey is likely to have affected students' thinking, this is not something we see as a disadvantage as it meant that students had an opportunity to gather their thoughts about the topics that were likely to be covered in the interview. Students were also asked to indicate their willingness to be interviewed. To make the selection of students for this interview study, we supplied class teachers with a list of students who said they were willing to be interviewed and who represented a range of faith positions including an atheistic stance. The final cohort of participants comprised these students and included some who were substituted on the day. In Table 2, we show the religious or nonreligious faith positions of the interview participants alongside those of the whole cohort who took part in the survey.

Data Collection

Data were collected from 61 students using semistructured interviews, a method commonly used in education to explore aspects of learners' thinking in depth (Bell, 2014). Typically, interviews lasted 1 hour, although this varied from individual to individual. Ethical approval for the research to proceed was granted by the lead author's university ethics' committee, and all ethical processes and considerations were complied with. Students and their parents gave permission for participants to take part and for the interviews to be recorded and transcribed. Pseudonyms for both the school names and the students were put into the transcripts, and we created names such that the first letter links each student with the school he or she attended.

Interview Protocol

Interview schedules were drawn up and were refined in the light of a preliminary study. The interview was semistructured, and the interviewer used follow-up questions to probe and clarify students' ideas. Students were also told that if they were uncomfortable with any question it is fine to say that they do not want to give an answer. Typically, interviews lasted 1 hour, although this varied from individual to individual. The themes relating to this paper focused on origins (the origins of the universe and the origins of life) and were

- Students' perceptions of science and religion and the relationship between science and religion on origins (the origins of the universe and life).
- Students' perceptions of how teaching about origins is managed in RE and science classrooms and students' reasoning about why there are differences.

From our preliminary interviews, we expected that students would vary in their levels of insight into how science and religion relate. To draw an understanding of what the range of insight is, many of the questions were designed to probe students' familiarity with ideas that research suggests are relevant when thinking about how science and religion relate. In the opening section of the interview, the interviewer explained that the aim of the research is to find out students' perceptions of the relationship between science and religion and asked each student whether this is something he or she had previously thought about. Next students were asked how they perceived the relationship between science and religion and this was followed by, "how would you describe science and how would you describe religion?" The next section of the interview schedule sought students' perceptions of how science and religion relate on the origins of the universe and of life. The questions included: "What are scientific ideas about the origins of the universe?," What are religious ideas about the origins of the universe?," "How do these ideas relate?," "What do you believe about the origins of the universe?," and "Suppose you're at home, how would you explain the origins of the universe to yourself?" This question was added to ensure that students appreciated that we were looking for their own answer and not for them to say what a teacher would judge to be the right answer. The next question was, "Have you come across any other ideas that people have about this?" This was to discover whether students could offer more than one view if, for example, their own view was that science and religion conflict. The pattern of questions was then repeated, now asking about "the origins of life."

The next part of the schedule asked students to talk about the teaching they receive in their science lessons and in their RE lessons about origins. These questions included "If you compare a science teacher explaining [the origins of the universe/life] with the way an RE teacher explains the same thing, do they teach it in the same way or differently?," "How they are similar (or different)?," "Does the teacher make what he or she says sound definite

when explaining it to you?," and "What sorts of activities would you do in a science lesson / RE lesson about origins?"

We noted previously that researchers such as Sjøberg and Schreiner (2007) have found that school students are not necessarily mindful of a distinction between science (the discipline of scientists) and science (the school subject). In our study, we found that some students were inclined in some of their answers to offer a mixture of terms associated with science, science lessons, and the science teacher. The interviewer was attentive to these kinds of slips and where the meaning was unclear, asked a follow-up question to ensure the student had understood the intention of the question and to elicit more from the student about his or her thinking.

ANALYSIS

Two researchers independently assessed and coded the transcripts in the manner suggested by Charmaz (2006, p. 49), starting from "the words and actions of respondents." These codes were then examined and categorized into groups of similar concepts. The transcribed data were originally encoded using a grounded theory-like open coding procedure through which "concepts are identified and their properties and dimensions are discovered in the data" (Strauss & Corbin, 1998, p. 101). The researchers met to compare codes and themes, and it was noted that the initial themes identified by each researcher were broadly similar and largely derived from the questions. The agreed themes that resulted from these discussions were

- the nature of science,
- the nature of religion,
- how science and religion relate on origins (the origins of the universe and the origins of life),
- the stances that RE and science teachers take on what is truth,
- the teaching methods and tools,
- the status of each subject,
- the teachers' personalities and commitments, and
- social pressures in RE and science lessons.

In our first meeting, we discussed the level of nuance we wanted to bring to our coding and agreed that the aims of this study would be best met if our codes reflected broad categories of attitudes and ideas that our theoretical studies and initial analysis had led us to expect to find. This led us to decide, for example, to use one code "science is facts/proof/experimentally proven" to mark a reference in a students' description of science to any of "science is fact," "science is certain," "science is proven experimentally," and similar ideas. We also discussed instances in which students used a term that seemed out of context such as where Freya (Year 11) referred to her "science teacher" as "science" when she compared the approach by an RE and science teacher. Freya said, "Science would do it more effective." Damien (Year 7) explained of his RE and science teachers that "They teach it differently because in science they'll like show it through experiments maybe ... and religious will like show it through videos and what people think, opinions." In these cases, students' meanings were clear from the context or from a follow-up question asked by the interviewer. We also noted and discussed the cases of students who, when asked about scientific and religious ideas about origins, gave an answer that was based on an experience in a science lesson. A case in point is Felicity (Year 9) who answers this question by saying, "In the science explanation there's ... they show you pictures and real stuff." When we reviewed the full transcripts

of these students, we noted that although they were asked a number of questions to elicit their insight into scientific ideas about origins, they had little to offer. This was also the case for many students who did not refer to their lessons in their answers. We concluded that in some cases, students were responding to questions about the scientific explanation of origins by referring to their experiences in science lessons because these were the insights that were most readily available to them.

One researcher then returned to the transcripts and produced an Excel document in which there were 11 columns (one per theme) and 61 rows (one per student). Each cell contained all the comments that each student made relating to a given theme, drawn into a paragraph of text (which we call a digest). The two researchers took the final set of codes, and each independently coded the data.

In parallel and to help us evaluate the analytical method, we enlisted two researchers who had not developed the analysis. One was the researcher who carried out the interviews, and one was a researcher in education who had not worked on the study. We chose 67 (10%) random (computer-generated) digests and asked the two researchers to code the data in each digest using the agreed coding system. Prior to beginning this coding, the two new researchers were trained using sample digests and codes. We met as a group of four to compare the way we had coded these 67 digests. To calculate our interreliability score, we used the percentage of agreement method (Goodwin, 2001). This approach has been used to assess the reliability of four raters coding psychological interviews whereby, as is the case in our own study, some of the raters are experienced and some are novices who are given training to carry out the task (Kay, 1991). To arrive at an interrater reliability score, we worked out the proportion of pairs of agreements among the four raters for each digest compared with the number of possible pairs of agreements. For 63 of the 67 digests, we had full concordance whereas for each of four digests we had one person disagreeing or uncertain. As such our total proportion of actual versus possible agreements is 0.97. This very high level of agreement is in part because of the design of our coding system which for some digests offered a small number of codes relating to our research foci and to commonly expressed ideas. Having evaluated the reliability of our coding strategy in this way, the two primary researchers then compared their analysis decisions for the remaining digests and produced a finished analysis document.

FINDINGS

In the following section, we present the findings that emerged from the data analysis in relation to the themes explored through interviews and consider these with respect to the research questions.

Students' Perceptions of Science and Religion

The characteristics of science that students frequently referred to were that science consists of facts, that science is certain, that science has proof, and that experiments are used in science to produce prove an idea right or wrong. One or more of these characteristics were identified by about two thirds of the students (41 of 61 interviewed). Gwendolyn (Year 9) said that "science is like straight hard facts," whereas Danny (Year 9) explained that science consists of ideas which are tested experimentally "to see what happens and that would come out with the results which would show it either to be proof or not to be proof."

Edward (Year 9) said "science is just anything that's proven right" and felt this could include a proof of God's existence if such proof were found. Many students linked the certainty of scientific ideas to the idea that science is very believable. Isobel (Year 9)

described the authority of science saying "science is there for you as a fact and you don't really question it." Darshan (Year 7) said "I think science does make it more convincing if you do a practical experiment to go with what you're learning about, because then you know you've done it for yourself as well."

The characteristics of religion that students expressed most frequently were that religion consists of opinions, that religious ideas do not need evidence, and that all religious ideas have equal status. Almost all, 57 of 61 students expressed one or more of these ideas. Felicity (Year 9), for example, explained that in "religion there isn't any evidence it's just something you believe in," whereas Irene (Year 7) said that religion is "what people believe and their opinions" and Hamish said "it's just your personal opinion." In their answers, many of the students contrasted the "facts" of science with what they saw as the "opinions" of religion. Thus Henrietta (Year 9) was one of the many who said that science consists of "proven facts" and her view of religion is that it is something "you can't prove."

Students who expressed the idea that all religious beliefs are equal in status included Ferdinand (Year 11) who said that religious ideas "are all as good as each other" because "One person shouldn't say, 'Well, you're wrong,' because nobody is right, nobody is wrong, it's what they personally they think." Farrah (Year 11) made a similar point, saying "[Religious ideas] are all as good as each other because everyone has their own viewpoints and no one should say what's right and what's wrong."

Danny (Year 7) explained what happens when scientific "facts" overlap with "religious opinions" stating "Well, like science is more like trying to find proof about it but religion is like opinions and sometimes science ... scientists don't agree with people's opinions."

Students' Perceptions of How Science and Religion Relate on Origins (the Origins of the Universe and the Origins of Life)

For this theme, we had four codes which were "contradictory," "negotiated," "compatible," and "uncertain." Elizabeth (Year 12) was one of 25 students who said the accounts by science and religion of the origins of life and the universe were contradictory, describing the relationship as a "definite conflict." Irma (Year 9) said "I think they do contradict each other. Sometimes I believe in God and his creation but sometimes I'm more convinced to the science side of it." Horace (Year 9) said science and religion conflict "a lot," adding "I think to be honest science outweighs the Bible." Farrah (Year 11) made a similar point saying "Religion was a way to explain things but now science contradicts it."

Twenty-two students in this cohort said that although science and religion conflict it might be possible to make them fit together, a view we have previously called a "negotiated view" (Billingsley, 2013). Estelle (Year 12) said, "Religion and science contradict but they can work together." Ida (Year 9) said, "They can fit together ... you'd have to cut out bits of the ideas to make them fit." Donald (Year 11) explained that although there are contradictions, "they both intertwine to mean that they can both be true." Nine students in this cohort saw science and religion as compatible. Four students said there was no relationship or that they were unsure or that there are too many unknowns to form a position.

What Are Students' Perceptions of How Teaching About Origins is Managed in Each Classroom and What Reasoning Do They Give for Why There Are Differences?

The findings relating to this research question are presented using subheadings corresponding to each of five themes.

The Stances the Teachers Take on What Is Truth. The comments expressed by most students (52/61) included the idea that a science teacher presents one view and expects the class to accept it as true while an RE teacher tells students it is for them to decide what to believe.

Darshan (Year 7) explained that in RE "We're given a choice of what to believe, we're not forced into believing anything in particular that we don't have to." Glenn (year 7) said RE and science lessons on origins were taught differently

> because an RE teacher kind of lets you have more questions and stuff, I think. You know, they're like, "What do you believe?" whereas a science teacher is more, "This is what happened," you know, "These are the facts I've been told to teach you,"

Giselle (Year 12) said of her science and RE teachers:

> A science teacher may just sort of say, "This is what happened" and that it's definitely true, whereas RE teachers, more would say like that, you know, "Some people believe that it happened like this, whereas others believe it happened like that."

Students also felt that the science and RE teachers could be expected to respond differently to students' own ideas. Isobel (Year 9) explained that "In RE lessons it's an open discussion . . . there's still that freedom in RE to choose your own beliefs . . . whereas in science there is much more taking notes and 'This is how it is,'"

In the view of Ewan (Year 7), if students put forward a number of different ideas in a science lesson . . . "at the end of the day if something like that happens our science teacher will overrule."

Another point of interest that emerged during our analysis for this theme was that some students said that the RE teacher offered several different perspectives on origins whereas some others talked about a rivalry between the science classroom and RE classroom and said that RE teachers advocated a religious view. Here we illustrate both positions. Danny (Year 9) saw the role of the science lesson as to teach scientific facts and said that in RE, "a religious teacher will tell you like what seven different religions like tell you to believe." Jill (Year 7) was one of the students who perceived her science and RE classrooms as presenting different "sides" and said the teaching in RE would give more time to the religious side: "I do think that the religious education teacher does explain more obviously on the religious side but they do also, like sometimes reiterate the scientific or whatever you want to call it."

Teaching Methods and Tools. Almost two thirds of students (39/61) in the study said when asked that the types of activities they expected to experience in each subject were different. In other cases, students listed types of activities but did not explicitly identify the methods as different.

In a science lesson on origins, it was felt, particularly by those in the younger years (age 11 and 13) that they could expect to see experiments and first-hand evidence. In RE, in contrast, students expected that the ideas would be communicated through stories and people's opinions. Damien (Year 7) said:

> They teach it differently because like science they'll like show it through experiments maybe . . . and religious will like show it through videos and what people think, opinions.

Several students said they found the teaching about origins in science lessons to be more convincing. Felix (Year 7) said that the way the scientific account was presented "makes you believe in it more with experiments and everything." Fraser (Year 7) also said that he found the presentation given in science lessons to be more convincing because, "You have videos and stuff of it actually happening, whereas you haven't really got videos and stuff like that that are realistic of God, of him doing it."

The Status of Each Subject. Some students (10 of 61) explained that they would pay more attention to the teaching in a science lesson on origins rather than an RE lesson because science as a subject has a higher status. In England, science is a core subject (i.e., one that is compulsory till the age of 16) and is also part of a new performance measure that will be taken into account during the regular inspection of schools. RE has not been included (DfE, 2015). Felicity (Year 9) said, "You would take the science one more seriously" [Interviewer: "And why is that?"] "because it's a core subject." Ferdinand (Year 11) felt that science is "stronger" than religion, and this was because "we generally have more science lessons than RE lessons."

The Teachers' Personalities and Commitments. To explain why teaching in a science lesson on origins differs from the teaching in an RE lesson, over a half (34/61) students made a comment about the personalities and/or commitments of one or both of their teachers. The majority of comments about science teachers were that they are very knowledgeable and speak with authority. Danny (Year 9) said his teacher was confident of his facts because of what he has "studied and what he's researched at university." Fritz (Year 11) claimed a science teacher will have "obviously done their Masters."

Some students explained that science lessons and RE lessons approach origins differently because of the different sensitivities of the teachers. Ingrid (Year 7) explained that her science teacher would "write it on the board and we'd copy it," whereas her RE teacher "will give us the ideas and ask how we feel and so, he'll be sensitive to other people's religions and stuff." Horace (Year 9) felt his science teachers were unable to relate to religion and that "they're obviously not religious people" whereas RE teachers "do take into account all the mass of evidence from science and things like that." Donald (Year 11) said that when teaching about origins teachers were likely to be influenced by their personal commitments:

> Our science teacher would have a more scientific approach to it, and more scientific bias, and it's the same for the RE teacher, they both have their own bias on the situation.

Irma (Year 9) also felt the teachers' personal commitments would influence their approaches:

> I think they teach it very differently, because a science teacher depends on their facts and all the logical knowledge that they have been taught originally. And, a religious teacher, and an RE teacher, depends on their faith, and they've just got to believe it.

Teachers of RE were often perceived by students to be people with a religious faith. Fritz (Year 11) said, "A religious teacher will usually be a religious person." Elizabeth (Year 12) felt that RE teachers were less knowledgeable about the facts of science and less committed to them. She compared her science and RE teachers by saying:

> I just think it's because like when you see your science teacher you're like, oh they know everything, they know why it happened ... Whereas in RE it's just like they ... they just know the views, they don't know whether it's actually true.

Declan (Year 11) felt that his science and RE teachers' approaches varied from teacher to teacher:

> It depends on the teacher.... My biology teacher always says when we were learning about Darwin and evolution, 'This is one option you know but there are many others and all sorts of' whereas our chemistry teacher ... yes the chemistry teacher is one end of the scale, biology teacher is in between and then an RE teacher gives absolutely everything and allows us to make up our own minds.

Social Pressures. Over a third of students (24 of 61) said that they were careful not to voice opinions or questions in lessons about origins that might seem to challenge another person's religious beliefs. Most of these comments were made in the context of discussing the RE lesson. Elizabeth (Year 12) said, "It's always ... it's always like you're going to offend somebody ... and you just don't want to cause offence. I mean it's somebody else's beliefs, you can't judge anybody on that."

Josephine explained why she had once held back a question in RE:

> We had some Christians come in and talk to us about their theory of creation and I wanted to ask about how that fits in with like dinosaurs and things like that but I didn't because I thought that might be offensive.

Forty-five students made a comment indicating students would not ask a question that related to science in an RE lesson about origins, whereas only five students said that they would feel able to raise questions about religion in a science lesson. In most cases, the students who said that such questions would not be raised explained that this is because it would be seen as a diversion from the goal of the lesson. Eammon (Year 9) said, "God really doesn't come into science syllabuses", and Estelle (Year 12) explained that

> In Science, although they're not very open with religion, I think that's a good thing ... because your exams aren't open to religion and so I think they do have to be quite strict on [keeping to] science.

Several students said that there is not much time for questions in general in science lessons. Glenn (Year 7) said, "I think we're rather reluctant because our teacher is ... well, she tries ... she tries to get things done." Edward (Year 9) wished there could be more questions and discussions in science lessons about how science and religion relate on the basis that he would learn more. He explained, "For a start you're more likely to listen when you're involved."

DISCUSSION

Students' Perceptions of Science and Religion and the Relationship Between Science and Religion on Origins (the Origins of the Universe and Life)

In a previous section of this paper, we explained that, in England, students are expected to learn in RE lessons why scholars say that science and religion are not necessarily incompatible. We also noted that to have this insight, students need an appreciation that there are differences of opinion on the natures of science and religion (Brooke & Cantor, 1998) and that many religious texts about origins are primarily concerned with different types of questions to the questions addressed by science (Poole, 2007). Another important concept is that some claims are not amenable to scientific investigation (Hutchinson, 2011), an idea which is also emphasized in the curriculum for science.

A minority of the students participating in this study demonstrated an understanding of these ideas, whereas almost a third (19) of the cohort presented a negotiated narrative of science and religion in which "bits were edited out" of each account to mesh them together. These findings are consistent with previous research which shows that a large proportion of students suppose that science and religion address the same types of questions (Billingsley et al., 2013). In many cases, when students compared science and religion, they were contrasting the perceived certainty of science with the perceived uncertainty, relativism, and pluralism of religion.

Very few students seemed to be in a position to talk about why science does not necessarily compete with religion. Indeed when one student, Danny explained how in his view science and religion relate, he said, "Religion is like opinions and sometimes science ... scientists don't agree with people's opinions."

How Students Explain the Differences They Perceive in the Teaching They Receive in Science Lessons and RE Lessons on Origins

When students described their experiences in RE and science lessons on origins, most said that in the RE classroom, they heard about different ideas about origins and were given a choice about what to believe whereas in the "fact realm" of the science classroom, students said the teacher presented the scientific view and (in the perceptions of most students) told students that this is the way it is. As such we notice that students are frequently characterizing both science the discipline, and science the subject in similar ways, a finding which echoes findings by Leach et al. (2003). We also notice parallels between students' descriptions of religion and of the pedagogy they associate with the RE classroom. Thus religion was widely perceived to consist of ideas that cannot and/or should not be criticized or judged, whereas the RE classrooms was described as a space that is uncritical and open to a range of views including students' own beliefs. These findings seem to be consistent with previous studies which have reported that in RE lessons students are often collating and describing different points of view but are not given frameworks that they can use to critically examine the different positions they review (OFSTED 2010).

It seems reasonable to say that for both subjects, the boundary between the subject and the discipline is a soft one. This is supported by a number of findings such as that many students supposed that the RE teacher would necessarily be religious, many supposed the RE teacher would defend a religious worldview, and at least one student called their RE teacher the "religion teacher" indicating that the student did not see a reason to identify a

distinction between teaching religion and the teaching carried out by the RE teacher. In a similar way, science teachers and science lessons were strongly associated with science to the extent that in some cases the word "science" was used as a truncated way to refer to a science teacher.

In their science lessons, students expect the teacher to present facts that they are expected to accept as true, a finding that is consistent with previous research (see, e.g., Driver, 1989; Gilbert et al., 1982; Leach et al., 2003; Millar & Osborne, 1998; Osborne & Dillon, 2008). These findings that students could readily characterize the teaching in each subject are indications of how attuned students had become to the subject cultures in each classroom (Aikenhead, 1996). In their RE lessons, they expect to be given more than one perspective and a choice about what to believe. Many students also contrasted the experimental "proof" and visual evidence they expected to see in a science lesson on origins with the lack of visual evidence they expect to see in RE for the religious account. When students explained how this applies in an RE lesson about origins, they described the choice in different ways. Some anticipated that they would hear many religious views and to be asked to form their own opinions; others said they were offered a choice about whether to accept science or religion. Some students, including Donald, supposed that although the RE teacher would not press them into accepting a particular answer, RE teachers have a bias toward religion and science teachers a bias toward science. Other comments were that science is a subject that you would take seriously, whereas RE is a subject with a lower status. Students contrasted the qualifications they supposed their teachers to have and their teachers' attitudes to questions and discussion. Very few students seemed to be in a position to talk about the types of questions each discipline addresses or be able to articulate why science does not necessarily compete with religion. The boundary rules which students use to make sense of the teaching they receive about origins are presented in Figure 1.

CONCLUSION

The findings of this study indicate that there are social and pedagogical barriers that can impede students' developing interdisciplinary insight into how science and religion relate. The barriers we identified via this study are also likely to interfere with students' developing insight into how science relates to the humanities more generally.

The first barrier is that the conceptual links between the ideas set out in the RE and science curriculum documents can be masked from students by their tendency to see their classrooms as separate cultures which deal with knowledge and learning in individualistic ways. When students in this study talked about science and religion, they frequently contrasted the perceived certainty of science with the perceived relativism and uncertainty of religion. These perceptions of science and religion seem to be inferred from students' experiences of how knowledge claims are presented and managed in each classroom. Such findings are consistent with research that identifies links between students' perceptions of science and their experiences in science classrooms (see, e.g., Driver, 1989; Gilbert et al., 1982; Leach et al., 2003; Millar & Osborne, 1998; Osborne & Dillon, 2008). We also drew attention previously to the notion of situated cognition (Hennessy, 1993) and the idea that school subjects become subject cultures (Stodolsky & Grossman, 1995). When the findings of the current study are viewed in the light of those theories, it is clear that teachers and curriculum documents need to do more to facilitate border crossings between subjects for students (Aikenhead & Jegede, 1999; Anderson et al., 1996; Costa, 1995). This study revealed that the science classroom is perceived by students to be a space that is concerned with facts. In contrast, the RE classroom is seen by students as a space in which a range of ideas can be presented but there are no criteria to say whether one idea is better than

Students' perceptions of:	Science lessons		RE lessons
The natures of science and religion	Science consists of facts, which are tested using experiments.		All ideas in religion are equally valid and you cannot say one is better than another.
	SOFT BOUNDARY		SOFT BOUNDARY
The stances in RE and science lessons on Origins on truth	The scientific account is presented as 'the way it is'.	FIRM BOUNDARY	You are given a choice about what to believe and opportunities to voice your own view.
The teaching methods and tools	There are experiments and you are shown evidence and videos.		There are stories and people expressing their opinions.
The status of each subject	You take it more seriously.		It has a lower status.
The teachers' personalities and commitments	The teachers are well qualified and very knowledgeable about science. Some students believe their science teachers are closed-minded and can be insensitive to children's beliefs.		The teacher is not as well qualified nor as knowledgeable about science. The teacher is sensitive to children's beliefs.
Social pressures	The teacher is pressed for time does not want questions that slow the lesson down or are off-topic.		It is important not to say or ask anything that could offend someone.

Figure 1. Summary of the boundary rules students use to explain their classroom.

another. This lack of a critical framework means that the choice to reject science seems to students to be acceptable within the epistemological framework that they suppose exists in their RE lessons. In addition, the inflexible and content-driven approach that students perceive to be the norm in science lessons constrains the questions that students feel it is appropriate to ask and fosters a sense that science works in isolation and shuns the insights that might be drawn from other disciplines. This perception of the nature of science is unfortunate as it is counter to the position held by many scientists (Reiss, 2010; Taber, 2013) and works against efforts in the RE classroom to ensure students are not limited to a view of science as necessarily scientistic. We noted previously that scientism is the view that science is the only valid way to address a question (Stenmark, 2001) and the value for students of being able to recognize this position and also to recognize that it is not a necessary presupposition of science (Cobern, 2000). It seems unlikely that students will achieve the intellectual progress required to these insights without effective teaching (Reich, 1991). Students' capacities to explore and learn about cross-disciplinary topics were further limited by their sense of what they should and should not discuss in each

subject and, for this theme (origins), by the additional pressure not to express a view or ask a question that might offend other people.

RECOMMENDATIONS

That students are interpreting the teaching they receive through a framework which says that subjects have firm boundaries and work independently is perhaps not very surprising given that their lessons take place in different physical spaces with different subject teachers. One way that educators might reduce the influence of these boundary rules is to provide a session with a cross-disciplinary perspective in a library (or similar multidisciplinary space).

To help students to strengthen their understanding of the nature of science we suggest that students would benefit from more teaching about the limits of science and that in science lessons, students could look at cross-disciplinary questions to develop their understanding ideas about how questions can be addressed and what types of evidence may be helpful for different types of questions. While this could include looking at questions which bridge science and religion, we agree with other commentators who have pointed to the benefits for students' developing understanding of the nature of science of working with questions which bridge science and other disciplines in the humanities (Harris & Ratcliffe, 2005; Lederman et al., 2014; Ratcliffe, 2009; Reiss, 2010).

To further develop students' understanding of the relationships between science and religion, we suggest students could have opportunities to look at whether science opposes the possibility of the creation of the universe by God or gods. We also recommend that students are given more opportunities to explore scholarly discussions about the meaning, language, and historical contexts of religious accounts of creation.

We noted that many students said that they experienced two different and inconsistent stances on truth in RE and science lessons that teach about origins. It is important to emphasize to students that science and religion are not necessarily incompatible (Poole, 2007) and that the view that science and religion are compatible is present in all the major world religions (Reiss, 2010). Finally, this study points to the need for research exploring other areas where there are disciplinary overlaps to see if similar factors are working against inter-disciplinary communication elsewhere.

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