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Science and Religious Education Teachers' Views of Argumentation and Its Teaching

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Abstract
Argumentation, the justification of claims with reasons and/or evidence, has emerged as a significant educational goal in science education in recent years. It has also been noted as an important pedagogical approach in numerous school subjects. Yet, there is limited understanding of how teachers' views of argumentation and its teaching compare in different school subjects. In order to ensure coherence in the implementation of the school curriculum, it is important to understand such views particularly in the context of subjects that are often positioned to be in conflict with each other, for example in the context of science versus religious education. In this paper, we present an empirical study on how science and religious education teachers view argumentation and its teaching. The data are drawn from a survey of secondary school teachers of 11–16-year-old students in England. Twenty-nine teachers were presented with an online survey in order to collect data on various aspects of their views including pedagogical strategies that support argumentation. Qualitative and quantitative results suggest that teachers of both subjects consider argumentation to be a significant aspect of their subject although particular nuances exist in how the teachers interpret argumentation. Furthermore, the data suggest that there are statistically significant differences in terms of the perceived frequency of pedagogical strategies used to support argumentation in lessons.

Keywords Argumentation · Teacher views · Religious education

Introduction

Teachers often face difficult judgements that demand understanding of various kinds of information, values and ethical principles. For example, in the context of biology lessons students might question whether or not genes should be edited, appealing not only to scientific knowledge but also to religious and ethical values. Some teaching and learning scenarios

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might demand teachers and students to consider both scientific and religious issues together. For instance, students might ponder about religious values related to end-of-life decisions in conjunction with scientific evidence on the sustainability of life. Such judgements are often made through arguments. 'Argument' is often defined as the justification of knowledge claims with evidence and reasons (Toulmin 1958). Argumentation in the school context can be considered as the engagement with arguments, for example through construction or critique. Many judgements thus encountered by teachers and students in relation to science and religion are underpinned by arguments.

A generic definition of an argument might be similar in both science and religion in terms of the presentation of a claim and reasons e.g. 'Day and night occur because of a spinning earth' in science; and 'Humans should not kill other humans because life is sacred' in religion. However, there may also be potential differences in how reasons and evidence are characterized in science versus religion and how argumentation is taught in schools in the context of either subject. At this point, a distinction needs to be drawn between 'religion' on the one hand, and 'religious education' or 'religious studies' on the other. Religion has a complex nature, and it is not a subject per se. Religious education (RE) or religious studies are offered as a subject in schools in some parts of the world. There is evidence that often students use 'religion' and 'religious studies' interchangeably (Billingsley et al. 2016). In some countries, such as England, religious education is taught as part of secondary school curricula and involve the coverage of historical, social and philosophical background of different world religions (e.g. Oxfordshire County Council 2015).

While the interface of science and religion has been extensively studied in the educational research literature, for example in the context of evolution versus creationism debate (e.g. Basel et al. 2014; Lawson and Worsnop 1992; Thagard and Findlay 2010) and teachers' conceptions about the science-religion more broadly (e.g. Castéra and Clément 2014), research on argumentation in the context of the interphase of science education and RE is virtually inexistent (e.g. Erduran et al. 2019). Furthermore, although there is research on science teachers' views about the science and religion comparison (e.g. Blancke et al. 2012; BouJaoude et al. 2011; Mansour 2015), there are very few studies that have involved both science and RE teachers in the same study (e.g. McKinney et al. 2014). There are potential avenues of research to understand how argumentation works in science and RE, both in terms of understanding the place of arguments in each school subject and also in terms of how the teaching and learning of argumentation can be supported in lessons across school subjects.

In terms of science and RE lessons, then, argumentation can be viewed as a cross-curricular theme. Establishing coherence across the school curriculum is pivotal for ensuring that students are supported in meaningful learning in a holistic sense. Furthermore, argumentation can act as a bridge between subjects. For example, the existing interphase of science and RE primarily through debates about evolution and intelligent design (e.g. Thagard and Findlay 2010) often presents science and religious education as disparate and contradictory, presenting challenges to establish coherence in the broad school curriculum. Yet, argumentation is already an existing component of both science and RE curricula (e.g. Department for Education 2014; Oxfordshire County Council 2015). Understanding how teachers view argumentation and its teaching can be instrumental in ensuring coherence in cross-curricular content, not in the sense of having a uniform definition of argumentation but in the sense of collectively accounting for subject-specific as well as cross-subject features of argumentation. Ultimately, given the central

role teachers play in curriculum implementation and thus student learning, it is important to understand how science and RE teachers view argumentation and its teaching.

Our primary objectives in this paper are twofold: (a) to provide a review of how argumentation can be framed in science and religious education; and (b) to investigate empirically how teachers of science and RE view argumentation and its teaching. There is already a vast amount of research on argumentation in science education (e.g. Lin et al. 2014), some of which point to teachers' difficulties in teaching argumentation (e.g. Dawson and Venville 2010). Science education can potentially benefit from understanding how teachers of other subjects, such as RE that has a long tradition argumentation (McClintock 2010), deal with argumentation in their teaching. In the rest of the paper, then, we provide an overview of existing research on argumentation in science and RE and subsequently describe the empirical study conducted with science and RE teachers. Teachers are key actors in enabling students' learning in schools, and they are pivotal to implementation of curriculum goals. Hence, understanding of how teachers view argumentation can be useful in ensuring that they are provided with appropriate professional support in order to enact argumentation in their lessons. The empirical study aimed to investigate science and RE teachers' views of argumentation in general and in relation to their teaching practice in particular. Qualitative and quantitative measures of teachers' responses to a set of questions have been analysed. The study raises questions for future research on teachers' professional development in argumentation.

Review of Literature

Argumentation in the context of traditionally disparate school subjects such as science and RE raises questions about how argumentation is framed. There are at least three theoretical bodies of research framing argumentation studies: (a) developmental psychology, including the distributed cognition perspective (e.g. Kuhn and Udell 2003; Mason 1998); (b) language sciences as for instance the theory of communicative action (e.g. Lemke 1990; Russell 1983); and (c) interdisciplinary investigations drawing on history, philosophy and sociology of science (e.g. Kelly and Takao 2002; Siegel 1995) and religious studies (Smith 2016). Educational research on argumentation could potentially benefit from a robust theoretical orientation, and it can itself potentially inform foundational disciplines through empirical research in schools. For example, discussions about the extent to which argumentation research in education contributes to cognitive and metacognitive processes could inform the situated cognition perspective (Brown and Campione 1990). The development of communicative competences and particularly critical thinking by means of argumentation would add to the theory of communicative action and the socio-cultural perspective (Habermas 1981). Understanding the development of reasoning through argumentation in school subjects would extend knowledge about teaching and learning philosophy of science Giere (1991) and developmental psychology (Kuhn and Crowell 2011). The multitude of disciplinary orientations underpinning argumentation studies as well as the potential reciprocal relations with educational research point to the scope of argumentation in application to different disciplines and school subjects. For instance, the framing of argumentation as a communicative competence is relevant for learning both in science and RE given the broad remit of this competence in schooling. Likewise, the foundational literature from cognitive psychology illustrates how argumentation plays a role in the development of metacognitive skills, which are important for learners' self-regulation (e.g. Hacker et al. 2009) about arguments. In the rest of this section,

we review how argumentation is related to research in science and RE teaching and learning more specifically by focusing on how science and RE teachers view argumentation and its teaching.

Argumentation in Science Education

Within science education, argumentation has been an area of research that has gained significant attention in recent years (Lee et al. 2009). This attention by researchers to argumentation studies was also visible in the recent review by Lin et al. (2014) showing that most of the top 10 highly cited papers in science education between 1998 and 2002 were concerned with the topic of argumentation. This sense of 'argumentation' refers to the body of empirical work conducted in science education research. Although argumentation is prevalent in research, explicit emphasis on argumentation is not always existent in many science curricula around the world. For example, although previous versions of the science curriculum had numerous references to argumentation (La Velle and Erduran 2007), the current national science curriculum in England for the age group 11–14 years old has related themes (e.g. explaining data, taking into account new evidence) but no direct reference to the words argumentation through the use of words such as 'argue' or 'argumentation':

Through the content across all three disciplines, pupils should be taught to:

- Understand that scientific methods and theories develop as earlier explanations are modified to take account of new evidence and ideas, together with the importance of publishing results and peer review...
- Present reasoned explanations, including explaining data in relation to predictions and hypotheses.
- Evaluate data, showing awareness of potential sources of random and systematic error. (Department for Education 2014, p. 201)

In science education, argumentation is conceived as a discursive practice through which scientific knowledge claims are justified or evaluated based on empirical or theoretical evidence (Erduran and Jiménez-Aleixandre 2007). Researchers addressed various emphases of argumentation in science education: developing conceptual understanding (e.g. Erduran et al. 2017; Dawson and Venville 2009), understanding scientific epistemology (e.g. Erduran and Jiménez-Aleixandre 2007; Sandoval and Millwood 2005), increasing investigational capability (e.g. Kelly and Takao 2002; Najami et al. 2020) and domain-specificity of subject knowledge (Erduran 2019; Kulatunga et al. 2014; Pabuccu and Erduran 2017). Although different characterizations of argumentation such as frameworks of Stephen Toulmin (Toulmin 1958) and Douglas Walton (Walton 1996) have been advocated in science education (e.g. Gray and Kang 2014; Ozdem et al. 2013), there is widespread consensus that argumentation is central to scientific reasoning and it is significant for science teaching (Nielsen 2013; Nussbaum 2011).

Argumentation in Religious Education

Research on argumentation in RE is complex partly due to how religion is positioned in education. First, there are different curricula and syllabi from faith and state schools. While state schools may provide a comprehensive account of religious studies covering all religions,

faith schools often provide more devotionally nurturing approaches into one religious tradition (e.g. Church of England). Under the former model, students would have to understand different forms of argumentation between and within different religions. Furthermore, the notion of argumentation is complex in RE itself because the nature of any argumentation, notably the aim of 'learning from religion(s)', is contested (Fancourt 2017; Gearon 2012; Teece 2010). What is typically referred to as 'religious education' in the state school sector is an interdisciplinary approach that draws on history, philosophy and social studies of religions (Department for Children, Schools, and Families 2010).

The work of our research team has elsewhere reported a prominent presence of argumentation-related concepts within RE curriculum documents in England (Chan et al. 2020). Insofar as argumentation can be considered the process of engaging with arguments or argument construction, it is evident that RE syllabi in England generally appear to include argumentation as a core skill. For example, the Oxfordshire County Council (2015) Locally Agreed Syllabus makes both implicit (e.g. reasoned viewpoints) and explicit (e.g. reasoned argument) reference to arguments, indicating that argumentation skills are core to learning in this subject:

- '…does not seek to impose [but to] question and explore their own and others' understanding of life' (p. 10)
- 'formulate reasoned opinions/arguments in relation to controversial issues and truth' (p. 11)
- '…develop their evaluative skills, showing reasoned and balanced viewpoints when considering their own and others' responses' (p. 32)
- '…respond sensitively and with reasoned argument to religious beliefs and concepts' (p. 34)

Hence, in terms of curriculum standards, while the science curriculum in England has fairly implicit reference to argumentation, some RE syllabi have overt references to it. In terms of research, some parallels can be drawn. Research in RE focusing on argumentation has used similar analytical frameworks as science education research. For instance, similar to science education researchers' emphasis on the use of Toulmin's framework (e.g. Jimenez-Aleixandre et al. 2000), Gottlieb (2001) applied Toulmin's framework in Jewish education. He used Toulmin's argument model to investigate children's and adolescents' reasoning process concerning the question of whether or not to believe in God. Similarly, within the German tradition of RE, researchers have investigated the argumentation in connection to broad science and religion debates (Schmidt et al. 2015, 2017; Shulman 2008) as well as the specific creation versus evolution issue (Basel et al. 2013; Francis and Greer 1999; Weiß 2016). Although there is considerable research on argumentation in both science education and RE and some similar threads can be identified between these lines of research, focus on teachers and teachers' views about argumentation is particularly scarce (e.g. Billingsley et al. 2013; Choi et al. 2019; Simon et al. 2006; Sampson and Blanchard 2012; Zohar 2007).

Teaching Argumentation: Science and Religious Educaiton Teachers' Views

At this time, there is virtually no research on how science and RE teachers' views and perceptions of argumentation contrast although more broadly, there is research on

teachers' views about argumentation about socio-scientific issues (Martín-Gámez and Erduran 2018). Yet, many questions related to science and RE concern argument as a central feature of reasoning. For example, if we take the Toulmin's framework of argument (Toulmin 1958), it is plausible to think of science and religion examples involving claims, reasons and justification. The overarching structure of an argument can be similar in terms of the advancement and justification of claims. There may be differences between the nature of argumentation in teaching science versus teaching religious studies as well as what teachers take 'arguments' to be in their own subject as well as another subject.

It is beyond the scope of this paper to resolve philosophical debates about the nature of knowledge or arguments in science and religions. Our aim is not to generate a normative or prescriptive account of how arguments ought to be constructed in science and religion. We believe that this is the task of experts in philosophy of science and of philosophy of religions who indeed explore such questions to a great extent in their work by discussing the nature of evidence and reason in science and religions (e.g. McGrath 2011; Stenmark 2004). Our interest for the present paper is to better understand teachers' views of argumentation at the level of school subjects (science and RE) for pedagogical purposes. The pedagogical use of argumentation in school subjects will have a relation, of course, to the wider academic disciplines and inquiries. However, argumentation in schooling will be mediated by teachers' perspectives and other educational goals including curriculum standards. It is relevant to differentiate between 'argument as product' and 'argumentation as process' as they apply to problems in science and religious education. As such, we are interested in exploring how science and RE teachers view the nature of arguments and the processes of argumentation including pedagogical strategies that support students' engagement in argumentation.

Investigating cross-curricular links may potentially provide recommendations not only for teaching practice but also, ultimately, for curriculum design. Considering the extensive and explicit reference to arguments and argumentation in RE syllabi (Oxfordshire County Council 2015) in contrast to a lack of any explicit emphasis in the science curriculum in England (DfE, 2014), there may be opportunities for enhancing curriculum content, for example by including more specific pedagogical guidelines for teachers to use argumentation as a strategy in their teaching. The aim of the empirical project reported in the rest of this paper was to understand how science and RE teachers view argumentation and its teaching. The study thus aims to contribute to the considerable research base on argumentation studies that have already illustrated its relevance for curriculum, teacher education and learning (e.g. Erduran et al. 2015; Schwartz and Baker 2017). Exploration of the contrast of science and RE teachers is meant to identify new avenues for cross-disciplinary innovation, by exploring novel areas at the interface of teaching science and RE. The formation of complex argumentation spanning scientific and religious input has been scarcely studied because the topic itself requires collaboration between science and RE education researchers and teachers, which is fairly rare. Understanding the complex and important issue of argumentation at the interface of science and RE both methodologically (i.e. How we can study such argumentation in teachers' views?) and in terms of content (i.e. How do teachers of very different subjects such as science and RE view argumentation in the context of another school subject?) is a key motivation of the empirical study.

Methodology

Research Questions

The empirical study reported in this section was guided by the following research questions:

1. How do science and RE in-service teachers view argumentation?
2. How do science and RE in-service teachers view their use of pedagogical strategies that support the teaching of argumentation?

Context of the Study

The study was conducted with science and RE teachers in England. The teachers were recruited through a university-school teacher training partnership programme to participate in a 3-year funded research project. The study presented is part of this research project that aims to infuse argumentation in science and RE in English schools. As part of the project, there are ongoing workshops on teaching and learning strategies on argumentation. The data presented in this paper were collected before the implementation of the workshops prior to the teachers beginning the work of the project. Information about the project was sent to local schools that are part of the partnership and the teachers volunteered to participate. It was indicated in the information that a goal of the project was to engage science and RE teachers from the same school to work together. Hence, the teachers from both subjects put themselves forward in pairs. In-service science and RE teachers who teach 11- to 16-year-old students in secondary schools were recruited to participate in a survey. RE is a subject taught in schools in England. Although it is not part of the national curriculum, the 150 local authorities distributed in 9 official regions have their respective agreed syllabi. As a school subject, 'Religious Studies' is assessed at high stakes examinations such as A-levels in England (AQA 2019). Within the national science curriculum in England, argumentation is related to the 'Working Scientifically' component, particularly to 'development of scientific thinking' and 'analysis and evaluation' (DfE, 2014). Argumentation is also a component of the various regional RE syllabi in England (LCC 2016) where it is explicitly indicated as a learning outcome, although as mentioned earlier, the use of the word 'argument' is more prevalent in the RE syllabi (Chan et al. 2020). Hence, argumentation is either implicitly and explicitly promoted in the curricula, and in this sense, the teachers from both subjects would have had the incentive to participate in the project.

Data Sources

The data sources were responses to a survey by 29 teachers; 18 (62%) respondents were female. Fifteen respondents were science teachers, and 14 were RE teachers. Given that there may be sensitivities around religious affiliation and providing this information could not be obtained anonymously for ethical reasons, we did not ask the teachers to express their religious faith, if any, and hence, we do not have any data on their religious backgrounds. It is plausible that one can be an RE teacher in England and not belong to a religion or be a science teacher and have a religion. Experience of teachers ranged from 6 months to 30 years with a median of 11 years. Teachers were also teaching at a range of schools, both state and independent schools, as well as faith schools and secular schools.

Survey

An online survey was developed and administered to the teachers (see Appendix). The survey was designed to capture teachers perceived use of pedagogical strategies that support argumentation, their views on argumentation and their perceptions of the 'other' subject (i.e. their comparisons between argumentation in science and religion). The data collected through the survey were intended to serve two purposes: (a) to inform the development of subsequent workshops in the project and to ensure they were suited to the participants needs and (b) to provide baseline data. Face validity of the items was established through a review process with a subject matter expert who was external to the project team.

Data Analysis

Quantitative response data were analysed in the data processing software SPSS, and qualitative responses were analysed using NVivo 11 software. Initial analysis involved data summary techniques including the production of descriptive statistics for quantitative data. Qualitative data was subjected to early stages of thematic analysis (Braun and Clarke 2014) for each question item to get a sense of the overall range of responses for each item. Demographic information was imported to NVivo, which allowed for production of cross-matrices to examine the differences and similarities between RE and science teachers' responses. In the case of the qualitative data, the responses were categorized on the basis of the themes that were targeted in the questions. For example, in the case of the question 'how would you respond if a student did bring up religion in your science lessons? Or science in your religion lessons?' the theme was 'views on addressing the other subject'. In this paper, we are using the qualitative data as an illustrative account to provide an indication of how teachers perceive argumentation. As such, the coding of the teachers' remarks is rather direct. A coding scheme was not generated to guide data analysis deductively, but instead an inductive approach was used to group remarks into the most clear and apparent categories based on their semantic meaning (Braun and Clarke 2014) with minimal additional interpretation. Table 1 in the results section exemplifies of a resulting scheme and how the data relate in a very direct manner to the category title. For example, the category of 'Because of overlap or to show overlap' consists of quotes that explicitly use the word 'overlap' or very clearly indicate an overlap with synonymous language. The qualitative analysis is not meant to provide full analytical outcomes which have been published elsewhere (Guilfoyle et al. 2020). Where appropriate, Mann-Whitney *U* tests were conducted on quantitative responses to ascertain the statistical significance of difference between science and RE teachers, for example in the case of their frequency of use of pedagogical strategies. Mann-Whitney *U* tests were selected on the basis that the data set was non-parametric (Mann and Whitney 1947).

Results and Findings

Science and RE Teachers' Views of Argumentation: Common Aspects

On the importance of argumentation in their respective subject, all 29 teachers considered argumentation as either important (24 teachers) or somewhat important (5 teachers). Teachers' responses to the nature and importance of argumentation showed several

Table 1 Teachers' reasons for addressing the 'other' subject in their own subject teaching. The numbers indicate the instances each theme was mentioned by a different teacher

Theme and number of instances	Example excerpt
1. Because of overlap or to show overlap (2 RE/4 Sci)	'Overlap in lots of topics e.g. creation, environment, medical ethics' (RE teacher) 'As a different perspective and to show pupils how overlapping ideas are.' (RE teacher) 'History of science often affected by religious beliefs. […]' (Science teacher)
2. To make students capable of taking an ethical stance (0 RE/1Sci)	'There are often moral issues that arise, mainly when talking about biological issues such as: genetic modification, IVF, 'playing god', or issues to do with the environment: should we chuck rubbish into space, who's responsibility is it to look after earth etc. This means students can think about whether or not they support the idea, and do not just take information at face value, they justify it to themselves.' (Science teacher)
3. To bring in counter arguments or alternative views (3 RE/2 Sci)	'Because science offers an alternative worldview which most students can relate to. They often say things like 'I believe in science' as though it is their faith!' (RE teacher) 'In response to a learner comment or behaviour (e.g. student doing a Nazi salute),or referring to alternative explanations for a scientific phenomenon.' (Science teacher)
4. To support understanding of a topic (4 RE/0 Sci)	'It is part of the syllabus It links into the topics explored It can deepen understanding' (RE teacher) 'The topic requires a degree of scientific understanding (e.g. Religious views on the origin of the universe or life).' (RE teacher)

common themes across the two subjects: argumentation as a way of justifying claims, the ability to draw on a range of sources, and argumentation as an important general skill. First, teachers described argumentation primarily as an act (or ability) of justifying claims using evidence. As shown in the examples that follow, teachers mentioned key elements of an argument such as claims ('conclusion', 'opinion', 'point of view', 'case'), evidence ('facts', 'information') and reasoning ('structured support', 'to back up') in describing argumentation.

> '[Argumentation is] providing structured support to present a point of view in a reasoned and systematic manner.' (Science teacher)
> 'Using evidence and logic to back up a case.' (Science teacher)

Second, RE and science teachers commonly addressed the ability to draw on a range of information sources as an important element of the argumentation skill to be cultivated. They considered it important to collect, analyse and synthesize information to reach a conclusion.

> 'To be able to find a conclusion and opinion as a result of analysing a range of evidence. It is also looking at how this opinion is expressed, using a good line of reasoning.' (RE teacher, emphasis added)
> 'Pupils need to assimilate a volume of information before coming to a conclusion.' (RE teacher, emphasis added)
> 'In science, it helps to look at all the information and allow students to reach their conclusions and allow them to understand how accepted theories are supported and came to be.' (Science teacher, emphasis added)

Third, both teacher groups recognized the significance of argumentation as a general skill required for children aged 11–14 years. In particular, in describing its relevance to students' lives, both groups often drew on the nature of their respective subjects (i.e. RE and science) as illustrated in the following examples:

> 'The subjective nature of the subject [RE] means that the students need to assimilate a volume of information before coming to a conclusion. It also allows these conclusions to be continually tested throughout their life.' (RE teacher, emphasis added)
> 'The application of science and technology is often debated in the public sphere and justification of the use of new techniques needs to be clearly communicated.' (Science teacher, emphasis added)

Despite some common aspects in how science and RE teachers view argumentation in their subject, there were also contrasting themes, which are presented in the next section. The examples of contrast are illustrative of the nuance about how the teachers consider their subject itself relates to argumentation.

Science and RE Teachers' Understandings of Argumentation: Contrasting Aspects

One significant point of divergence among the two groups was found in the way the teachers described why argumentation is important. Three science teachers mentioned evidence base as an important aspect of argumentation in relation to students' lives. For example, teachers said

> 'It's important for students to realise there are different views, but also that we can arrive at answers that are worth more than simple opinions through examining and testing evidence.' (Science teacher, emphasis added)
> 'A lot of science is based on theories which need to be supported by evidence, there are a lot of theories which we cannot prove out right, and which have conflicting evidence to support/disprove, but as scientists we need to be able to decide which theories are correct/most likely to accurately represent what is happening.' (Science teacher, emphasis added)

In contrast, no RE teachers made explicit reference to evidence in explaining the importance of argumentation. Their descriptions of why argumentation is important seemed to reveal different understandings in the two subjects of what counts as evidence. While supporting a view in science seemed to mean justifying reference to specific standards, i.e. scientific knowledge or theories, for RE teachers, arguments were considered more as supporting a view comparative to another view. RE teachers' responses suggested that they recognised the utility of having diversity of pedagogical strategies in teaching their subject. The examples mentioned by the RE teachers ranged across different scientific disciplines (i.e. physics, biology, environment, medicine), indicating that there are diverse opportunities that the two subjects could mutually interact. The RE teachers also indicated that when science is brought up in their teaching, they could point to how RE and science are interrelated such as through overlap or through common pedagogical approaches, for example through encouraging students to take a stance.

When asked why teachers bring in topics from RE (if science teacher) or from science (if RE teacher), several themes came up as summarized in Table 1. The table includes the frequency with which teachers of each subject referred to the particular theme. Some teachers suggested that they bring the other subject up in their class because there is often

an obvious overlap between the topics being addressed while others explicitly wanted to point to such overlap. Furthermore, some teachers found that bringing in topics from the other subject supported the understanding of their own subject. One science teacher mentioned RE perspectives as necessary to take an ethical stance or position to scientific questions. In RE, science perspectives were often brought in to support arguments or to bring in alternative views or counter arguments (e.g. 'To understand non fundamentalist religious perspectives you often need students to have an established knowledge of the scientific explanation for the same'). Comparatively, science teachers did not argue that religious studies questions could support understanding of scientific topics, but rather pointed out that there could be an overlap such as religious understanding influencing history of science.

Science and RE Teachers' Self-Reported Use of Pedagogical Strategies that Support Argumentation

As part of the survey, the teachers were asked a range of questions on frequency with which they use different pedagogical strategies that would encourage argumentation in lessons such as engagement in group discussions and debates. The Mann-Whitney *U* test was used to test whether there were significantly different distributions in answers between RE and science teachers. Note that lower median means more frequent use. Results showed significant differences in the self-reported use of classroom activities between science and RE teachers. As demonstrated by Table 2, RE teachers were found to use a wider range of activities in their lessons, particularly group discussions ($p = .002$, $z = -3.30$) and debate ($p < .001$, $z = -4.20$), exemplifying arguments ($p = .041$, $z = -2.17$), valuing different positions ($p < .001$, $z = -4.95$),

Table 2 Science and RE teachers' self-reported use of pedagogical strategies in their lessons (0 = every lesson, 5 = never)

Strategy	Science teachers ($n = 15$) *Mdn*	RE teachers ($n = 14$) *Mdn*	Test statistic *U*	Standardized test statistic *z*	*p*	Effect size *r*
6.1 Group work	2	1.5	73.5	−1.52	.172	
6.2 Pair work	1	1	118	.67	.591	
6.3 Group discussion	2	1	35	−3.30	.002	.61
6.4 Pair discussion	1	.5	62.5	−2.07	.063	
6.5 Debate	3	1	12.5	−4.20	< .001	.78
6.6 Role play	3	2	74	−1.46	.186	
6.7 Open class discussion	1.5	1	59	−1.92	.077	
6.8 Encourage listening	0	0	77	−1.47	.234	
6.9 Exemplify arguments	2	1	58	−2.17	.041	.40
6.10 Value different positions	2	0	0	−4.95	< .001	.92
6.11 Check students' evidence	1	.5	55	−2.36	.03	.44
6.12 Use writing frames	2	1	81.5	−1.10	.31	
6.13 Get students to evaluate arguments	2	1	28	−3.63	< .001	.67
6.14 Get students to anticipate counterarguments	2	1	8	−4.48	< .001	.83
6.15 Encourage reflection	1	0	66.5	−1.80	.09	

checking students' evidence ($p = .003$, $z = -2.36$), getting students to evaluate arguments ($p = < .001$, $z = -3.63$) and anticipate counterarguments ($p < .001$, $z = -4.48$). Table 2 presents the distribution of responses for each strategy and also graphically shows that RE teachers report using these pedagogical strategies more often than science teachers.

When the trends in the pedagogical strategies are represented by subject visually in terms of frequency of use, the representation illustrates that RE teachers are more inclined to include pedagogical strategies that would support the teaching of argumentation than the science teachers were (see Table 3). The visual representation of colour distribution represents the number of teachers indicating the self-reported frequency of the use of a particular pedagogical strategy. The RE teachers report to use more frequently the pedagogical strategies that support argumentation than the science teachers given the colour concentration is skewed towards more frequent use, as opposed to the science teachers' representation being more distributed across the frequency of use. It is particularly noteworthy that more science teachers chose 'rarely' and 'never' than the RE teachers, suggesting that science teachers are less likely to utilize strategies that would facilitate the learning of argumentation.

Three strategies (i.e. debate, valuing different positions and getting students to anticipate in counterarguments) were found to be particularly underused by science teachers compared with RE teachers ($z < -4$). This result can be explained in relation to the above findings about the teachers' understandings of argumentation. Given that RE teachers tend to acknowledge that there is no definitive answer and perceive arguments as supporting different viewpoints, the relatively frequent use of these three strategies make more sense. This is because these strategies presuppose the possibility of multiple positions or viewpoints on the same issue. In contrast, it is likely that science teachers' perception of arguments as 'a road to the correct view' has made them less engaged in using these instructional activities in science lessons. For example, once a student has successfully constructed a scientific argument, it would be considered satisfactory enough to science teachers without particularly anticipating any possible counterarguments. When asked to what extent the 'other' subject was brought up on class, it appeared that questions of science were more frequent in RE than vice versa according to the Mann-Whitney U test of the responses ($p = .001$, $z = -3.57$). Eight RE teachers (57%) reported that the questions of science regularly arise in RE lessons, while a majority of science teachers (73%) responded that RE-related issues sometimes arise in their science lessons.

Conclusions and Discussion

Argumentation has garnered much attention in educational research (e.g. Erduran et al. 2015; Nussbaum 2011) including science education (Jimenez-Aleixandre et al. 2000) and RE (e.g. Gottlieb 2001) in recent years. Although much research has been conducted in the context of science education and RE (e.g. Billingsley et al. 2016; BouJaoude et al. 2011), there has been virtually no research about how teachers view argumentation at the interface of science education and RE. The paper reported an empirical study that aimed to investigate how science and RE teachers view argumentation and its teaching. The findings of the empirical study illustrate the similarities and differences between science and RE teachers' views of argumentation in relation to their own subject and pedagogy. Both cohorts of teachers took argumentation to be an important skill for their students to acquire. However, the RE teachers reported using pedagogical strategies that support argumentation more frequently than science teachers. Some strategies (i.e. debate, valuing different positions and getting students to anticipate counterarguments) were

Table 3 RE and science teachers' self-reported use of pedagogical strategies in their lessons

Pedagogical strategy	RE Teachers					Science Teachers				
	Every Lesson	Regularly	Sometimes	Rarely	Never	Every Lesson	Regularly	Sometimes	Rarely	Never
Group work	0	7	7	0	0	1	3	8	3	0
Pair work	1	12	1	0	0	5	7	3	0	0
Group discussion	3	9	2	0	0	0	4	9	2	0
Pair discussion	7	6	1	0	0	2	10	3	0	0
Debate	2	7	5	0	0	0	0	5	8	2
Role play	0	2	6	5	1	0	0	5	8	2
Use open class discussion	4	8	2	0	0	2	5	5	2	0
Encourage listening	11	3	0	0	0	8	6	1	0	0
Exemplify arguments	5	5	4	0	0	1	5	7	2	0
Value different positions	14	0	0	0	0	0	4	9	2	0
Check students' evidence	7	6	1	0	0	2	8	4	0	1
Use writing frames	2	7	3	1	1	0	7	5	3	0
Get students to evaluate arguments	3	10	1	0	0	0	4	8	3	0
Get students to anticipate counter	1	11	2	0	0	0	0	8	6	1
Encourage reflection	8	3	3	0	0	2	9	4	0	0

found to be particularly underused by science teachers compared with RE teachers. The findings of the paper thus contribute to the research literature in both school subject areas as well as research on cross-subject teaching. Despite the existence of research including systematic reviews, of the use and effects of small group discussions in high school science teaching (Bennett et al. 2010), few studies had previously focused on how science teachers' self-reported use of pedagogical strategies such as using small group discussions and how such strategies may compare with those reported by teachers of other school subjects.

Much has been reported about science teachers' skills in teaching argumentation (e.g. Cigdemoglu et al. 2017; McNeill and Pimentel 2010). Yet, only a few studies have reported about teachers' views about argumentation (e.g. Liu and Roehrig 2017; Sampson and Blanchard 2012). In particular, the comparative aspect of science teachers' views of pedagogy of argumentation in science and another school subject is virtually inexistent in science education research. The findings suggest that RE teachers tend to acknowledge that there is no definitive answer and perceive arguments as supporting different viewpoints. In contrast, it is likely that science teachers' perception of arguments as 'a road to the correct view' has made them less engaged in using these instructional activities in science lessons. Previous research on science teachers' views about the science and religion comparison (e.g. BouJaoude et al. 2011) focused on fairly general characteristics of each in relation to school teaching and primarily used science teachers as the sample internationally (e.g. Castéra and Clément 2014). Furthermore, very few studies actually involved both science and RE teachers in the same study (e.g. McKinney et al. 2014).

The empirical study reported in the paper contributes to literature by offering understanding of how science and RE teachers make sense of argumentation and how they view its use in their own teaching, thus providing a nuanced approach to the science versus religion debate in education (e.g. Mansour 2015) and representing the voices of RE teachers in relation to how the science-religious education is viewed. The representation of the teachers' voices across school subjects is important in establishing coherence across the school curriculum so that students are provided with meaningful education. The findings can potentially feed into professional development of teachers to support the development of strategies for teaching science and RE. In this respect, future research could potentially focus on not only the investigation of teachers' views but also their teaching practice. For example, science and RE teachers' pedagogical implementation of argumentation in their subject can be examined to understand how the subject and its pedagogy may impact how students engage in argumentation.

Overall, the paper is unique in bringing together data on traditionally disparate cohorts of teachers who rarely collaborate on a research and development efforts. Although there is typically minimal interaction between science and RE teachers internationally, there are times when issues concerning the other subject do come up in lessons (e.g. Billingley et al., 2016) where teachers need to be in a position to address students' questions. By highlighting the similarities as well as differences of how science and RE teachers view argumentation and its teaching, the paper provides insight into how the teaching and learning of argumentation can be improved in both subjects. Ultimately, argumentation as a pedagogical strategy can serve as a bridge in traditionally disparate subjects in schools helping both teachers and students to critically engage with curriculum content.

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Appendix

Survey on Teachers' Use of Pedagogical Strategies to Support Argumentation

Q1. What is your name? _____

Q2: Are you a teacher of Science or Religious Education?

Science	Religious Education

Q3: How many years have you been teaching? [_____]

Q4: What do you understand by the term "Argumentation"?

Q5: From your point of view, is learning of argumentation important in your subject area?

Important	Somewhat Important	Not Important
Reason for your answer:		

Q6: From the list below, estimate the frequency you use the activities in your lessons.

I…	Every Lesson	Regularly	Sometimes	Rarely	Never
Use Group Work					
Use Pair Work					
Use Group Discussion					
Use Pair Discussion					
Use Debate					

Use Role Play					
Use Open Class Discussion					
Encourage listening					
Exemplify arguments					
Value different positions					
Check students' evidence					
Use writing frames					
Get students to evaluate arguments					
Get students to anticipate counter-arguments					
Encourage reflection					

Q7: If a colleague in your subject area asked you for advice about how they might teach higher order thinking skills/ reasoning, what would you advise them to do?

Q8: {If Science Teacher} Do issues involving religion ever arise ***in your science lessons***?

Q8: {If RE Teacher} Do issues of science ever arise ***in your RE lessons***?

Regularly	Sometimes	Rarely	Never

Q8a: If issues of religion (if science teacher) or science (if RE teacher) do arise, it is introduced by:

A. Teacher / B. Student / C. Both student and teacher.

Q9: Following from Q8, if you said that the teacher introduces the topic (A or C), why do you bring (science/religion) into your subject?

Q10: Following from Q8, how would you respond if a student did bring up religion in your science lessons? Or science in your religion lessons?

Q11: In your opinion, how do you view the comparison between arguments in science and arguments in religion?

Very different	More different than similar	There are both similarities and differences	More similar than different	Very similar
Please explain your answer:				

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