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To what extent do pupils perceive science to be inconsistent with religious faith? An exploratory survey of 13-14 year-old English pupils

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Abstract

Scientists hold a wide range of beliefs on matters of religion, although popular media coverage in the UK commonly suggests that atheism is a core commitment for scientists. Considering the relationship between religion and science is a recommended topic in the English National Curriculum for lower secondary pupils (11-14 year-olds), and it is expected that different perspectives will be considered. However it is well established that many pupils may have difficulty accessing sophisticated ideas about the nature of science, and previous research suggests some may identify science with scientism. To explore pupil impressions of the relationship between science and religion, 13-14 year old pupils were surveyed in one class from each of four English secondary schools, by asking them to rate a set of statements about the relationship between science and religion, and scientific and religious perspectives on the origins of the world, and of life on earth, on the value of prayer and on the status of miracles. The survey revealed diverse views on these issues, reflecting the wider society. However it was found that a considerable proportion of the pupils in the sample considered religious beliefs and scientific perspectives to be opposed. The basis and potential consequences of such views are considered, and the need for more attention to this area of student thinking is highlighted.

Key words: Science and religion; pupil perceptions; nature of science; worldviews; scientism

Introduction

The present paper reports findings from a study asking 13-14 year old (Year 9, or Y9) pupils in England to rate their level of agreement with a set of statements about science, religion, and how they might relate. The most salient perspective presented in popular UK culture was that

science and religion are in some sense inherently opposed, alternative worldviews. Yet such a perspective only represents one strand of thinking in a complex and sophisticated area of scholarship (Barbour, 1966; Fulljames & Stolberg, 2000). The arguments presented in such scholarship are not usually met by school age learners, who may commonly lack the levels of conceptual development (Perry, 1970; Shayer & Adey, 1981) and epistemological sophistication (Leach, Hind, & Ryder, 2003) needed to engage with such ideas. We were therefore interested in how English secondary age pupils understand the relationship between science and religion.

Science and Religion

Understanding the relationship between science and religion is complicated because neither is a fixed and unitary entity, and any notion of how they relate has to be seen against a particular cultural background (Brooke & Cantor, 1998: 21). However Barbour (2002: 1) suggests that the ‘conflict’ view - seeing science and religion as ‘enemies’ - is given the most media attention as it is able to offer a more ‘exciting’ news story. For example, in England, which is the context for the research discussed below, a national television channel has in recent years broadcast a number of programmes written and presented by Richard Dawkins who presents atheism as being rational, modern, and the only acceptable position that can be taken by someone who accepts a scientific worldview. In a series about Charles Darwin, Dawkins criticised science teachers for engaging with pupils’ religious views about creation and evolution in science lessons (Taber, 2008). Yet to ignore pupil comments reflecting convictions that may lead them to reject science seems to be poor science teaching. Taking an authoritarian approach shows disrespect for pupils’ beliefs (Reiss, 2008); misrepresents the nature of science which is based on rational argument rather than fiat; and is pedagogically suspect in terms of widely accepted constructivist notions of teaching and learning (Taber, 2009).

Several researchers have now sought to discover and describe the views held by school pupils, university pupils and teachers regarding the relationship between science and religion (Billingsley, 2004; Brickhouse, Dagher, Letts, & Shipman, 2000; Cobern & Loving, 2002; Loving & Foster, 2000; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000). Almost two decades ago, Fulljames and colleagues (Fulljames, Gibson, & Francis, 1991) carried out several large-scale surveys in the UK and found *a negative relationship* between attitudes towards Christianity and interest in science; and that the antecedents which produce this negative correlation are pupils’ belief that Christianity *necessarily* involves creationism, and the perception of science as scientism – the view that science is the only source of reliable knowledge about the world.

From more recent work, Hansson and Redfors (2007a, 2007b) report that 18-19 year old pupils interviewed in small groups in Sweden saw scientism as a *necessary* presupposition of physics, which indeed led to a perception of conflict between physics and religion. Whilst many *individual* scientists would indeed adopt such a worldview, many others find no contradiction between scientific work and holding religious faith. Smith (1994: p.595) has argued that “concerns about scientism are well founded. There are indeed teachers who teach evolution as a doctrine to believe, who encourage pupils to accept science and reject religion (as if the two were mutually exclusive)”. Some science educators do indeed argue that science and religion are fundamentally incompatible (Good, 2005).

Surveys in the UK have found a majority of pupils in post-compulsory education either accept or are uncertain about (rather than reject) the position that science is in conflict with religion

(Wilkinson, 2005). In the Australian context, Billingsley (2004) found that pupils in higher education commonly recalled the scientific and religious aspects of their formal secondary schooling as having the nature of an ‘either/or’ situation, where a choice of adopting the viewpoint presented in one area of the curriculum effectively excluded acceptance of teaching in the other domain. Three quarters of the students in a sample of 40 believed that science and religion are exclusive and that science necessarily opposes every kind of divine action, including an act of Creation.

Esbenshade (1993) has argued that, “pupils’ perceptions of a lack of compatibility between science and religion can be troubling for them. So troubling, in fact, that a significant percentage of our most motivated and capable pupils feel they may be deterred from a science career” (p.336). This is a matter of concern for science educators, especially in those many countries where significant proportions of the population have religious faith.

The context of the present research

The study reported here was undertaken in England, a multi-cultural society where many schools include pupils from a wide range of religious backgrounds. Most schools in England are not associated with a particular religion and are open to all children regardless of faith background. However, a significant minority (about a third) of state schools *do* have a ‘religious character’.

England has a National Curriculum, introduced at the start of the 1990s that specifies the programme of study in the core subjects English, Mathematics and Science, as well as in most other school subjects. Religious education is a compulsory component of the secondary school curriculum, although the relevant curriculum document is a Non-Statutory (i.e. for guidance) National Framework. This Framework refers to links between science and religion, and, in particular, that during lower secondary science, (known as ‘Key Stage 3’, for 11-14 year-olds) pupils should be taught about “religion and science: issues of truth, explanation, meaning and purpose” and “exploring the connections between religious education and other subject areas such as the arts, humanities, literature, science” (QCA, 2004: 29). It is noted that pupil learning about religion and science should build upon learning in science classes relating to “empirical questions, evidence and scientific explanations” (p.29) that is teaching relating to ‘the nature of science’.

The National Curriculum for science to be taught in secondary schools has recently been revised for both 11-14 year olds (QCA, 2007a) and 14-16 year olds (QCA, 2007b), and the new curriculum has a strong emphasis on teaching about the nature of science or ‘how science works’. A range of studies suggests that secondary pupils may struggle with aspects of the nature of science (Driver, Leach, Millar, & Scott, 1996; Grosslight, Unger, Jay, & Smith, 1991; Justi & Gilbert, 2000; Taber, 2006). Pupils commonly seem to acquire a notion that scientists produce hypotheses that are unproblematically tested, and that if ‘proved’ become facts. Indeed, Hanley reports a science teacher justifying the exclusion of discussion of religious views in science on the grounds that “science is a factual subject not a subject about opinions and personal beliefs” (Hanley, 2008: 10).

In some countries there has been a long-standing debate about how classroom teachers should deal with science and religion issues in the classroom (Good, 2005; Scott & Branch, 2003). In recent years there has been increasing concern among the UK science education community that pressure groups campaigning against the teaching of evolution are becoming increasingly

active (Poole, 2008; see also the exchange of correspondence in the letters pages of the June and September 2008 issues of *School Science Review*).

Exploring secondary age pupils' views about science and religion

Within science education, there is a well-established and extensive research programme that looks to inform teaching by investigating the ideas that pupils commonly bring to class relating to curriculum topics (Taber, 2009). Often these ideas are not consistent with target knowledge – and can act as significant factors in pupils' classroom learning. For example, most pupils have an alternative understanding of the relationship between force and motion that acts as an 'intuitive' theory (McCloskey, 1983). Similarly, research into the nature of religious beliefs in childhood suggests that "many concepts central to major religious traditions are not as opaque to young children as often thought" (Barrett, 2000: 30), and indeed some lines of research in the cognitive sciences "tentatively suggest that children's explanatory approach may be accurately characterized as intuitive theism" (Kelemen, 2004: 299).

It would be unreasonable to expect secondary school pupils to have developed fully thought-out positions regarding the relationship between science and religion, as can be found in scholarly literature on the topic (Cray, Dawkins, & Collins, 2006; Polkinghorne, 2008). Indeed, given that scholarly accounts of how science and religion may be seen as compatible tend to be quite sophisticated, and often require an ability to read religious texts as figurative (Alexander, 2008), it could be argued that school-age learners are likely to make sense of both the nature of science, and the teachings of religion in simplistic, literal ways and *not* to have developed the forms of thinking needed to appreciate how religion might be seen as consistent with science (Perry, 1970). Such an assumption would be consistent with research exploring secondary pupils' scientific thinking (Driver et al., 1996). We were interested to find out:

- *how do secondary pupils respond to suggestions that science and religion are opposed?*

Methodology

We decided to prepare a survey instrument which could allow pupils to show levels of agreement / disagreement with a range of statements about science and religion and the relationship between them. Such an instrument can only offer limited insights into the nuances of pupil thinking but allows data to be readily collected across whole classes of pupils, and so provides an indication of whether particular views might be held by substantial proportions of pupils.

Questionnaire design

The questionnaire (see Appendix 1) was designed in the light of our reading of previous research, and in particular of possible positions that pupils might be expected to adopt. The instrument consisted of 39 statements, asking for a response on a 5-point (strongly agree / agree / not sure / disagree / strongly disagree) Likert scale (Cohen, Manion, & Morrison, 2000); a question about religious upbringing; and the invitation to make any further comments on any issue raised in the questionnaire. For each of the Likert-scaled items, pupils were offered an additional non-scale response option ('I do not understand the question') to avoid them feeling forced into a response if they were not clear about the meaning of the statement.

We included a range of statements suggesting science and religion were opposed (e.g. 'Science and religion disagree on so many things that you cannot believe both'), or that

scientists would typically reject religious ideas (e.g. ‘The scientific view is that God does not exist’). However to provide balance, we also included some statements reflecting a contrasting perspective (e.g. ‘Science supports my faith in God’). We selected four particular themes for inclusion because our reading suggested they might act as foci for considering whether science and religion were opposed: the origin of the universe; the origin of life on earth; the possibility of supernatural miracles; and praying to God. Given that previous research had suggested that young people adopting a scientific viewpoint tended to see science as necessarily contrary to religion, we included items on the nature of science, some of which expressed a scientific perspective.

Pilot

The questionnaire was piloted with two classes who were not going to be completing the survey, from one of the schools that agreed to allow us to collect data. The questionnaire was administered by one of the research team (the third author) to intact classes of Y8 (12-13 year olds) pupils and Y11 (15-16 year old) pupils in Abbey Church School. (School and pupil names in this report are assumed names used to maintain anonymity of the schools as agreed when negotiating access for our research.) This suggested that 15-20 minutes would be sufficient for completion of the questionnaire by Y9 pupils. It was felt that no changes to the questionnaire, or its administration, were indicated.

The sample

The sample for the present study comprised one Y9 class in each of four diverse English secondary schools. These pupils were in the final year of the educational phase when pupils are expected to study the relationship between science and religion (QCA, 2004). In order to ensure geographical spread, schools from different national regions were identified using an educational directory (Tierney, Sinkie, & Gregory, 2005) and were approached by letter or email. Schools were given details of the project, and the nature of the survey, so that informed consent to completing the questionnaire could be obtained. The sample of 109 pupils was drawn from four very different schools (see Table 1), giving some reassurance that findings did not reflect atypical local circumstances.

Table 1: Some characteristics of the study schools

School	Locale	Region of England	Size	Pupils surveyed	Notes:
A – Abbey Church School	small city centre	East Anglia	c.600	31	Church school
B –Borough Comprehensive	suburb of large city	South East	c.1600	27	No selection of pupils in terms of religion, ability or gender.
C – Ceaside Comprehensive	coastal town	North East	c.400	24	Area of relative social deprivation
D – Dalesview Grammar	small rural town	North	c.600	27	School selects on ability – admits boys only

Data collection

The questionnaire was administered by school staff, to one Y9 class in each school. A researcher (the third author) visited each of the four schools, and interviewed three of the pupils from each surveyed class, which allowed a check on the pupils’ interpretation of questionnaire items. Data was transferred from questionnaire sheets to a computer file to enable ready handling and analysis of the data.

Findings

Pupil experience of undertaking the questionnaire

We undertook one-to-one interviews with three pupils from each class surveyed. Pupils were asked about their experience of completing the questionnaire. None of the pupils reported any difficulties in understanding the instructions or the process of completing the questionnaire. No particular problems were identified with the design of the questionnaire, although it was found that some interviewees' notions of what was meant by natural laws were at best vague, which should be considered when considering responses to items 33 and 34.

Some of the interviewees found some aspects of the questionnaire challenging, but not to the extent that it prevented them making sense of the task, which they generally reported as finding an interesting activity. One of the pupils interviewed did indicate that she had made a 'random' response selection on one item, where she was unsure how to respond. However this was an isolated instance and we were confident that pupils generally understood the task, and were able to offer responses reflecting their genuine views on the statements presented. During the interviews pupils were also asked open-ended questions relating to some of the key themes in the questionnaire, and the pupils were readily able to offer views relating to such issues suggesting that *the topics* treated in the questionnaire were quite accessible and intelligible to these young people (Taber et al., In press).

Pupil responses to the questionnaire

One hundred and nine (109) Y9 pupils were surveyed, although there were small numbers of non-responses for some items. The 'do not understand' option was generally used to a limited degree. One pupil from Abbey Church School noted on her questionnaire that she had used this response when "I don't want to answer the question [because] I don't want my opinion known".

Given the exploratory nature of the study, and the lack of representativeness in the sample, we limit our results to presenting descriptive statistics as broadly indicative of what might be found in the wider population. The results are reported in approximate 'fractional' terms where appropriate, but the full response frequencies are provided in Appendix 2. In discussing the responses below we use 'agree' and 'disagree' to *include* 'strongly agree' and 'strongly disagree' respectively to simplify language.

At the end of the questionnaire, pupils were asked to 'please add here any comments you would like to make'. These comments may provide insight into those areas where the pupils felt they wanted to explain or justify a response or simply make a point about the issues the questionnaire raised for them. We report some of these comments below in juxtaposition to the most relevant questionnaire item.

Religion

102 of the pupils were prepared to respond to '*Which of the following best describes your religious upbringing*'. 71 selected Christian, 6 atheist, 4 each Islamic and Hindu, and 1 chose Jewish. A further 16 selected the 'other' category. One pupil interestingly commented that: "I have no religious upbringing as I believe in all laws of Physics". However, another had clearly decided not to affiliate with either science or religion: "I am not religious although I am christened. My parents never made me religious and I don't believe in God and I hate science". Upbringing does not necessarily equate to personal beliefs of course, and one pupil noted that "I became a Buddhist on my own".

About a fifth of pupils agreed with the statement that *'I am NOT religious – I don't have any religious beliefs'*. A clear majority of the sample disagreed with the statement, and on this item most of these strongly disagreed. Responses on these two items suggest that the sample broadly reflected national trends, where census data suggest most people in Britain consider themselves to have a religion, and for the majority this is Christianity (National Statistics, 2008).

Pupil perceptions of the nature of science

Three quarters of the respondents agreed with the statement that *'I think that science is a reliable source of information'*; a third of these strongly agreeing. Most pupils agreed that *'scientists try to explain how things work'*. One pupil commented that "scientists are very good they find out things for us that we probley neaver [sic, probably never] knew about". There was also a large majority who agreed that *'in science, theories become facts once they are proved'*.

Several item statements reflect what might be referred to as a 'scientific-deterministic' worldview, where everything is potentially knowable from within science. Reaction to the statement that *'one day, we may be able to explain the whole universe using science alone'* was evenly split. About a sixth of the pupils agreed with the statement that *'one day we will be able to predict everything that happens using scientific equations'*. About half of the sample disagreed, including 15 who disagreed strongly. About a fifth of pupils agreed with the statement *'I believe the laws of nature decide everything that happens in the universe'*. Again, a larger proportion of respondents disagreed with this statement. More respondents agreed, than disagreed, with the statement *'science says the laws of nature decide everything that happens in the universe'*.

Origin of the universe

There was an approximately even split between those who agreed *strongly* that *'I accept that God created the universe'*; those who agreed, *but not strongly*; those who were not sure; and those who disagreed. Most of those that disagreed, strongly disagreed. When asked to comment on the statement *'I believe that the universe was created in the way the Bible describes'*, about a third of the pupils selected the extreme responses: with very similar numbers *strongly* agreeing and *strongly* disagreeing. Overall, there was more disagreement with this item than agreement, but (assuming that pupils understood what we meant by 'the way the Bible describes', a point we return to in the discussion) *only a minority of our sample disagreed with a description of creation that contradicts current scientific understanding* (see figure 1).

Almost half of the respondents agreed with the statement that *'I accept the scientific theory that the whole universe was created in a big bang'*. Yet, over a quarter of the respondents disagreed with this widely accepted scientific theory, and about half of these strongly disagreed (see figure 2). One pupil commented that "I think God created the world and there is no such thing as the big bang".

About a third of the sample had strong opinions on the statement that *'a good scientist can NOT believe that the universe was created by God or a higher being'*. About half of the pupils disagreed with this statement, including 22 who strongly disagreed. However, over a quarter of the sample did agree with this view, including about a tenth of the respondents who strongly agreed (see figure 3).

Figure 1. Rating of agreement with item 20: “I believe that the universe was created in the way the Bible describes”

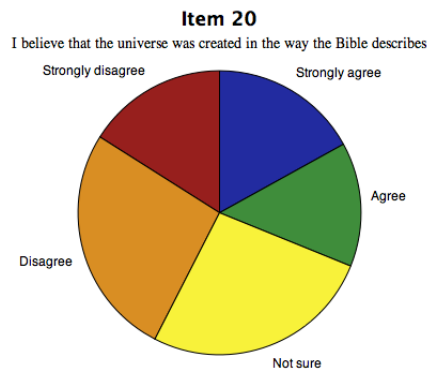
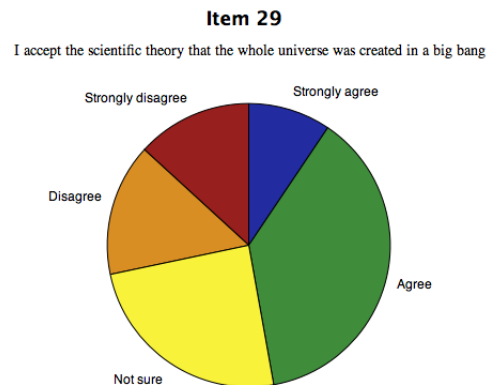


Figure 2. Rating of agreement with item 29: “I accept the scientific theory that the whole universe was created in a big bang”



Similarly, nearly a third of the respondents had strong responses to the statement that ‘*a good scientist cannot believe that the universe was created about 6000 years ago*’, which divided the pupils quite markedly. Over a quarter of the pupils agreed with the statement, including 14 that strongly agreed; and a third disagreed, including 15 who strongly disagreed.

Figure 3. Rating of agreement with item 10: “A good scientist can NOT believe that the Universe was created by God or a higher being”

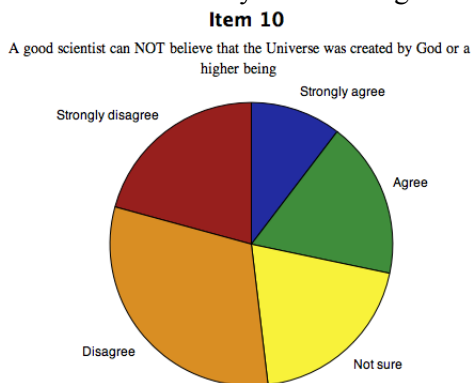
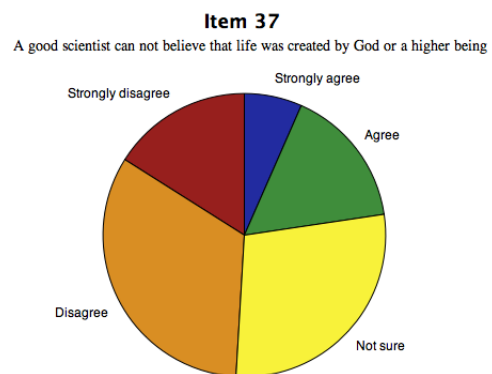


Figure 4. Rating of agreement with item 37: “a good scientist cannot believe that life was created by God or a higher being”



Origin of life and living things

Almost half of the respondents agreed with the statement ‘*I accept that God created all the living things on earth*’ including about a fifth who strongly agreed. About a third of the pupils disagreed, half of who strongly disagreed with the statement. Just over half of the pupils responding agreed with the statement ‘*I accept the scientific theory of evolution as the explanation for all the different kinds of life on earth*’. About a sixth of the pupils disagreed with this statement, about half of these selecting the ‘disagree strongly’ option. About half of the pupils disagreed with the statement ‘*a good scientist cannot believe that life was created by God or a higher being*’. However, almost a quarter of the respondents agreed (see figure 4).

Pupil perceptions of miracles

About half of the respondents agreed that *‘the scientific view on miracles is that they are imagined or fluke events’*; twice the proportion that disagreed. Just over half of the pupils agreed that *‘I believe miracles can happen as religion describes’*, with a just over a fifth of the respondents strongly agreeing with this position. Only about a sixth of respondents disagreed. One respondent commented “I believe that the big bang created the world and I feel strongly that God is not real and that miracles are flukes and not down to God”. About half of the pupils disagreed with the statement that *‘a good scientist cannot believe that supernatural miracles are possible’*. However, almost a quarter agreed with this statement - including six who strongly agreed (see figure 5).

Figure 5. Rating of agreement with item 36: “a good scientist cannot believe that supernatural miracles are possible”

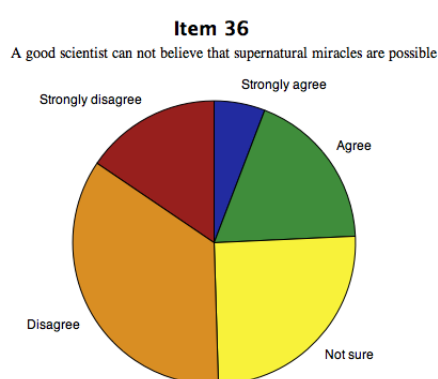
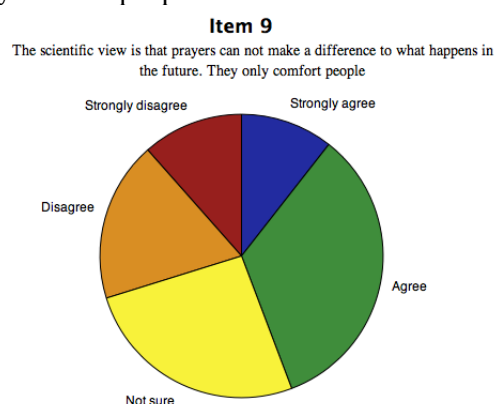


Figure 6. Rating of agreement with item 9: “the scientific view is that prayers cannot make a difference to what happens in the future. They only comfort people”



Prayers

Two thirds of the pupils agreed that *‘the religious view is that prayers can make a difference to what happens in the future’*. About half of the respondents agreed that *‘I pray and believe that my prayers can make a difference to what happens’*, including 18 who strongly agreed. About a third of the pupils disagreed with the statement, including 14 who strongly disagreed. One pupil commented that “I think that God does exist, I think this as this was the way I have been brought up. I also feel that, if I were to pray, something good will come of it”.

About a fifth of the pupils had strong views on the statements that *‘the scientific view is that prayers cannot make a difference to what happens in the future. They only comfort people’*. Almost half of the respondents agreed, including 11 who strongly agreed, whilst over a quarter disagreed, including 12 who disagreed strongly (see figure 6).

The relationship between science and religion

Almost half of the pupils agreed with the statement that *‘the scientific and religious versions of how the universe began cannot both be true’*, including 13 who strongly agreed. Just under a third of the pupils disagreed with this statement, including 10 who strongly disagreed. One pupil commented: “I think the big bang probably happened, but I still believe God created life on earth”.

Over a quarter of the pupils in the sample agreed with the statement that *‘religious ideas about how the universe began have been proved wrong by science’* including five who strongly agreed (see figure 7).

Figure 7. Rating of agreement with item 28: “religious ideas about how the universe began have been proved wrong by science”

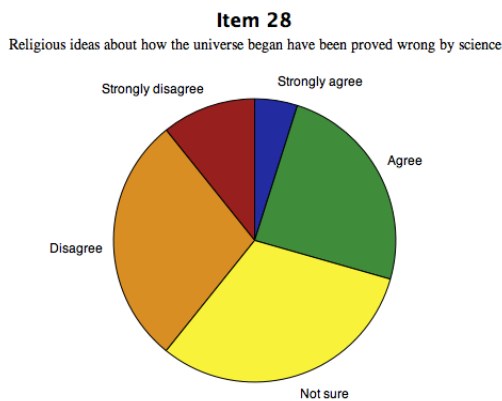
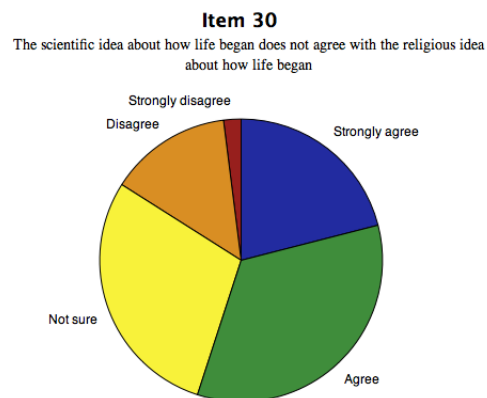


Figure 8. Rating of agreement with item 30: “the scientific idea about how life began does not agree with the religious idea about how life began”



Most of the pupils agreed with the statement that ‘*the scientific idea about how life began does not agree with the religious idea about how life began*’, including a fifth of the respondents who strongly agreed. Only 16 disagreed, including just two who strongly disagreed (see figure 8).

A quarter of the pupils agreed that ‘*science and religion disagree on so many things that you cannot believe both*’ whilst two-fifths disagreed (see figure 9). One pupil commented that “science and religion run parilell [sic, parallel] but hardly ever interlink”. However, another pupil wrote that “I think religion and science are two very different topics but you can’t believe in both because they contrast themselves”, and another noted that “I believe more in scientific theories than religious theories, because science proves things, a lot of things, but religion only proves certain things”.

Figure 9. Rating of agreement with item 2: “science and religion disagree on so many things that you cannot believe both”

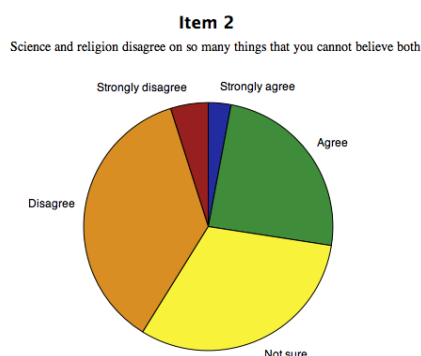
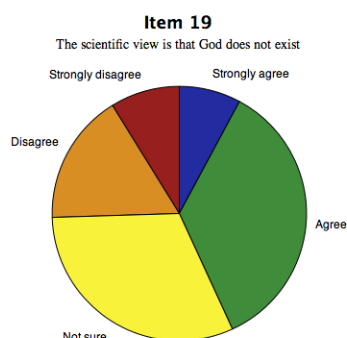


Figure 10. Rating of agreement with item 19: “the scientific view is that God does not exist”



Over a quarter of respondents agreed with the statement that ‘*I think a lot about whether science and religion fit together*’. Most respondents agreed with the statement that ‘*I would like to know more about whether science and religion fit together*’, including 13 who strongly agreed. At the end of the questionnaire one pupil wrote “I feel that while the topic is discussed a little in RS, it should be done more - especially in science”. Another pupil commented “This has really made me think”.

Of those expressing an opinion about the statement that '*science supports my faith in God*', almost half of the sample disagreed with this statement, including 17 who strongly disagreed. Only 18 pupils agreed with this statement, and just one of these agreed strongly. One pupil commented: "scientists say the more they understand about the Big Bang and creation the closer they come to finding God". Another reported: "I believe that Science and God fit together - Science backs him up".

About two fifths of the sample agreed with the statement that '*the scientific view is that God does not exist*', whereas about a quarter disagreed (see figure 10). Pupils commented that "I think a scientist can be religious and have religious beliefs", and the clumsier "scientists don't have to have no religious beliefs".

Over a third of respondents agreed with the statement '*one day science may prove that God exists*', whilst a quarter disagreed, including 10 who strongly disagreed. Respondents were more evenly divided in their reaction to the statement '*one day science may prove that God does not exist*', with somewhat more disagreeing, than agreeing. This was one of the few items where an extreme option was relatively popular, with most of those disagreeing, doing so strongly. Nonetheless, three-fifths of the pupils did not exclude the possibility of proofs of the non-existence of God.

The pupils were split fairly evenly in their responses to the statement '*I am confused about what to believe - we are told different things about how the universe and life began*'. Two fifths of the respondents agreed with the statement, including 14 whom strongly agreed; with slightly fewer disagreeing with the statement.

Discussion

Our starting point for this study was a concern about a view commonly propagated in the UK popular media to the effect that science and religion are in competition, and so that acceptance of science *necessarily* involves the rejection of religious faith. We are aware that science is indeed understood by some as a worldview that excludes any possibility of the supernatural (Cray et al., 2006), but that this is just one possible stance on the relationship of science and religion (Barbour, 1988). Many scientists around the world hold a religious faith, and for these members of the scientific community, science and religion are clearly not perceived to be incompatible. The sample of just over a hundred pupils from four diverse English schools presented a spread of views on the statements we offered for consideration.

Pupils' views on science and religion

On a range of items it seems substantial proportions (over a quarter of the sample, sometimes considerably more) of pupils *did* perceive science and religion to be in conflict: agreeing

- that a 'good scientist' could not believe in a creator;
- that scientific and religious accounts of how the universe began were inconsistent;
- science had disproved religious ideas about the origins of the world;
- scientific and religious accounts of how life began were in conflict.

Most tellingly, only a minority of our sample *disagreed* with the suggestion that science takes the view that God does not exist.

Pupils' understanding of religious ideas

Our sample seemed to broadly represent the British population in the sense that most pupils associated themselves with a faith position, usually Christianity. The proportions of pupils

considering scientific ideas about the origins of the universe and life to be contrary to religion may reflect a common assumption that scriptural accounts are to be taken as offering quasi-scientific reports, rather than seen as conveying spiritual truth. This is certainly suggested by the substantial proportion of pupils claiming to believe the Universe was created in the way the Bible describes, and perhaps explains why a similar proportion of respondents actively rejected the ‘big bang’ model despite being unlikely to know much about the evidence in its favour; as well as, perhaps, why so many pupils agreed they were confused about what to believe about origins. This is something we feel should be explored in further research. We would be interested to know how many pupils consider that a six (24 hour) day creation of the world, with different types of living thing created in their modern form, is a necessary part of a Christian belief.

Pupil’s perceptions of the nature of science

Previous research has suggested pupils in England demonstrate a quite limited appreciation of the nature of science (Driver et al., 1996; Grosslight et al., 1991; Justi & Gilbert, 2000; Taber, 2006), and this was reflected in our survey. Not only did we find that a substantial proportion of pupils considered science to take a stance on matters (such as the existence of God) that are generally felt to be outside its remit, but most considered science to be in the business of testing theories to convert them into facts – perhaps explaining how religious ideas were seen to be disproved. This is despite recent efforts to make the nature of science a prominent and more explicit feature in the curriculum (QCA, 2007a).

This is probably linked to the level of support in our survey for statements of a general ‘scientistic’ slant – previously found to be associated with negative perceptions of religion (Fulljames et al., 1991; Hansson & Redfors, 2007a, 2007b) - that everything can be explained by science, with scientific laws understood deterministically and so providing absolute predicative power – a position that goes well beyond what most scientists would claim.

Overview of our findings

We accept that there is no consensus among scientists on how the relationship between science and religion should be understood, and some individual scientists do see a necessary conflict (just as others find personal harmony between science and religions, and yet others take other perspectives). Yet in terms of the nature of science itself, we would suggest science has no inherent position on the existence of God, and certainly does not automatically exclude religious belief. However, in a country where most people claim some level of religious faith, our findings suggest that many secondary pupils consider science to be the basis of explaining and predicating everything, capable of absolute knowledge, and able to definitively dismiss God and religion. This is a distorted view of the nature of science, and a view that if adopted by pupils with religious faith, could potentially have practical consequences when important decisions about future study and careers are made. It seems quite feasible that perceiving science to reject religion could deter some pupils from considering further study of science. This again is worthy of follow-up in further research.

Limitations of the study and directions for further research

The present study reports a survey of a modest sized sample, which restricts the generalisability of our findings. There are also inherent limitations to questionnaire-based research as a means for exploring pupil thinking in any depth.

Sampling

Clearly one direction for future research would be to collect more representative data (for example, surveying whole year groups in schools). Some of the approaches to relating science

and religion that have been reported among professional scientists (Alexander, 2008; Bovey, 2008) require nuanced thought, of a kind that may only develop in many people during college-age years (Perry, 1970). This suggests that it would be useful to compare responses in comparable populations of different age (such as different year groups in the same school where admissions policies and patterns are stable). For example it would be interesting to see if there are clear trends as pupils move through the secondary age range towards the point where they make choices about further education or employment.

Pupil interpretation of survey items

A clear limitation of survey methodology of the type employed here, is that it is largely 'confirmatory' rather than 'exploratory' (Biddle & Anderson, 1986; Taber, 2007), in that survey items reflect points of interest that researchers bring to the study. Statements may be interpreted in idiosyncratic ways, and may not always relate to respondents' own conceptions of what is salient about a topic. Research into children's ideas in science has long established the folly of assuming pupils share researchers' meanings for terms (Watts & Gilbert, 1983) and understanding of concepts (Taber, 2009).

So the research team's understanding of miracles is one of *supernatural* events: events that are inherently *beyond* explanation in science because they are considered to occur despite being inconsistent with natural laws. Yet one of the pupils commented "I believe there is supernatural but science can prove what it is". Similarly, when we refer to "the way the Bible describes" creation, we are implying the accounts given in the first chapters of Genesis, which - when taken literally - suggest both that the universe was brought to its present state in less than a week, and that whole categories of living things were separately formed by discrete acts of special creation. Given the level of apparent agreement with statements reflecting the Biblical accounts, we feel there is a need to find out whether acceptance of these accounts is actually based on familiarity with what is set out in these texts.

Responses to a range of presented statements can only give limited insight into the nature of student thinking. Research has often found learners *entertaining* several alternative ways of understanding a science concept without being fully committed to a particular view (Taber, 2009). Pupils' thinking can be more or less coherent across aspects of topics (Claxton, 1993; Solomon, 1992; Taber, 2000), allowing what seems to the observer the concurrent acceptance of contrary ideas. Billingsley's (2004) previous research that suggested that secondary pupils may often treat scientific and religious ideas as belonging to independent domains with non-overlapping ranges of application (cf., Gould, 2001) may be relevant here. Given the limitations of survey approaches, techniques allowing more in-depth exploration of pupil ideas are indicated.

Moreover, for those pupils who consider scientific perspectives are contrary to *their own* faith-based commitments, we would like to know something about the extent to which this might lead them to reject science, or to consider scientific courses and careers unsuitable options for their future.

Further directions for research

An approach such as in-depth, semi-structured interviewing (offering flexibility to move beyond a set list of questions) is needed to start exploring questions such as these. It has been argued that such alternative approaches (surveying large numbers, but in limited depth, cf. exploring thinking in depth, but for limited numbers) need to be seen as complementary, and that a programme of research may depend upon several 'swings' of the 'methodological

pendulum' between focusing in detail, and then testing the generality of findings on a larger scale (Taber, 2009).

Questions about such matters as the origins of the universe are inevitably somewhat abstract and so intellectually demanding; and so meaningful engagement presumably depends upon high levels of cognitive development (Shayer & Adey, 1981). We would be interested in finding out, for example, whether those pupils who agreed that "one day we will be able to predict everything that happens using scientific equations" were offering a well-thought out position or were merely finding an unfamiliar notion had immediate, if superficial, appeal.

Conclusions

We were not surprised to find some pupils rejecting scientific theories about origins, and accepting alternative views based on literal reading of scripture. However *the level* of support for such positions seems much higher than might be expected in a country where most people claim association to Churches that have accepted scientific accounts of the origins of the Universe and of living things. In a national context where not enough young people are attracted into the sciences (HCSTC, 2005) it may well be significant that a fair proportion of our respondents considered that the scientific perspective denies the existence of God, and so excludes people of faith from being 'good scientists'.

We consider that our findings are intriguing, and certainly suggest issues that deserve further exploration. The questions raised by this work suggest a complementary strand of work to other areas of enquiry exploring aspects of pupil thinking and conceptual development in science (Black & Lucas, 1993; Driver, 1989; Fensham, 2004), and further research in this area could offer insights into these core concerns in science education. As well as this inherent interest, these issues may be of pragmatic importance in terms of ongoing concerns both about the need to produce scientifically literate citizens for modern societies (Millar & Osborne, 1998) and about attracting young people into science-based careers. As Reiss (2008) has suggested, this is an area where a broad programme of research would seem to be indicated.

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Appendix 1: Pupil questionnaire

The pupils were asked to complete a questionnaire with 40 items. All but one (i.e. item 40) of the items asked pupils to rate a statement on a five-point scale Likert-type scale (Strongly agree / Agree / Not sure / Disagree / Strongly disagree) but each item also included the option 'I do not understand the question'.

The pupils were given the following instructions for rating the statements:

“Read each statement carefully.

Decide which of the choices best suits your point of view.

Choose only one answer to each statement. Circle the answer you have chosen.”

The items pupils were asked to rate were:

1. Scientists try to explain how things work
2. Science and religion disagree on so many things that you cannot believe both
3. The scientific view on miracles is that they are imagined or are fluke events
4. In science, theories become facts once they are proved
5. I sometimes feel that pupils' religious beliefs are overlooked in science lessons
6. In our science lessons, the teacher doesn't like to answer religious questions
7. Different religions have different ideas about how the universe began
8. I would like to know more about whether science and religion fit together
9. The scientific view is that prayers can NOT make a difference to what happens in the future. They only comfort people.
10. A good scientist can NOT believe that the Universe was created by God or a higher being
11. I think that science is a reliable source of information
12. A good scientist can NOT believe that the universe was created about 6000 years ago
13. Religion is a set of beliefs that cannot be proved
14. I believe miracles can happen as religion describes
15. I get the impression that most science teachers don't approve of religious ideas
16. I am NOT religious – I don't have any religious beliefs
17. One day, we may be able to explain the whole universe using science alone
18. Science supports my faith in God
19. The scientific view is that God does not exist
20. I believe that the universe was created in the way the Bible describes
21. I accept that God created the Universe
22. I am confused about what to believe – we are told different things about how the universe and life began
23. In our religious studies lessons, the teacher doesn't like to answer questions about science
24. I accept that God created all the living things on earth
25. I pray and believe that my prayers can make a difference to what happens
26. The scientific and the religious versions of how the universe began CAN NOT both be true
27. One day we will be able to predict everything that happens using scientific equations
28. Religious ideas about how the universe began have been PROVED WRONG by science
29. I accept the scientific theory that the whole universe was created in a big bang
30. The scientific idea about how life began does not agree with the religious idea about how life began

31. The religious view is that prayers CAN make a difference to what happens in the future
32. I accept the scientific theory of evolution as the explanation for all the different kinds of life on earth
33. Science says the laws of nature decide everything that happens in the universe
34. I believe the laws of nature decide everything that happens in the universe
35. I think a lot about whether science and religion fit together
36. A good scientist can NOT believe that supernatural miracles are possible
37. A good scientist can NOT believe that life was created by God or a higher being
38. One day science may prove that God does not exist.
39. One day science may prove that God exists.

The final question (40) asked pupils “Which of the following best describes your religious upbringing?”. Pupils were presented with the options Christian, Jewish, Islamic, Hindu, Atheist, Buddhist, Other. Those who responded ‘other’ were invited to elaborate if they wished: “if you answered ‘other’, you may wish to tell us how you would describe your religious upbringing” (followed by space for completion).

Pupils were also invited to make any additional comments to expand upon any points.

Appendix 2: Frequency of responses to Likert-scaled items

Item	Strongly agree	Agree	Not sure	Disagree	Strongly disagree	Sub-total	Do not understand question	Total answering
1	25	73	9	1	0	108	1	109
2	3	25	32	37	5	102	6	108
3	14	40	25	17	9	105	4	109
4	34	57	8	7	2	108	0	108
5	9	21	31	31	12	104	5	109
6	4	19	40	31	14	108	0	108
7	30	62	12	3	0	107	0	107
8	13	46	16	25	4	104	1	105
9	11	35	27	19	12	104	3	107
10	11	19	21	33	22	106	2	108
11	27	53	20	4	2	106	2	108
12	14	17	40	20	15	106	2	108
13	5	30	24	35	12	106	1	107
14	22	36	28	15	3	104	4	108
15	4	16	32	47	6	105	3	108
16	11	11	11	27	45	105	2	107
17	7	33	26	29	12	107	1	108
18	1	17	37	33	17	105	3	108
19	8	36	32	17	9	102	3	105
20	18	15	28	28	17	106	1	107
21	26	28	27	10	16	107	1	108
22	14	29	22	26	14	105	3	108
23	0	6	37	41	23	107	2	109
24	22	30	23	17	17	109	0	109
25	18	33	22	18	14	105	4	109
26	13	34	24	23	10	104	4	108
27	2	16	35	39	15	107	1	108
28	5	25	32	29	11	102	7	109
29	10	40	26	16	14	106	2	108
30	21	34	29	14	2	100	9	109
31	28	39	23	8	3	101	6	107
32	14	36	29	9	8	96	9	105
33	6	32	42	20	5	105	3	108
34	5	18	41	32	6	102	6	108
35	6	25	13	45	17	106	2	108
36	6	19	26	36	16	103	5	108
37	7	17	30	35	17	106	2	108
38	9	23	32	17	23	104	4	108
39	6	31	41	16	10	104	4	108