Secondary school students' epistemic insight into the relationships between science and religion – a preliminary enquiry

Res Sci Educ (2013) 43:1715–1732
DOI 10.1007/s11165-012-9317-y

Secondary School Students' Epistemic Insight into the Relationships Between Science and Religion—A Preliminary Enquiry

Berry Billingsley · Keith Taber · Fran Riga · Helen Newdick

Published online: 14 September 2012

Abstract A number of previous studies have shown that there is a widespread view among young people that science and religion are opposed. In this paper, we suggest that it requires a significant level of what can be termed "epistemic insight" to access the idea that some people see science and religion as compatible while others do not. To explore this further, we draw on previous work to devise a methodology to discover students' thinking about apparent contradictions between scientific and religious explanations of the origins of the universe. In our discussion of the findings, we highlight that students' epistemic insight in this context does seem in many cases to be limited and we outline some of the issues emerging from the study that seem to boost or limit students' progress in this area.

Keywords Origins · Epistemology · Science · Religion · Evolution · Contradictions · Conflict · Belief · Origins

Introduction

Does the universe have a purpose? Is life here by anything other than an accident? These are the so-called Big Questions (Shipman et al., 2002) that occupy the minds of many people at some time during their lives. As practitioners in science education, we argue that it is

B. Billingsley (✉) · H. Newdick
Institute of Education, University of Reading, Reading, UK
e-mail: b.billingsley@reading.ac.uk

H. Newdick
e-mail: h.s.newdick@reading.ac.uk

K. Taber
Faculty of Education, Cambridge University, Cambridge, UK
e-mail: kst24@cam.ac.uk

F. Riga
Faraday Institute for Science and Religion, Cambridge, UK
e-mail: fr223@hermes.cam.ac.uk

valuable to look at what students believe science says about these questions and whether, in some students' minds, science interacts with their religious beliefs. In this paper, we report on secondary level students' thinking about what they perceived science and religion to say about the origins of the universe and of life. The central aim was to discover whether students were able to access a range of perspectives on how science and religion relate when they are asked to explain what they believe about the origins of life and the universe.

Background

A common starting point in this and other discussions about the relationships between science and religion is to highlight that, underpinning what has been a long and vigorous debate, there is a diversity of views about which view of science and of religion should be compared (for example, see Barbour, 2002; Brooke, 1991). Brooke (1991, p. 321) says, for example, that "There is no such thing as **the** relationship between science and religion. It is what different individuals and communities have made of it in a plethora of different contexts". An individual's perspective on the relationship between science and religion depends, then, on how that individual perceives the nature of science and the nature of religion.

One perspective is that science and religion are compatible. Gould (1999, p. 6) explains that, if we agree that science "covers the empirical realm" while religion "extends over questions of ultimate meaning and moral value", then neither can comment on the claims of the other and there can be no contradictions between them.

Not everyone accepts, however, that religion can be confined in the way Gould describes. Barbour (1988, 2002) notes that, if the beliefs held by Young Earth Creationists about how and when the universe began (beliefs that certainly concern the empirical realm) are compared with the account from mainstream science, conflicts are readily apparent.

We turn now to review a number of studies which have looked at young people's thinking about science and religion. Many researchers exploring students' thinking about science and religion have identified the need to consider carefully how young people decide what to believe. The topics that are addressed by both science and religion, such as the origins of human existence, matter to students beyond the context of their science classrooms. As Reiss (2008) highlights, the importance of religion within some worldviews can lead students to say that religion is more credible to them than science (for example, see Roth, 1997). The point is made by Hokayem and BouJaoude (2008, p. 388) that religious beliefs "cannot be treated as misconceptions but have to be included as part of an individual's 'cultural milieu' that requires detailed description and analysis rather than modification".

A methodology commonly employed in this area of research is to enquire into students' thinking about the relationship between science and religion by looking at what each young person believes about the natures of science and religion (Billingsley, 2004; Dagher & BouJaoude, 1997; Francis et al., 1990; Fulljames et al., 1991; Hansson & Redfors, 2007a, 2007b; Hokayem & BouJaoude, 2008; Scharmann, 1993; Schneller, 1982; Smith, 1994). For example, from their research, Hansson and Redfors found that 18- to 19-year-old students in Sweden tended to see physics as necessarily scientistic and this underpinned a perception by those students that physics and religion are incompatible. Fulljames et al. (1991) report on a series of large-scale surveys with secondary school students in the UK. Their report identifies a negative correlation between acceptance of "creationism" and positive attitude toward science and also a negative correlation between "scientism" and positive attitude toward religion. Scientism is the view that science alone is the route to reliable knowledge,

an idea expressed by Bertrand Russell (1935, p. 243): "Whatever knowledge is attainable, must be attained by scientific methods; and what science cannot discover, mankind cannot know."

We move now to the question of whether students are in a position to draw on a range of perspectives on the natures of science and religion when forming their views on the relationship between them. In our current study, we will be looking at students' access to a range of views on the relationship between the scientific and religious explanations of the origins of the universe and life. Central to our study is our concern that students are unlikely to progress to a level of understanding in which they can explain why there are different views among scholars about the relationship unless they receive teaching formally or informally about the ideas which underpin the different models. The basis for this concern is set out shortly, after an explanation in the next paragraph of the ideas which underpin the Independence model. In the Independence model, it is said that the explanations from science and religion relating to origins are not incompatible because they are different types of explanation.

Those who support this view argue that religious texts are not sources of scientific truths but instead present theological truths using the scientific models of their day (for example, see Alexander, 2008; Berry, 1996; Haught, 1995; Peacocke, 1993; Polkinghorne, 1996; Wilson, 1998). Science is also said to be bounded, and in this context, it is said that the types of questions which are outside the realm of science are, "Is the universe a cosmic accident or was it planned? Does life have any meaning or purpose? Why is there something rather than nothing?" (Poole, 2005, p. 310). Independence is one of a number of viewpoints that see science and religion as compatible in relation to the origins of the universe and life. An example of another such view is Deism, which says that God created the universe long ago and then left it to operate in accordance with scientific rules of cause and effect (Alexander, 2008).

Our circumspection that these ideas might be challenging for younger learners is supported by research by Reich (1989, 1991). Reich carried out interviews across a 10-year period looking at respondents' thinking about origin, evolution and characteristics of the universe and God's role in it. He produced a model of religious development that saw as key issues: (1) students' ability to deal with metaphors, analogies and symbols, (2) epistemic cognition, (3) relational and contextual reasoning and (4) ontological development. Reich (1991) concluded that the Independence view is particularly challenging and argued that this is why it is not widely adopted by the public, even though it is described in numerous publications by religious scientists. Sharpe (1991) was reluctant to have one particular view put on an intellectual pedestal and argued that a more even-handed indication of a high level of understanding in this context might be the ability to decide whether a conflict can rightfully be redefined in terms of a complementary relationship or not.

On this basis, it seems reasonable to say that students would need to have a relatively high level of what we will term "epistemic insight" to explain why there are different views of the relationship between science and religion on origins. It is likely that they would also need to be provided with a motivation to explore their own thinking. Cultural studies of science education have shown that most people are comfortable with holding apparently conflicting ideas unless there is an impetus that leads them to examine what they believe (Treadgust & Duit, 2008)

The final section of this review describes a study by Billingsley (2004) which in many ways was a forerunner to the current study. Billingsley (2004) interviewed 40 undergraduate students in the Australian context to discover their thinking about the relationships between science and religion on questions where there are said to be conflicting views. The topics were drawn from a discussion by Polkinghorne (1998). The Australian study differed from some of those described already in that students were asked not only how they saw the

relationship at the point of the interview but also how they approached these questions in their "everyday lives" outside the interview setting. One of the findings to emerge from the study was the observation that many of the students chose to live with what they perceived to be contradictory ideas rather than make choices between beliefs. Over a third of the sample said that they saw science and religion as contradictory but were undecided about what to believe. One said, "I'm interested but I feel like a spectator. I'm watching to see which one wins. I'm not interested in resolving it; it's just interesting" (Billingsley, 2004). Another said, "If I'm thinking about religion, I take a religious kind of view, but if I'm thinking in a science way, I take the science view" (p. 282).

Another finding was that, in some cases, students had not thought to compare science and religion before the interview. One said, for example, "I haven't thought about them together before … I was taught to believe both of them and I haven't formed my own belief. My beliefs are in two different areas … I need to sit down and take a closer look" (p. 93).

The study concluded that it would be useful to have a typology of young people's views on the relationships between science and religion which reflected the finding that students seemed to bring widely differing levels of interest and insight to the research interview.

Our current study, then, was informed by these previous studies. The primary aim is to devise a systematic method to determine the extent to which each student understands why some people see science and religion as compatible and some other people do not, that science and religion are not necessarily incompatible. A secondary aim was to devise a category system to describe students' own views of the relationship. The motivations for the third and fourth research questions were to determine the extent to which the students taking part find these types of questions interesting to explore and whether they perceive they have access to teaching on these types of questions. These aspects were chosen because we surmised that they are likely to affect students' progression in thinking about the relationships between science and religion. They are also aspects which teachers and teaching can to some extent influence.

The research questions are:

1. What is the student's view of the relationship between what science and religion tell us about the origins of the universe and life?
2. Does the student understand that there are many views of the relationship underpinned by different views of science and/or religion in relation to this theme?
3. What are students' attitudes towards thinking about questions relating to the relationships between science and religion?
4. What are students' perceptions of the teaching they receive on the relationships between science and religion?

Context

Our current study is set in the English secondary school context. In England, Science and Religious Education (RE) are currently compulsory curriculum subjects for students up to the age of 16, although parents can choose to withdraw their children from RE lessons. There is a statutory program of study for Science set out in a National Curriculum; the guidance document for RE is provided within a non-statutory national framework. The decision about what students study in RE is made by various organisations, depending on the type of school. Community schools under the auspices of the Local Education Authority

follow a locally agreed syllabus determined by the Standing Advisory Committee for RE; schools with a religious foundation can develop their own locally agreed syllabus. Academies and free schools may use any locally agreed syllabus or set their own.

Methodology

For this study, four schools in geographically diverse areas of England were selected using an education directory (Tierney et al., 2005) and assigned pseudonyms in this report. In each school, one class of year 9 students (aged 13–14 years old) was selected by the head teacher to take part in a survey. Students completed a questionnaire which presented 39 statements (see Appendix 1). Many of these statements expressed the view that science and religion are opposed, for example, "The scientific view is that God does not exist". For balance, other statements presented the view that science and religion can be complementary, such as "Science supports my faith in God". From each class, three students were selected by their class teacher to take part in an interview. The teacher did not have access to the completed questionnaires when making this selection. The interviews were carried out by one researcher (the third author) and took place in each of the schools during a 1- to 3-day period. The interviewer was a qualified teacher, with previous experience of teaching secondary age students. The interviews were semi-structured, adopting a general approach which has been used widely in science education to elicit students' thinking about various topics in relation to conceptual understanding, attitudes to science, etc. (Bell, 1995; Gilbert et al., 1985; White & Gunstone, 1992). Interviewees were told that their names would not be used in our reports of findings. The interviews were recorded using digital recorders, with the participants' knowledge and permission. The students and schools were given pseudonyms and these are as follows:

- Alisha, Andrea and Anita were students at Abbey School, a church school in the centre of a small city;
- Barinder, Brenda and Brian were students at Borough School, a large comprehensive school in the suburb of a major city;
- Chas, Christine and Colin were students at Ceeside School, a smaller comprehensive school in a coastal town;
- David, Dean and Dominic were students at Dalesford Grammar, a state-maintained grammar (i.e. selecting on ability) school in a rural town.

An analysis of the findings from the survey is available (see Taber et al., 2011a, paper in *Science Education International*). We have also carried out an analysis of the interview study which categorised students' stances according to whether, for example, a student saw religion as taking precedence over science or science as taking precedence over religion (Taber et al., 2011b, paper in *Science Education*). In this paper, we are interested in the level of epistemic insight demonstrated by students taking part in the interview study.

The interview schedule (Appendix 2) had several sections. In the first section, students were asked whether they had found the survey interesting and whether it had been straightforward to complete (see Appendix). In the second section, the purpose was to discover the extent to which students had encountered and reflected on these types of questions before the interview, in classrooms and, more widely, in their everyday lives. The third section explored students' ideas about the natures of science and religion. This section included the following questions:

- Are there any religious texts that you consider sacred?

- When you think about what these texts say, do you find that they seem to contradict with what you hear in science? (explain how/why not)
- Do you think other people see this text as contradicting science?

We think it is important to make the point that, when they agree to compare what science and religion say about origins, it is feasible that some students are now "engaging" in a task that they would not ordinarily undertake. We model the interview task in the way shown in Fig. 1.

The final section of the interview sought to identify whether students were aware of other perspectives on origins alongside their own. This part is copied here for convenience (Section 4: The Range of Views on Evolution and Creation of Appendix 2):

- What are some of the things OTHER people believe about how the universe began?
- Why do you think people think different things about the creation of the universe?
- What are some of the things OTHER people believe about how living things come to be on earth?
- Why do you think people think different things about how different types of living things came to be on earth?

Analysis

The interview transcripts were carefully studied and passages were highlighted which were deemed to relate to the research questions. These passages were ones that included discussions between the interviewer and interviewee around the theme of origins to enable us to address the first two research questions. They also included passages where students described their attitudes towards thinking about these types of questions and also references to thinking or learning about this area in school or outside school prior to the interview.

Research Question 1: Students' Views of the Relationships

The first author sought to categorise each student's view of the relationship between science and religion on each of the beginning of the universe and on the beginning of life by looking for perceptions of contradictions between what science and religion say on each topic. As the questions in our interview schedule shows, we had intended to treat the beginning of the universe and the beginning of life as distinct topics and to discover whether students seemed

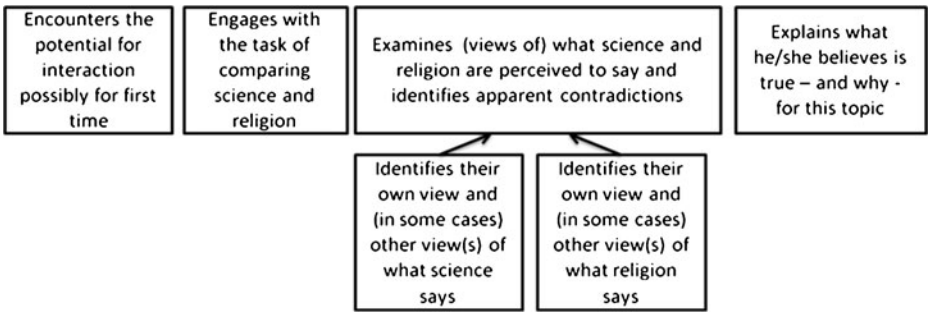

Fig. 1 Model of the interview task

to perceive more contradictions on one topic rather than the other. In the event, however, the transcripts did not facilitate this distinction. Students addressed both the beginning of the universe and also of life within the answers they gave to each set of questions. This is no doubt because the creation of both the universe and life appear in the same Judaeo–Christian–Islamic story. Andrea, for example, contrasted the Big Bang with Adam and Eve as though these were alternative accounts of our "origins", saying she sometimes wondered, "how can there be the big bang and then, how could there be Adam and Eve and … the story of the creation". This issue was shared with the team and the decision was made to treat origins as one topic and to look at students' perceptions of contradictions between science and religion relating to this broader area.

The first author devised a provisional category system based on her reading of the transcripts. The categories produced by the first author together with unmarked transcripts were shared with the team who provided notes and ideas electronically leading to modifications of the category names. This category system and illustrative comments within each category were then shared with two science education tutors who were external to the project. These external reviews resulted in further minor modifications to clarify the category descriptions. The final categories of students' views of the relationship are Contradictory, Negotiated, Unexplored and Unknowable. The categories, their descriptions and illustrative comments are given as follows.

Contradictory

Half the sample of students was judged to have said that science and religion make contradictory claims about the origins of the universe. The students in this group sometimes described science and religion as providing explanations of origins which are wholly incompatible and sometimes identified instances where they perceived contradictions lay.

Chas, talking about the origins of the universe said, "The scientists have said that the Big Bang is one theory and the Bible said it's another theory, so, which one do you basically believe?" When he came to the questions relating to the origins of life on Earth, Chas said, "it's like the religion again, like, people believe that God made the Earth, and many people believe that it's just like the cycle of—people—things, like monkeys—became people." Chas was asked, "And why do you think there are these different …?" Chas's answer was, "because science has said one thing and the Bible has said another and so—that's about it—two things contradicting each other".

Brian gave few details in his description of the relationship. He commented that, "It's like—in the books, they believe what their religion believe in it, and it kind of goes against what scientists believe actually happened, in that subject".

Brenda described the Big Bang and Creation by God as mutually exclusive ideas. In her view, those with faith positions believe in the Creation. She said, "If you don't have um a religion, then you might think that it was the Big Bang; because I have religion, I think it was God who created it, so yeah".

Four students (Alisha, Brenda, Andrea and Colin) said that science and religion provide contradictory descriptions of the timeline. Colin said, for example, "The religious theory is God creating the world in seven days, but the scientific theory is a lot different".

Alisha also identified a second source of contradiction, saying, "I think, in a way science and RE is kind of like, like rivals, because they do—I think they would contradict each other because, um, in RE they say you're meant to believe this because of God's word, in science they say well no there must be a reason, so it's kind of hard to like, it's kind of like sides to sort of choose, where you like follow your faith, or where you like—there's always a reason

for everything sort of thing". This suggests to us that Alisha sees the realms of science and religion as overlapping because she does not seem to see these differing tests of validity as relating to different types of questions. It is interesting to note that, in Alisha's rationale, it is the science and RE classrooms that are said to be in conflict. This may be a slip of the tongue or perhaps Alisha sees each of her classrooms as siding with one of the rival methods of validation.

Andrea identified that, in her mind, another potential contradiction between science and religion was that "scientists kind of, don't understand religion" and that "God isn't an actual material person, he's a spiritual person". From these comments, we infer it is likely that Andrea sees materialism as a necessary position for a scientist and then rejects this view for herself.

Negotiated

In our review of the literature, we identified some of the models which, in scholarly writing, underpin the view that science and religion can be compatible. We noted that in the Independence view, science and religion are said to provide different types of explanations which necessarily cannot contradict, while in Deism, God is necessary (only) to explain why there is a universe at all.

None of the 12 students we interviewed for this study said that there are no contradictions between science and religion. This said, four students said that, with thought, it is possible to see that science and religion could be compatible. The comments offered by these students could be considered to resonate with the thinking which underpins Independence, but they could also be considered to be consistent with Deism. For this reason, the views expressed by these students were placed into one category which we labelled the category "Negotiated" on the basis that these students said that there may be ways to see science and religion as compatible. The first example is a comment by Dean which we present to illustrate why we deemed that these students see the relationship as "negotiated" rather than as straightforward. Dean was asked whether the ideas we have from science and religion about the beginning of the universe contradict. He said, "Sometimes yeah [they do contradict] like with creation and everything, but the Bible isn't always taken literally, for instance, some people just think it's a story, that's used to display morals".

A second student, David said that science and religion "don't go down the same track, some can have different ideas, but they can be linked together, but not straight away, you have to think about it a bit more". In another section of his interview, David was asked whether science and religion contradict in relation to the beginning of life. David said, "to an extent, but then you get back to how evolution started—must've start—been caused by something, and science can't prove what started it all in the first place". On the basis that David saw science and religion as potentially compatible, his response is placed into this category.

Dominic found it difficult to answer the question of whether science and religion "contradict" as "I like to think that science might be proving religion in a way, or religion might help scientists, and stuff, so if you—cos like some of them, you need to elaborate on your answer a bit more to say what it means really". When he was asked whether evolution is an idea that contradicts with a religious view, Dominic said, "I wouldn't say evolution necessarily contradicts it, because it could be God created animals and they just evolved into us, or something like that".

Anita was asked whether science and religion conflict in relation to what they say about the beginning of the universe, she said, "It's really interesting because all the different

theories, they clash, but like when you think about it deeper like with the big bang, we don't know why it happened, it could've been God creating the universe with the big bang". This remark seemed clearly to fit the category of "negotiated". When Anita was asked to consider whether there is a contradiction between the idea of God creating life and the idea of evolution, she said, "Scientists believe in evolution, and the Bible says that all things were created as they are, and it's … kind of weird, cos like God could've created animals as the um (pause) as cells, and then they could've evolved, yeah—the Bible doesn't say that, it says kind of different". Anita's response suggests that she was uncomfortable about stepping too far from a literal reading of the Biblical description. After discussion, Anita's approach was labelled as "negotiated", but to a degree, it bridges "contradictory" and "negotiated".

Unexplored

In this sample, 1 of the 12 students said that she had not thought about this issue until the point of the survey. Christine said that she had found it challenging to complete the survey because, "I've met religion, and I do science, but I've never had'em both together, like, I never knew it could link in such a way". Later, Christine said, "I knew that people say that God makes the Earth sometimes, and some people say it's caused [by] the Big Bang …, but I didn't connect it, or link it in any way to do with science and religion". This view of the relationship was labelled "Unexplored' and is an approach that was also evident in the study of tertiary level students' approaches (Billingsley, 2004).

Unknowable

The view expressed by Barinder did not fit into any of the previous categories. He explained that, in his view, we should not expect to know with any certainty how the universe began. He said, "There could be all different ways of, making it happen, and there's no real reason cos no-one's been there to see it". At another point in the interview, Barinder said, "Different religions think different theories, like Hindus believe that there was 'om' coming, like from no-where, and then all of a sudden there was a big bang, and then it all came".

It seems relevant to say that Barinder associated his perspective with his Hindu faith and also to note that, in the studies by Billingsley (2004) of tertiary level students' views, there were individuals in that sample, some of whom were Christians, who felt, like Barinder, that these questions are unanswerable. This perception of the relationship was labelled "Unknowable" on the basis that Barinder felt that, since there will never be a definitive understanding of our origins, there is no value in comparing science and religion.

Research Question 2: Epistemic Insight (Awareness of Many Views of the Relationship)

For each student, we sought to discover whether he or she was able to access more than one view of the relationship. Working with the transcripts, we arrived at two labels to describe the range of views in this sample. Those were "No evidence of insight into other views (of the relationship)" and "Some evidence of negotiating the nature of religion". The basis for this was that, in this sample, none of the students talked about different views of the nature of science. There were, however, students who explained that the nature of religion is not absolute and this has an impact on how science and religion seem to relate. We begin this discussion with examples of cases that seemed straightforward to categorise.

As we illustrated previously, Anita and Dean were aware that people can have different ideas about how to interpret the Christian Creation story and that this can lead them to draw

different conclusions about how science and religion relate. Barinder also offered an explanation to say why different people hold different views of the relationship. His starting point was that people have different religious views because of their different cultural backgrounds. He explained that, for Hindus, the nature of the religious account is such that there does not seem to be a contradiction between the scientific and religious explanations of origins. He was also aware that, for other people who believe in "Adam and Eve", there can be a contradiction.

In contrast with the analysis given by Anita and Dean, Andrea was of the view that Christians would all accept, as she did, a literal interpretation of the story. She said, "The Pope would believe in the story of creation and Adam and Eve, and other Christians would believe that as well".

Alisha, like Andrea, seemed to think that everyone with a religious view would regard science as making contradictory claims. The researcher asked her, "Do you think other people would think that the Bible contradicts with science?" Alisha said, "I think they would … I remember a book about it saying about how half of it couldn't be true, because it just doesn't go in with the rules of science".

Brenda saw science and religion as opposed throughout her interview and did not mention any other perspectives. In her view, individuals accept the account they are brought up to believe. She said, "I think if you've been brought up being told that, that you've (come) from monkeys and stuff, then that's what you'll believe in".

Chas and Brian seemed to know of no other views of the relationship beyond the one they each held, which was that science and religion are opposed. Chas, for example, was asked by the researcher whether he has considered that science and religion "might not be against each other". He said, "Well, I hadn't really thought about it to be honest". Brian was asked whether his answers about religion would apply to any religion or just to a specific religion. His answer was, "I'm atheist, so, I don't really know". As we noted previously, Christine considered the relationship for the first time in the interview. From the transcript, we concluded that she was not aware of different ways to describe the relationship between the scientific and religious views.

We move now to the cases that were not as straightforward to categorise. In his interview, Dominic recalled a lesson that had looked at different views of the relationship. He said, "I think in year 7 [when 11–12 year olds] we were doing about 'Does God exist?' and we did talk a lot about the Big Bang, and that if like did God start the Big Bang? Or like did it just happen, or, stuff like that, but that was quite a while ago". It seems from this comment that Dominic remembers discussing the nature of science and whether it can be compatible with a divine act of Creation. As we reported earlier, Dominic's own view was that evolution does not necessarily conflict with a religious perspective because, "it could be God created animals and they just evolved into us". He was asked, "Do you think other people see the Bible as contradicting with science?" Dominic's reply was, "Well, yes, because a lot of the time if people have made these theories, the church often goes against it, especially with the evolution theory". We concluded from his remarks that Dominic knew that there are different views of what science and religion say.

Another student, Colin also referred to studying this theme in a lesson saying, "We did have a very detailed discussion in science about what we believed in, about religion, and science, and comparing them together—it was really interesting". We could not find, however, any evidence to show that Colin could access an understanding that there are different views of the natures of science and/or religion. For example, when Colin talked about what science and religion say about origins, he presented them as contradictory historical narratives: "[there's the] the scientific [version] coming from possibly plants turning into small animals, evolving—millions

and millions of years—evolving into us, and then there's the religious version being God creating the [universe] and then Adam and Eve, that theory… They're very different, because they do contradict each other". We concluded that Colin was not accessing an understanding that there are different views of what science and religion say.

David, in his interview, expressed the opinion that science and religion are potentially compatible. When he was asked whether other people might see science and religion as contradictory, he said, "I think there would be other people who do because other people can think anything". In our analysis, David's view was recorded as demonstrating some understanding of the idea that the nature of religion is not absolute, partly on the basis of his explanation for the way that religion and evolution might fit together (described previously).

Research Questions 3 and 4

To address the third and fourth research questions, the authors studied the transcripts independently and made notes of comments that were perceived to address (for research question 3) the student's attitude towards thinking about these kinds of questions and (for research question 4) what the student recalled about the teaching he or she had received. Reviewing our notes collectively led to the identification of themes which could be used to discuss the views of the students both individually and as a group. These themes are set out and illustrated as follows.

Research Question 3: Attitudes to Thinking About These Questions

Theme 1: These are Questions that I Think About in My Own Time

Five of the 12 students said that they found the topics in the survey very interesting and that they raised questions which they think about in their own time. Three students (Alisha, Anita and Dean) explained this interest by saying that it fitted into a broader interest to reflect on their own religious faith positions. Anita who described herself as a Christian was asked, "Have you spent time thinking about these issues?" Anita replied, "Definitely!" Later, Anita explained, "I like to challenge my faith, and it's like get closer to God by challenging it". Dean said these kinds of questions are the kinds of things "you think about when you're on the bus and there's no one to talk to or something". Of his faith position, he said, "I like to call myself a Buddhist, but I don't think there are any real texts that I think were written by a god or gods". The third student in this group, Alisha, a Christian, explained her interest in the survey by saying that, "faith is a big part of everyone's lives".

In the cases of two students (Dominic and Colin), their interest had been stimulated, they said, by a discussion or trip provided by their teachers. Dominic, who described himself as a Christian, was asked whether he had thought about these kinds of questions before the interview and his answer was, "yeah—definitely, cos, I think, there was—something [for a school trip] I went to was all about this sort of stuff about science and religion, and it sort of got you thinking a lot about the whole idea". Colin described himself as an atheist. He said, "We did have a very detailed discussion in science about what we believed in, about religion, and science, and comparing them together—it was really interesting".

Theme 2: These Questions are Interesting But Not Something I Think About

Three students said that, although these kinds of questions are interesting, they were not the types of questions they explored in their own time. Brenda described herself as a Christian.

She explained that, even though she had found the survey interesting to fill in, she had not given these ideas thought prior to the survey, "I just didn't really think—there was a reason for me to actually kind of ponder the thought". Brenda saw the relationship as necessarily contradictory. Andrea described herself as a Christian and explained that, although she saw the relationship between science and religion as interesting and important, ordinarily, she avoided thinking about it because it's "easier not to think about it cos it's just too confusing". The third student in this group is Christine who, prior to the interview, had not considered the notion that there could be a relationship between science and religion.

Theme 3: I Have No Interest in Thinking About These Questions

All but two students said that they had found the statements in the survey interesting to consider. Brian described himself as an atheist and said he was not interested in thinking about the relationship. Chas, a student at Ceeside Comprehensive and also an atheist, said that he was "not that interested" in thinking about these kinds of questions. He explained that, "I understand a lot about religion, but me personally, I don't believe in religion".

Research Question 4: Recollections of Teaching

Theme 4: These Questions are Outside the Topics that Science and RE Classrooms Look At

Seven of the 12 students said that they could not recall any teaching about the relationships between science and religion in their Science or RE lessons. The reason given by four of the students to explain why the topic had not been explored was that each classroom had its own areas to cover and they could not envisage a situation in which these topics would be raised in either Science or RE lessons. Brenda expressed the view that teachers would only want to be asked questions that were appropriate for their subject. Brenda said, "We don't really talk about RS in science. I don't think the teacher really brings it up, and no-one ever asks about it, so there's no need for her to bring it up. And the same with RS, no-one really asks the science questions because you'd really more ask your science teacher about that instead of asking your RE teacher".

Chas said, for example, "We don't do science and religion, we don't bond them together, we have two different lessons". Brian similarly could not recall any teaching about the relationships, saying that, in their Religious Studies' lessons, students discussed their beliefs and that, in science, "We don't really talk about things that relate—can relate to religion".

David also felt that these kinds of topics were outside the remit of either classroom. He said he would not consider asking a question in a science lesson about one of these topics he had talked about the interview, saying, "We don't ask science teachers questions any more at the moment, because we don't think that they'd answer them. We wouldn't have thought (pause)—oh they won't answer that because it's not on their topic".

As we noted previously, in the case of Christine, prior to the interview, she had not considered the potential for interaction between science and religion. This perspective was also present in her description of the teaching she received. She said, "When I'm in science, I don't think about religion sometimes, because it don't have nothing to do with it […] it just don't come into your head".

For David, Brenda, Brian, Chas and Christine, questions about the relationships between science and religion seemed to fall outside what was covered in Science lessons and RE lessons. Two other students also described boundaries as in operation but these students saw the boundaries as implemented by teachers and/or students as ways to avoid talking about issues that might be in some sense problematic.

We gave a section from Alisha's interview previously in which she said that her Science and RE classrooms presented "rival" perspectives. Alisha said that her teachers had "never put religion and science together". It seemed to be Alisha's opinion that these topics were avoided by her teachers because, "[the teachers] are very careful in this school cos it's a Christian based school and [….] otherwise we'll have—we'll end up with, people becoming incredibly confused". Alisha later added that, "I think like the science teachers do try and avoid them a bit because if they do like answer they have to think about what they really are going to say, cos people could be against it because of their religion—could be different".

Barinder was the second student who seemed to feel that the perspectives offered in his Science and RE classrooms to be at odds with each other. He said that he would like some of these questions to be covered in class because it would "explain it a little bit more, because it's confusing—science says one thing, RS says the other".

Theme 5: My Teachers are Open to Looking at These Types of Questions

In contrast to the views discussed in the previous section, five students said that they had received teaching about the relationships between science and religion. For three of the five, the teaching was something they remembered with enthusiasm. Anita said that she had opportunities to ask questions at school and that her science teachers were "quite open to the fact that we are Christian". She said, "If you ask a question about, 'well does that prove that God doesn't exist?' they kind of give you an explanation that would be open to your opinions". As we explained previously, for two students (Collin and Dominic), the discussion had stimulated an interest that extended beyond the end of the session. For David and Dean, there had been some discussion of this theme in RE lessons but they had not given the ideas further thought outside those lessons.

The results from this analysis are set out in Table 1.

Table 1 Results of the analysis of the research questions

Students	View of the relationship	Insight into a range of views of relationship	Attitude towards exploring these questions	Recalls receiving teaching on the relationships
Anita, Dominic, Dean	Negotiated	Some evidence of insight into a range of views	Interested and engaged in exploring	Yes
David	Negotiated	Some evidence of insight into a range of views	Interested but not engaged in exploring	Yes
Barinder	Unknowable	Some evidence of insight into a range of views	Interested but not engaged in exploring	No
Colin	Contradictory	No evidence of insight into a range of views	Interested but not engaged in exploring	Yes
Alisha, Brenda and Andrea	Contradictory	No evidence of insight into a range of views	Interested but not engaged in exploring	No
Brian and Chas	Contradictory	No evidence of insight into a range of views	Not interested	No
Christine	Unexplored	No evidence of insight into a range of views	Unaware of the potential for science and religion to interact	No

Discussion

Research Questions 1 and 2

The primary aim of this study was to devise a way to assess students' levels of epistemic insight when they consider the relationships between science and religion. The categorisation method we devised does not assume that compatibility is necessarily a more insightful view. Rather, we see the ability to recognise different possible views, suggesting that the student's own view is not simply considered a default position, but as more insightful, assuming everyone else should share one's own perspective.

On the basis of this preliminary study, we argue that the assessment method is effective and also that it is one that can be useful in the context of science education. The findings from these interviews highlight that, for many students in the sample, there is not the option of seeing science and religion as compatible because the natures of science and religion are seen as absolute. For most students in the current study, science and religion were perceived to present contradictory claims. The religious account was perceived by many students to specify 6 or 7 days for Creation. Most of the students knew only of one view of what religion says and one view of what science says. Students who perceived science and religion as somewhat compatible explained that the religious account need not be read literally. Discussion about the nature of science was less frequent, but one student described the ways to test the truthfulness of claims that are presented in Science and RE classrooms as "rivals".

A secondary aim for this study was to devise a category system for students' views of the relationship between science and religion. As we explained, a number of authors have presented typologies of the ways that the relationships have been described in scholarly and popular media. We argue that the interviews carried out for this study demonstrate the need in this context of a category system which is tailored to the approaches taken by secondary school students. The system we devised based on this sample of interviews was:

- Contradictory,
- Negotiated,
- Unknowable,
- Unexplored.

Research Questions 3 and 4

The motivation for the third and fourth research questions was to look at some potential factors which we surmised might affect students' progress and which are aspects that teachers can influence. Our basis for the choice of potential factors is that students are more likely to progress in their understanding of a range of views of the relationships between science and religion if they find these types of questions interesting to explore and if they have access to teaching about the relationships between science and religion. In this sample, we notice that the majority of students (10 out of 12) said they were interested in exploring questions about science and religion and some students said these were questions they considered outside lessons for their own interest. For some, this interest linked to a wider interest in thinking about their own faith positions, and for some others, it had been stimulated by an experience provided by teachers. Two students said they had no interest in thinking about the relationships between science and religion. In this sample,

some students were more motivated than others to seek a resolution about what to believe. One student, Andrea, said that, although these questions are of interest, she had not felt motivated to give them much thought. Andrea talked about having two opposing viewpoints which she kept compartmentalised. This state of "cognitive division" resonates with findings by Jegede (1997) who reports that cognitive division and collateral learning are strategies employed by students to manage conflicting schemas in cases where neither is rejected.

In this sample, only 5 of the 12 students recalled receiving teaching on the relationships between science and religion; 7 said that these kinds of questions had never been addressed by their teachers. In the views of some of the students, there is a shared understanding between students and teachers that these kinds of topics are best avoided.

Limitations

This study has met its primary aim of devising a way to assess students' understanding of the idea that science and religion are not necessarily contradictory. The second aim was to devise a typology that can be used to categorise the approaches taken by this age group. The typology presented here is based on a relatively small number of interviews and is not intended as a complete system, but rather to highlight some of the characteristics which make the approaches by young people distinctive and which seem to be important to notice in the context of education. We intend to carry out further research to produce a typology which reflects a greater understanding of the factors that affect students' progress in this area of thinking. The analysis we carried out for the other two research questions have raised a number of issues that we would like to look at in more depth. We noticed that many of the students in this study talked about which kinds of questions they feel is appropriate to ask in their lessons. Some students who saw science and religion as necessarily competing said it would be inappropriate to ask questions that might "put the teacher in a difficult spot". This suggests that a further study could usefully look in more depth at the factors which affect students' attitudes to asking questions in this context.

Conclusions

A majority of students in this sample found questions about the relationships between science and religion to be interesting. What students seemed to lack were the intellectual tools needed to explore the dilemmas in any depth. Many students seemed tied to the view that science and religion are in competition to address a common set of questions. To move students towards greater epistemic insight, we suggest that students need more opportunities to consider and compare the natures of science and religion. In this study, 7 of the 12 students said that the relationships between science and religion had not been addressed in their lessons. Our study also suggests that the level of interest among students for exploring these topics is greater than might be superficially apparent because students find ways to manage the beliefs they have (even if those beliefs are contradictory) rather than actively seek further insight.

Acknowledgments We would like to thank the staff and pupils in the four schools who contributed to this study. The study reported in this paper derives from the *Learning about Science and Religion* (LASAR) Project, under the auspices of the Faraday Institute for Science and Religion, based at St. Edmund's College, Cambridge. The project is supported by John Templeton Foundation grant number 15389.

Appendices

Appendix 1: Sample Questionnaire Statements

As explained in the main text, the interviewees were drawn from classes who have completed a survey instrument asking them to rate agreement/disagreement with a series of statements. These statements included:

- The scientific and the religious versions of how the universe began cannot both be true.
- I would like to know more about whether science and religion fit together.
- Science supports my faith in God.
- I believe that the universe was created in the way the Bible describes.
- Different religions have different ideas about how the universe began.
- I accept the scientific theory that the whole universe was created in a big bang.
- I accept that God created all the living things on earth.

Appendix 2: The Semi-Structured Interview Schedule

Section 1: Feedback on Filling in the Questionnaire

- Did you find completing the survey for us difficult (why?/why not?)
- Did you think this was an interesting topic (why?/why not?)
- Did you find it easy to know what to say about science (why/why not?)
- Did you find it easy to know what to say about religion (why/why not?)
- Were there any questions that were not clear?
- Were there any questions that it was difficult to know how to answer?

Section 2: Classroom Experience and Range of Familiar Views

- Have you met these issues before?
- Had you thought about these issues before? (when?/why?)
- Have you come across any times in school where you, or someone in your class, found that what they were being taught in science seemed to go against their religious beliefs? (can tell me about that …)
- Do you think your answers about religion would apply to all religions?

Section 3: Nature of Science and Nature of Religion

- In the questionnaire you were asked about the big bang theory, and the theory of evolution …
- What do you think a theory is?
- Are theories true/have they been proved?
- In the questionnaire you were asked about laws of nature …
- Have you learnt about any laws of nature? (which one(s)?)
- What do you think a law of nature is?
- Where do you think laws of nature come from?
- Are there any religious texts that you consider sacred?
- When you think about what these texts say, do you find that they seem to contradict with what you hear in science? (explain how/why not)
- Do you think other people see this text as contradicting science?
- What do you think the term miracle means?

- What is your view about miracles—can they happen?
- Does science support or contradict your view?

Section 4: The Range of Views on Evolution and Creation

- What are some of the things OTHER people believe about how the universe began
- Why do you think people think different things about the creation of the universe?
- What are some of the things OTHER people believe about how living things come to be on earth?
- Why do you think people think different things about how different types of livings came to be on earth?

References

Alexander, D. (2008). *Creation or evolution: Do we have to choose?* Oxford: Monarch.

Barbour, I. (1988). Ways of relating science and theology. In R. J. Russell, W. R. Stoeger, & G. V. Coyne (Eds.), *Physics, philosophy and theology: A common quest for understanding* (pp. 21–42). Vatican City State: Vatican Observatory.

Barbour, I. (2002). *Nature, human nature, and God*. London: Society for Promoting Christian Knowledge.

Bell, B. (1995). Interviewing: A technique for assessing science knowledge. In S. M. Glynn & R. Duit (Eds.), *Learning science in the schools: Research reforming practice* (pp. 347–364). Mahwah: Lawrence Erlbaum Associates.

Berry, R. J. (1996). *God and the biologist: Faith at the frontiers of science*. Leicester: Apollos.

Billingsley, B. (2004). The Public's perceptions of the apparent contradictions between science and religion, PhD Thesis, University of Tasmania.

Brooke, J. (1991). *Science and religion: Some historical perspectives*. Cambridge: Cambridge University Press.

Dagher, Z. R., & BouJaoude, S. (1997). Scientific views and religious beliefs of college students: The case of biological evolution. *Journal of Research in Science Teaching, 34*(5), 429–445.

Francis, L. J., Gibson, H. M., & Fulljames, P. (1990). Attitude towards Christianity, creationism, scientism and interest in science among 11–15 year olds. *British Journal of Religious Education, 13*(1), 4–17.

Fulljames, P., Gibson, H. M., & Francis, L. J. (1991). Creationism, scientism, Christianity and science: a study in adolescent attitudes. *British Educational Research Journal, 17*(2), 171–190.

Gilbert, J. K., Watts, D. M., & Osborne, R. J. (1985). Eliciting student views using an interview-about-instances technique. In L. H. T. West & A. L. Pines (Eds.), *Cognitive structure and conceptual change* (pp. 11–27). London: Academic.

Gould, S. J. (1999). *Rocks of ages: Science and religion in the fullness of life*. New York: Ballantine Books.

Hansson, L., & Redfors, A. (2007a). Physics and the possibility of a religious view of the universe: Swedish upper secondary students' views. *Science & Education, 16*(3–5), 461–478.

Hansson, L., & Redfors, A. (2007b). Upper secondary students in group discussions about physics and our presuppositions of the world. *Science & Education, 16*(3–5), 1007–1025.

Haught, J. F. (1995). *Science and religion: From conflict to conversation*. New York: Paulist.

Hokayem, H., & BouJaoude, S. (2008). College students' perceptions of the theory of evolution. *Journal of Research in Science Teaching, 45*(4), 395–419.

Jegede, O. (1997). School science and the development of scientific culture: A review of contemporary science education in Africa. *International Journal of Science Education, 19*(1), 1–20.

Peacocke, A. (1993). *Theology for a scientific age: Being and becoming—Natural, divine and human*. Minneapolis: Fortress.

Polkinghorne, J. (1996). *Scientists as theologians: A comparison of the writings of Ian Barbour, Arthur Peacocke and John Polkinghorne*. London: SPCK.

Polkinghorne, J. (1998). *Science and theology: An introduction*. London: SPCK.

Poole, M. (2005). Science and education. In C. Southgate (Ed.), *God, humanity and the cosmos* (pp. 303–320). London: Continuum.

Reich, K. H. (1989). Between religion and science: Complementarity in the religious thinking of young people. *British Journal of Religious Education, 11*, 62–69.

Reich, K. H. (1991). The role of complementarity reasoning in religious development. *New Directions for Child and Adolescent Development, 1991*(52), 77–89.

Reiss, M. J. (2008). Should science educators deal with the science/religion issue? *Studies in Science Education, 44*(2), 157–186.
Roth, W. M. (1997). The interaction of students' scientific and religious discourses: Two case studies. *International Journal of Science Education, 19*(2), 125–146.
Russell, B. (1935). *Religion and science*. New York: Holt.
Scharmann, L. C. (1993). Teaching evolution: Designing successful instruction. *The American Biology Teacher, 55*(8), 481–486.
Schneller, R. (1982). The science–religion problem: Attitudes of religious Israeli youth. *Youth and Society, 13* (3), 251–282.
Sharpe, K. (1991). Relating science and theology with complementarity: A caution. *Zygon: Journal of Religion and Science, 25*(4), 365–385.
Shipman, H. L., Brickhouse, N. W., Dagher, Z., & Letts, W. J. (2002). Changes in student views of religion and science in a college astronomy course. *Science Education, 86*, 526–547.
Smith, M. U. (1994). Counterpoint: Belief, understanding, and the teaching of evolution. *Journal of Research in Science Teaching, 31*(5), 591–597.
Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2011a), To what extent do pupils perceive science to be inconsistent with religious faith? An exploratory survey of 13-14 year-old English pupils. *Science Education International, 22*(2), 99–118.
Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2011b), Secondary students' responses to perceptions of the relationship between science and religion: Stances identified from an interview study. *Science Education, 95*, 1000–1025.
Tierney, J., Sinkie, E., & Gregory, J. (Eds.). (2005). *Education yearbook 2005/2206*. Harlow: Pearson Education.
Treadgust, D., & Duit, R. (2008). Conceptual change: A discussion of theoretical, methodological and practical challenges for science education. *Cultural Studies of Science Education, 3*, 297–328.
White, R. T., & Gunstone, R. F. (1992). *Probing understanding*. London: Falmer.
Wilson, E. O. (1998). *Consilience: The unity of knowledge*. New York: Vintage.