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The Development of an 'Attitudes to Science and Religion' Instrument for Secondary School Students: How Are the Attitudes of Students to Science and Religion Associated with Student Religion and Other Characteristics?

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Abstract: This article uses data from students in England to pilot and validate an 'Attitudes to Science and Religion' instrument which explores secondary school students' perceptions of the relationship between science and religion, as well as their attitudes towards science and towards religion. This instrument was developed in part from previous studies and is intended for educators and researchers for both pedagogical and research purposes. The post-pilot questionnaire was then used with 1102 Year 9/10 students from 18 schools in England to answer two research questions: (1) Is there a relationship between students' attitudes towards science and their perceptions as to whether science and religion are compatible? (2) What are the characteristics of students who report that science and religion are compatible? Students who reported that science and religion were compatible had more positive perceptions of science and of their ability in science, were more likely to have future aspirations in science and showed more positive attitudes towards science education. There was no statistically significant difference between Christian and Muslim students in their responses about the compatibility of science and religion, nor about whether evolution and creationism should be taught in the science classroom. Muslim students were as positive as were Christian students about their science education and the benefits of science; however, they were less positive about the role of science in explaining the world. Students who reported science and religion as being compatible were more likely to hold religious beliefs than a belief in scientism. Implications of this research are that there ought to be a place for discussion about the relationship between science and religion within school lessons and that high quality discussion is likely to be fostered by developing students' critical thinking skills.

Keywords: survey; science; religion; Christian; muslim; attitudes

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1. Introduction

1.1. School Students' Views about Religion and Science

Science educators within England as well as in other countries are becoming increasingly interested in the relationship between science and religion, in large measure because of the ways that student perceptions of the relationship between the two may have an impact on students' engagement with science in the classroom. Policy makers and practitioners in industrialised nations are concerned with the numbers of students who do not continue to study science subjects once these become non-compulsory [1–3]. There is a concern that some young people reject scientific ideas because they contradict their religious beliefs [4]; such contradictions could be a possible barrier towards having a scientific career [5]. Within industrialised as well as other countries, there are groups of people for whom religion is an important part of their lives; for these people, religion influences the way they see the world [6]. It is therefore an important part of education to consider the impact of religious beliefs on learning and perceptions of school subjects such as science [7]. Research suggests

that some students from certain faith backgrounds (e.g., Christian creationists or many of those of Muslim faith) disagree with the view that religion and all of science are compatible; such students have been found to indicate there is a conflict between religion and science or that the two occupy non-interacting domains. For example, Taber et al. (2011a) [8] undertook a qualitative study in England with 12 secondary school students from four schools and found that the students' perceptions about the relationship between science and religion lay on a spectrum from compatibility to conflict. Hanley et al. (2014) [4] categorised some 200 secondary students depending on both their understanding of and the amount of engagement they were prepared to have with the relationship between science and religion, again finding a considerable spectrum of views, while Yasri and Mancy (2012) [9] found that there was a link between students' perceptions of the relationship between religion and science and their subsequent approach to classroom learning.

Over the past twenty years, there has been an increasing amount of work on students' views about science and religion; existing research suggests that many young people believe that science and religion do not complement each other [10,11]. Billingsley et al. (2016) [12] examined the interactions between school teaching and school students' developing knowledge and also the students' understanding of science and religion after they had experienced some cross-disciplinary teaching. The study concluded that pedagogical and social barriers can prevent students from understanding how science and religion relate to each another.

Whilst some of the existing research has been quite informative about how students learn science, often it has been based on data collected from small numbers of students, as we discuss in more detail in the following section. In addition, some of the research studies have been explicit about the religious backgrounds of their respondents whilst others have not, lumping them together.

1.2. Validity and Reliability of 'Science and Religion' Surveys

There is no one single 'attitude towards science'; there are a range of constructs that can be used to measure attitudes towards various aspects of science and attitudes towards various aspects of science education. The need to acknowledge and account for such distinctions has been reported by a number of authors, notably Osborne, Simon and Collins (2003) [13], although the use of validated constructs within science educational research remains somewhat hit and miss. There is an ongoing concern within science education that the process of instrument development too often lacks psychometric validity [14]. What has typically happened in previous studies that have explored understandings of the relationship between science and religion is that new instruments were developed that only went through a non-statistical, subjective validation process using 'panel validity'; instruments were theoretically scrutinised by a panel of people without the use of statistical testing. However, such subjective testing in isolation from statistical testing is not a good way of establishing instrument validity [15,16]. Through the use of factor analysis and tests of inter-correlations, researchers can provide statistically validated reasons to place items together to create an overall construct if individual items are able to load onto one factor [17,18]. Furthermore, the use of Cronbach's alpha can indicate whether items that constitute a scale are reliable [19]. For these reasons, in this article, we first describe how we designed and validated an 'Attitudes to Science and Religion' instrument. We then use this instrument to answer the following research questions: (1) Is there a relationship between students' attitudes towards science and their perceptions as to whether science and religion are compatible? (2) What are the characteristics of students who report that science and religion are compatible?

Hokayem and BouJaoude (2008) collected mixed methods data from 11 students of Christian and Muslim faith [20]. They used two surveys to collect the quantitative data; however, data from 11 students are unlikely to be statistically reliable or generalisable. Hokayem and BouJaoude used instruments that had been validated previously: Measure of Acceptance of Theory of Evolution (MATE) and Test of Preferred Explanations. There was no discussion about using factor analysis to verify the underlying dimensions of

the instruments. Hokayem and BouJaoude established content validity by asking five university professors with experience in the field of evolutionary biology to rate the survey and, having done this, ran a Cronbach's alpha test (the alpha was high). The use of MATE itself has been criticised [21]; although it is widely used in evolution education, it was only developed and validated on the original sample of participants with no testing of whether it works similarly amongst people of different backgrounds.

A study by Kasmo et al. (2015) [22] had a good sample size (640 Malaysian adults); however, there was no discussion about construct validity or panel validity. The conclusions of Kasmo et al. (2015) [22] were based on the findings of just two questions, with no justification as to why there was no construct level analysis. Southcott and Downie (2012) [23] modified a survey used by one of the authors a decade earlier [24] which explored attitudes towards evolutionary biology in undergraduates. The sample had just over 200 students but Southcott and Downie (2012) [23] did not state how content validity was established. That study, along with the others described so far, did not include a range of scientific questions (it concentrated on evolutionary biology), nor did it take into account the views from people of different faith positions. A study by Nadelson and Southerland (2012) [21] in the US devised an instrument to assess acceptance of evolution among students on three subscales: microevolution, macroevolution, and human evolution. Just over 300 students completed surveys, with most (226) being undergraduates and 87 from high school. That study, while understandably focussing only on evolution, successfully established the validity and reliability of the survey: initial construct validity was determined by a panel of biologists, and then there was a clear and well-defined process of statistical validation and establishment of reliability. Taber et al. (2011b) [25] developed a survey which asked 109 Year 9 students from four schools various questions about science and religion and how they relate. However, the study did not report on construct validity or reliability.

Some studies have looked at what happens in the classroom and at teachers' perceptions of whether students can be helped to see that science and religion can be compatible. Billingsley et al. (2014) [26] conducted a qualitative study on 16 science and RE (Religious Education) teachers about how they collaborated with teachers in other curriculum areas and what they saw as their responsibility when teaching students. The science teachers felt that their approach was impacted by students' religious beliefs while the RE teachers found it difficult to make sure all students understand how science and religion relate to each another. Yasri et al. (2013) [27] developed an instrument designed to elicit views on the possible relationships between science and religion and to provide reliable information about the degree of agreement with each of these possible relationships. Their study was undertaken in three different research contexts: Thailand (n = 327), Pakistan (n = 173) and Scotland (n = 86). Validity of the instrument was established by asking teachers at Thai primary and secondary schools and six postgraduate students to review the instrument. There was no discussion about using statistical methods to assess validity and reliability, nor about how to address the possibility that understandings varied between the three participating countries.

Astley and Francis (2010) [28], in their survey of 187 female students in a sixth form school (age 16–19), found that there was a positive association between attitudes towards science and towards religion, once they had taken account of individual differences in students' views about creationism and scientism. Whilst their paper did not discuss validity using factor analysis (reliability was reported), their instrument builds on their earlier work that did undertake a considerable amount of work on validation. So, for example, Astley and Francis (2010) [28] used the 'Attitude towards religion' [29] and 'Attitude towards science' [28] scales and developed their 'Scientism' scale from two earlier measures of scientism [30,31] which were based on much larger samples of students. Astley and Francis (2010) [28] did not indicate whether the validity of this amended scale was tested via factor analysis. For 'Creationism', they amended an earlier scale developed by Francis and Greer (1999a) [32]. Of all of the instruments developed and cited to date, it was that of

Astley and Francis (2010) [28] that seemed most appropriate to our own work, with the added incentive of their scales having been validated across large samples.

2. Methodology

In this article, we show how we developed an instrument, an 'Attitudes to Science and Religion' (ASR) survey, to determine the ways in which secondary school students perceive science and the relationship(s) between religion and science. We developed the ASR instrument because existing tools lack adequate validation and/or are not applicable for students from a range of faiths or non-faith positions. We then present findings from our use of this instrument in England to determine if there is a relationship between students' attitudes towards science and their perceptions as to whether science and religion are compatible, and to ascertain the characteristics of students who report that science and religion are compatible.

This article reports on two datasets: pilot data and main study data. The pilot data together with the main study data are used to help verify underlying components of the instrument, whilst findings are reported using analysis of data from only the main study. In the pilot phase, we designed, piloted and validated an 'Attitudes to Science and Religion' instrument, a survey which explores secondary school students' understandings of the relationship(s) between science and religion as well as their attitudes towards science and to religion. The survey went through two iterations before being used in the main study; adaptations were made both before piloting, when the survey went to an international advisory group, and after piloting.

2.1. Reliability and Validity of the Surveys

2.1.1. Pilot Survey

The pilot version of the survey was sent to an international panel of experts in the study of science and religion (from a number of faith and non-faith positions). We took on board their advice and made changes to the instrument before piloting it. Their advice helped to identify inappropriate/ambiguous wording and confirm the adequacy of the questions within the instrument. The pilot survey contained more items than the final survey; we removed items that had little or no relationship with the various constructs of interest.

The pilot survey drew on previous related survey instruments; there were both challenges and advantages to this. Using pre-tested items gives some assurance that constructs have worked in the past with different samples (construct validity); however, we did find that we had to draw from a range of previous work as no previous study, as discussed above, had looked at all the issues we were interested in (science, religion, their inter-relationship and general attitudes to science). We also found that previous research measured certain attitudes in slightly different ways (e.g., students' commitment to their religion). Some surveys used single items, some used constructs; we tried where possible to incorporate these different approaches and then later used statistical testing to check the trustworthiness of our decisions about how to measure a particular concept.

We made judgements about which items suited our research purposes and would therefore be likely to enable us to answer our research questions. We ensured that our measures of students' attitudes to religion were comparable across different faiths and for students of no faith. Even within one religion, there are diverse views, and we also had to be sensitive to the realities that there is a diversity of views as to how science is understood, and that religious understanding can impact scientific understanding [33]. We used factor analysis to confirm the underlying dimensions of the survey measures; Table 1 indicates that there is fair to high reliability (Cronbach's alpha from 0.6 to 0.9) for all of our constructs in the pilot sample. We retained items within factors for the final survey if they had a minimum loading of 0.55 on the factor analysis; Table 1 also shows the total variance explained for each extracted factor using factor analysis with varimax rotation.

We used varimax rotation as it reduces the number of variables that have high loadings on each factor.

Table 1. Reliability and validity of constructs.

		Main Survey Sample		Pilot Sample	
Factor	**Number of Items**	**Variance Explained Using Factor Analysis (%)**	**Reliability**	**Variance Explained Using Factor Analysis (%)**	**Reliability**
Competitiveness	5	50.9	0.83	46.83	0.81
Critical thinking	5	53.2	0.85	52.10	0.84
Religiosity	10	70.0	0.96	69.11	0.96
Attitudes to theistic faith	7	76.1	0.81	79.62	0.82
Creationism	5	65.5	0.77	69.54	0.82
Trust in scientists	8	54.0	0.78	54.10	0.78
Public value of science	5	65.4	0.90	61.21	0.88
Scientism	6	44.4	0.85	47.39	0.84
Interest in doing science	10	56.0	0.92	52.22	0.92
Extrinsic motivation	8	72.7	0.96	69.41	0.95
General value of science	7	71.6	0.95	65.30	0.93
Awareness of environmental issues	8	58.7	0.92	57.03	0.91
Science self-concept	6	72.6	0.94	72.22	0.94
Science removes the need for God	4	66.3	0.89	69.83	0.90
Compatibility between science and religion	6/3	43.4	0.65	45.21	0.59
Perceptions of science lessons	4	77.3	0.93	N/A	N/A

Notes: Constructs in bold were those that were associated with 'Compatibility between science and religion' in the final multivariate model.

2.1.2. The Final Survey

The final survey covered a range of issues about students' experiences and attitudes to religion and science, the interaction between the two, and other important measures, e.g., a measure of students' critical thinking skills. We re-ran the factor analysis with the final survey and had similar results to the pilot (see Table 1). Table 1 also indicates that there is fair to high reliability for all of the constructs in the final survey. We calculated the values of the constructs as the average of the individual items which underpinned each construct; we reverse coded items where necessary so that higher scores reflected more agreement/more positive responses for the items and the overall construct. Tables 1–3 display the key items/factors used within the analysis. We used a six-point Likert scale for

each construct/item reported within this article. A high score represents strong agreement, with scores above three indicating positive responses/high agreements with statements. The scale used for each item was: (6) 'Strongly agree', (5) 'Agree', (4) 'Slightly agree', (3) 'Slightly disagree', (2) 'Disagree' and (1) 'Strongly disagree'. Table 3 provides more detailed information about the individual scales in terms of the individual item responses and the relationship between each individual item and the overall construct.

Table 2. Descriptive statistics (ordered by descending means).

Item/Factor	M	SD
I see myself as open to new experiences	4.75	1.15
Critical thinking	4.53	0.91
Public value of science	4.38	1.09
Competitiveness	4.37	1.06
General value of science	4.26	1.16
Trust in scientists	4.18	0.81
Extrinsic motivation	4.05	1.27
Perception of science lessons	3.91	1.33
Awareness of environmental issues	3.88	1.11
Would you support creationism being taught alongside evolution in the RE classroom?	3.78	1.39
Compatibility between science and religion	3.81	1.02
Science self-concept	3.70	1.19
Interest in doing science	3.63	1.15
Scientism	3.50	1.05
My family has a strong religious faith.	3.48	1.81
Attitudes to theistic faith	3.46	1.65
Would you support creationism being taught alongside evolution in the science classroom?	3.38	1.51
Science removes the need for God	3.29	1.36
Religiosity	3.29	1.52
I have a strong religious faith.	3.24	1.84
Creationism	2.67	1.19
There is no place for science in my life	2.11	1.31

Notes: Means ('M') and standard deviations ('SD') are reported.

Table 3. Main scale properties of key constructs.

Overall Construct with the Underlying Items	Item-Factor (R)	Item Responses (%)					
		Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
Competitiveness							
I like doing better than others in tests.	0.795	2.6	5.2	8.6	25.0	30.4	28.3
I get satisfaction in taking part in competitions and challenges.	0.741	5.5	8.5	11.7	28.3	27.8	18.2
I often try to outperform others in tests, competitions or tasks.	0.849	5.8	11.4	14.8	27.3	23.0	17.7
I want to be the best in school.	0.818	8.0	14.2	14.6	21.6	20.1	21.4
Getting high marks in school is very important to me.	0.656	2.1	2.1	3.6	15.9	30.8	45.5
Critical thinking							
It is important for me to get information to support my opinions.	0.785	2.6	3.6	7.0	27.6	39.7	19.5
I usually have more than one source of information before making a decision.	0.812	2.4	5.4	12.6	30.1	35.2	14.1
I back my decisions by the information I have.	0.817	2.0	3.2	9.3	25.3	44.8	15.4

Table 3. *Cont.*

Overall Construct with the Underlying Items	Item-Factor (R)	Item Responses (%)					
		Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
I listen to the ideas of others even if I disagree with them.	0.771	3.0	4.0	9.0	21.9	39.1	23.0
I keep my mind open to different ideas when planning to make a decision.	0.754	2.4	3.7	7.2	24.6	41.4	20.7
Religiosity							
I regularly think about religious issues.	0.765	18.9	18.8	14.6	21.9	16.7	9.2
I believe that God or something divine exists.	0.888	17.6	12.2	10.7	15.0	14.0	30.5
I regularly take part in religious services.	0.860	32.3	18.4	10.1	14.4	13.3	11.5
I often pray.	0.890	34.5	14.7	9.1	13.7	13.5	14.5
I usually experience situations in which I have the feeling that God or something divine acts in my life.	0.887	27.3	15.2	10.9	15.7	15.8	15.1
I am interested in learning more about religious topics.	0.779	18.9	12.6	11.7	19.9	20.1	16.8
I believe in an afterlife—e.g., immortality of the soul, resurrection of the dead or reincarnation.	0.732	15.2	11.8	9.8	19.0	17.8	26.4
It is important for me to take part in religious services.	0.903	28.0	19.0	11.1	15.3	15.3	11.3
Personal prayer is very important for me.	0.926	30.5	16.3	10.0	11.8	13.5	18.0
I often experience situations in which I have the feeling that God or something divine wants to communicate or to reveal something to me.	0.833	34.4	16.9	13.9	14.1	10.7	9.9
Attitudes to theistic faith							
I don't find it hard to believe in God.	0.784	16.1	14.9	14.7	10.9	17.2	26.2
Prayer helps me a lot.	0.904	31.0	16.9	10.9	11.6	15.2	14.5
I don't think going to worship is a waste of my time.	0.740	12.9	9.4	14.4	14.8	16.5	32.1
I know that God is very close to me.	0.928	26.8	16.4	10.9	15.5	15.3	15.2
God helps me to lead a better life.	0.941	26.2	15.2	11.0	12.3	15.9	19.5
I know that God helps me.	0.948	28.2	13.6	10.3	12.7	15.8	19.3
God means a lot to me.	0.951	27.6	13.7	10.4	11.1	12.2	25.0
Creationism							
The animals and plants we know today have not evolved from earlier kinds of animals and plants.	0.618	27.9	33.0	18.0	8.2	4.9	8.0
God created all the species of animals and plants directly.	0.799	26.3	16.5	12.7	15.6	13.2	15.6
I don't accept the idea of evolution giving rise to new kinds of animals and plants over millions of years.	0.589	29.2	29.7	19.0	9.6	5.0	7.5
I believe that God made the world in six days of 24 h.	0.783	39.5	18.6	13.2	10.9	9.5	8.3
God made woman out of man's rib.	0.783	46.3	18.4	11.8	8.5	6.1	9.0
Trust in scientists							
Scientists do not ignore evidence that contradicts their work.	0.577	3.4	7.7	21.1	23.4	28.4	16.0
Scientific theories are not weak explanations.	0.680	2.4	5.4	11.5	23.0	34.5	23.1
We can trust scientists to share their discoveries even if they don't like their findings.	0.553	5.8	8.8	17.2	33.3	24.8	10.1
Scientists do value the ideas of others.	0.622	2.6	7.0	18.3	23.8	31.8	16.5
I trust that the work of scientists to make life better for people.	0.643	4.7	5.2	12.0	25.8	33.9	18.5

Table 3. *Cont.*

Overall Construct with the Underlying Items	Item-Factor (R)	Item Responses (%)					
		Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
Scientific theories are trustworthy.	0.686	5.2	7.3	18.7	33.8	25.6	9.4
We can trust scientists because they are biased in their perspectives.	0.639	2.3	5.1	18.8	30.9	26.4	16.4
We can trust scientists to evaluate the work of other scientists.	0.628	4.6	4.4	14.4	34.4	32.0	10.4
Public value of science							
Science can give us absolute truths.	0.811	6.3	10.0	26.7	29.2	17.6	10.1
Science alone can provide truths about nature.	0.827	7.2	9.6	17.8	29.7	23.3	12.5
Science will eventually give us complete control over the world.	0.767	14.2	19.6	27.5	20.6	10.7	7.4
Theories in science can be proved to be definitely true.	0.781	6.9	11.6	25.5	28.8	19.3	7.9
The laws of science will never be changed.	0.652	8.2	18.4	35.1	20.0	10.7	7.7
Nothing should be believed unless it can be proved scientifically.	0.698	14.6	17.5	25.9	19.2	12.0	10.8
Interest in doing science							
I often take part in science-related activities e.g., after school science clubs, reading about scientific issues.	0.635	21.6	28.3	16.2	18.0	10.4	5.5
Learning about scientific issues is important for my future.	0.751	6.8	10.1	15.8	30.0	23.2	14.1
I have a lot of interest in topics in physics.	0.782	13.9	15.8	18.5	24.9	15.7	11.2
I have a lot of interest in topics in chemistry.	0.819	10.9	11.9	16.9	23.6	21.7	15.1
I have a lot of interest in the biology of plants.	0.797	10.6	12.9	19.0	26.8	18.5	12.2
I have a lot of interest in human biology.	0.774	8.5	9.1	14.1	24.6	23.9	19.8
I have a lot of interest in topics in astronomy.	0.777	9.1	14.2	17.7	23.4	19.3	16.4
I have a lot of interest in topics in geology.	0.774	13.2	16.2	22.5	25.8	14.0	8.2
I have a lot of interest in the ways scientists design experiments.	0.782	9.4	12.0	18.1	28.9	18.5	13.2
I have a lot of interest in what is required for scientific explanations.	0.818	10.9	11.1	22.9	26.1	17.2	11.7
Extrinsic motivation for science							
Making an effort in science is worth it because it will help me in the work that I will do later on.	0.867	9.1	6.1	10.1	24.2	28.0	22.5
Learning science is worthwhile for me because it will improve my career prospects.	0.876	7.0	6.8	11.6	24.6	28.8	21.2
Science is an important subject for me because I need it for what I want to study later on.	0.892	8.2	9.8	19.0	20.5	22.5	20.0
I will learn many things in science that will help me get a job.	0.901	7.2	7.5	15.7	24.3	25.0	20.3
Some concepts in science help me see how I relate to other people.	0.793	6.2	9.0	18.2	33.3	22.8	10.6
I will use science in many ways when I am an adult.	0.874	7.2	9.6	17.2	27.4	22.4	16.3
Science is very relevant to me.	0.892	7.1	9.3	18.9	24.5	22.4	17.9
When I leave school there will be many opportunities for me to use science.	0.873	7.5	8.9	17.5	25.7	23.2	17.2
General value of science							
I find that science helps me to understand the things around me.	0.861	6.1	6.1	13.5	26.7	28.7	18.8

Table 3. *Cont.*

Overall Construct with the Underlying Items	Item-Factor (R)	Item Responses (%)					
		Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
Learning about science is important to help me understand the world I am living in.	0.875	6.0	5.3	13.4	26.7	29.1	19.5
Advances in science and technology usually improve people's living conditions.	0.874	5.8	4.4	9.9	29.1	31.3	19.5
Science is important for helping us to understand the natural world.	0.888	5.4	5.4	11.1	27.7	32.3	18.1
Advances in science and technology usually help improve the economy.	0.869	4.9	5.2	13.5	33.3	28.3	14.7
Science is valuable to society.	0.878	4.8	5.0	11.8	26.1	31.9	20.3
Advances in science and technology usually bring social benefits.	0.835	4.8	5.6	16.1	30.7	26.4	16.4
Awareness of environmental issues							
I can recognise the science question that underlies a newspaper report on a health issue.	0.760	9.0	11.0	19.3	30.1	21.1	9.6
I can explain why earthquakes occur more frequently in some areas than in others.	0.774	6.3	8.8	12.0	22.6	27.0	23.3
I can describe the role of antibiotics in the treatment of disease.	0.804	6.1	10.4	15.2	30.8	23.6	13.9
I can identify the science issues associated with the disposal of garbage.	0.819	8.0	10.3	21.1	29.4	20.2	11.0
I can predict how changes to an environment will affect the survival of certain species.	0.828	5.9	6.5	11.8	27.6	30.3	17.9
I can interpret the scientific information provided on the labelling of food items.	0.823	7.2	7.9	20.3	31.0	20.7	12.8
I can discuss how new evidence can lead you to change your understanding about the possibility of life on Mars.	0.805	8.6	10.5	19.6	28.7	20.5	12.1
I can identify the better of two explanations for the formation of acid rain.	0.748	11.3	15.1	23.6	28.2	13.7	8.0
Science self-concept							
Learning advanced science topics would be easy for me.	0.824	13.3	16.0	21.5	27.3	15.1	6.8
I can usually give good answers to questions in science tests.	0.854	5.6	9.1	16.6	33.4	27.0	8.3
I learn science topics quickly.	0.907	8.6	9.6	23.9	28.6	20.4	8.7
Science topics are easy for me.	0.892	8.9	11.8	27.0	30.6	15.5	6.2
When I am being taught science I can understand the concepts very well.	0.902	7.4	8.7	20.7	29.1	23.6	10.5
I can easily understand new ideas in science.	0.863	7.7	9.6	19.3	30.7	20.8	12.0
Science removes the need for God							
It is science alone, not God, that explains the origin of the world.	0.858	19.1	18.2	21.0	17.3	14.0	10.4
The laws of nature leave no room for God to act in the world.	0.898	17.0	16.0	24.9	20.5	13.5	8.1
God doesn't influence the world in the same way as the laws of nature.	0.836	14.0	14.8	21.2	22.3	17.2	10.5
Evolution leaves no room for God to influence how life develops.	0.868	16.5	14.6	25.2	19.4	12.4	11.9
Compatibility between science and religion							
Science explains things in one way; religion explains them in another.	0.613	8.1	6.9	14.1	24.9	31.9	14.0
Religion and science both explain the origin of the world in different ways.	0.662	7.5	6.7	14.1	24.5	31.1	16.1

Table 3. *Cont.*

Overall Construct with the Underlying Items	Item-Factor (R)	Item Responses (%)					
		Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
Evolution is God's way of bringing species into existence.	0.586	15.3	14.8	21.1	25.4	15.3	8.1
I believe science and religion are not at odds with each other.	0.646	9.6	14.9	22.1	24.8	20.2	8.4
It is possible to believe in a God and still hold the view that life on earth, including human life, evolved over time as a result of natural selection.	0.667	8.0	7.3	12.2	26.0	26.3	20.2
Perceptions of science lessons							
I generally have fun when I am learning science topics.	0.909	7.9	11.8	12.6	28.5	25.4	13.7
I like reading about science.	0.892	13.9	19.4	18.0	22.6	17.0	9.1
I enjoy getting new knowledge in science.	0.929	6.9	8.1	11.0	26.6	30.3	17.0
I am interested in learning about science.	0.914	7.0	8.7	10.8	24.3	30.3	18.9
Scientism							
Science can give us absolute truths	0.811	6.3	10.0	26.7	29.2	17.6	10.1
Science alone can provide truths about nature	0.827	7.2	9.6	17.8	29.7	23.3	12.5
Science will eventually give us complete control over the world	0.767	14.2	19.6	27.5	20.6	10.7	7.4
Theories in science can be proved to be definitely true	0.781	6.9	11.6	25.5	28.8	19.3	7.9
The laws of science will never be changed	0.652	8.2	18.4	35.1	20.0	10.7	7.7
Nothing should be believed unless it can be proved scientifically	0.698	14.6	17.5	25.9	19.2	12.0	10.8

Notes: The name of the construct is in bold with the individual items that create each construct immediately below the construct name; 'Item-factor' shows the Pearson correlation coefficient (R) between the item and the overall construct (all significance at $p < 0.001$). 'Item-responses' show the valid percentages per response-category.

2.1.3. Constructs Retained in the Final Survey

The relationship between science and religion: We had a few constructs which explore the way students perceive that science and religion relate to one another. Of these, our key dependent variable construct is 'compatibility between science and religion'; it is also the construct that we developed afresh whilst the remaining constructs were slightly modified from existing research. From the pilot to the final survey, this construct underwent substantive modifications. We began with a three-item measure which, mid-piloting, appeared to work well; however, once we looked at its reliability within the final pilot sample, the reliability fell. Furthermore, the three items measured student views about whether it was possible that science and religion could explain the world in different ways and it became apparent, particularly after having spoken to some teachers about students' views of science and religion, and after examination of the findings of certain open-ended questions on the survey, that students could express the view that the two subjects explain the world in different ways while their own beliefs might be somewhat different (e.g., they themselves might think that only science can explain the natural world). The three items 'science explains things in one way; religion explains them in another', 'religion and science both explain the origin of the world in different ways' and 'evolution is God's way of bringing species into existence' were therefore supplemented with two further items: 'I believe science and religion are compatible' and 'It is possible to believe in a God and still hold the view that life on earth, including human life, evolved over time as a result of natural selection'. The final five-item construct had good reliability.

The 'science removes the need for God' construct was used in the pre-pilot survey and retained in the final survey.

Attitudes to religion and/or God: There were three overall constructs which measured attitudes to religion and/or God: 'religiosity', 'attitudes to theistic faith' and 'creationism'. The Centrality of Religiosity Scale (CRS) is a measure of the importance or salience of religious meanings to one's personality [34]. It has been applied in different versions in a multitude of studies in sociology of religion, psychology of religion and religious studies in various countries. We took our scale of 'attitudes to theistic faith' from the work of Astley et al. (2012) [29]. For 'creationism' we were well informed by the work of others (e.g., Hawley et al., 2011). Given that we intended to use items to explore creationism for students from non-Christian as well as Christian backgrounds, we adapted slightly a construct already in existence [35] which we anticipated would be understood by students of no faith, as well as by those from a range of faiths.

Attitudes to science: Most of our measures of attitudes to science were taken from existing research with some minor modifications. The constructs 'interest in doing science', 'extrinsic motivation in science', 'general value of science', 'public value of science' and 'awareness of environmental issues' were all included in the pre-pilot survey and taken from various iterations of the Programme for International Assessment [36] surveys with the exception of 'public value of science', which was originally developed by Astley and Francis (2011) and also appears in subsequent PISAs. Each of these measures was found to have an association with the 'compatibility with science and religion' construct and all were retained in the final survey. The construct 'trust in scientists' was amended from a larger construct originally tested on US undergraduate students [37]. The items for 'scientism' (a view that only science can explain the world) were taken from Astley and Francis (2010) [28].

Attitudes to science in school: These were measured by: valuation of science lessons; perceptions of lessons and science self-concept (see Table 3).

Psychological measures: Previous research has identified several dimensions to the 'competitiveness' construct [38] and these scales (given that they contain sub-scales) are a questionnaire in themselves and the language used is not always accessible to students. We therefore used a shortened version of the construct which we had adapted for secondary students in a previous work [39]. We also had an item which measured students' 'openness' towards accepting novel situations. This was the only other personality measure that was retained, given its association with the 'compatibility between science and religion' construct. 'Critical thinking' entails being able to evaluate situations and provide reasons for undertaking a certain action. We developed a shorter version of a tool which was used as part of a larger evaluation instrument to measure critical thinking skills amongst young people in the United States [40].

2.2. Sample

Initially, we contacted schools in England that had particular student demographics: those with a high proportion of Christian students, those with a high proportion of Muslim students and those with typical proportions of Christian and Muslim students (on the grounds that these are the two largest faith groups in England). The only way we could determine what the likely faith of students were within schools was to go by a school's designation (or not) as a faith school and to use ethnicity as a proxy. However, after very low take up rates in our attempts to recruit for the main phase, despite contacting approximately 75 schools, we decided to contact all secondary schools in England for which we had contact email addresses (circa 3000, about 80% of the total).

The data from the main phase come from 18 schools. The final survey (as with the pilot) was conducted online; school teachers organising the surveys were given survey links and a protocol to read to the students. Students who completed surveys for the main phase were in either Year 9 or Year 10 (ages 13/14 or 14/15). The vast majority of students completed the surveys within timetabled lesson time although a small proportion opted to have the

surveys set as homework. The survey explicitly asked students to indicate their faith (or none). In our main survey sample, we had the following categories: Atheist/Agnostic 349 (32%), Christian 278 (25%), Muslim 187 (17%), Sikh 50 (5%) and other faiths 240 (22%). In the 2011 census for adults in England, the figures for these faith categories were: Atheist/Agnostic (the census uses the term 'no religion') 25%, Christian (59%), Muslim (5%), Sikh (1%) and other faiths which includes Jews, Hindus and Buddhists (2.4%).

3. Results

3.1. Key Measures Used and Their Inter-Relationships

Table 2 outlines the means and standard deviations of the key constructs and items. Of the constructs which explored issues in science, students were most in agreement with the 'public value of science' (mean of 4.38) and the 'general value of science' (mean of 4.26). Students within this sample had high levels of critical thinking skills (mean of 4.53) and were not likely to hold creationist views (mean of 2.67). These initial findings indicate that beliefs about science vary depending on what was asked of students. Students held more positive views about the various constructs that asked about the value of science (to students themselves or the world around them) as opposed to beliefs in scientism. In addition, students were less likely to hold creationist views than they were to have a faith or a belief in God.

Once constructs were formed, we considered the constructs' (and certain items') relationships with our key dependent variable, the 'compatibility between science and religion' construct. Table 4 indicates that there are low-medium inter-correlation values between most of the predictor variables and 'compatibility between science and religion'.

Table 4. Correlations between core constructs (or certain items) and students' perceptions of the 'compatibility between science and religion'.

Construct/Item	R	Sig.
General value of science	0.444	**<0.001**
Competitiveness	0.242	**<0.001**
Critical thinking	0.360	**<0.001**
Religiosity	0.354	**<0.001**
Attitudes to theistic faith	0.290	**<0.001**
Creationism	0.071	**0.021**
Trust in scientists	0.143	**<0.001**
Public value of science	0.391	**<0.001**
Scientism	0.176	**<0.001**
Science removes the need for God	0.125	**<0.001**
Interest in doing science	0.317	**<0.001**
Extrinsic motivation	0.354	**<0.001**
Awareness of environmental issues	0.409	**<0.001**
Science self-concept	0.312	**<0.001**
Science lessons	0.295	**<0.001**
Awareness of environmental issues	0.409	**<0.001**
* Would you support creationism being taught alongside evolution in the science classroom?	0.483	**<0.001**
* Would you support creationism being taught alongside evolution in the RE classroom?	0.487	**<0.001**
* I have a strong religious faith	0.296	**<0.001**
* My family has a strong religious faith	0.285	**<0.001**
* I intend to study science after the age of sixteen	0.246	**<0.001**
* I see myself as open to new experiences	0.342	**<0.001**

Notes: Pearson correlations coefficients are reported. Significant coefficients ($p < 0.05$) are highlighted in bold. * These are individual items and not constructs.

From a statistical point of view this is perfectly acceptable: correlations that are too high would suggest that the independent and dependent variables were not sufficiently different from one another, whilst no associations would have led us to discount all the variables

within our multi-variate analysis. Positive associations between the construct 'compatibility between science and religion' was found with a number of perception of religion constructs: religiosity (r = 0.354, $p < 0.001$), attitudes towards theistic faith (r = 0.290, $p < 0.001$) and even creationism (r = 0.071, $p = 0.021$). Significant associations were also found with perceptions of science constructs: public value of science (r = 0.391, $p < 0.001$), extrinsic motivation in science (r = 0.354, $p < 0.001$), interest in doing science (r = 0.317, $p < 0.001$), general value of science (r = 0.444, $p < 0.001$), awareness of environmental issues (r = 0.409, $p < 0.001$), self-concept (r = 0.312, $p < 0.001$), perception of science lessons (r = 0.295, $p < 0.001$), scientism (r = 0.176, $p < 0.001$), trust in scientists (r = 0.143, $p < 0.001$) and science removes the need for God (r = 0.125, $p < 0.001$). There were also positive associations with other constructs: science self-concept (r = 0.312, $p < 0.001$), competitiveness (r = 0.242, $p < 0.001$) and critical thinking skills (r = 0.360, $p < 0.001$).

The rather high correlations between 'compatibility between science and religion' and attitudes to science (such as public value of science, general value of science and extrinsic motivation in science) suggest that students with more positive attitudes to science (who believe in the benefits of science to their own lives and to wider society) are more likely to report that science and religion are compatible. Following on from this, there was a positive association between 'compatibility between science and religion' and students reporting that they would like to continue with studying science after the age of sixteen (r = 0.246). The associations also indicate that students who reported that science and religion were compatible were more likely to report that they would support creationism being taught alongside evolution in the science classroom (r = 0.483) and in the RE classroom (r = 0.487).

Students Who Score High/Low on Compatibility between Science and Religion

We created a dichotomous variable from our 'compatibility between science and religion' construct; students were split into those who felt the two were compatible and those who did not. Analysis (Table 5) which looked at the differences between the survey responses of students who felt science and religion were compatible and those who did not found that students who felt the two were compatible were significantly more likely to have positive attitudes to science (general value of science, effect size = 0.79, belief in the public value of science, effect size = 0.74); greater understanding of environmental issues (effect size = 0.71)]; extrinsic motivation in science (effect size = 0.62); positive perceptions of science lessons (effect size = 0.56); a higher science self-concept (effect size = 0.52); interest in doing science (effect size = 0.51) and greater trust in scientists (effect size = 0.28). Whilst such students were more likely to indicate that they believed in a divine entity (attitudes to theistic faith, effect size = 0.51), they were not more positive about creationism.

Table 5. Comparison (*t*-tests) of students who score highly or lowly on the construct 'Compatibility between science and religion'.

Item/Factor	Difference	
	Sig.	**D**
Compatibility between science and religion	**<0.001**	2.791
General value of science	**<0.001**	0.79
Competitiveness	**<0.001**	0.41
Critical thinking	**<0.001**	0.66
Religiosity	**<0.001**	0.65
Attitudes to theistic faith	**<0.001**	0.51
Creationism	**0.447**	0.05
Trust in scientists	**<0.001**	0.28
Public value of science	**<0.001**	0.74
Scientism	**0.002**	0.23
Science removes the need for God	**0.045**	0.15
Interest in doing science	**<0.001**	0.51

Table 5. *Cont.*

Item/Factor	Difference	
	Sig.	D
Extrinsic motivation	**<0.001**	0.62
Awareness of environmental issues	**<0.001**	0.71
Science self-concept	**<0.001**	0.52
Science lessons	**<0.001**	0.56
Would you support creationism being taught alongside evolution in the science classroom?	**<0.001**	0.87
Would you support creationism being taught alongside evolution in the RE classroom?	**<0.001**	0.82
I intend to study science after the age of sixteen	**<0.001**	0.39
I see myself as open to new experiences	**<0.001**	0.61

Notes: Means ('M') and standard deviations ('SD') are reported. Mean differences (*t*-tests) show the absolute magnitude ('D'; Cohen's d) and significance ('Sig.'; *p*-values). Significant differences ($p < 0.05$) are highlighted in bold.

3.2. The Views of Christian, Muslim and Sikh Students

We used ANOVA (with Bonferroni correction) to explore whether there were statistically significant differences in the survey responses between students of different faith (Tables 6 and 7).

Table 6. ANOVA of survey responses to constructs/items by religion.

Construct/Item	Atheist/Agnostic (A)		Christian (C)		Muslim (M)		Sikh (S)		Other (O)		ANOVA	
	M	SD	M	SD	M	SD	M	SD	M	SD	Sig. (*p*)	Eta^2
Compatibility between science and religion	3.32	1.00	3.95	0.82	3.84	0.90	4.12	0.98	3.68	0.99	**<0.001**	0.078
Would you support creationism being taught alongside evolution in the science classroom?	3.11	1.52	3.57	1.47	3.49	1.42	3.61	1.25	3.41	1.59	**0.007**	0.016
Would you support creationism being taught alongside evolution in the RE classroom?	3.40	1.46	4.05	1.29	3.87	1.26	3.94	1.09	3.92	1.42	**<0.001**	0.038
Science removes the need for God	3.87	1.30	3.07	1.20	2.24	1.07	2.93	1.14	3.55	1.31	**<0.001**	0.172
Religiosity	2.00	0.85	3.80	1.20	4.93	0.83	4.44	1.01	3.02	1.41	**<0.001**	0.490
Attitudes to theistic faith	2.03	0.91	4.03	1.28	5.34	0.82	4.49	1.21	3.21	1.50	**<0.001**	0.514
Creationism	1.94	0.86	3.03	1.12	3.85	0.95	2.83	0.71	2.33	1.04	**<0.001**	0.328
I have a strong religious faith	1.60	0.95	3.93	1.40	5.20	0.99	4.80	1.16	2.99	1.73	**<0.001**	0.516
My family has a strong religious faith	2.04	1.25	4.08	1.43	5.25	1.02	4.88	1.24	3.20	1.74	**<0.001**	0.421
There is no place for science in my life	2.06	1.34	2.00	1.15	2.52	1.45	2.14	1.38	1.97	1.26	**<0.001**	0.021
Trust in scientists	4.44	0.78	4.09	0.74	3.74	0.77	4.13	0.74	4.26	0.80	**<0.001**	0.087
Public value of science	4.41	1.22	4.36	0.99	4.18	1.01	4.61	0.92	4.45	1.07	0.052	0.009
Scientism	3.73	1.08	3.33	0.94	3.04	0.92	3.64	0.96	3.69	1.09	**<0.001**	0.061
Interest in doing science	3.56	1.20	3.55	1.14	3.58	1.11	4.09	1.01	3.77	1.12	**0.011**	0.013
Extrinsic motivation	4.00	1.30	3.95	1.22	4.14	1.24	4.48	1.05	4.11	1.34	0.090	0.008
General value of science	4.25	1.25	4.25	1.06	4.18	1.10	4.46	1.01	4.31	1.22	0.682	0.002
Awareness of environmental issues	3.80	1.21	3.85	1.04	3.93	1.06	4.16	0.99	3.94	1.12	0.300	0.005
Science self-concept	3.57	1.27	3.65	1.12	3.82	1.18	4.11	1.00	3.78	1.15	**0.025**	0.012
Perception of science lessons	3.75	1.33	3.86	1.34	4.17	1.29	4.60	1.19	3.86	1.32	**<0.001**	0.024
I see myself as open to new experiences	4.58	1.23	4.89	1.05	4.89	1.02	5.16	0.79	4.66	1.23	**<0.001**	0.021
Competitiveness	4.07	1.10	4.44	0.97	4.70	0.92	4.76	0.92	4.39	1.11	**<0.001**	0.049
Critical thinking	4.34	0.95	4.56	0.83	4.73	0.79	5.05	0.64	4.51	0.99	**<0.001**	0.037

Notes: Means ('M') and standard deviations ('SD') are reported. Mean differences (ANOVA) show the magnitude (eta^2) and significance ('Sig.'; *p*-values). Significant differences ($p < 0.05$) are highlighted in bold. A = Atheist/Agnostic; C = Christian; M = Muslim; S = Sikh; O = Other.

Table 7. ANOVA by religion (paired comparisons between students of different faith backgrounds).

	ANOVA with Bonferroni Comparisons (Sig. (*p*))									
Construct/item	**A-C**	**A-M**	**A-S**	**A-O**	**C-M**	**C-S**	**C-O**	**M-S**	**M-O**	**S-O**
Compatibility between science and religion	**<0.001**	**<0.001**	**<0.001**	**<0.001**	1.000	1.000	**0.013**	0.511	1.000	**0.050**
Would you support creationism being taught alongside evolution in the science classroom?	**0.006**	0.177	0.604	0.364	1.000	1.000	1.000	1.000	1.000	1.000
Would you support creationism being taught alongside evolution in the RE classroom?	**<0.001**	**0.014**	0.249	**0.001**	1.000	1.000	1.000	1.000	1.000	1.000
Science removes the need for God	**<0.001**	**<0.001**	**<0.001**	0.063	**<0.001**	1.000	**0.001**	**0.021**	**<0.001**	**0.042**
Religiosity	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.002**	**<0.001**	**0.043**	**<0.001**	**<0.001**
Attitudes to theistic faith	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.100	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Creationism	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	1.000	**<0.001**	**<0.001**	**<0.001**	**0.015**
I have a strong religious faith	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.505	**<0.001**	**<0.001**
My family has a strong religious faith	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.002**	**<0.001**	0.917	**<0.001**	**<0.001**
There is no place for science in my life	1.000	**0.001**	1.000	1.000	**<0.001**	1.000	1.000	0.740	**<0.001**	1.000
Trust in scientists	**<0.001**	**<0.001**	0.104	0.083	**<0.001**	1.000	0.149	**0.025**	**<0.001**	1.000
Public value of science	1.000	0.194	1.000	1.000	0.806	1.000	1.000	0.162	0.138	1.000
Scientism	**<0.001**	**<0.001**	1.000	1.000	**0.040**	0.585	**0.002**	**0.004**	**<0.001**	1.000
Interest in doing science	1.000	1.000	**0.040**	0.384	1.000	**0.037**	0.360	0.084	1.000	0.945
Extrinsic motivation	1.000	1.000	0.227	1.000	1.000	0.127	1.000	1.000	1.000	0.874
General value of science	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Awareness of environmental issues	1.000	1.000	0.574	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Science self-concept	1.000	0.338	0.073	0.616	1.000	0.226	1.000	1.000	1.000	1.000
Perception of science lessons	1.000	**0.006**	**<0.001**	1.000	0.157	**0.003**	1.000	0.394	0.189	**0.003**
I see myself as open to new experiences	**0.008**	**0.032**	**0.008**	1.000	1.000	1.000	0.222	1.000	0.415	**0.046**
Competitiveness	**<0.001**	**<0.001**	**<0.001**	**0.003**	0.072	0.418	1.000	1.000	**0.026**	0.227
Critical thinking	**0.027**	**<0.001**	**<0.001**	0.265	0.460	**0.003**	1.000	0.232	0.146	**0.001**

Notes: Significant differences ($p < 0.05$) are highlighted in bold. A = Atheist/Agnostic; C = Christian; M = Muslim; S = Sikh; O = Other.

3.2.1. Religious Faith

Students of Muslim faith and students of Sikh faith were more likely to report having a strong religious faith and that their families had a strong religious faith when compared to those of Christian faith. With respect to our constructs that measured different aspects of religious attitudes/beliefs (a measure of religiosity, a measure of theistic faith and a measure of belief in creationism), Muslim students scored more highly on all three compared to Christian students and to Sikh students. Sikh students scored more highly on religiosity than did Christian students.

3.2.2. The Value of Science

Students of Christian faith were more likely to report that science can explain the world's existence compared to those of Muslim or Sikh faith. Students of Christian faith had greater 'trust in scientists' than did those of Muslim or Sikh faith and were more in agreement about 'science being the ultimate truth' than were those of Muslim faith. Students of all faiths responded similarly about the benefits of science. So, for example, they were all in agreement about the 'public value of science', 'interest in doing science', the 'general value of science', their 'awareness of environmental issues' and the importance of 'extrinsic motivation in science'. Atheist students were more likely to report that they trust in scientists and see science as being the ultimate source of truth than were those of faith backgrounds. However, there was no difference between atheists and those of religious faith when asked about benefits of science.

3.2.3. Science in the Classroom and Science Education

Students were generally positive about their science lessons and their self-concept in science. The analysis indicates that whilst there is no difference between students of Muslim or Christian faith in their perceptions of their science lessons, students of Sikh faith

expressed the most positive views. There were no differences between students of different faiths in their science self-concept. Atheists reported a lower self-concept and perceptions of science lessons than did Muslim students.

3.2.4. Religious Content in RE and Science Lessons

Students were asked whether they 'would support creationism being taught alongside evolution in the science classroom' and, separately, in the RE classroom. There were no statistically significant differences in responses between students of the three faiths (Christianity, Islam, Sikhism) where samples were large enough to warrant such analysis; however, students who were atheist/agnostic were less likely to report support such teaching. Whilst students who identified as having a religious faith were generally positive about creationism being taught in the science classroom, they were more positive about it being taught in RE lessons. Students who identified as having a religious faith were generally positive about 'science lessons to include religious views, for example about how the world was created' with Muslim students being statistically significantly more likely to report they would like this compared to Christian students.

3.2.5. The Relationship between Science and Religion

All students were least in agreement with the construct 'science removes the need for God', with an implicit indication that perhaps most students were in agreement about science and religion being compatible; in addition, there were no differences in responses between students of Christianity, Islam and Sikhism for this construct. Students of all faiths were generally positive about the construct 'compatibility between science and religion'. However, atheist/agnostic students were less likely to report that science and religion were compatible when compared to Christian, Muslim or Sikh students.

3.3. Students' Views about Science and Religion as Predictors of Seeing Science and Religion as Compatible

As the ANOVA analysis indicated that there were no differences in views about the 'compatibility of science and religion' between students of different faiths, we did not control for religious faith within our regression analysis. We did initially control for gender and, whilst this did at first come up with a significant difference, any effect of gender was lost once we accounted for the perception of science and religion constructs. This section explores which survey measures about science and religion are positively associated with the construct 'compatibility with science and religion'. We conducted Tolerance and VIF tests to confirm there were no problems with multicollinearity. The adjusted R^2 of our model is 0.352 (i.e., the linear regression explains 35.2% of the variance in the data). The F-ratio shows that the model is a good fit for the data: $F(7, 923) = 65.935$, $p < 0.001$. Table 8 demonstrates that high levels of 'compatibility between science and religion' are positively associated with: 'public value of science' ($b = 0.217$) 'attitudes to theistic faith' ($b = 0.206$), having an open personality ('I see myself as open to new experiences') ($b = 0.143$), having a strong religious faith ($b = 0.142$), 'general value of science' ($b = 0.113$) and having critical thinking skills ($b = 0.073$), and negatively associated with 'There is no place for science in my life' ($b = -0.087$).

Table 8. Linear regression predicting the construct 'Compatibility of science and religion'.

Item/construct	Beta	Sig. (*p*)
(Constant)	0.159	**<0.001**
Critical thinking	0.072	**0.035**
I see myself as open to new experiences	0.143	**<0.001**
General value of science	0.113	**0.007**
Public value of science	0.217	**<0.001**
Attitudes to theistic faith	0.206	**<0.001**
I have a strong religious faith.	0.142	**0.001**
There is no place for science in my life	−0.087	**<0.002**
Explained variance (adjusted R^2)	35.2%	

Notes: Standardised coefficients ('Beta') and significance ('Sig.'; *p*-values) are reported. Significant coefficients ($p < 0.05$) are highlighted in bold.

4. Conclusions

This article seeks to answer two research questions: (1) Is there a relationship between students' attitudes towards science and their perceptions as to whether science and religion are compatible? (2) What are the characteristics of students who report that science and religion are compatible? In order to answer these questions, we developed and then used a new instrument to measure secondary school students' attitudes to science and religion.

4.1. The Development of the 'Attitudes to Science and Religion' Instrument

The pilot version of the Attitudes to Science and Religion (ASR) instrument (a survey) contained a larger number of items than did the final version; many of those concerned with personality traits were dropped for the final version as they had no statistically significant independent association with the key dependent variable 'compatibility between science and religion'. As anticipated, the pilot version of the survey helped with survey refinement and validation. We provide two versions of the ASR instrument: a shortened version for researchers who only wish to explore the factors that are associated with compatibility with science and religion (Supplementary Materials File S1), and a longer version (Supplementary Materials File S2) for those who want to explore how attitudes to science, to religion and to science and religion might depend on various student characteristics (e.g., faith, gender).

Our survey is not designed to replace instruments such as the Evolutionary Attitudes and Literacy Survey (EALS) [41] as we are not looking comprehensively to establish student knowledge of science, nor their attitudes to specific science topics such as evolution. Our survey is designed to be used as an instrument to assess students' attitudes to science (in general), religion (in general) and the inter-relationship(s) between the two. Our standalone constructs therefore enable researchers to include additional measures (such as those in EALS) should they be desired.

We intend the ASR instrument to be available for educators and researchers interested in science and religion to assess student attitudes, the role of belief in science understanding and attitudes and changes in attitudes. Historically, surveys on science and religion have tended to simplify, even polarise, the relationship between science and religion, sometimes requiring respondents to make a choice between being scientifically orientated or influenced by religion; our survey enables respondents to give more nuanced responses. We measure beliefs about scientism, beliefs about creationism, attitudes towards theistic faith and whether students believe that religion and science are compatible. The ASR survey is designed to be sensitive to the fact that there is a diversity of ways in which science and religion are each understood, which is important, given that religious understanding can impact scientific understanding [33]. In fact, our findings did indicate that beliefs about science depended on precisely what was asked with, for example, more positive views being expressed about the value of science (to students themselves or the world around

them) than about scientism. Comparably, students were less likely to hold creationist views than they were to have a belief in God.

4.2. Compatibility of Science and Religion

In our study, many students indicated that science and religion are compatible; this is in alignment with existing research [4,26]. Unsurprisingly, students of no faith were least likely to report that science and religion are compatible. Students of different faiths manifested some differences in how they saw science and religion, but not about whether science and religion were compatible. In Muslim countries, literalistic readings of religious texts are the norm; any contradictions by science to religious texts are typically rejected [42], and teachers in such countries have been found to have their attitudes to science influenced by their interpretations of religion [43].

It may be that living in a Western, predominantly non-Muslim cultural context (e.g., in schools in England where students are taught by science teachers who are not necessarily influenced by religious faith), significant numbers of British Muslims (like other British people) are more amenable to believing there is little or no contradiction between science and religion. At the same time, we found that Muslim students were less positive about science than were Christian students. For example, whilst Christian students were more in agreement about 'science being the ultimate truth', Muslim students reported more positively about having a strong religious faith and about attitudes towards theistic faith.

Students who held that science and religion are compatible had more positive perceptions of science and their science education. Indeed, Table 3 demonstrates that students who reported that science and religion are compatible had significantly more positive views about every aspect of science than did students who reported that science and religion were not compatible. These findings suggest that teaching curriculum subjects in a non-compartmentalised way and creating opportunities at school to help students see that science and religion may not be in conflict may contribute to some students developing more positive attitudes towards science, as also concluded by Billingsley et al. (2018) [44].

Our analysis found that students who reported that science and religion are compatible manifested a number of characteristics; in particular, they were more likely to be positive about the role of science in improving the world and they demonstrated great critical thinking skills.

4.3. Limitations and Implications

There were some unavoidable limitations with the research. Given that the survey was correlational, causality cannot be robustly established. In addition, the sample of schools was not representative of schools in England. The survey asked about students' views of the relationship between religion and science; further research could look at students' views of the relationship between science and other subjects (e.g., philosophy, psychology, history). It is possible that students (particularly those steadfast in their religious or scientific beliefs) may be more comfortable thinking about the relationship between science and such subjects than between science and religion. Additionally, it would be good to have data about the extent to which classroom interventions affect student responses to the ASR survey.

The principal implication of these findings from our study is that there is value in discussing the relationship between science and non-science subjects in classrooms; such discussions can demonstrate to students that bodies of knowledge that sit outside of science (e.g., aesthetics, ethics, religion) are not redundant. At present, within the secondary school curriculum of many countries, there is little opportunity to engage with subjects in a cross-curricular way [26,45,46]. Our findings suggest that there may be a value for these discussions. Such discussions seem likely to be of value given the increasing interest in schools in both creationism and intelligent design. Traditional teaching across science and Religious Education classes does no usually enable students to develop their epistemic insight, which leads to a lack of reflection about how science and religion might be related. We recognise that students may find it difficult to transfer knowledge learnt

from one curriculum area to another [47]. Billingsley et al. (2016) [12] concluded that it was unreasonable to expect students to engage in cross-curricular learning because in their study students were simply unable to make links across RE and science [12]. Given the value of these discussions, a way to help such learning would be to have a place for them within the science curriculum. Teachers would do well to create learning opportunities to examine the nature of science and help students develop epistemic insight [48].

This would require professional development for teachers to equip them with the skills required to deliver such lessons; effective teaching is necessary to help reach these aims [49]. Cross-curricular teaching and collaboration across subjects has proved difficult for departments to implement [24,26], even with additional support for such collaboration [12].

Alongside this, there is likely to be value in science and other school subjects developing critical thinking skills in students; this should help students to think about the relationships between subjects and to consider the extent to which what is learnt in one subject can be used in another. Our findings indicate that despite the widespread notion that religion and science have mutually exclusive explanatory systems leading to contradiction between them, this does not have to be the case. The low correlation between 'compatibility between science and religion' and 'scientism' compared to the higher correlations between 'compatibility between science and religion' and both 'attitudes towards theistic faith' and 'religiosity' (Table 4) suggests that those students who have developed a sound understanding of the limitations of science are more likely to accept that there can be consonance between religion and science. An implication for educators is that talking about the limitations (boundaries) of science may actually help students to engage with learning science and thus have a positive impact on their scientific knowledge. Regardless of students' faith backgrounds, an aim of science education should be to develop students as rounded individuals who are able to understand how science relates to their everyday lives and to those of others with different beliefs.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/educsci12120937/s1, File S1. The Attitudes to Science and Religion (ASR) Instrument Short version) Developed by Tamjid Mujtaba & Michael Reiss, UCL. File S2. The Attitudes to Science and Religion (ASR) Instrument Developed by Tamjid Mujtaba & Michael Reiss.

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