The religio-scientific frameworks of pre-service primary teachers: an analysis of their influence on their teaching of science

Stolberg, Tonie

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Abstract

Scientific and religious ways of thinking are central to an individual's cognitive and cultural ways of making sense of the world. This paper explores what foundational concepts pre-service primary teachers are employing when they teach science. The study measured the attitudes to science and religion of 92 pre-service primary teachers. The categories traditionally used to describe the ways individuals' relate science and religion were found to be inadequate when attempting to reflect the attitudes' of the respondents. An alternative, phenonomenoligically based diagnostic framework was then proposed, constructed as a two dimensional scale on which participant's attitude to science/religion was assessed as either 'epistemic' or 'pragmatic'. Analysis of interviews with a representative sample of eight of the teachers showed that individual religio-scientific frameworks could be linked to distinct differences in approach to the teaching of science. The impact of identifying the religio-scientific framework of pre-service teachers on the design of future educational programmes was then discussed.

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Introduction

What we believe, and the knowledge we act upon, is guided by ways of thinking that mostly go unnoticed or, at the very least, are only reflected on occasionally - perhaps at times of personal crisis. However, one of the many roles a teacher has to perform in her class is to facilitate her pupils to undertake this task explicitly as part of their everyday schooling. The experienced professional would also be expected to reflect upon their own beliefs and values and how they shape their teaching practice as part of their continuing professional development (Reiss 1993, Poole 1998, Cobern 2000). What of the neophyte teacher? What ways of thinking are they bringing into the profession? What foundational concepts are they employing - perhaps implicitly - in the way they teach? This paper will focus on two particular epistemic strands of thinking: the scientific and religious, which are central to an individual's cognitive and cultural ways of making sense of the world. This paper will describe pre-service primary teachers' attitudes to science-and-religion and their influence on approaches to the teaching of science.

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Why focus on pre-service primary teachers' ways of thinking about science *and* religion? Teachers of primary-aged (five to eleven years old) children aren't known to be 'scientifically minded' and are more likely to have science backgrounds similar to the lay public than secondary science teachers (Cobern and Loving 2002). Some may even possess belief systems that are alienated from the scientific orthodoxy (Keranto 2001, Lake 2005). So for teacher educators to be able to understand their trainees' beliefs and approaches to the teaching of science one must also look at what might

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contribute to a teacher's sense of identity. This would allow the development of practices that might then enable pre-service teachers to reflect on what actually informs their own approach rather than transmitting information, which might be verbally accepted but may never completely adopted (Hubbard and Abell 2005). An understanding of the conceptual framework based on both religious and scientific attitudes should give an insight into a frame of reference that has been shown to impact on an individual's scientific reasoning (Roth and Alexander 1997, Cobern 2000). Some scholars maintain that science and religion are, metaphysically speaking, incompatible and their irreconcilability a necessary prerequisite for scientific competence (Mahner and Bunge 1996a, 1996b). Whatever the philosophical desirability for their estrangement, I agree with Gauld's assertion that scientific and religious habits of mind are similar. "In both cases openness to argument and evidence, scepticism, rationality and objectivity are all held in high regard; in both some ideas are more protected from attack while others are more open to challenge; and in both, at any time, there are various degrees of commitment to theories from sceptical rejection to passionate endorsement. Both habits of mind stem from the same scholarly attitude and any difference between them is probably due to differences in what are counted as appropriated evidence and good reasons." (Gauld 2005, p. 302)

Attempts to rationally delineate what might lie behind observed attitudes to teaching science have met with difficulty. Personal views are necessarily complex and may lack the internal consistency the researcher hopes to identify. The 'teacher' may not always behave as such, with their views

stubbornly refusing to fit into a clearly defined box separate and identifiably different from that of their 'student' (Fysh and Lucas 1998), or ideas that may be viewed as congenial and trustworthy by an individual may seem paradoxical or even self-contradictory to an outside observer (Jackson et al. 1995).

The majority of the previous research has focused on the impact of an individual's beliefs on the acceptance or otherwise of the concepts underpinning the teaching of the science curriculum. This has been particularly the focus of researchers in the United States, since the secularisation of the American school curriculum precludes the study of the interaction of scientific conceptual development on a student's religious education. Tertiary level educational studies have focused on the impact of an individual's religious beliefs on their acceptance of standard scientific theoretical models such as biological evolution (Cobern 1994, Smith 1994, Ayala 2000), or how a student's belief system shapes their understanding of the nature of science in general (Brazelton et al. 1999), or particular areas of scientific understanding such as astronomy (Brickhouse et al. 2000, Shipman et al. 2002). Even a student's future career choice (Esbenshade 1993) has been analysed in terms of its potential impact on future science education strategies and the likelihood of changes in public perceptions with regards to science policy decisions such as those surrounding environmental issues (Petersen 1997).

Work in other countries that have different educational environments to that found in the United States have, nevertheless, focused on very similar issues. Even where 'religion' refers to public and personal dimensions of Islamic faith, in contrast to the broadly Christian context of students in the majority of research, the focus is on how scientific education is influenced by the prevailing socio-religious context (Anees 1995, Loo 1999, 2001).

Even more limited is research that focuses specifically on the learning and teaching of science-and-religion as an interdisciplinary area with its own pedagogical issues and concerns (see Fulljames and Stolberg 2000, Stolberg and Fulljames 2003). In 1996, *Science & Education* devoted a complete issue to the theme, 'Science, Religion and Education'. The articles focused on the appropriate metaphysical basis for the teaching and learning of science, and whether a particular approach is still appropriate when the curriculum is extended to include discussion of issues within a historical or cultural context.

Within the United Kingdom context, research has focused on secondary level education. There are a considerable range of common issues that both science and religious educators could address concerning the data, nature and application of science (Bausor and Poole 2003). However, empirical research has been limited to the relationship between students' attitudes towards science and attitudes towards religion and the influence on these attitudes of particular views of science (scientism) and of religion (creationism) (Fulljames et al. 1991, Fulljames 1996), and how these may be different within

the distinctive religious context of schooling in Northern Ireland (Francis et al. 2001).

The objectives of this study are therefore to bring together issues raised by previous research, and to act as a starting point for research into the impact of science-and-religion on learning and teaching in primary education. There are three main aims; firstly, to describe the ways of relating science and religion used by pre-service primary teachers. Secondly, to assess how their way of relating science and religion might influence an individual pre-service primary teacher's views on the nature and purpose of science education. Thirdly, to gather base line data for future research into the influence of science-and-religion in other areas of primary teaching and learning.

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Sample

The participants were a self-selected sample, all of whom were graduates undertaking a one-year post-graduate initial teacher education qualification to teach primary aged children. The course was based at a large urban university in the multi-culturally diverse English West Midlands. Questionnaires and interviews were administered at the end of the course's first semester, during which participants had already observed and taught a limited number of science classes in local primary schools.

The participant sample reflected the make-up of people undertaking primary initial teacher education at this institution. Out of the 92 trainees who agreed to take part in the study, 11 were male and 81 were female. 19 were aged

between 17 and 21, 67 aged between 22 and 36, and six aged between 37 and 65. 18 of the respondents had undertaken a higher level course in science, achieving a post-16 level qualification whilst at secondary school, and six of the trainees had studied science, or a scientifically-related subject at degree-level.

Semi-structured interviews were conducted with eight students. The eight students were selected from the 92 trainees who had completed the questionnaire on the basis of their willingness to be interviewed and the practicability of arranging interviews. Although this is a small sample size, the interviewees selected were an accurate reflection of the respondents as a whole in terms of their identification with a religious group and use of personal prayer. The gender balance of questionnaire respondents was also mirrored in the sample with seven of the interviewees being female and one male. The only major discrepancy is that half of the interviewees indicate having studied science to a higher level than that required for entry onto the initial teacher education programme. This is higher than the proportion in the whole cohort, which is at only 20%.

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Measures - Questionnaire

Identification with a religious group was assessed by a four point scale: strongly, to some extent, marginally, not at all.

Personal prayer was assessed by a three point scale: regularly, sometimes, never.

Attitude towards science was measured using a scale of ten items selected from a widely used larger scale developed by Menis (1989), the ten item scale's validity as an accurate measure was confirmed in subsequent studies (Francis et al. 1999, Stolberg and Fulljames 2003). Each item was assessed on a five point Likert scale.

Scientism was measured using a six item scale which was a modified version of the instrument used by Fulljames et al. (1991). The items reflect the view that scientific methods and scientific theories can attain to absolute truth. Each item was assessed on a five point Likert scale.

Ways of relating science and religion were assessed using five independent items which detailed the different ways in which the science-religion relationship is often described (see Fulljames and Stolberg 2000, Cantor and Kenny 2001). Each item was assessed on a five point Likert scale.

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Measures - Interviews

Interview questions explored further the areas investigated in the questionnaire and also how the pedagogic approaches of interviewees are influenced by their perceptions of the nature and purpose of science education, their ways of relating science and religion and the impact of their views on their teaching of science.

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The first two questions: 'What, in your opinion, is the relevance of teaching science to primary-aged pupils?', and 'Should your views on a subject influence how science should be taught?' explored interviewees' views as to the nature and purpose of science education and how their attitudes as to why science should be taught might affect the way they teach science.

The final three questions: 'What, in your opinion, is the relevance of teaching religion to primary-aged pupils?', 'Should religion influence the practice and content of science education?' and 'Should the religious traditions of the pupils in your class affect the way you teach science?' explore the interviewees' attitudes to the nature and purpose of religion and the influence of this epistemic approach on the nature and purpose of science education.

Procedures and analysis

The questionnaires were administered by the author, who emphasised that confidentiality and anonymity of respondents would be respected. One-tailed, bivariate correlations were then performed on the raw data using the SPSS statistical package. Correlations were said to be significant when $p \leq 0.05$.

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The interviews were conducted individually by the author; every interviewee was sent the questions in advance and had a minimum of two weeks to study the question before being interviewed. Approval was obtained before audio-recording of the interview was begun. It was made clear to the interviewees at

the start of the interview that they need only respond to questions in the schedule if he or she wished to do so. That they may, at any time, clarify points they have made or conclude the interview. Confidentiality and anonymity were emphasised, and it was explained that pseudonyms would be used in reports of the research. All the interviews were recorded and at a later date transcribed.

Deleted: Analysis of the data used standard procedures in the analysis of qualitative data and included both literal and interpretative reading of the data.

Results & Discussion

Part 1. Questionnaire

For each section of the questionnaire the frequencies of responses will be presented and the internal consistency of scales tested. It will then be possible to consider the relationships between different ways of relating science and religion and other variables measured by the questionnaire.

Religious commitment: Responses to items about identification with a religious group and personal prayer indicate that there was diversity in the personal religious commitment of the pre-service primary teachers who completed the questionnaire although a majority indicated some level of commitment. 19% identified strongly with a religious group, 23% identified to some extent, 20% marginally and 38% not at all. 22% stated that they prayed regularly, 40% sometimes and 38% never. There was a high positive correlation between identification with a religious group and personal prayer ($r = 0.785$, $p < 0.001$).

Attitude towards science: table 1 presents responses to items exploring attitude towards science. There is widespread agreement with three items that focus on the economic benefits of science. At least four-fifths of respondents agree that "science is very important for a country's development" and that "scientific inventions improve our standard of living", while over three-fifths agree that "money spent on science is well worth spending". Four of the items are concerned with more a general evaluation of science. About two-thirds of respondents reject the statement that "scientific discoveries do more harm than good" and almost unanimously accept that "science is useful for solving the problems of everyday life". In contrast, only 48% agree with the statement "science will help to make the world a better place in the future" and 46% disagreeing with the statement "science and technology are the cause of many of the world's problems", with almost two-fifths of respondents not sure how to respond to these items. Similar high levels of uncertainty are found in the responses relating to three items relating to the environment and to relationships in society. Nevertheless, a majority of respondents reject the statement that "science has ruined the environment", whilst 46% disagree that "much of the anxiety in modern society is due to science". The item "scientific inventions have increased tensions between people" attracts the highest negative evaluation. 56% of respondents agree with this statement while 27% are not sure. Overall most respondents seem to have a positive attitude towards science but with some ambivalence about the role of science in society.

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The internal consistency of the scale of attitude towards science is demonstrated in table 2 by the bivariate relationships between the ten items, and is confirmed by the calculation of the alpha coefficient as 0.712. All items make a significant positive correlation to at least one other item except for, "science has ruined the environment". There is a significant positive three-way correlation between the items, "science is very important for a country's development", "money spent on science is well worth spending" and "science will help to make the world a better place in the future".

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Scientism: table 3 presents responses to items exploring scientism. Amongst pre-service primary teachers there is little support for the view of science described as scientism. In particular, there is strong rejection of the statements that "nothing should be believed unless it can be proved scientifically" (74%) and that "science will eventually give us complete control over the world" (72%). The internal consistency of the scale of scientism is demonstrated in table 4 by the bivariate relationships between the six items, and is confirmed by the calculation of the alpha coefficient as 0.701. There is a significant positive correlation between the item, "science will eventually give us complete understanding of the world" and "nothing should be believed unless it can be proved scientifically" or "science will eventually give us

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complete control over the world" but the responses to the latter two statements do not show a significant correlational relationship with each other.

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Ways of relating science and religion: table 5 presents responses to five independent items in the questionnaire which explored ways in which science and religion may be related. There is a significant (two-thirds) majority of respondents who see conflict as the way to view science and religion, but almost two-thirds of respondents also agree that “interaction between science and religion can be of benefit to both” and “both science and religion are important for human well-being”. A minority of the respondents have the views represented by Barbour's categories of independence and integration (see Cantor and Kenny 2001). Only 22% agreed that "science and religion should be kept completely separate" and even fewer (8%) agreed that "deep down science and religion are one and the same", although it may be noted that about one-fifth of the respondents were not sure how to respond to any of the items. It is possible that these respondents might happily subscribe to a coherent epistemic view and yet are aware of important differences between scientific and religious discourses.

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These five items are not intended to form a scale and table 6 presents the bivariate relationships between these items. However, the logical consistency of the responses is indicated by the polarization in the attitudes held by pre-service primary teachers. Those respondents who view any relationship between science and religion to be beneficial, whether it be 'hard' epistemological integration or 'softer' social dialogue indicate significant positive consequences for human well-being. There are also those students who would see any interaction as threatening to their religious views and, presumably, scientific convictions. This interpretation is confirmed by the significant negative correlation shown in table 6 between the items representing independence and dialogue ($r = -0.623$, $p < 0.001$).

It is possible that some trainees are in the process of formulating their position and in terms of the categories used by Shipman et al. (2000) - distinct, convergent, transitional and confrontational - their responses might be regarded as transitional. Alternatively, it may be that many of the pre-service primary teachers distinguish between different aspects of their lives and the relative relevance of their scientific and religious ways of thinking. In these instances scientific and religious epistemologies are orthogonal and so, "science and religion should be kept completely separate" whilst there are other areas where, at the very least, no detrimental consequences are perceivable so, "interaction between science and religion can be of benefit to both" is deemed appropriate, or at least countenanced. If there are substantial numbers of students who think in this way it is questionable whether the general categories - of Barbour or of Shipman - can be of much use in

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interpreting pre-service primary teachers' views of the science-religion relationship.

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Relationships between ways of relating science and religion and other variables: It is now possible to consider the relationships between different ways of relating science and religion and other variables measured by the questionnaire. As there is a complex multivariate interaction it is appropriate to introduce the variables in sequence, noting relationships with age, level of science education and religious commitment as well as with other variables already introduced. Because of the small number of male participants in the study, no reliable conclusions can be assigned to the gender difference of the pre-service primary teachers. The sequence will be, firstly attitude towards science, secondly scientism, and then finally the ways of relating science and religion. Table 7 presents the bivariate relationships between age, level of science education, identification with a religious group, attitude towards science, scientism, and four ways of relating science and religion: conflict, independence, integration and dialogue.

[insert table 7 about here]

The pre-service primary teachers in our sample have overall a very positive attitude towards science and there is no significant difference between the attitude towards science of respondents who are older than those who are younger or in their level of science education. Attitude towards science is not

related to religious commitment, as measured by identification with a religious group, suggesting that religious commitment may be combined with a positive attitude towards science but not necessarily so.

There is only one significant relationship between scientism and any of the other variables - a positive correlation with pre-service primary teachers' views on the independent nature of scientific and religious activities. As most respondents strongly rejected scientism (73%) the range of scores on the scientism scale is limited, so there may need to be caution in the interpretation of this result. Nevertheless, it may be noted that there is no significant relationship with attitude towards science, suggesting that for pre-service primary teachers it is possible to have a positive evaluation of science without accepting that science attains to absolute truth.

While there is not a significant relationship between scientism and level of science education of pre-service primary teachers, there is significant negative relationship between one item on the scientism scale, "theories in science can be proved to be definitely true" and the level of science education ($r = -0.393$, $p < 0.001$). This might be indicative of respondents whose own formal science education has enabled them to gain an increased awareness as to the difficulty of making truth claims in science.

Opinion tended to support the traditional viewpoint of conflict between science and religion. However, there are no significant relationships between

responses to the item about conflict and age, level of science education or any of the other variables measured.

Even though one-third of respondents were either unable or unwilling to say whether science and religion are independent activities, the rest of the pre-service primary teachers questioned were very clear in their views. Interaction and constructive dialogue are highly desirable and would be mutually beneficial to both, and our ultimate quest for knowledge and understanding. This is especially the case when addressing environmental issues, ($r = -0.464$, $p < 0.001$) and is the prevalent position of the younger teachers and those who have higher levels of science education - no matter their level of religious commitment.

This is however, not the same as thinking that science and religion are one and the same. A large majority (64%) of pre-service primary teachers disagree that science and religion are essentially the same. Although dialogue is desirable, it is especially when the aims and objectives are common to both; whether it is "human well-being", ($r = +0.300$, $p < 0.001$) or "control over the world" ($r = +0.330$, $p < 0.001$) that science and religion work together for the benefit of all.

Intermediate conclusions

Unsurprisingly, pre-service primary teachers hold a range of views about science and religion and, therefore, differences emerge in their ontological status. Pre-service primary teachers in this study appear to have made a

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judgement as to their role and purpose. This corroborates Roth and Alexander's findings that prospective teachers "all showed evidence of a strong sense of the context of their own beliefs and attitudes in relation to science and religion" (Roth and Alexander 1997, p. 131). As has been stated already, it is questionable whether the normal, general categories are of much use in interpreting pre-service primary teachers' views of the science-religion relationship. How can we therefore to best describe the range of attitudes held by pre-service primary teachers?

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If the responses to the questionnaire accurately reflect different and distinctive ways of relating science and religion, previous research suggests that this should affect their approach to the teaching of science (Cobern 1994, 1996, 2000a, 2000b; Jackson et al. 1995; Keranto 2001; Cobern and Loving 2002; Zeidler et al. 2002; Hubbard and Abell 2005; Lake 2005). I agree with Cobern (2000b) that in the everyday practice of teaching and learning of science the philosophical distinction between the competing truth claims of knowledge and belief are blurred. However, the results of the questionnaire seem to suggest that pre-service primary teachers do have differences is the epistemological importance they give to the truth claims of science and religion. How might these implicit assumptions make themselves apparent in their approaches to the teaching of science and how might we be able to distinguish between different interactions? Before suggesting a possible means by which this may be achieved, I have assumed that the attitudes individual teachers are expressions of the meanings they themselves use, as "sensitive people trying to feel at home in the "real" world." (Dahlin 2001, p. 453; also Kozoll and

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Osborne 2004). Thus this phenomenologically informed approach is an attempt to construct a diagnostic tool to gauge to what extent science/religion occupies a formative position in the lives of these teachers and the influence it might exert on their teaching. If a pre-service primary teacher's attitude has an 'epistemic' dimension, then it becomes integral in shaping the individual's whole thinking, not just in a mere cognitive sense when considering unambiguously scientific or religious issues, but also their morals and values. However, if their attitude is 'pragmatic', science and/or religion may be viewed as very successful and important 'tools' for humanity to solve problems and improve its well being, with little or no meaningful impact on the way they conduct their life. If two similar dimensions are constructed for an individual's religious and scientific frames of mind and drawn orthogonally, (see figure 1) then a point on this two dimensional scale would represent an individual's religio-scientific framework.

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From the questionnaire it would appear that a proportion of pre-service primary teachers could be positioned in the upper-left quadrant ('epistemic' religion-'pragmatic' science). These are respondents for whom science and religion should necessarily be kept separate, religious commitment is strong and vital, science is important but its role is to help us technically and solve problems some, such as environmental degradation, for which it may have been partly responsible in the first place.

From the questionnaire, it would appear that very few of our pre-service primary teachers would populate the upper-right quadrant ('epistemic' religion-'epistemic' science) of figure 1, as only seven of the 92 respondents viewed scientific and religious integration as a meaningful enterprise.

Where might the remaining pre-service primary teachers reside? Due to the indecisive nature of many of their responses, one might suggest that they may be clustered about the cross-over point. Is this where we should also locate the atheistic and unscientifically minded pre-service primary teacher? Not necessarily so, from the questionnaire, there were no significant differences found for respondents who indicated no religious commitment and those whose religious commitments are strong. One task of the interviews is therefore to identify how the views of pre-service primary teachers who have no personal religious commitment can be accommodated within a religio-scientific framework.

Part 2. Interviews

There are two stages in the interpretation of the interview data. Firstly, to identify a range of views as to the nature and purpose of science education and secondly, to then give examples of interviewees using the different religio-scientific frameworks and evidence of its ability to discriminate between pre-service primary teachers' approaches to the teaching of science.

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The tasks of the interviews will be to see if examples of different religio-scientific frameworks can be identified and describe the ways in which they manifest themselves in terms of pre-service primary teachers' understandings of nature and purpose of science education and their approaches to the teaching of science.¶

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Nature and purpose of science education: Many of the pre-service primary teachers see their duty and the role of science education as the didactic transference of knowledge and skills, both to act as the foundation for future transferable life-skills but also to satisfy their pupils' natural inquisitiveness. It would be remiss of teachers (some would go as far as to say negligent) not to enable all their pupils to become more cognisant of themselves and the world they inhabit. Here is an example from Kim.

KIM: It is important for children to understand the world around them and how it works, because the world largely does go by scientific principles. But not just to give them a better understanding of the world around them, but also of their body – how their body works – nutrition etc. It's important that they're taught about these things from an early age – to get a level of understanding that they can build on.

For Lucy, unlike some other subjects, it's also democratic and accessible to all.

LUCY: It's also one of the few subjects – not like numeracy and literacy, where the focus is on teaching ability groups – that gives you the opportunity to teach mixed ability groups and that gives children more opportunities to excel, because it's not just about writing and arithmetic. So if you've got some children who are not brilliant at numeracy or literacy, then they have a chance to do something practical that they can be good at.

The value of a primary science education for these pre-service teachers therefore goes beyond just enabling children to learn more scientific facts and

skills, but also addresses foundational issues which, as Tracy points out, might not be addressed anywhere else but in the science class.

TRACY: In my opinion, science is what explains the world and everything comes down to science. Science gives children an appreciation of just what is around – they can't just neglect it, they can't ignore what's happening.

These pre-service primary teachers are therefore willing advocates for their pupils to learn about science. Most of the reasons given are unquestionably utilitarian but, for some, the teaching of science also enables primary-aged children to engage in a broader educational discourse. Can any variation be at least, in part, explained by the religio-scientific framework of the teacher? Examples of various frameworks will now be described, as well as evidence of their influence on the interviewees' approach to the teaching of science.

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Religio-scientific frameworks:

i) Examples of 'epistemic' religion-'epistemic' science frameworks

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Two of the pre-service primary teachers interviewed, Kelly and Claire would appear to utilise just such a framework. It is interesting to note the difference in the level of authority given to the two epistemic strands. For Kelly, both science and religion have equal validity as bases for understanding behaviour and actions.

KELLY: I think we tend to categorise science as fact and religion as more "airy-fairy" and not factual, and I think we've got our understanding of science and religion a bit wrong. Neither of them is all about facts, a lot of science is just hypothesis and speculation and a lot of religion is as well. When we're teaching both science and religion we need to be very, very careful giving constantly just fact, fact, fact, but more ideas and discussion. The two are more interrelated than you think, because it's all about understanding the world around us – that's what science and religion are all about... They can have similar views on things, but put in slightly different ways. Sometimes they contradict, but not all scientists say the same things, so it's a very complex issue.

This epistemic equality does appear to influence the way Kelly approaches her science teaching, with an openness that allows a religious engagement with scientific topics, which doesn't threaten the legitimacy of the scientific conclusions that might be reached by the pupils.

KELLY: I'll give an example, in looking at the Earth, Moon and the solar system; you could bring in how ideas in religion have influenced their study and how scientific understanding has changed and how people from different religions have viewed the world, so there's definitely room for mix and match.

For Claire, religion is epistemically of greater significance. This is not to say that scientific ways to knowing are unimportant, just that they are directed by a religious worldview.

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CLAIRE: I'm actually a Quaker and they integrate science as part of the religion. In Quaker statement of belief, they say that you can draw inspiration from the sciences. If you want someone who sees a clash between science and

religion, then I'm the wrong person because I don't have a clash. I can't think of a religion that is any more relaxed!

As science informs Claire's fundamental beliefs, so her approach to science teaching would allow for her pupils to have a more personalised engagement with issues.

CLAIRE: My personal view is that everybody should be curious about the world around them… There are also deeper things that are more general, say you were talking about social responsibility and behaviour, then that would go into environmental and health education – drugs use in science. It helps tackle the deeper side of things; it's more about you, more personal, you don't have to read a book to get an answer, it's more about looking inside you.

ii) Examples of 'epistemic' religion-'pragmatic' science frameworks

For three of the interviewees, Kim, Karla and Tracy the role and limits of scientific knowledge are clear and well defined.

KIM: I personally believe that God created the world and that science is part of that world... The human body is just an incredible thing – it's so amazing the way that it works, that I think that it can't just be to chance and evolution, there must be something higher acting on it; there must be something more going on than just chance.

KARLA: In science, certain things have to happen to facilitate other things, but as to the deeper meaning of why something happens, you would probably have to look more towards religion and faith.

There is the acknowledgment, even by the agnostic Tracy, that a religious sense of knowing also serves an ontological function.

TRACY: I have real problems with a lot of religion, purely because I know everything can be explained in certain ways... What I can't understand, which is where religion comes in, is the mystery, and ... that could be brought in for a deeper, soul-type explanation of the world.

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This appreciation of alternative ways of viewing appears to allow a non-dogmatic approach to science teaching.

KIM: Whatever you teach children, they should be given the chance to decide whether they accept, reject or believe it. They have to have it presented to them in a way to accept or reject it. What's your role in that process? Letting them know this is what science is about, and from the start to present it in a way that is not biased, so that from the start they have got that open-mindedness themselves, so that as they develop as people and grow older into teenagers and adults, that's when they can then maybe make proper informed decisions.

Their role is therefore to be an unbiased facilitator, presenting science objectively, with the children making up their own minds as to the relative importance of the scientific knowledge presented.

KARLA: As a teacher it is important to try and present children with the known facts, and to try not to put our own views into things if we can and remain one step removed from what we're teaching... I have always been aware that we cannot say with absolute certainty about anything we know in the known world is what we know so far. Are you as conditional with everything you teach, or just in science? I would probably like to think that I keep an open mind about all sorts of things - certain things where there is

an element of human opinion – we should always keep an open mind.

TRACY: I actually think that children should have access to information to give them the opportunity to challenge what they believe. I don't think you should grow up just believing what your parents have told you, I think you should challenge the world. If you challenge it and still come to the same conclusions, then OK. You should at least have access otherwise who else is going to give it to you? If you're not going to get the scientific explanation on certain things at school, where else are you going to get it from, and I feel, as a teacher, it is my responsibility.

iii) Example of a 'pragmatic' religion-'epistemic' science framework

Only one of the pre-service primary teachers interviewed, Lucy, appears to use this framework. For Lucy science gives the individual some of the necessary life-tools for rational independent thinking and decision making. Whereas, as an atheist, religious understanding can only, at its best, enable an individual to appreciate cultural similarities and differences to their own, at its worst it is limiting and indoctrinating.

LUCY: One of my bugbears with religion is that lot of religions, kind of indoctrinate their children from a very early age – it's difficult to change views as you get older. I don't really agree with that, I think people should have a broad awareness of all the different aspects of things and then come to their own conclusions.

When I was very small I had all these things fed to me when I was at Sunday school, there is a little thing that hopes there is something there really, but my scientific mind thinks, no, there probably isn't. Do you see it like that; do you have a 'scientific mind'? Yes, I definitely think so... I have read quite a few books that look back over where some of the Bible stories came from, looking at the historical facts, and I find that fascinating! It kind of put my mind at rest; I can see now that there are historical

happenings that could explain lots of these events that are written about in the Bible, and I can understand how people would write them in stories in order to pass them on. Are you rationalizing in a logical way the genesis of those stories? Yes definitely, and that's a reference to my own beliefs.

For Lucy, her role as teacher - especially in science - is to empower her pupils' through giving them access to the knowledge and skills they might need for equality of decision making and opportunity later in life - no matter the religious heritage of the child.

LUCY: I've got a child, and I would like to think that she would grow up being able to make her own decision about things and hopefully, whatever decision she makes, as long as she has a good reason for it, I would be able to support that. I would like to think all children have that opportunity.

Lucy appears to be aware of the potential difficulties such an attitude might cause when teaching areas of the curriculum such as sex education. She is, however, very clear as to what her approach would be.

LUCY: It's the duty of the teacher, to give the children the knowledge and the skills to make their own decisions about things… Sex education is an area where religion impacts on science, and I, personally, don't think that's fair, but then I suppose I should respect the parents' views and religious beliefs. I would try to persuade the parents, because I feel the outcome of not giving them everything might have a negative impact on those children's lives.

iv) Examples of 'pragmatic' religion-'pragmatic' science frameworks

Two of the interviewees, Charles and Dawn can be placed in this framework but their impacts are strikingly different.

For Charles, both science and religion are sets of facts and skills one is obliged to know *about* rather than learn *from*. This obligation is carried into his approach to the teaching of science, where the content and rationale of a directed National Curriculum determines why and what science is taught.

CHARLES: You have to teach science – it's in the National Curriculum – you have to teach it, so you don't have a choice. You see what I mean, when I say science is like a religion, people believe in it, but it is what everyone is made to believe now, and it does seem a shame to have to teach it, but it is a fact and we know it is the truth – we believe it is the truth. We think that they have to know it, and the government think they do. Do they have to know it? No they don't.

For Dawn, religious and scientific understandings are both useful for probing the diverse nature of peoples and the physical world they inhabit. This pragmatism is reflected in her approach to science teaching which focuses on the utility of scientific enquiry.

DAWN: I think religion isn't just about someone's belief in God, it's so much more about the way people live... I think of religion as a way into worldliness.

You can't answer any children's questions – even about simple things – dinosaurs, the planets, ideas drawn from their toys and play – without science. You can start their thinking, by taking their curiosity in a directional way and make them realise that they can be curious about something, you can research something and then get the answer, so learning the process of thinking.

Conclusions & Implications

It would appear to be possible to assign a religio-scientific framework to each of the pre-service primary teachers interviewed and, furthermore, to relate differences in their approach to the teaching of science to their framework.

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Zeidler et al. (2002) found differences in the extent to which students' compartmentalized scientific knowledge versus personal knowledge and opinion. Although certain students viewed scientific knowledge as that which is supported by concrete evidence and facts, Zeidler found that they would not consider the use of scientific evidence to convince other people to change their personal opinions. This would chime with a 'pragmatic' religion-'pragmatic' science framework as exemplified by Charles and Dawn, for whom the teaching of science is requisite, but see their role as purveyors of knowledge and skills, rather than advocates of how their pupils might make use of them.

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This arms-length attitude is the direct opposite to those pre-service primary teachers, like Lucy, who see scientific knowledge and skills as essential in allowing an individual to make informed life-choices. Those who use a 'pragmatic' religion-'epistemic' science framework see it as their duty to teach their pupils the science they need to know, no matter their background.

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The pre-eminence of scientific dogma would be rejected by those whose teaching is informed by an 'epistemic' religion-'pragmatic' science framework. Pre-service primary teachers such as Kim, Karla and even the agnostic Tracy accept (like all the interviewees) that the teaching of science is necessary and useful but see their role as non-judgemental sources of information but how their pupils' use the scientific knowledge they gain and the scientific skills they develop will be ultimately be mediated by their individual circumstances.

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This *laissez-faire* attitude to the usefulness of scientific knowledge would be seen by those teachers who use an 'epistemic' religion-'epistemic' science framework as an opportunity missed. Science is valuable as the means to acquire a deeper and richer appreciation of our physical and material world but also as *one* possible way to examine metaphysical issues. Kelly and Claire might disagree as to the authority that should be given to scientific truth-claims (Lake 2005), but both approach the teaching of science as a potentially life-changing, life-enhancing subject.

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The implications for teacher education are therefore significant. Teacher educators need to be aware of the personal religio-scientific framework that, in part, governs trainees' and their own (Nyhof-Young 2000) approaches to the teaching of science. For many pre-service primary teachers will have a strong sense of the context of their own beliefs and attitudes in relation to science and religion (Jackson et al. 1995). These may well be based on ideas which have become congenial and trustworthy, and any new ideas that might be

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introduced as part of a teacher education programme might elicit one of two possible defensive reactions; the recontextualisation of their learning to suit their predispositions (Cobern 1993), or heightened scepticism of any new approach as it is seen as an attempt at indoctrination (Jackson et al. 1995, Roth and Alexander 1997, Shipman 2002). Teacher educators need therefore to be responsive to the diverse nature of the approaches their trainees will have to the teaching and learning of science and not deny the fact that for some there is a *de facto* connection of some scientific conceptions to morals and values; and as Cobern (2000) suggests be made part of the instructional process. How this is to be done is beyond the scope of this study, but will form the basis of future investigations.

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	Agree %	Not sure %	Disagree %
Science is useful for solving the problems of everyday life	91	7	2
Science has ruined the environment	7	37	56
Science is very important for a country's development	89	9	2
Money spent on science is well worth spending	68	24	8
Much of the anxiety in modern society is due to science	18	36	46
Scientific inventions improve our standard of living	80	14	6
Scientific inventions have increased tensions between people	56	27	17
Science will help to make the world a better place in the future	48	37	15
Scientific discoveries do more harm than good	5	30	65
Science and technology are the cause of many of the world's problems	20	34	46

	B	C	D	E	F	G	H	I	J
A	-0.193 NS	+0.121 NS	+0.295 0.004	-0.195 NS	+0.233 NS	-0.012 NS	+0.196 NS	-0.178 NS	+0.008 NS
B		-0.332 0.001	-0.202 NS	+0.269 0.009	-0.169 NS	0.185 NS	-0.089 NS	0.197 NS	0.136 NS
C			+0.435 0.000	-0.132 NS	+0.274 0.008	+0.003 NS	+0.398 0.000	-0.351 0.001	+0.097 NS
D				-0.201 NS	+0.537 0.000	-0.049 NS	+0.524 0.000	-0.227 NS	+0.031 NS
E					-0.079 NS	+0.326 0.002	-0.139 NS	+0.254 NS	+0.412 0.000
F						-0.143 NS	+0.515 0.000	-0.222 NS	0.028 NS
G							-0.123 NS	+0.091 NS	+0.386 0.000
H								-0.351 0.001	-0.047 NS
I									+0.157 NS

Key: A = Science is useful for solving the problems of everyday life; B = Science has ruined the environment; C = Science is very important for a country's development; D = Money spent on science is well worth spending; E = Much of the anxiety in modern society is due to science; F = Scientific inventions improve our standard of living; G = Scientific inventions have increased tensions between people; H = Science will help to make the world a better place in the future; I = Scientific discoveries do more harm than good; J = Science and technology are the cause of many of the world's problems; NS = not significant.

	Agree %	Not sure %	Disagree %
Science will eventually give us complete understanding of the world	32	36	32
Theories in science can be proved to be definitely true	29	36	35
The laws of science will never be changed	16	34	50
Theories in science are never proved with absolute certainty	59	22	19
Science will eventually give us complete control over the world	5	23	72
Nothing should be believed unless it can be proved scientifically	15	11	74

	B	C	D	E	F
A	+0.115 NS	+0.173 NS	-0.057 NS	+0.533 0.000	+0.456 0.000
B		+0.173 NS	-0.255 NS	+0.147 NS	+0.178 NS
C			-0.049 NS	+0.230 NS	+0.057 NS
D				-0.013 NS	+0.052 NS
E					+0.260 NS

Key: A = Science will eventually give us complete understanding of the world; B = Theories in science can be proved to be definitely true; C = The laws of science will never be changed; D = Theories in science are never proved with absolute certainty; E = Science will eventually give us complete control over the world; F = Nothing should be believed unless it can be proved scientifically; NS = not significant.

	Agree %	Not sure %	Disagree %
Both science and religion are important for human well-being	57	19	24
Conflict between science and religion is inevitable	65	24	11
Science and religion should be kept completely separate	22	32	46
Deep down science and religion are one and the same	8	28	64
Interaction between science and religion can be of benefit to both	58	31	11

	B	C	D	E
A	-0.201 NS	-0.303 0.003	+0.387 0.000	+0.365 0.000
B		+0.248 NS	-0.194 NS	-0.091 NS
C			-0.206 NS	-0.623 0.000
D				0.315 0.002

Key: A = Both science and religion are important for human well-being; B = Conflict between science and religion is inevitable; C = Science and religion should be kept completely separate; D = Deep down science and religion are one and the same; E = Interaction between science and religion can be of benefit to both; NS = not significant.

	B	C	D	E	F	G	H	I
A	-0.082 NS	-0.001 NS	-0.128 NS	-0.028 NS	+0.057 NS	+0.021 NS	-0.130 NS	-0.079 NS
B		+0.032 NS	0.118 NS	-0.150 NS	-0.074 NS	-0.018 NS	-0.091 NS	-0.072 NS
C			-0.163 NS	-0.068 NS	-0.163 NS	-0.209 NS	-0.097 NS	0.217 NS
D				-0.096 NS	-0.034 NS	-0.117 NS	-0.073 NS	-0.033 NS
E					+0.130 NS	+0.309 0.003	+0.119 NS	-0.236 NS
F						+0.248 NS	-0.194 NS	-0.091 NS
G							-0.206 NS	-0.623 0.000
H								+0.315 0.002

Key: A = Age; B = Level of science education; C = Identification with a religious group; D = Attitude towards science; E = Scientism; F = Conflict; G = Independence; H = Integration; I = dialogue; NS = not significant.