Contemporary Trends and Issues in Science Education 48

Berry Billingsley
Keith Chappell
Michael J. Reiss *Editors*

Science and Religion in Education

Springer

Contemporary Trends and Issues in Science Education

Volume 48

SCOPE

The book series *Contemporary Trends and Issues in Science Education* provides a forum for innovative trends and issues connected to science education. Scholarship that focuses on advancing new visions, understanding, and is at the forefront of the field is found in this series. Accordingly, authoritative works based on empirical research and writings from disciplines external to science education, including historical, philosophical, psychological and sociological traditions, are represented here.

More information about this series at http://www.springer.com/series/6512

Berry Billingsley • Keith Chappell
Michael J. Reiss
Editors

Science and Religion in Education

Springer

Editors
Berry Billingsley
LASAR (Learning about Science and Religion)
Canterbury Christ Church University
Canterbury, UK

Keith Chappell
LASAR (Learning about Science and Religion)
Canterbury Christ Church University
Canterbury, UK

Michael J. Reiss
Institute of Education
University College London
London, UK

ISSN 1878-0482 ISSN 1878-0784 (electronic)
Contemporary Trends and Issues in Science Education
ISBN 978-3-030-17233-6 ISBN 978-3-030-17234-3 (eBook)
https://doi.org/10.1007/978-3-030-17234-3

This Springer imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To Mike Poole and John Polkinghorne,
and in memory of Geoff Whitty

Foreword

The field of science and religion has changed dramatically over the last 30 years, as scholarship has challenged and revised many traditional assumptions about the relationship of the natural sciences and religious faith, both in the past and in the present. The most important of these changes has been the systematic dismantling of the myth of the 'warfare' of science and religion, which was invented in the nineteenth century and thoroughly discredited by the end of the twentieth century. Yet many of these changes in our understanding have yet to trickle down into both science education and religious education, prompting many to ask what can be done to alter this unsatisfactory situation. How can we move beyond the 'conflict thesis' and develop more reliable and constructive approaches to framing the relationship of science and religion in an educational context?

This book will be an invaluable resource in bringing about this much-needed change for teachers and researchers in the fields of education, science and religious education and the growing specialist field of science and religion. It largely results from extensive research developed by the 'Learning about Science and Religion project' (Billingsley 2013; Billingsley et al. 2018), which has a welcome focus on the fields of science education and religious studies. It provides a rich range of material which will help its readers to explore and assess the latest research and thinking relating to science education in the context of the relationships between science and religion.

This collection of chapters brings together theologians, philosophers, scientists, educationalists and others with a view to encouraging dialogue and to help those engaged in teaching share good practice. In addition to looking at key themes in this field – such as the models of the interaction of science and faith and our understanding of the origins of the universe, biological evolution and the laws of nature – the work includes several substantial pieces of research and reflection on the practical application of current research in the classroom. Its interdisciplinary and international approach makes this particularly valuable as a resource, which has the potential to transform this educational field – not merely by bringing it up to date, but by allowing it to offer a framework within which both science and faith can mutually flourish.

Andreas Idreos Professor of Science and Religion
Oxford University, Oxford, UK
Alister McGrath

References

Billingsley, B. (2013). Students' perceptions of apparent contradictions between science and religion: Creation is only the beginning. In N. Mansour & R. Wegerif (Eds.), *Science education for diversity* (pp. 329–338). Dordrecht: Springer.

Billingsley, B., Nassji, M., Fraser, S., et al. (2018). A framework for epistemic insight. Research in science education.

Contents

Chapter 1
Introduction

Berry Billingsley, Keith Chappell, and Michael J. Reiss

Aims

The focus of this book is on science and religion in education. The three of us, as editors, are passionate about education in general and about science education in particular. We see education as having a tremendous role to play in helping humanity if we are to live together justly and sustainably. We also want students to understand how different spheres of human knowledge contribute to our humanity and to the ways in which we attempt to interpret the world about us. Through the perspectives of experts from a wide range of specialisms, the chapters collected here offer research findings, ideas and recommendations from theologians, philosophers, scientists, educationalists and others with a view to encouraging dialogue and helping those engaged in teaching to share good practice. We hope it serves as a useful resource for teachers and researchers in the fields of education, science, religious education and the growing specialist field of science and religion. It should also provide a key collection of research and thought for those engaged in research in science education and religious studies.

B. Billingsley (✉) · K. Chappell
LASAR (Learning about Science and Religion), Canterbury Christ Church University, Canterbury, UK
e-mail: berry.billingsley@canterbury.ac.uk; k.chappell403@canterbury.ac.uk

M. J. Reiss
Institute of Education, University College London, London, UK

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_1

Structure

The book is structured into three parts, which critically consider, in turn, (i) existing models for the relationship between science and religion, (ii) possible new models and empirical studies and (iii) the practical application of current research in the classroom. In this way, the questions explored in the chapters move during the course of the book from examining science and religion to examining science and religion in education.

The rationale for developing the book began with work conducted as part of the LASAR (Learning about Science and Religion) project (Billingsley et al. 2012). Several of the chapters stem from or are linked to LASAR's research, and these are complemented by a broad range of invited authors bringing interdisciplinary and international perspectives to bear on the questions and themes that LASAR addresses.

Relationships Between Science and Religion

The relationships between science and religion are complex – and often it seems that talking about those relationships is more complex still. Questions which bridge science and religion cross many boundaries, and this is especially the case in schools and other educational institutions. The boundaries that a curriculum puts around different types of knowledge and different ways of constructing knowledge work well in so many ways in education, but they can become barriers if they become systematic and entrenched. At the heart of this book is a belief that a model of the relationship between science and religion that presumes conflict to be the only way in which they can be viewed does neither science nor religion justice. Furthermore, it is unhelpful educationally and impacts negatively on other important relationships between science and culture.

The chapters that follow take advantage of the opportunity to step outside the immediate pressures of a classroom and to look at ways to think about the relationships between science and religion through each of a series of narratives or focus questions. Research in England and Australia which is reported further in this book reveals that students generally perceive issues of religion in science classes to be 'off-topic', sensitive, contentious and inappropriate. Thus, despite having questions about science and religion, they rarely ask them. This is not to say that the science classroom is necessarily an appropriate place to discuss all these questions but rather to note that the questions can exist for students whether or not they are voiced. In many schools and particularly in many school science departments, it is felt that issues to do with religion are best avoided in school science lessons, even in those schools and countries where the relationships between science and religion are explicitly included in other parts of the school curriculum, for instance, in religious education. Typically, there is a lack of opportunity for trainee science teachers during their initial teacher education to share perspectives and develop their own positions about how science and religion relate to each other (Reiss 2008). This is one of the many factors which leave teachers of science feeling they are not responsible or qualified to support students' development on questions where science interacts with religious matters (Billingsley et al. 2014). More generally, it is difficult to see how we can design effective and purposive educational activities, whether in science or in other school subjects, unless we respond to how students are interpreting and making sense of what they are taught.

There are a number of ways in which students' lives and their beliefs about science and religion interact; understanding the lives and worlds that students experience can help us to create more engaging and efficacious education. Too often, school science is perceived by students as irrelevant and uninteresting. What we want is a science education that motivates and engages all learners while also allowing such learners to develop the scientific knowledge, understanding and skills that they will need if they are to progress with their science studies, once science is no longer mandatory for them. As such, omission of any consideration of how to manage students' questions about science and religion when planning school science lessons has certain disadvantages (Mujtaba et al. 2017). Some of those disadvantages and missed opportunities are introduced and explored further in the introduction and in later chapters.

The Natures of Science and Religion

The natures of science and religion have themselves shifted over time, and thus, the relationship between science and religion has also changed over the years (Harrison 2015); indeed, the use of the singular, 'relationship', risks giving the impression that there is only one way in which the two relate. Similarly, attempts to create or define distinctive roles or realms for science and religion have produced lively discussions but no easy answers, leaving educators with the dilemma of what, if anything, to say to their students.

This in turn helps to point to two key issues on which science and religion interact: one is to do with understandings of reality and the other to do with evidence and authority. Separating these issues would suggest that they can be analysed and managed separately – but, as we will see, exploring one often raises questions that relate to the other.

Worldwide, religion is important to many people, including young people; a survey undertaken in 2011 in 24 countries found that 73% of respondents under the age of 35 (94% in primarily Muslim countries and 66% in Christian majority countries) said that they had a religion/faith and that it was important to their lives (Ipsos MORI, 2011). Consider, now, the question of the scriptures as a source of authority. Among the great majority of religious believers, the scriptures of their religion (the Tanakh, the Christian Bible, the Qur'an and the Vedas, including the Upanishads, the Guru Granth Sahib, the various collections in Buddhism, etc.) have an authority by very virtue of being scripture. Interview studies reveal that the question of which has the greater authority, science or religion, perplexes many young people and that this confusion is already present in primary school children (Billingsley & Abedin, 2016). For some children, this complexity is mostly in the context of a personal commitment to scriptural authority, which may be associated with beliefs and practices at home. The sense of perplexity and concern can be all the deeper for those children who recognise that their peers hold different positions on faith and on the authority of scriptures in comparison with their own. Cutting across this already complex picture, in a school science lesson, the voice of authority is a teacher. A student who supposes he or she is in a science lesson to learn science is understandably likely to feel that they must adopt in that setting the view that science is correct – which may be thought to mean that religious views are incorrect when they contradict established science. A child in primary school described trying to make sense of science and religion as like living with parents who cannot agree.

If we move to look at how the issue of authority in science is discussed by philosophers and historians of science, the particular pressures of the classroom are swapped for an emphasis on the changing nature of scientific knowledge and methods over time and on the limitations of any given set of scientific ways of knowing. Newton's *Principia* and Darwin's *On the Origin of Species* are wonderful books. That said, given that science has since made enormous progress, we are in a better position to comment on their power and limitations in explaining observable phenomena of the material world (Reiss, 2014). Historically, we can see the significance and impact for people at each of those times of seeing the material world through Newtonian/Darwinian eyes. However, Darwin knew almost nothing about the mechanism of inheritance despite the reliance on inheritance in his argument, so parts of *The Origin* were hugely out of date over a hundred years ago. In some situations, then, a teacher might address the issue of authority by emphasising that science does not have a position on what answer if any is ultimately 'the truth'. Indeed, teachers might want to help students understand that science makes progress when existing explanations are thrown into doubt by the discovery of new evidence or the generation of new ways of thinking about phenomena. It would be unhelpful, however, if a teacher's explanation to this effect was applied more widely than intended and suggested to students that *the* way to address apparent conflicts between science and religion is to say that science may 1 day move its position.

As a case in point, and as is well known, there are many people including many students who reject evolution on the basis that they perceive it to conflict with their religious beliefs. For those who accept the theory of evolution, there is much about it that is intellectually attractive. For a start, a single theory provides a way of explaining a tremendous range of observations; for example, why it is that there are no rabbits in the Precambrian, why there are many superficial parallels between marsupial and placental mammals, why monogamy is more common in birds than in fish and why sterility (e.g. in termites, bees, ants, wasps and naked mole rats) is more likely to arise in certain circumstances than in others.

This raises the question as to what a science teacher might want his or her students to know about the relationships between religion and evolution. Students, indeed most adults, have limited access to activities that would help them to engage with the explanatory power of evolution. For many young people, key ideas about evolution are learnt to pass examinations, which means that evolution is a theory which addresses questions, which for the most part, they are not in the practice of asking.

As with any large area of science, there are parts of what we might term 'front-line' evolution that are unclear, where research scientists still actively work, attempting to discern what is going on or has gone on in nature. But much of evolution is not like that. Evolution is a well-established body of scientific knowledge that has built up over 150 years as a result of the activities of many thousands of scientists. The following are examples of statements about evolution that currently lack scientific controversy:

- All of today's life on Earth is the result of modification by descent from the simplest ancestors over a period of several thousand million years.
- Natural selection is a major driving force behind evolution.
- Evolution relies on those occasional instances of the inheritance of genetic information that help (rather than hinder) its possessor to be more likely to survive and reproduce.
- Most inheritance is vertical (from parents) although some is horizontal (e.g. as a result of viral infection carrying genetic material from one species to another).
- The evolutionary forces that gave rise to humans do not differ in kind from those that gave rise to any other species.

There are many reasons why someone may reject aspects of the theory of evolution. After all, if the theory of evolution is taken to include the origin(s) of life itself, it may seem to defy common sense to suppose that life in all its complexity could evolve from non-life. Then, there is the tremendous diversity of life we see around us. To many, it hardly seems reasonable to presume that giant pandas, birds of paradise, spiders, orchids and the authors of this book all share a common ancestor – yet that is what the mainstream evolutionary theory holds. In addition, the theory of evolution can be unsettling for existential reasons (Tracy et al. 2011; Newall 2017).

Students (with and without a religious faith) may or may not be ready to look in depth at how science and religion relate. What might be a more important point for teachers to emphasise is that the diverse community of scientists includes many with a religious faith and many without (Ecklund et al. 2019) and, further, that religious communities include many scientists (Ecklund and Scheitle 2018). There is as such no need to choose between creation by God and evolution. Some authors (see, e.g. Scott 1999) have attempted to communicate a range of different stances by presenting them as positions on a directional line. In that case, at one pole, there are materialists who maintain that there is no possibility of anything transcendent lying behind what we see of evolution in the results of the historical record (fossils, geographical distributions, comparative anatomy and molecular biology) and today's natural environments and laboratories. At the other pole, according to this view, there are advocates of creationism, inspired by a literal reading of certain scriptures. But even when reduced to this linear continuum, there are many more positions that lie in between, including ones for those who hold that evolutionary history and human history can be providential.

By extension, some teachers may feel that a more helpful model when talking about how religion and evolution relate with young people is to theorise two orthogonal axes (Billingsley et al. 2016). This means that an analysis of contemporary and student attitudes to religion and to evolution can help to disrupt the misperception held by some students that 'the more the religious, the less the scientific' (Billingsley et al. 2012).

This discussion helps to illustrate why in the organisation of this book, the chapters in the first section of this book engage more deeply with ways to understand and convey how science relates to religion; the second section of the book includes research and discussion exploring students' responses to evolution, and the third section offers educational activities that are designed to take these kinds of considerations into account. This third section is meant therefore to complement both existing academic writing on the relationships between science and religion (e.g. the various contributions in Hardin et al. 2018) and existing suggestions for use in the classroom (e.g. Poole 2007; Stolberg and Teece 2010).

Positions of Religion and Science with Regard to the Nature of Reality

Turning now to the second major point of interaction and beginning with religion, there are many religions and it is difficult to answer the question 'What does religion say about the nature of reality?' in a way that satisfies the members of all religions. Keith Ward (2008) has reviewed the six major world religions (Buddhism, Christianity, Judaism, Hinduism, Islam and Sikhism) and concludes that most of these talk about the existence of a supernatural god or gods and all discuss human existence as a journey towards some kind of improved form. So, if this is something that can be said about religion, what can we say about science? Can science be described in relation to or as a counterpart to religion?

Consider, to begin with, boundary treatments, which suggest that the fields and enquiry of science can be isolated from those in religion. One such boundary was famously proposed by Galileo who wrote in a 1615 Letter to Madame Christine of Lorraine, Grand Duchess of Tuscany, that the Bible explains how to go to Heaven, not how the heavens go (Gingerich 1982). Another attempt to create a firm boundary which has some similarities to this proposition was mounted by Gould (1997) and included the argument that science is concerned with seeking to explain what is, whereas religion is more often concerned with questions about what should be. There is also a very influential view of reality in the West, which takes up a Platonic/Cartesian view of reality in which matter and mind are said to be two separate categories, which can be studied independently. While 'mind' is not a religious entity as such, for many people this 'mind-matter' dualism has also become a useful way to separate and characterise the domains of science and religion in relation to the 'material body and nonmaterial spirit/soul'. The idea is that the mind/soul/spirit is not made of a material substance and is opaque to scientific enquiry.

To introduce some of the themes that will follow, the boundary that is suggested by separating mind and matter does not seem to address the range of living things that students learn about in biology and also steps around the issue that the fields that are open to scientific enquiry shift over time.

Educationalists have also engaged with these kinds of boundary questions. While writing about the need for students to 'recognise the limits of science and the power of other ways of thinking that are also functional in the world', DeBoer (2000, p. 592) explains that 'There are emotional and spiritual aspects to our existence that fall outside the realm of science, and the line between these and the nature of scientific thought needs to be drawn so that students can more fully comprehend what science is and what it is not'. Rather than a firm boundary, it has been proposed that questions can be more or less amenable to science because science 'produces, demands and relies on empirical evidence' (McComas 2008, p. 251).

Science and religion both have something to say about big questions about the nature of reality and human personhood (Billingsley et al. 2018). These big questions can stimulate our curiosity about questions we can seek to address in science – a line taken by Wagner and Briggs (2016) whose argument is summed up in the title of their book: *The penultimate curiosity: How science swims in the slipstream of ultimate questions*. In that case, compared with science, religion seems to be more concerned with issues of meaning and purpose.

It is more difficult to say now, and particularly in the future, what kinds of questions and methods are beyond the scope of science. Some of the areas that scientists are currently investigating are already contentious, and new areas are likely to be added as science advances.

For education and educationalists, these difficult questions are pertinent because the young people in school today include the scientists who will soon be working in these fields. Consider the implications of developments in instrumentation. We can now study events that happen at very low temperatures, at great distances, at enormous speeds and at magnifications that simply were not possible even a few decades ago. It is interesting to ponder on the extent to which certain matters currently outside of mainstream science may one day fall within the compass of science, partly because of advances in instrumentation, and how this may in turn change how causal relationships are characterised and understood within science. Take dreams, for example. It may be that these will continue to be deemed by science journal editors and other gatekeepers of science to be too subjective for scientific study, but it may be that developments in the recording of brain activity will swing scientific opinion to the view that we can obtain a sufficiently objective record of dreams for them to be amenable to rigorous scientific study. Given the importance of dreams in religion and religious histories (if for no other reason), it will be important that scientists are thoughtful and epistemically insightful about the language that is ascribed to what they are discovering and how much it explains. The fields of science also shift for reasons that are as much to do with theorisation as with technical advances (Reiss 2013). Consider beauty. Aesthetics for a long time was not considered a scientific field. But there is now, within psychology and evolutionary biology, growing scientific study of beauty and desire (e.g. Ryan 2018). Indeed, a number of the social sciences are being nibbled away at by the natural sciences and if one believes some scientists, we are moving towards a day when the only valid knowledge will be scientific knowledge (Atkins 2011). These are just some of the factors that are increasing the pressure on schools and school curriculum boundaries to take into account these kinds of metaphysical discussions and offer students some support.

Issues around reductionism which are hinted at here will be explored more deeply in the chapters to come together with explorations that consider which views of reality (i.e. metaphysical positions) are consistent with science. While these are difficult questions for schools, to our advantage and to the advantage to all the authors who have chapters in this book, issues around the nature and borders of science have long been a focus for scholars of science and religion. To address and inform the ways that educators approach these kinds of epistemic issues, rather than begin with questions raised by modern science, many of the chapters here seek to provide some initial clarity by providing historical context and discussion around longstanding questions and cases. Examples are Galileo and Copernican heliocentrism, Darwin and evolution, science and miracles and arguments about the sanctity of life. Each of these studies exposes ideas and assumptions that are widely held about the natures of science and religion that may otherwise remain unexplored (and other examples could have been chosen – e.g. Stanley 2007, 2015).

Teaching that explores such cases provides one way in which a teacher can help his or her students to become more insightful about the 'nature of science', in other words, to deepen their understanding of what the fields of scientific enquiry are and also of what the methods used in scientific enquiry are. Beginning with such longstanding cases can also work as an invitation to students to raise and reflect on their own situations; after all, many of the social pressures, pedagogies and subject boundaries experienced in schools today reflect priorities and ways of understanding reality that have historical antecedents.

While educators cannot precisely anticipate for their students the issues that future scientists and citizens will need to address, we can help students to maintain open minds by looking at the frameworks and principles that are applied by those considering today's contentious issues. Here, and as a layperson's introduction, we provide a snapshot of what a metaphysically reductive account might look like. In that case, our sense of self and perception of a continuous 'mind at work' is an illusion; feelings that we ascribe to our moral compass cannot be explained using any kind of reference to an external greater good and our thoughts, hopes, passions and memories are illusions produced by the complex biochemistry and associated material manifestations (anatomy, neuronal activity) of the brain. A different view of the person with a mind is offered by those philosophers, theologians and scientists who argue that reality consists of not only material particles (atoms, electrons, quarks) and objective entities (tables, chairs) but also of things that become apparent only once we widen the scope – thoughts, a sense of self, mathematics, aesthetics and ethics. These entities are experienced subjectively, but they can still be real and have actual influence, even if they are not within the scope of science and its instruments.

A possible risk for a science teacher who references or discusses the changing content of science and different perspectives on its borders is that students will become less enthusiastic and less committed to the study of science (Konnemann et al. 2016). After all, one of the characteristics of science lessons that teachers hear from their students is that at least in 'science', there *is* a right answer. This highlights the need for another lens through which the relationships between science and religion can be discussed. Students are in school to learn (among other things) how knowledge is constructed, articulated and tested in scholarship. For many decades, this learning has been shaped by subject boundaries, textbooks, units, topics and the further atomisation of learning about knowledge into individual lessons and homework tasks. To what extent, we might ask, is it useful in an age of search engines and free online resources for students to be learning about knowledge only within these atomistic boundaries as opposed also to learning about the nature of knowledge when they look across their subjects and beyond? One of the key responsibilities of the teacher of science is to teach students about the nature of science. Students' capacities to become epistemically insightful about science's nature are impeded, however, if their practical experiences are focused only on activities designed to showcase existing and established knowledge. Students enjoy the reliability of school science but, as we have already identified, it is important that they are not misled by their experiences into supposing that attempting to investigate and explain reality scientifically is less complex than it is.

In setting up these book sections and borders between them, we are aware that we artificially separate our authors and our themes into groups and then order their discussions! The groupings and the ordering are akin in many ways to the groupings and ordering of units in a course. It might be worth saying at this point that we see borders in education – and in books – as useful for teaching and communicating; our concerns pertain to where those borders have become entrenched and their influences on students' learning are not examined and addressed. We would emphasise that there is no requirement for the reader to move sequentially from one chapter to the next; this book also has an index.

References

Atkins, P. (2011). *On being: A scientist's exploration of the great questions of existence*. Oxford: Oxford University Press.

Billingsley, B. & Abedin, M. (2016). *Primary children's perspectives on questions that bridge science and religion: Findings from a survey study in England*. Paper presented at the BERA (British Education Research Association) annual conference, Leeds.

Billingsley, B., Taber, K., Riga, F., & Newdick, H. (2012). Secondary school students' epistemic insight into the relationships between science and religion; a preliminary enquiry. *Research in Science Education*, 1–18. https://doi.org/10.1007/s11165-012-9317-y.

Billingsley, B., Riga, F., Taber, K. S., & Newdick, H. (2014). Secondary school teachers' perspectives on teaching about topics that bridge science and religion. *The Curriculum Journal, 25*(3), 372–395.

Billingsley, B., Borgeaud, J. & Knapp, Z. (2016). *Teaching science and religion: Student teacher perceptions.* Paper presented at the Values and Education, Winchester.

Billingsley, B., Nassji, M., Fraser, S., & Lawson, F. (2018). A framework for epistemic insight. *Research in Science Education, 48*(6), 1115–1131. https://doi.org/10.1007/s11165-018-9788-6.

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching, 37*(6), 582–601.

Ecklund, E. H., & Scheitle, C. P. (2018). *Religion vs. science: What religious people really think*. York: Oxford University Press.

Ecklund, E. H., Johnson, D. R., Vaidyanathan, B., Kirstin, R. W., Matthews, K. R. W., Lewis, S. W., Thomson, R. A., Jr., & Di, D. (2019). *Secularity and science: What scientists around the world really think about religion*. New York: Oxford University Press.

Gingerich, O. (1982). The Galileo affair. *Scientific American, 247*(August), 118–127.

Gould, S. J. (1997). Nonoverlapping magisteria. *Natural History, 106*(2), 16–22.

Hardin, J., Numbers, R. L., & Binzley, R. A. (Eds.). (2018). *The warfare between science and religion: The idea that wouldn't die*. Baltimore: Johns Hopkins University Press.

Harrison, P. (2015). *The territories of science and religion*. Chicago: University of Chicago Press.

Ipsos MORI (2011). *Views on globalisation and faith*. See https://www.ipsos.com/sites/default/files/migrations/en-uk/files/Assets/Docs/News/ipsos-globaladvisor-views-on-globalisation-and-faith.pdf.

Konnemann, C., Asshoff, R., & Hammann, M. (2016). Insights into the diversity of attitudes concerning evolution andc creation: A multidimensional approach. *Science Education*. https://doi.org/10.1002/sce.21226.

McComas, W. F. (2008). Seeking historical examples to illustrate key aspects of the nature of science. *Science & Education, 17*(2–3), 249–263.

Mujtaba, T., Reiss, M. J., & Stones, A. (2017). Epistemic insight: Teaching about science and RE in secondary schools. *School Science Review, 99*(367), 67–75.

Newall, E. (2017). Evolution, insight and truth? *School Science Review, 99*(367), 61–66.

Poole, M. (2007). *User's guide to science and belief: Questions of faith*. Oxford: Lion.

Reiss, M. J. (2008). Should science educators deal with the science/religion issue? *Studies in Science Education, 44*, 157–186.

Reiss, M. J. (2013). Religion in science education. In N. Mansour & R. Wegerif (Eds.), *Science education for diversity: Theory and practice* (pp. 317–328). Dordrecht: Springer.

Reiss, M. J. (2014). What significance does Christianity have for science education? In M. R. Matthews (Ed.), *Handbook of historical and philosophical research in science education* (pp. 1637–1662). Dordrecht: Springer.

Ryan, M. J. (2018). *A taste for the beautiful: The evolution of attraction*. Princeton: Princeton University Press.

Scott, E. (1999). The creation/evolution continuum. *Reports of the National Center for Science Education, 19*, 16–23.

Stanley, M. (2007). *Practical mystic: Religion, science, and A. S. Eddington*. Chicago: Chicago University Press.

Stanley, M. (2015). *Huxley's church and Maxwell's demon: From theistic science to naturalistic science*. Chicago: Chicago University Press.

Stolberg, T., & Teece, G. (2010). *Teaching religion and science: Effective pedagogy and practical approaches for RE teachers*. Abingdon: Routledge.

Tracy, J. L., Hart, J., & Martens, J. P. (2011). Death and science: The existential underpinnings of belief in intelligent design and discomfort with evolution. *PLoS One, 6*(3), e17349. https://doi.org/10.1371/journal.pone.0017349.

Wagner, R., & Briggs, A. (2016). *The penultimate curiosity: How science swims in the slipstream of ultimate questions*. Oxford: Oxford Univeristy Press.

Ward, K. (2008). The big questions in science and religion. In *West Conshohocken*. Pennsylvania: Templeton Foundation Press.

Prof. Berry Billingsley specialises in Science Education and leads the LASAR (Learning about Science and Religion) research team at Canterbury Christ Church University. Her interests include students' ideas about the nature of science and, more broadly, developing strategies to support the development of epistemic insight, young people's engagement in science, artificial intelligence, Big Questions bridging science, religion and the wider humanities and the communication of science and technology news in the media. Equipped with a physics degree, Berry's first career was with the BBC where she produced and presented television and radio programmes including BBC World Service's 'Science in Action', BBC TV's 'Tomorrow's World' and BBC Education's 'Search out Science'. She then travelled to Australia to become a senior project manager with the Department of Education. She regularly publishes in science education.

Dr. Keith Chappell is a Research Fellow in the Learning about Science and Religion team at the University of Canterbury. He has previously taught biological sciences at the University of Reading and the University of Derby. Besides his interests in biology, he writes in the field of theology and religious studies, having been a Las Casas scholar at Blackfriars Hall, Oxford studying Christian social teaching. He is a Visiting Lecturer at the Maryvale Institute, Birmingham and Liverpool Hope University. He is also a theological advisor to the Catholic Bishops' Conference of England and Wales. In addition to science and religion, he is engaged in research in the sociology of religion and the philosophy of biology.

Michael J. Reiss is a Professor of Science Education at UCL Institute of Education, Visiting Professor at the Universities of Kiel, York and the Royal Veterinary College, Honorary Fellow of the British Science Association and of the College of Teachers, Docent at the University of Helsinki, a Fellow of the Academy of Social Sciences and a Priest in the Church of England. He is the President of the International Society for Science and Religion and of the International Association for Science and Religion in Schools and has research and consultancy interests in science education, bioethics and sex education.

Part I
Beyond Barbour

Chapter 2
Beyond Barbour: New Ways of Teaching the Relationship Between Science and Religion

Bethany N. Sollereder

Virtually, every college course on science and religion starts the same way: an overview of Ian Barbour's (1998) fourfold typology on the relationship between science and religion. He categorises interactions between these contested categories as fitting into four broad typologies:

Conflict: Science and religion impinge on each other's truth claims in ways that are mutually exclusive, so that growth in one discipline necessarily leads to the diminishment or retreat of the other.

Independence: Science and religion operate in separate spheres of knowledge, such as fact and value, or measurement and meaning. Stephen Jay Gould's concept of science and religion being 'Non-Overlapping Magisteria' (NOMA) is the most popular example of independence (Gould 1999).

Dialogue: Science and religion have many points of overlapping interest and contain striking methodological parallels, with neither being completely objective or subjective. As such, they can both listen to the contributions of the other in reformulating paradigms or asking new questions.

Integration: Science and religion have a directly overlapping relationship with each other, and evidence from one can be used to bolster or build positions in the other. Natural theology, for example, claims to be able find evidence for God's existence from an exploration of nature.

Despite its usefulness for introducing ideas about science and religion, Barbour's typology has been critiqued for failing to take account of the full complexity of the historical relationship (Cantor and Kenny 2001) or for simply being too abstract to apply with precision to real-life situations (Southgate and Poole 2011). Peter Harrison, in a recent example, raised questions about the historical viability of the very categories of 'science' and 'religion' (2015). Neither 'Science' nor 'Religion'

B. N. Sollereder (✉)
Postdoctoral Fellow in Science and Religion, University of Oxford, Oxford, UK
e-mail: bethany.sollereder@theology.ox.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_2

is an easily recognisable category, nor do they refer to stable and distinct institutions. Rather, the institutionalisation of these categories is an important historical development from an earlier understanding of *scientia* and *religio* as the practice of intellectual and moral virtues. Overlooking this change leads to problematic anachronisms. Harrison compares 'science' and 'religion' to the ever-changing boundaries and laws of nation states and describes the misleading content of a statement such as 'In the year 1600, Egypt went to war with Israel' when neither Egypt nor Israel existed as nation-states during the early modern period. It is, therefore, very difficult to apply historically viable typologies of relationship when the very essences of the subjects have changed so dramatically.

In addition to the numerous philosophical critiques, Barbour's categories are abstract, theoretical and difficult to grasp even by undergraduate-level students. What chance, then, do primary or early secondary students have of clearly understanding these concepts?

In choosing 'Beyond Barbour' as a theme, first at the Learning about Science and Religion (LASAR) conference on Science and Religion in Education hosted in Oxford in December 2016, and then as part of this book, we hoped to uncover pedagogical strategies that would help explain the complex relationship of science and religion to younger learners. In the papers that follow, McLeish and Dumler-Winckler present theoretical alternatives to Barbour's approach that address the complexity and dynamism of these disciplines.

Manninen's paper gives new illustrations for the typologies, while Paive and Easton's surveys explore how school-aged children perceive the existing relationship between science and religion. Our hope is that readers will be able to use these contributions to create innovative teaching materials that will help students achieve a more robust understanding.

Not every presentation at the conference was able to be included in this book. One innovative example of the strategies presented at the conference not represented here was the brilliant session by Dr. Matt Pritchard on science and magic. Through a variety of visual illusions and seemingly impossible events (e.g. a round tin rolling down and then rolling up a ramp with no motor, magnet, or other attachment), Pritchard challenged the limits of empirical certainty and encouraged the learners to see science as an open-minded practice of discovery that is willing to observe, enquire, learn, sleuth for variables, fail and try again. The session raised interesting questions about the nature of freewill, the reliability of memory and the difficulty of discovering what is real. Although Pritchard did not link science to religion, he ably demonstrated that the claim to objective true knowledge by scientific positivists or scientific materialists is easily undone—a claim equally challenged by mainstream quantum physics since the 1950s, where the experimenter is inevitably part of the experiment. Although it would require some practice, the use of magic and illusion was highly engaging and helpfully illustrative of the complexities of knowledge in the sciences.

Another pedagogical strategy presented was to use biography as a way into the complexities of the science and religion relationship. Since both science and religion are practices lived out in the lives of human beings, comparative approaches to biography can reveal complexities of trying to work out these two endeavours in concrete terms. Take, for example, George John Romanes (1848–1894).

Romanes was a keen student who arrived at Cambridge on the path to ordination. He even wrote a prize-winning essay on how prayer could be effective in a world ruled by physical laws, an attempt to work out integration between his commitment to science and to Anglican religion. But, like Darwin his hero, he fell in love with biology. Unlike Darwin, Romanes then turned violently against religion, anonymously publishing a treatise called *A Candid Examination of Theism* (1878) in which he attempted to show how religion was irrational, untenable and false. It was a classic 'conflict' position in the Barbour typology. After university, he married a devout Anglican and seems to have softened towards religion. For years, Romanes sustained what seems to be a position of independence. He did his science in one world, and yet continued to allow and attend religious education in his home for his children and his servants. While he did not consider himself an atheist during this time, nor was he a believer, he still saw great value in the practice of religion. Finally, near the end of his short life, he seems to have had another dramatic change of heart and began compiling a book called *Thoughts on Religion* (Gore 1895) that would be edited and published posthumously by Charles Gore. Romanes revisits his earlier work, *A Candid Examination of Theism*, and tries to show the flaws in reasoning in his early work, or more accurately, to show that logical scientific reasoning was not the only valid source of truth. It fails to achieve a position of integration, but could easily be seen as an example of dialogue. However, greater nuance can be added by, for example, bringing out Romanes's deep *regret* over the loss of his faith during his years of conflict and independence. He ends the *Candid Examination* lamenting over the 'ruination of individual happiness' and his sense that with the 'negation of God the universe to me has lost its soul of loveliness'. It is a striking difference in attitude from the brash voices of the New Atheists who represent the paradigmatic examples of conflict in our age. Synchronic examples are also possible in biography. Rather than someone who changes through distinct positions over time, as does Romanes, the example of St. George Jackson Mivart (1827–1900) shows that someone can hold various aspects of these positions at the same time towards different aspects of science and religion. John Hedley Brooke and Geoffrey Cantor write that Mivart:

> … perceived 'conflict' between the Darwinians' overstated commitment to natural selection and his understanding of the human condition in which mental and moral attributes were important but could not be explained by natural selection. Likewise he used an 'independence' strategy when arguing that the Galileo affair should teach us that science is for scientists and theology for theologians. Each had its own proper domain. Yet he also conceived a form of dialogue when arguing that both science and religion are rational activities; he insisted that neither scientists nor theologians should forsake their critical faculties. Finally, much of his own research was empowered by specific integrationist strategies. Thus he perceived the world framed by the divine architect and he directed his research to elucidating archetypes. (Brooke and Cantor 1998, 276)

Biography can draw out complexities that the simple presentation of Barbour's categories miss. In addition, biography highlights the lived dynamics of science and religion, elucidating the importance of culture, language, motivation, history and environment. One finds that one cannot ask the question of the relationship between science and religion without reaching into all the spheres and disciplines of human endeavour. It is an inescapably multi- and inter-disciplinary task. As such, the questions of science and religion can contribute meaningfully to the task of crossing the oft-arbitrary divisions of classroom disciplinary boundaries and help students to see the claims of both science and religion in proper perspective.

References

Barbour, I. (1998). *Religion and science: Historical and contemporary issues*. London: SCM Press.

Brook, J. H., & Cantor, G. (1998). *Reconstructing nature: The engagement of science and religion*. Edinburgh: T&T Clark.

Cantor, G., & Kenny, C. (2001). Barbour's fourfold way: Problems with his taxonomy of science-religion relationships. *Zygon, 36*, 765–781.

Gore, C. (Ed.). (1895). *Thoughts on religion*. Chicago: Open Court.

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

Harrison, P. (2015). *The territories of science and religion*. Chicago: University Of Chicago Press.

LASAR, Conference on Science and Religion in Education, announcement available online: http://lasarcentre.com/?page_id=975. Accessed 8 Dec 2018.

Romanes, G. J. (1878). *A Candid Examination of Theism*. London: Trübner & Co.

Romanes, G. J. (1896). *The life and letters of George John Romanes*. London: Longmans, Green, and Co.

Southgate, C., & Poole, M. (2011). Introduction. In C. Southgate (Ed.), *God, humanity and the cosmos: A textbook in science and religion* (3rd ed., pp. 3–43). London: T&T Clark.

Bethany N. Sollereder is a Postdoctoral Fellow in Science and Religion at the University of Oxford. She specialises in theology concerning evolution and the problem of suffering. Bethany received her PhD in Theology from the University of Exeter and an MCS in interdisciplinary studies from Regent College, Vancouver.

Chapter 3
Turning Barbour's Model *Inside Out*: On Using Popular Culture to Teach About Science and Religion

Tuomas W. Manninen

Introduction[1]

Ian Barbour (1997) proposed a fourfold taxonomy for modeling the science-religion relationship.[2] According to Barbour's taxonomy, there are four main categories of how science and religion might relate to one another: conflict, independence, dialogue, and integration. Although Barbour's model is no doubt the most widely known in the discussions of the science-religion relationship, it has also received a fair share of criticism. Moreover, Barbour's model is by no means the only model out there; many competing and more nuanced views are easily found.

In the call for papers for the "Science and Religion in Education Conference 2016," the organizers posed the following challenge:

> Ian Barbour proposed four major models to convey how science might relate to religion: Conflict, Independence, Dialogue, and Integration.

[1] I would like to express my gratitude to Dr. Bertha A. Manninen – my wife and my colleague – not just for providing me with the inspiration for writing this paper but also for our two daughters, Michelle and Julia. who have provided a convenient excuse for adults to enjoy movies such as *Inside Out*; to Mr. Frank Scarpa, for extensive discussions on Barbour's taxonomy and criticism thereof; to the students in my "Science and Religion" classes over the years (especially in 2016 and 2017, when they were subjected to this particular argument); and to the audience members at the "Learning about Science and Religion" Conference at Oxford in October 2016, for all their constructive comments.

[2] My discussion on Barbour's taxonomy draws primarily from the formulation given in his *Religion and Science: Historical and Contemporary Issues* (1997). This formulation can also be found, e.g., in Barbour's *When Science Meets Religion* (2000: Chapter 1).

T. W. Manninen (✉)
School of Humanities, Arts, and Cultural Studies, Arizona State University, Glendale, AZ, USA
e-mail: tuomas.manninen@asu.edu

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_3

Are these ideal for teaching or are there more effective and participatory ways to involve learners in the discovery of how science and religion might relate?
What is a novel way to explain the relationship between science and religion?
What are effective models for helping children to conceptualise the relationship between science and religion?
Can visual models help early learners understand the sort of claims science and religion make? (LASAR 2016).

This chapter is a modest attempt at providing an answer to these questions by weaving them together. In my attempt to do so, I will draw an analogy between Barbour's taxonomy and the anthropomorphic emotions in the Disney/Pixar animation, *Inside Out* (Docter & Del Carmen 2015). I will begin with a short synopsis of Barbour's model (in Section "Motivation for This Chapter"), along with a synopsis of *Inside Out* (Section "Barbour's Account"). Moving on, I draw from my background as a philosopher who has been teaching a postsecondary course titled "Science and Religion" annually for nearly a decade. I will also briefly elaborate on (as well as defend) the practice of using popular culture as a way of teaching about philosophy.

Next (in Sections "Problems with Barbour's Account" and "Regarding the Practicalities"), I move to argue that employing popular culture items for the purpose of explaining (or illustrating) philosophical concepts can be extended beyond just this: instead of merely providing an engaging way of illustrating the topic, the popular culture item can be used for showing ways how the topic could be developed further. All this notwithstanding, this paper will defend the usefulness of Barbour's model in teaching about the science-religion relationship by making a modest proposal: in light of the criticism abound, Barbour's four-category taxonomy remains suitable for conceptualizing the relationship, especially in ways that are accessible to younger audiences.

Source Materials

Motivation for This Chapter

On the whole, philosophers have drawn from examples in the popular culture ever since Plato, even if this kind of popular philosophy has fallen out of fashion over the years. However, starting in 1999, a veritable sub-genre of philosophical books weaving together academic philosophy and popular culture has emerged: professional philosophers have tried their hand in teaching philosophical concepts by using both popular culture items and popular culture icons. The series had its beginnings with *Seinfeld and Philosophy*, moving on to *Simpsons and Philosophy* – and subsequently to all points beyond. As of writing this, there are two main publishers in this genre, together with a handful of emerging ones, as well as others with one-off titles. By March 2017, Open Court Press has published a total of 107 volumes in its *Popular Culture and Philosophy* series, with (at least) 11 more in various stages of preparation, to be released by 2018. In its *Philosophy and Popular Culture* series, Wiley-Blackwell has 48 titles in print, with about a dozen more in various stages of preparation. In addition, Rowman and Littlefield recently launched its *Great Authors and Philosophy* series, which – to date – includes published volumes focusing on the works of Stephen King and Jane Austen, with more titles in preparation.[3]

As William Irwin, the philosopher who pioneered this genre, explains:

> Chapters in these books aim to introduce a philosophical question, problem, issue, or historical figure to general audience by making connections with pop culture. The goal is often to correct mistaken, incomplete, or shallow philosophical notions in the popular culture. The idea is not, for example, that *Star Wars* can tell you about Heidegger's view of technology. Rather, *Star Wars* supplies examples and can be the basis for thought experiments to illustrate Heidegger's view of technology (Irwin 2010: 50).

Insofar as my argument in this paper goes, I agree with Irwin's approach: I plan to illustrate a complex issue (the science-religion relationship) by mapping it onto a popular film and one especially geared toward younger audiences. Where I may go beyond Irwin's claim is in this: I will argue that the relationship between abstract concepts and popular culture items ought to be viewed as *reciprocal* – instead of merely mapping the abstract issue onto the film for illustrating it. I will outline a way for modifying the theoretical account by mapping the message of the film (particularly its conclusion) back to the theoretical account. Although this approach does not provide a complete picture with all the nuances, it shows that we can go beyond merely illustrating theoretical concepts through popular culture.[4]

Barbour's Account

Ian Barbour has argued for the following model for providing "a systematic overview of the main options today" (1997, 76): these are *conflict*, *independence*, *dialogue*, and *integration*. Although this model has its limitations – as Barbour himself acknowledges – he argues that the relationship between science and religion can be understood using the following four models.

Conflict: Drawing from the historical accounts (e.g., the cases of Galileo and Darwin and how these were, respectively, received by the public), Barbour identifies the two opposites in the theological spectrum. There is scientific materialism, which

[3] For Rowman and Littlefield, information about the *Great Authors* series can be found at https://rowman.com/Action/SERIES/RL/GAP#. The Wiley-Blackwell series can be found at https://andphilosophy.com/books/ and Open Court Press at http://www.opencourtbooks.com/categories/pcp.htm.

[4] As far as I can tell, there have not been any plans for a volume on "*Inside Out* and Philosophy." Still, this is not to say that philosophers have not written on this issue. For one example, there is the essay by Sirvent and Reyburn (2015), "Inside Out and Philosophy: What does it mean to be okay?" at the Wiley-Blackwell site for the *Philosophy and Popular Culture* series. For another example – and one that served as inspiration for this chapter – see B. Manninen (2016).

holds (in its metaphysical formulation) that "only the entities and causes with which the science deals are real; only science can progressively disclose the nature of the real" (1997: 78). At the opposite end, we find biblical literalism, a view committed to biblical inerrancy and a literal reading of the scripture (1997: 8284).

Independence: Barbour views this position as a way to avoid conflicts between the two camps: if science and religion are each given "its own distinctive domain and its characteristic methods that can be justified on its own terms," there is no genuine need for the two to fight one another (1997: 84).

Dialogue: According to Barbour, this is an umbrella group of diverse positions that occupies the territory between *independence* and *integration*: science and religion can employ parallel methodologies in their inquiry, or they can mutually work out the boundaries/limits of their respective enterprises while retaining their own identities (1997: 90–95).

Integration: The fourth position represents another diverse set of authors who argue "that some sort of integration is possible between the content of theology and the content of science" (1997: 98). Historically, this position has included authors in the tradition of natural theology; more recently, the proponents of the anthropic principle can also be found under this heading. In addition, proponents of theology of nature – with whom Barbour claims to be "in basic agreement" (1997: 105) – and those working in process philosophy are considered as those representing the integration view.

This is an admittedly cursory overview of the four categories in Barbour's model, but it suffices for the purpose of outlining the options. When it comes to Barbour's own preferences among the options, we will return to this discussion later.

Main Feature: Inside Out

In the 2015 Disney/Pixar animated film *Inside Out*, the audience is presented to the life and actions of 11-year-old Riley – and how those are controlled by anthropomorphic personifications of emotions: Joy, Sadness, Anger, Disgust, and Fear.[5] As Riley encounters various situations in daily life ranging from the ordinary (e.g., playing hockey or spending time with her best friend) to life-changing (e.g., when Riley's family moves across the country and she has to start over in a new school, etc.), one of the five emotions is in charge. And, depending on who is in charge at the moment, the corresponding memory of the event (yellow for Joy, blue for Sadness, red for Anger, etc.) gets stored in her consciousness as a memory orb – a representative token – with that hue.

During the early scenes of the film, it is established that Joy is primarily in charge of Riley's emotions – and she wishes to keep it that way. (Referring to the collection

[5] Link to the official movie trailer: https://youtu.be/yRUAzGQ3nSY.

of the memory orbs, Joy recounts, "Anyways, these are Riley's memories. And they're mostly happy, if you notice – not to brag.") After all, she was the first on the scene, and she clearly resents Sadness (who followed her in the Control after 33 seconds). The other emotions – Anger, Disgust, and Fear – followed at some subsequent point; the precise timing is not revealed in the film; nor is it important for our purposes.

In Act 2, after Riley's family moves cross-country (from Minnesota to San Francisco, CA), and Riley starts to adjust to her new life, things in the Control go awry: both Joy and Sadness are whisked away into Riley's long-term memory – which means that all of Riley's emotional responses are characterized by Anger, Disgust, or Fear, as they take turns at the helm.

This already shows how the analogy between the five emotions and Barbour's four categories falters somewhat. Still, the numerical discrepancy aside, we can press on with making the analogy work: Barbour's four categories *can* be mapped onto the five emotions, with only a minor fibbing with the details.

The nearly disastrous consequences are not resolved until Act 3: Fear, Anger, and Disgust alone cannot replicate the responses of Joy and Sadness, and, inevitably, Riley's emotional stability is left unbalanced. Ultimately, the five main emotions are reunited – with the dual realization that, first, Riley's memories, and emotions alike, are multifaceted, and, second, no one emotion can be fully in charge. Visually, this is shown by the change in the memory tokens, whereas the tokens in the beginning were unicolorous, the post-realization ones are represented by dual-color tokens in the final act.

By analogy (and with all the accompanying difficulties therewith)[6], the science-religion relationship follows along a similar process, and the anthropomorphic emotions can be mapped onto Barbour's model. Hence, even if the five-emotion control of an individual (as depicted in Act 1 of *Inside Out*) was adequate in her preadolescence, it was inadequate for Riley's adolescent world. Similarly, Barbour's four-category model for the science-religion relationship may – or does – serve as a starting point, even if it cannot survive the subsequent criticism that is both unabated and nuanced. Moreover, given the multifarious nature of specific religions, we see that just as all the five emotions were needed, so are all the four categories in Barbour's model.

[6] See, e.g., David Hume's warning about arguments based on analogies in *Dialogues Concerning Natural Religion*:

> After having experienced the circulation of the blood in human creatures, we make no doubt, that it takes place in *Titius* and *Maevius*. But from its circulation in frogs and fishes, it is only a presumption, though a strong one, from analogy, that it takes place in men and other animals. The analogical reasoning is much weaker, when we infer the circulation of the sap in vegetables from our experience that that the blood circulates in animals; and those, who hastily followed that imperfect analogy, are found, by more accurate experiments, to have been mistaken (2007 [1779]: Part 2.7).

Problems with Barbour's Account

Over the years, Barbour's model – the basics of which were outlined above (in Section "Barbour's Account") – has received a fair share of criticism. In fact, Barbour himself is aware of some of these as he presents the model (2000:4–6); in the years since, the list of critics has only grown longer.[7]

Here, I wish to add to this list by applying the moral of the story which illustrates one particular weakness in Barbour's view.

In Act 2 of the film, Joy and Sadness are removed from the Control, leaving only Anger, Disgust, and Fear to produce Riley's emotional responses to what life throws at her – like her experiencing the first day at a new school, her learning that her best childhood friend is having fun with someone else, her trying out for the local junior hockey team, and so on and so forth. One scene in particular gives a strong illustration of this difficulty. Riley sits down for dinner with her parents, and the emotional responses that Fear, Disgust, and Anger produce, in trying to mimic the missing emotions, fall ways off from the genuine ones:

[Riley's mom tells her about upcoming tryouts for a junior hockey team, Riley's cherished hobby]
Fear [to Disgust, pushing her to the dashboard]: "Here, you pretend to be Joy".
[Disgust touches a button on the dashboard.]
Riley [apathetically, to her mother] "Oh yeah, that sounds fantastic".
Fear [to Disgust]: "What was that? That wasn't anything like Joy!
Disgust: [sarcastically] "Um, because I'm not Joy".
Fear: "Yeah, no kidding".

In outlining his taxonomy, Barbour appears to view the *conflict* position – or positions – negatively.

> They both (i.e., *scientific materialism* and *biblical literalism* alike) claim that science and theology make rival literal statements about the same domain, the history of nature, so that one must choose between them. I will suggest that scientific materialism and biblical literalism both represent a misuse of science. The scientific materialist starts from science but ends by making broad philosophical claims. The biblical literalist moves from theology to make claims about scientific matters. In both schools of thought, the differences between the two disciplines are not adequately represented (1997, 78).

Barbour – as well as many other authors writing on the science-religion relationship – seemingly eschew the *conflict* position in favor of finding an alternative way which then would allow science and religion to both be endorsed. For slightly dif-

[7] Among the more recent critics of Barbour's model are Geoffrey Cantor and Chris Kenny (2001: 765) who claim that Barbour's model is too much tied to the contemporary issues and it does not provide "a very useful or analytically helpful" framework to historians whose studies focus on the past episodes in science-religion relationship; Mikael Stenmark (2007, Chap. 10) and Taede Smedes (2008: 235), who argues that Barbour's model "echoes the logical positivist vision of unification and has a strong bias toward science", which makes it tantamount to 'cultural scientism'.

ferent reasons, Barbour also expresses hesitation about the success of the *independence* view:

> If science and religion were totally independent, the possibility of conflict would be avoided, but the possibility of constructive dialogue and mutual enrichment would also be ruled out. […] I will argue that none of the options considered above [i.e., the different ways in which the *Independence* position have been articulated] is adequate to that task (1997, 89).

Again, there are authors other than Barbour who make similar claims – that since the current versions of the *independence* position are found wanting, they can be passed over (mostly in silence). Barbour sums up his stance on the different positions as follows:

> … I will try to do justice to what is valid in the *Independence* position, though I will be mainly developing the *Dialogue* position concerning methodology and the *Integration* thesis with respect to the doctrines of creation and human nature (1997, 105).

But why exactly would this be a bad thing? In light of my overall analogy between Barbour's taxonomy and *Inside Out*, it seems that following Barbour's proposal (i.e., setting both *independence* and *conflict* aside and focusing on the other two) would be tantamount to leaving just Anger, Disgust, and Fear in charge.

Although Barbour may have a point that the *conflict* position should be avoided – not the least because it frequently misconstrues the respective claims advanced by both science and religion – this appears to be true only when we consider science and religion in an abstract fashion. Once we bring the considerations to the level of what individuals believe – what their religious views are or how they understand science – we see that *conflict* (not to mention *independence*) is indispensable, inasmuch as Joy and Sadness are at the Control. To illustrate this, here's an anecdote from a "Science and Religion" class I taught in the recent past. In a response paper where the student was asked to reflect on their religious beliefs in light of a presentation of the scientific consensus on evolutionary history of life, one student wrote:

> I know that, being Catholic, I am supposed to believe in Adam and Eve, but when the science says that evolution is a fact, I have to take a step back and wonder which one is right.

The student who wrote this response was flabbergasted when they learned about the 1996 address to the Pontifical Academy of Sciences by Pope John Paul II, where it was stated that "some new findings lead us [the Catholic Church] toward the recognition of evolution as more than an hypothesis" (1996). In brief, despite the fact that the Catholic Church has publicly stated that scientific discoveries do not conflict with the Church's theology, this remains true at a somewhat abstract level. But when the issue is put to an individual member of the Church, the abstractions may fade away.[8] Hence, while it may be advisable to avoid the *conflict* position when dealing

[8] On this point, it may be useful to recall the *demarcation problem* in philosophy of science – the endeavor to delineate what counts as science proper, and what is just pretend-science. Without delving into this debate any further, it may be useful to apply a similar consideration when it comes to demarcating (or defining) religion. Even if we can define what Catholicism is, what Lutheranism

with the science-religion relationship in the abstract, it is rather unavoidable when it comes to personal encounters of the same.

Going back to consider Barbour's position after this objection, it boils down to the fact that his taxonomy operates on a very abstract level. When individuals become aware of the science-religion relationship, they do so on a far more personal level than the model proposed by Barbour. However, it is not certain that any of Barbour's competitors do better here.

At the end of *Inside Out*, the five main emotions are reunited – with a twofold realization. First, Riley's memories – and emotions alike – are multifaceted: there may be more than just one emotion in charge. Second, no one emotion can be fully in charge – at least, not all the time. As noted above, this is shown by the memory tokens changing from single-color to dual-color tokens. To expand on the need for the full panoply of options, let us go back to the film. Throughout *Inside Out*, the five-emotion control of an individual with just one in charge (as depicted in Act 1 of *Inside Out*) was adequate for Riley's preadolescence. However, it became inadequate for Riley's adolescent world: at the end of the film, the control panel that allowed only one emotion to be in control gets replaced with a panel where each of the five emotions can provide inputs. (And this is also more in line with how the adults' control panels are depicted in the film.) By analogy, Barbour's four-category model for the science-religion relationship may (or does) serve as a starting point, even if it cannot survive the subsequent criticism. Moreover, given the nature of specific religions, we see that just as all the five emotions were needed, so are all the four categories in Barbour's model.

We will return to address these considerations below (Section "Final Assessment"). But before that, let us focus on some practical issues when it comes to employing the approach of teaching about Barbour's taxonomy using an animated film.

Regarding the Practicalities

I propose earlier that the film *Inside Out* can be employed for teaching about a particular model (Barbour's) of the science-religion relationship. As with any proposals, there are both advantages as well as liabilities.

is, or what any of the world religions is, this is very much in the abstract. But what about religion as it is experienced on the personal level? In his seminal book, *Varieties of Religious Experience*, William James argued that any definition of religion was arbitrary. For the purposes of his own lectures, he proposed the following: "Religion, therefore, as I ask you arbitrarily to take it, shall mean for us the *feelings, acts, and experiences of individual men in their solitude, so far as they apprehend themselves to stand in relation to whatever they may consider the divine*" (James 1958[1902], 42; emphasis in the original).

Advantages

An obvious advantage of employing this particular method is that it makes it easier to convey abstract theoretical concepts – such as Barbour's science-religion taxonomy – in terms that are more accessible. The method may be geared toward younger audiences (secondary students, rather than postsecondary students), but this should not be viewed as "dumbing down" the subject matter. In fact, this is one of the cornerstones of public philosophy: making complex ideas available to the general public who have no formal background in philosophical discourse, in general, and very little knowledge of technical philosophical jargon, in particular. To quote William Irwin on this point:

> Whatever one thinks of the role of jargon in scholarly writing, its place should be minimal in popular writing. If physicists can write books of popular science with virtually no equations, philosophers can write books for a general audience with limited jargon. In fact, it is a common experience that being compelled to write that way can lead to a deeper understanding on the part of the writer (Irwin 2014:183).

Moreover, being able to convey an issue to the audience without resorting to technical jargon offers advantages that can be easily utilized in a more advanced discussion of the issue. If the audience is at a loss when it comes to understanding the basics of the topic, this undermines the possibility for building up on the basics.

As I argue above, the method in question is also reciprocal in that the moral of the story from *Inside Out* can be played back to the theoretical concept, providing the germs for advancing the discussion beyond just painting the picture. In brief, although the method may not convey a polished version of Barbour's taxonomy, it allows for a first draft version to be conveyed in easy-to-understand terms; although the picture that this method paints may be inexact or indistinct, it may well be that this is precisely what is needed in taking the first steps.[9]

Liabilities

Problem with Familiarity

The main obstacle in using *Inside Out* in teaching about Barbour's model is that it rests on the assumption that the audience is familiar with the movie. For if the audience has not seen the film, now there is the problem of explaining one unfamiliar item (Barbour's model) in terms of another unfamiliar item. The assumption that the audience has seen the film is not entirely unwarranted, though. The film was released in 2015, and based on box office results, *Inside Out* ranked fourth in US total gross,

[9] On this point, Wittgenstein's remark about concepts with blurred edges is most instructive: "Is it even always an advantage to replace an indistinct picture by a sharp one? Isn't the indistinct one often exactly what we need?" (Wittgenstein 1953: §71a).

and seventh in worldwide total gross sales.[10] Admittedly, this issue is easily addressed by arranging a viewing of the film (or, some of the key scenes) in conjunction with the presentation. In fact, I employed the latter approach when I introduced Barbour's taxonomy in my "Science and Religion" seminar in Spring 2017, where out of the ten students in total, only two students had seen the film, but an additional four either knew about it or had heard about it.

Problem with Time Limitations

As with any popular culture item, there are time-based limitations, which can exacerbate the familiarity problem. While employing a popular film from 2015 in class presentations for a few years afterward is straightforward, the familiarity will decrease over time. From a personal experience, I recall that when I was an undergraduate philosophy major in late 1990s, I found my instructors' references to *Star Trek* quite congenial; having grown up watching (nearly all) the episodes of *Star Trek* and *Star Trek: The Next Generation*, I had no problems understanding my professor's reference to transportation (when discussing Derek Parfit's *Reasons and Persons* where he employs a similar example) or to Mr. Spock's comments of how "the needs of the many outweigh the needs of one" (in discussing the various formulations of John Stuart Mill's *happiness principle*). However, and as I have learned the hard way when employing these examples in my own teaching repertoire, these references have not aged well. For the current generation of students, references to Captain Kirk or Mr. Spock are more likely to invoke thoughts about the 2009 reboot of the *Star Trek* franchise (which, to date, includes three films), rather than about the original TV series from the 1960, never mind the fact that the latter has thrived in syndication. Again, this problem could be remedied by arranging a viewing of the film in conjunction with the presentation – other practical problems notwithstanding, of course.

"What's the Point?"

Another difficulty in employing this method is how to ensure that the audience gets the message?[11] In this particular case, the question is how to ensure that references to *Inside Out* illustrate points about Barbour's classification of the science-religion relationship. Put more bluntly, after employing this approach, how can I (as the instructor) ensure that the students receive the message I want to convey, instead of just thinking: "Yeah – we just watched *Inside Out* in the class this week."

---

[10] Source: http://www.boxofficemojo.com/yearly/chart/?yr=2015&p=.htm and http://www.boxofficemojo.com/intl/weekend/yearly/?yr=2015&p=.htm. Information courtesy of Box Office Mojo. Used with permission

[11] My exploring of this point was prompted by an audience comment at the "Science and Religion in Education" Conference in October 2016.

Even after having employed this particular approach, and having encountered comparable responses, I do not find this objection to be particularly damaging to this approach. Instead, I see it as a *general* problem that extends far beyond this particular instance. That is, this is not a problem unique to my approach of using *Inside Out* as an illustration of Barbour's model of the science-religion relationship. If I have this problem, then so do many others, who use a popular culture item X to illustrate a concept Y in their teaching. However, given that this practice has persisted for quite some time, there seems to be very little substance to this objection. After all, the point of employing this approach (be it on this topic, or on some other) is not just to have a film day; viewing of the film is not the main oeuvre, but the hook.

Interpretation Problem

As I discuss earlier, I have a particular interpretation of Barbour's model in mind, when I employ this method. To recap, in using the film *Inside Out* to teach about Barbour's model of science-religion relationships, my goal is to offer an explanation of a new abstract concept in terms of something with which the audience is familiar. But in doing so, I seem to run headfirst into the problems of ostensive definition. Ludwig Wittgenstein articulated this problem in the following:

> If the definition explains the meaning of a word, surely it can't be essential that you should have heard the word before. It is the ostensive definition's business to give it a meaning. Let us then explain the word "tove" by pointing to a pencil and saying "this is tove". […] Now the ostensive definition "this is tove" can be interpreted in all sorts of ways. […] The definition then can be interpreted to mean:
>
> "This is a pencil",
> "This is round",
> "This is wood",
> "This is one",
> "This is hard", etc. etc. (Wittgenstein 1958, 2).

Thus, if the intended definition is not spelled out, the ostensive definition – whether using a pencil or a reference to a popular culture item – may be interpreted in various ways. This problem would admittedly be a significant one, albeit – again – not unique to my method.[12]

Besides, as a lesson on Barbour's model is unlikely to consist merely of viewing of the film, ways for addressing this problem are rather straightforward. Instead of expecting the students to draw the conclusions just after viewing the film, they can be directed to the intended interpretation quite easily. And besides, discussing the alternative interpretations is second nature to philosophy instructors.

[12] Without trying to be coy, the aphorism by Antonio Porchia captures this difficulty well: "I know what I have given you, but I don't know what you have received."

Dilution Problem

In attempting to illustrate a complicated concept (such as the science-religion relationship) by connecting it with a popular film (here, *Inside Out*), one runs the risk of inviting critics to dismiss such approaches offhand. An attempt to popularize philosophy will be to the detriment to the discipline and the intellectual rigor that it demands. Or that's what some critics are inclined to claim.

Above (in Section "Source Materials" and again in "Problem with Time Limitations"), I discussed my motivations for taking this approach, and I noted that I am not alone – not by a long shot – in employing popular culture items in explaining the (frequently abstract and often obscure) philosophical concepts. As an undergraduate student, many of the more memorable illustrations of these concepts provided by my instructors came from popular culture examples. What may have started as a cottage industry among philosophy instructors – a long time ago – has resulted in commercially successful genre. To borrow from William Irwin (again):

> Some people complain that we [the editors and authors of the "Philosophy and Popular Culture" series] should write books on more serious popular culture topics, such as *The Tudors*, but this misses the point as well. The goal is not to highlight or educate people about what is best in popular culture. We take the public's taste as a given, from their love of *The Simpsons* to their fascination with *The Matrix*, and start from there. Certainly we could write very good books on obscure art-house films like *Pi* or *Precious*, or TV series like *The Wire* or *Deadwood*, but the audiences were quite small in television and cinema terms and we would not reach the intended audience. We would be preaching to the converted. So publishing those books would not be in line with the mission of reaching as many varied people as possible with philosophy (Irwin 2010: 50).

Final Assessment

At the end of this chapter, let us take stock on where we stand. So far, I have presented one way for illustrating (and, depending on the audience, introducing) Ian Barbour's model of the science-religion relationship, highlighted some of the complications therein, and suggested a way to make revisions.

In my own experience, virtually any method I have attempted in my near decade of teaching the seminar "Science and Religion" has been successful – to an extent. Having tried out different ones, I cannot guarantee that this one fares any better. Still, this may be the best I can ever hope. Thus, when it comes to using Barbour's taxonomy of the science-religion relationships, I can say that it is a starting place that is very conducive for further developments.

In this sense, I have (at most) offered a qualified defense for using Barbour's model using my particular approach. However, Alister McGrath addresses some of these issues in the following:

> What difficulties are raised by this simple taxonomy? The most obvious is that it is inadequate to do justice to the complexity of history. […] It is difficult to refute this point. Barbour's fourfold scheme is useful precisely because it is so simple.
>
> Yet its simplicity can be a weakness, as much as a strength (McGrath 2010: 49).

I find that it is precisely for this reason that Barbour's simple taxonomy has become – and remains – popular: it makes an excellent, even if simplistic, starting point for the inquiry. And it is for this reason that its shortcomings in other aspects, as highlighted by plenty of critics, make it a better alternative than some of the other taxonomies. For example, take Mikael Stenmark's *How to Relate Science and Religion* (2004), which offers a multi-dimensional model, including practical, ethical, and ideological dimensions; in contrast, Barbour's taxonomy is not sensitive to these distinctions. Nevertheless, while Stenmark offers a model that is more nuanced than Barbour's, it is worthwhile to note that the former is built up from aspects of the latter – including both the successes and the shortcomings of Barbour's taxonomy.

And analogous cases are plentiful: it is for a similar reason why Rene Descartes's *Meditations on First Philosophy* is invariably included as required reading in virtually any introductory course to philosophy or why virtually any introductory physics course begins with Newtonian, rather than Einsteinian, mechanics. It is not because the aforementioned works by these authors got everything right but because these works provide an accessible entry point, and from this point onward, it is possible for the students to pursue their investigation further – should they be so inclined. In closing – and having enjoyed the benefit of presenting an earlier version of this chapter at the "Science and Religion in Learning" conference at Oxford – I submit it might be fitting to conclude in the words of a former Oxonian, philosopher J. L. Austin:

> Certainly, then, ordinary language is not the last word; in principle it can everywhere be supplemented and improved upon and superseded. Only remember, it is the first word (1979: 185).

And just as with Austin's claim about ordinary language, so with Barbour's claim about the fourfold taxonomy: even if we take these claims as the first word, that doesn't mean we have to take them as the last one.

Bibliography

Austin, J. L. (1979). *Philosophical papers* (3rd ed.). New York: Oxford University Press.

Barbour, I. (1997). *Religion and science: Historical and contemporary issues* , rev.ed. San Francisco: HarperCollins.

Barbour, I. (2000). *When science meets religion*. San Francisco: HarperCollins.

Cantor, C., & Kenny, C. (2001). Barbour's fourfold way: Problems with his taxonomy of science-religion relationships. *Zygon, 36*(4), 765–781.

Docter, P., & Del Carmen, R. [co-directors] (2015). *Inside Out* [motion picture]. United States: Disney/Pixar.

Hume, D. (2007[1779]). *Dialogues concerning natural religion*. Cambridge: Cambridge University Press.

Irwin, W. (2010). "Fancy taking a pop?" *The Philosophers' Magazine*, 2nd Quarter: 48–54.

Irwin, W. (2014). Writing for the reader: A Defense of philosophy and popular culture books. *Essays in Philosophy, 15*(1), 177–185.

James, W. (1958[1902]). *The varieties of religious experience*. New York: The New American Library, Inc.

LASAR ("Learning about Science and Religion") Project. (2016). *Science and religion in education conference 2016*. http://lasarcentre.com/science-and-religion-in-educationconference-2016/. Retrieved March 27, 2017.

Manninen, B. (2016). Suffering and soul-making in Disney/Pixar's Inside Out. *Journal of Religion and Film*, 20(2), http://digitalcommons.unomaha.edu/jrf/vol20/iss2/37.

Pope John Paul II. (1996). *Message to the pontifical Academy of Sciences: On evolution*. http://www.ewtn.com/library/papaldoc/jp961022.htm. Retrieved March 30, 2017.

Sirvent, R., & Reyburn, D. (2015). Inside Out and philosophy: What does it mean to be okay?. *Andphilosophy.com: The Blackwell Philosophy and Popular Culture Series.* https://andphilosophy.com/2015/11/07/inside-out-and-philosophy-what-does-it-mean-to-beokay/. Retrieved March 25, 2017.

Smedes, T. (2008). Beyond Barbour or back to basics? The future of science-and-religion and the quest for unity. *Zygon, 43*(1), 235–258.

Stenmark, M. (2004). *How to relate science and religion: A multidimensional model*. Grand Rapids: Michigan Eerdmans.

Wittgenstein, L. (1953). *Philosophical investigations* (3rd ed.). Englewood Cliffs: Prentice Hall.

Wittgenstein, L. (1958). *The blue and the brown books*. New York: Harper & Row, Publishers.

Tuomas W. Manninen is a Senior Lecturer in the School of Humanities, Arts and Cultural Studies at Arizona State University, where he regularly teaches courses in social/political philosophy, science and religion, and critical thinking – with particular emphasis on how these issues relate to contemporary events. Much of his research focuses on conveying philosophical themes in popular culture both to his students and to general audiences alike. Dr. Manninen has contributed chapters to *Philosophy and Terry Pratchett*, *Doctor Strange and Philosophy*, and other volumes in the Philosophy and Popular Culture genre. He earned his PhD in Philosophy in 2007 from the University of Iowa.

Chapter 4
Beyond Barbour: A Theology of Science from Ancient and Modern Thinkers

Tom C. B. McLeish

Assumptions Beneath the Categories: A Teleological Alternative

The Barbour categories have undoubtedly set a framework of unprecedented power and fruitfulness for the relational discussion of science and religion in the latter half of the twentieth century. However, as Ian Harrison (2015) points out in his recent book *The Territories of Science and Religion*, the very implied notion that science and religion *are* two 'territories' whose relationship might potentially be characterised by one of Barbour's four relations is itself a historically relative position. Harrison's metaphor of a mediaeval war between 'Israel' and 'Egypt' serves to remind us to question the essential relational assumption: are there really two ontologies (or epistemologies) of sufficient equivalence to bear any set of relational categories as potentially applying (there were no such separate territories, of course, in that period; the land currently assigned to these nations was then part of a single, Ottoman, empire)?

Conflict, independence, dialogue and integration are all candidates for *X* within the parsed sentence: 'a relationship of *X* characterises the relationship of science and religion'. Easily overlooked, the conjunction *and*' does much more work here than is apparent. Suppose 'and' is not the appropriate conjunction? It situated its two co-relatives to the same category (red *and* blue), it implies a liminal or at best overlap zone between them ('north' and 'south'), and it may already bias the discussion into oppositional mode ('rich' and 'poor'). Do science and religion have 'domains' of discussion? Are those domains distinct, overlapping or opposed? The first question can be answered affirmatively, but only universally. There is nothing that science is not prepared, to some degree, to talk about, for all talk has neurological

T. C. B. McLeish (✉)
Department of Physics, University of York, York, UK

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_4

and psychological correlates. The same is true of religion; whatever language one uses – 'Kingdom of God', 'God's world' – never excludes. So the second question runs into problems. Other conjunctions are possible that do much greater justice to the history and philosophy of science, and also to the cultural narratives of theology. A strong candidate is *of*, and the appropriate question now becomes 'what is a theology of science?' and its complement 'what is a science of theology?'[1]

The first of this couple of mutually-nested relations leads to a teleology, a story of purpose. A theology of science will describe within the religious narrative of a tradition what the work of science is *for* within that greater narrative. There have been examples, or partial examples, of this rich seam of questions asked of, for example, music (Begbie 2000) and art (Wolterstorff 1997). Note that working through a teleology of a cultural art by calling on theological resources does not imply a personal commitment to that theology – but might simply respond to the increasing restriction of academic thinking about purpose to departments of theology and religion. Intriguingly, it appears that some of the social frustrations that science now finds itself in result from missing, inadequate or even damaging cultural narratives *of* science.

In a search for a persuasive and practical theology *of* science, I first review, in section "Modern narratives of despair", some contemporary social science that unearths very different narratives that are eroding science within the public view. Section "A lost tradition: Narratives of hope in the biblical wisdom tradition" draws on what, at first, might seem an unlikely source of new narratives – the tradition of *Old Testament* Wisdom material. In particular the book of Job will prove extremely rich and relevant. Section "Historical transmission: Mediaeval and early modern teleologies of science" summarises briefly how this tradition of Biblical nature wisdom motivated the development of science in the Christian West from the high Middle Ages to the rise of early modern science. Finally in section "A theology of science and its consequences", I will draw on the sociological, theological and historical material to suggest how a theology of science may be crafted, which transcends Barbour's categories and which motivates a very different approach in education, politics, the media and the church.

Modern Narratives of Despair

A helpful exemplar with which to explore how we narrate science is given by nanotechnology – the application of material phenomena at length scales 10–100 times the atomic and its special property of self-assembly. In 2009, a major three-year European research project reported on a narrative analysis behind the ostensibly technical public debate evaluating risks and acceptability of nanotechnology. Their project report, *Recovering Responsibility* (Davies et al. 2009), tells a very different

[1] We will not be considering the second of these in the current chapter, but it encompasses the anthropology and neuroscience of religion, for two examples.

story to that of the claims and counterclaims of official public consultations. Its powerful application of qualitative social science unearthed underlying 'narratives of despair' – stories that permeate the debate – without necessarily surfacing within the superficial technical discussion. Identified by philosopher Jean-Pierre Dupuy (2010), they draw on both ancient and modern myths, and create an undertow to discussion of 'troubled technologies' that, if unrecognised, renders effective public consultation impossible. The research team labelled the narratives as follows:

1. Be careful what you wish for – the narrative of desire.
2. Pandora's box – the narrative of evil and hope.
3. Messing with nature – the narrative of the sacred.
4. Kept in the dark – the narrative of alienation.
5. The rich get richer and the poor get poorer – the narrative of exploitation.

The first three narratives of Dupuy unite in an 'ancient meta-story', the last two in a 'modern meta-story'. It is at first rather astonishing to find as superficially modern a set of ideas as nanotechnology awakening such a powerful set of ancient stories but would become less so in the light of a claim that the problematic engagement of the human with the material draws on ancient thought, sacred texts and stories.

Surveying briefly how they play out, new technologies, especially those whose functions are hidden away at the invisible molecular scale, have made exaggerated claims of benefits: longer, healthier lives at low cost, self-repairing materials and so on. But such hubris elicits memories of overpromising, so *be careful what you wish for*. The story of *Pandora's box* enters at this point; as another tale of released troubles, nanotechnology also implies irreversibility in both knowledge gained and in the environmental release of nanoparticles. The third 'ancient narrative' is a fascinating and perplexing one. Why would a secular age develop a storyline that warns us away from *messing with nature* because of its sacred qualities? The surge of secularisation has been charted, in the last century, in social theory from Emil Durkheim and in political philosophy from Hannah Arendt (1958) and others in our own. But 'the sacred' persists both within and without official religious communities. The fourth narrative of being *kept in the dark* speaks of asymmetries in political power between the governing and the governed. The fifth, of *the rich get richer and the poor get poorer*, extends the fourth: with exclusion comes lack of access to the benefits of knowledge and, worse, unequal exposure to their harmful consequences, for example, the resistance to GM crops in India (McLeish 2015).

The European nanotechnology study is interesting because through its unearthing of the fundamental importance of underlying narrative, it highlights in the most lurid possible contrast that science itself has no such source to draw on – *there is a narrative vacuum where the story of science in human relationship with nature needs to be told.* What might happen to public debate on contentious science and technology if there were an active ancient narrative that was more positive in its story of science? A candidate for such a narrative appears in George Steiner's deeply felt discussion of meaning and language, *Real Presences*, where he writes strikingly about the purpose of art: 'Only art can go some way towards making accessible, towards waking into some measure of communicability, the sheer inhuman otherness of matter …' (Steiner 1989 pp175ff). To a scientist this attempt at a teleology of art is striking. For surely a core function of science is precisely to establish some 'accessibility' communication between our minds and the 'sheer inhuman otherness of matter'. This 'narrative clue' turns out to resonate with much more ancient themes.

A Lost Tradition: Narratives of Hope in the Biblical Wisdom Tradition[2]

The ancient and rich book of Job offers a salient Biblical starting point for a narratology of the human relationship of the mind with physical creation. Long recognised as a masterpiece of ancient literature, Job has attracted and perplexed scholars in equal measures for centuries, and it is still a vibrant field of study right up to the present day. David Clines, to whom we owe the translation employed here, calls the book of Job 'the most intense book theologically and intellectually of the Old Testament' (Clines 2014). Job has inspired commentators across vistas of centuries and philosophies, from Basil the Great to Emmanuel Levinas. Its relevance to a discussion of the relation of science and theology is immediately apparent from the point at which God finally responds to Job in chapter 38v4[3]:

Where were you when I founded the earth?
Tell me, if you have insight.
Who fixed its dimensions? Surely you know!

The writer delineates a beautiful development of the core creation narrative in Hebrew wisdom poetry – a form found in Psalms, Proverbs and some of the prophets that speaks of creation through 'ordering', 'bounding' and 'setting foundations' (Brown 2010) – but now in the relentless urgency of the question-form, the voice continues by sharpening its questions, first, towards the phenomena of the atmosphere (38v22):

Have you entered the storehouses of the snow?
Or have you seen the arsenals of the hail,
…
The voice then directs our gaze upwards to the stars in their constellations, to their motion and to the laws that govern them (38v31):

Can you bind the cluster of the Pleiades, or loose Orion's belt?
Can you bring out Mazzaroth in its season, or guide Aldebaran with its train?
Do you determine the laws of the heaven?
Can you establish its rule upon earth?
…

[2] The argument here is a condensed form of the analysis of the book of *Job* in McLeish (2014).

[3] We take quotations of the text from the magisterial new translation and commentary by Clines (2014).

The questing survey next sweeps over the animal kingdom, then finishes with a celebrated 'decentralising' text that places humans at the periphery of the world, looking on in wonder at its centre-pieces, the great beasts Behemoth and Leviathan. This is an ancient recognition of the unpredictable aspects of the world: the whirlwind, the earthquake, the flood and unknown great beasts. Even these short extracts from the longer poem give something of the impressive, cosmic sweep of this text. In today's terms, we have, in the Lord's answer to Job, a foundational framing for the primary questions of the fields we now call cosmology, geology, meteorology, astronomy, zoology, etc. Without anachronism, we can, however, recognise an ancient and questioning view into nature unsurpassed in its astute attention to detail and sensibility towards the tensions of humanity in confrontation with materiality.

There is another reason that scientists today find this passage in Job so resonant – its *question form*. For we know that the truly essential and imaginative task in scientific discovery is not the finding of answers but the formulation of the fruitful question. The question, to which Chapter 38 is the answer, is the equally magisterial 'Hymn to Wisdom' of Chapter 28, which begins with a remarkable metaphor for human perspicuity into the structure of the world – that of the miner:

Surely there is a mine for silver, and a place where gold is refined.
Iron is taken from the soil, rock that will be poured out as copper.
An end is put to darkness, and to the furthest bound they seek the ore in gloom and deep darkness.
A foreign race cuts the shafts; forgotten by travelers, far away from humans they dangle and sway.
That earth from which food comes forth is underneath changed as if by fire. Its rocks are the source of lapis, with its flecks of gold.
The underground world takes us completely by surprise – why did either an original author or a later compiler suppose that the next step to take in the book was down a mineshaft? Reading on,
There is a path no bird of prey knows, unseen by the eye of falcons.
The proud beasts have not trodden it, no lion has prowled it …

There is something uniquely human about the way we fashion our relationship to the physical world. Only human eyes can *see* the material world from the new viewpoint of its interior. It is an enhanced sight that asks questions, that directs further exploration and that wonders.

The conclusion of the hymn points to the shocking parallel of the human wisdom of the miner and the divine wisdom of the Creator (28v23):

But God understands the way to it; it is he who knows its place.

For he looked to the ends of the earth, and beheld everything under the heavens, So as to assign a weight to the wind, and determine the waters by measure, when he made a decree for the rain and a path for the thunderbolt – then he saw and appraised it, established it and fathomed it.

It is by no means true that the wisdom hymn concludes that wisdom has nothing to do with the created world, for the *reason* that God knows where to find it is precisely because he ‘looked to the ends of the earth, …, established it and fathomed it’. It is, as for the underground miners, a very special sort of looking – involving number (in an impressive leap of the imagination in which we assign a value to the force of the wind) and physical law (in the controlled paths of rain and lightning). This is an extraordinary claim: that wisdom is to be found in participating with a deep understanding of the world, its structure and dynamics.

A reading of the entire book reveals that it continually navigates possible relationships between the human and the material, throughout the cycles of speeches, the Hymn to Wisdom and the Lord’s Answer (McLeish 2014). There are six alternatives presented through the various actors of the story. First is the ‘simple moral pendulum’ of Job’s ‘friends’ – the story of nature as both anthropocentric and driven by a moral law of retribution. Second is the ‘eternal mystery’ – the story that speaks of God’s exclusive understanding of nature’s workings in ways that humans can never know. Third is the contrasting idea of the ‘book of nature’ – the story in which nature constitutes a giant message board from its maker for those who have eyes to read it. Attaining its height in Elihu’s speech, humans are central to this relationship just as are pupils in a classroom (but this classroom belongs in a kindergarten, not a university). Fourth is the story of chaos: the uncontrolled storm, flood and earthquake. This is uniquely Job’s interpretation of his relationship with nature, but extrapolated in his anguish and exasperation. A fifth possible relationship with creation is made explicit (in denial) only once, by Job himself. It is the relationship of nature-worship.

A sixth storyline is hinted at, but it is not spoken with clarity. It hints at a balance between order and chaos rather than a domination of either. It inspires bold ideas such as a covenant between humans and the stones, thinks through the provenance of rainclouds, observes the structure of the mountains from below and wonders at the weightless suspension of the earth itself. It sees humankind’s exploration of nature as in *Imago Dei* and a participation in wisdom herself.

Remarkably, the first five perspectives map naturally onto the five ‘narratives of despair’ we met above (see under ‘Modern Narratives of Despair’):

1. Nature enshrines retributive moral law – *the narrative of exploitation.*
2. Nature is eternal mystery – *the narrative of alienation*.
3. Nature is a holy book to be read – *the narrative of the sacred.*
4. Nature is uncontrolled chaos (Job’s accusation) – *the narrative of evil and hope*.
5. Nature is an object of worship (Job’s denial) – *the narrative of desire*.

The sixth storyline, the search for wisdom through the perceptive, renewed and reconciliatory relationship with nature, begins to look like a potential source for a ‘missing narrative’ of nature in our own times. It is rooted in creation and covenant, rather than pagan or atheist tradition; it recognises reasons to despair but undercuts them with hope; it points away from stagnation to a future of greater knowledge, understanding and healing.

Historical Transmission: Mediaeval and Early Modern Teleologies of Science

We do not commonly ask today about purpose – it is academically awkward to do so in a secular environment – but that is a retrogressive feature of our times rather than a desirable norm. It also leads to serious misunderstandings of the history of science, for we tend to project the absence of teleology from our own times onto earlier epochs. Perhaps the most striking contrast between the mediaeval intellectual world and ours can be found in our differing teleologies.

An instructive and insightful example can be found in the work of the thirteenth-century polymath Robert Grosseteste. Master to the Oxford Franciscans in the 1220s and Bishop of Lincoln from 1235 to his death in 1253, Grosseteste wrote in highly mathematical ways about light, colour, sound and the heavens. His early science drew on the earlier Arab transmission of Aristotle into the 'twelfth-century renaissance' yet developed many topics well beyond the legacy of the ancient philosopher (he was the first, e.g. to identify the phenomenon of refraction to be responsible for rainbows). He also brought a developed Christian philosophy to bear upon the extraordinary period when natural philosophy was reawakening in Europe and developing the programmes of astronomy, mechanics and above all optics that would lead to early modern science (Cunningham and Hocknull 2016). It is of interest that this essential period, from about 1200 to 1600, receives so little attention in contemporary accounts of the history of science.

There are both simple and more sophisticated strands within Grosseteste's motivations to engage in natural science. On a delightfully straightforward level, at one point in his commentaries on the Psalms, he reflects that if the Bible chooses to convey truth to its readers through the illustrations of natural objects (trees, clouds, falling leaves, etc.) then it behoves us to discover as much as we are able concerning them, simply in order that we might better understand the scriptures. An application of this very direct thinking appears in an explanatory note accompanying his translation of John Damascene's *De Fide Orthodoxa*. Two chapters in the earliest manuscripts at his disposal, often omitted by earlier editors, concerned scientific topics that had no ostensible contact with the theological substance of the work as a whole. But Grosseteste reinstates both, explaining that:

These two chapters, namely the 24th about seas and the 25th about winds, are omitted in some Greek manuscripts; perhaps because they did not seem to contain a theological subject. But according to truly wise men, every notice of truth is useful in the explanation and understanding of theology.[4]

We see immediately the impressively connected philosophy of knowledge that drives his studies. Although he is perfectly able to distinguish theology and science, he takes the two as mutually dependent.

We cannot hope, however, to understand such a writer without recognising that his Christian worldview, and its story, provides the foundation for all his thoughts.

[4] Cf. Rome, Bibl. Vat., MS Chigi A.VIII. 245, f. 16va

For Grosseteste and his contemporary thinkers, the very possibility that we may grasp the order within the cosmos is that it and we are both created by God. Yet the incomplete and dulled nature of our understanding is one of the consequences of the 'fall', in which the Biblical story in *Genesis* of the first humans' disobedience mars our first innate abilities. Yet humankind is not abandoned by its creator, who becomes incarnate in the person of Jesus, initiating a process of healing towards a renewed future creation. In his *Commentary on the Posterior Analytics* (Aristotle' most detailed exposition of his scientific method), Grosseteste places a more sophisticated theological philosophy of science within this overarching Christian narrative of creation, fall and redemption. Employing a Boethian metaphor for the effect of the Fall on the higher intellectual and spiritual powers (in descending hierarchy those of understanding, memory, imagination) as a 'lulling to sleep' by the weight of fallen flesh, he maintains that the lower faculties, including critically the senses, are less affected by fallen human nature than the higher. Human understanding (*aspectus*) is now inseparable from human emotion and love (*affectus* – the disposition to be affected); the inward turning of the latter in our present state dulls the former. However, there is an avenue of hope that the once-fallen higher faculties might be reawakened: engaging the *affectus*, through the still operable lower senses, in the created external things of nature allows it to be met by a remainder (*vestigium*) of other, outer light. So, a process of re-illumination can begin once more with the lowest faculties and successively re-enlighten the higher:

Since sense perception, the weakest of all human powers, apprehending only corruptible individual things, survives, imagination stands, memory stands, and finally understanding, which is the noblest of human powers capable of apprehending the incorruptible, universal, first essences, stands![5]

Human engagement with the external world through the senses, necessary because of our fallen nature, becomes a participation in the theological project of salvation. Furthermore, the reason that this is possible is because this relationship with the created world is also the nexus at which human seeking is met by divine illumination. As a central example, the 'physics of light' grounded in the cosmogony of the *De luce* (*On light*) informs a 'metaphysics of light' as a vehicle to become a 'theology of light'. The implied restorative process that begins with an alertness to nature through our senses becomes one of Grosseteste's 'critical Aristotelian' moves. With Aristotle he insists that all knowledge of particulars and universals comes through the senses, but against Aristotle he allows this to be met with divine illumination. This double move even suggests a theological motivation for the novel combination of experiment and mathematics implied in his scientific works – in every case, it is at the meeting point of observed phenomena and mathematical reasoning that understanding is born.

The teleological employment of scientific investigation as an instrument of human participation in a reversal of the effects of sin in the fall is an idea that itself

[5] Robert Grosseteste *Commentary on the Posterior Analytics*, quoted in R.W. Southern (1992) *Robert Grosseteste; the growth of an English mind in medieval Europe*, Oxford: Clarendon Press p167

reawakens in the early modern period, especially (but by no means exclusively) in Francis Bacon's *Organum*, the philosophical articulation of early modern experimental science itself. Far from early modern science overthrowing everything Aristotelian and scholastic, the same narrative of new perception, sharpened by a reformed theology of Fall and Redemption, appears in Francis Bacon's motivation for experimental science (Bacon 1887):

The glory of God is to conceal a thing, but the glory of the king is to find it out: as if, according to the innocent play of children, the Divine Majesty took delight to hide his works, to the end to have them found out, and as if kings could not obtain a greater honour than to be God's playfellows in that game, considering the great commandment of wits and means, whereby nothing needeth to be hidden from them.

The educational consequences, in the light of the overwhelming counter-narrative that secular science overthrows any religious framing, are obvious.

A Theology of Science and Its Consequences

We can now draw together the threads from readings of ancient wisdom and historical reception and development of the motivational philosophy leading to modern science. Most of the constitutive themes of a 'theology of science', as a proposal to go 'beyond Barbour', have already emerged in our examination of Job and from our brief encounter with a mediaeval teleology of science. Taken together, they are (McLeish 2014):

- A long and linear history of engagement with nature.
- The surprising human aptitude for reimagining nature.
- The necessity of a search for wisdom as well as knowledge.
- The ambiguity and experience of pain.
- The delicate balance of order and chaos.
- The centrality of the question and the questioning mind.
- Above all, the experience of love.

Within all these themes, the theme of 'relationship' emerges constantly. Science experiences the negotiation of a new relationship between human minds and the physical world. The nature language of the Bible is consistently employed to describe and develop the relationship of care and of understanding between humans and a world that is both our home and also a frightening field of bewilderingly complexity. Although fraught with ambiguity, experiencing pain and joy in equal measure, knowing terror before the phenomenon of chaos as well as experiencing joy before the resplendent order of the cosmos, bewildered by ignorance yet granted a hard-won understanding, a Biblical theology of nature must be consistently relational.

These patterns are only amplified when refracted through a *New Testament* lens. Within his most painful correspondence (with Corinth), Paul, for example, rethinks the entire project of God's creation in relational terms, working around and towards the central idea of reconciliation. Arguing that those who have been baptised into the life with Christ can already view the world from the perspective of its future physical re-creation, he writes (2Cor v17):

Therefore, if anyone is in Christ – new creation; The old has gone, the new has come!
All this is from God, who reconciled himself through Christ and gave us the ministry of reconciliation:
That God was reconciling the world to himself in Christ.

The *ministry of reconciliation* is a stunningly brief encapsulation of the Biblical story of the purpose to which God calls people. I don't know a better three-word definition of Christianity, and it does very well as an entry point for *Old Testament* temple-based Judaism as well.

There is one relationship that tends to be overlooked in expositions of Christian theology – perhaps humbler than the more obvious broken human ones but just as profound. It is the relationship between humankind and nature itself. A theology of science, consistent with the stories we have told up to this point, situates our exploration of nature within that greater task. Science becomes, drawing on the ancient wisdom of Job, but within a Christian theology, the grounded outworking of the 'ministry of reconciliation' between humankind and the world. Far from being a task that threatens to derail the narrative of salvation, it actually participates within it. Science is the name we now give to the deeply human, theological task and ancient story of participating in the mending of our relationship with nature. We might summarise a *Theology of Science* as:

Science is the participative, relational and co-creative work within the Kingdom of God of healing the fallen relationship of humans with nature.

It is an extraordinary idea at first, especially if we have been used to negotiating ground between 'science' *and* 'religion', as if there were a disputed frontier requiring some sort of disciplinary peacekeeping force to hold the line. It also makes little sense within a view of history that sees science as an exclusively modern and secular development, replacing outworn cultural practices of ignorance and dogmatic authoritarianism with 'scientific method' and evidence-based logic. But neither of these assumptions stands up to disciplinary analysis on the one hand or to historical scholarship on the other.

Neither science nor theology can be self-authentic unless they can be universal. We need a 'theology of science' because we need a theology of everything. If we fail, then we have a theology of nothing. Such a theology has to bear in mind the tension that the same is true for science – it has never worked to claim that science can speak of some but not of other topics. Science and theology are not complementary, they are not in combat, and they are not just consistent – they are '*of* each other'. This is the first ingredient of a theology of science.

Just as there is no boundary to be drawn across the domain of subject, there is no boundary within time that demarks successive reigns of theology and science. It is just not possible to define a moment in the history of thought that marks a temporal boundary between the ‘prescientific’ and ‘scientific’ periods. The questioning longing to understand, to go beneath the superficies of the world in thought, to reconstruct the workings of the universe in our minds, is a cultural activity as old as any other. Furthermore, it is a human endeavour deeply and continually rooted in theological tradition. The conclusion is still surprising: far from being necessarily contradictory or threatening to a religious worldview in general, or to Christianity in particular, science turns out to be an intensely theological activity. When we do science, we participate in the healing work of the Creator. When we understand a little more of nature, we take a step further in the reconciliation of a broken relationship.

Does a theology of science do meaningful work for us? Does it provide any avenues to resolve the painful cross-currents around science in society? Does it suggest new tasks? These must be the test for any endeavour of this kind. We consider just one example here.

One leading contemporary commentator whose interest in the ‘politics of nature’ has not been marginalised is the French thinker Bruno Latour (2004). In a recent edited volume (Latour 2008), he explores the terrifying observation that ‘environmentalism’ has become a dull topic – with conclusions that are remarkably resonant with our own. They break down into four findings, in his own words: *a stifling belief in the existence of nature to be protected*, *a particular conception of science a limited gamut of emotions in politics*, *and finally the direction these give to the arrow of time.* This is a grand, overarching critique of the politics of nature, but even so, it homes onto the same narrative analysis as did the specific nanotechnology study we examined at the beginning. Latour’s identification of the ‘stifling’ move to withdraw all human corruption from a ‘Nature’ that should be maintained in some pristine condition is none other than the ‘messing with sacred Nature’ narrative by another name. He extracts the self-contradictory structure of this story of the Golden Age – nature reserves are artificial by definition. But the alternative ‘modernist’ trajectory is no less problematic. There the story is an overcoming of nature with control. We disengage from our environment, not through an ‘environmentalist’ dream of withdrawal from the sanctuary but through technological domination. Here Latour revisits the narrative of Pandora’s box because such a modernist hope is dashed on the rocks of the same increasingly deep and problematic entangling with the world that prevents withdrawal. Nature does not respond mildly to an attempt to control or dominate. So, neither narrative works both start with fundamentally misguided notions of the geometries and constraints of our relationship with nature.

Latour’s critique of the conception of science is equally resonant with the flawed view of the political process of debate around new technologies that we have already explored. Political action on scientific decisions is as paralysed by disagreement as it is by disengagement. Not every expert agrees that blood transfusion might transmit the AIDS virus – so we wait in inaction that condemns children to infection. There is no uniform view on the future trajectory of global warming and its connection with human release of carbon dioxide – so we meet and talk but do not implement. This is the ‘kept in the dark’ narrative with a twist – the political and public community self-imposes ignorance by demanding that scientists behave as a conclave, reading the same script and praying the same prayers, until the white smoke of majority expert agreement is released. The political life blood of a communally possessed and confident debate, widely shared and energised, respecting where specialist knowledge lies but challenged within a participating lay public, is simply not yet flowing in our national and international veins. At the close of his contribution to *Postenvironmentalism*, Latour makes an extraordinary move – one that meets our own journey head on. He calls for a re-examination of the connection between mastery, technology and *theology* as a route out of the environmental impasse.

The theological wisdom tradition we have been following, especially in the way that it entangles with the story of science itself, has brought us to the same point that Latour reaches from the perspective of political philosophy. One identifies the need, the other the motivation and resource, for a reengagement with the material world, and an acknowledgement that one unavoidable consequence of being human is that we have, in the terms of the book of Job, a 'covenant with the stones'. This extraordinarily powerful collision of metaphors surely points to the balanced and responsible sense of 'mastery' that Latour urges that we differentiate from the overtones of exploitative dominance.

Conclusions

Following a textual and historical thread – from ancient wisdom, through mediaeval and early modern thought, to contemporary debates on technology and environmentalism – points to a need for a teleology of science. This methodology also exposes the lack of any historical or philosophical support for the narratives around science so commonplace in educational settings today. Two current examples fall by the wayside. The first declares the scientific enterprise to be uniquely modern, the second that it is in irreducible conflict with religion, in general, and with Christian belief, in particular. Paradoxically, the restrictive framing assumption behind Barbour's categories has amplified, rather than resolved, these misconceptions. A relational narrative for science that speaks to the need to reconcile the human with the material, and that draws on ancient wisdom, contributes to the construction of new narratives that promise a healthier public discourse and an educational interdisciplinary project that is faithful to the story of human engagement with the apparently chaotic, inhuman materiality of nature.

References

Arendt, H. (1958). *The human condition* (p. 314). Chicago: University of Chicago Press.
Bacon, Francis (1887). In Spedding, J., Ellis, R. L., & Heath, D. D. (Eds.), *Works*. Volume III.
Begbie, J. (2000). *Theology, music and time*. Cambridge: Cambridge University Press.

Brown, W. H. (2010). *The seven pillars of creation*. Oxford: OUP.
Clines, David (2014). *World bible commentaries: Job.* Thomas Nelson pubs., Nelson, Vol. 3.
Cunningham, J., & Hocknull, M. (Eds.). (2016). *Grosseteste and the pursuit of religious and scientific learning in the middle ages*. New York: Springer.
Davies, S., Macnaghten, P., & Kearnes, M. (Eds.). (2009). *Chapter 12: Reconfiguring responsibility: Deepening debate on nanotechnology*. Durham: University.
Dupuy, J.-P. (2010). The Narratology of lay ethics. *NanoEthics, 4*, 153–170.
Harrison, P. (2015). *The territories of science and religion*. University of Chicago Press.
Latour, B. (2004) *Politics of nature: How to bring the sciences into democracy* (Catherine Porter, Trans.) Cambridge, MA: Harvard University Press.
Latour, Bruno (2008) "It's development, stupid !" or: How to modernize modernization. In Jim Procter (Ed.), *Postenvironmentalism.* MIT Press.
McLeish, T. (2014). *Faith and wisdom in science*. Oxford: OUP.
McLeish, T. C. B. (2015). The search for affirming narratives for the future governance of technology: reflections from a science-theology perspective on GMFuturos. In P. Macnaghten & S. Carro-Ripalda (Eds.), *Governing agricultural sustainability*. Oxon: Routledge.
Southern, R. W. (1992). *Robert Grosseteste; the growth of an English mind in medieval Europe*. Oxford: Clarendon Press.
Steiner, G. (1989). *Real presences*. London: Faber and Faber.
Wolterstorff, N. (1997). *Art in action; Toward a Christian aesthetic*. Grand Rapids: Wm, B. Eerdmans.

Tom C. B. McLeish, FRS, is a Professor of Natural Philosophy in the Department of Physics and also in the Centre for Medieval Studies at the University of York, UK. His research in 'soft matter and biological physics', is highly interdisciplinary, including industrial collaboration. He has published at academic and popular levels in theology/science and humanities/science issues including the books *Faith and Wisdom in Science* (OUP 2014) and *The Poetry and Music of Science* (OUP 2019). He is currently Chair of the Royal Society's Education Committee and a Trustee of the John Templeton Foundation.

Chapter 5
Beyond the Territories of Science and Religion

Emily Dumler-Winckler

The conflict thesis, the idea that science and religion compete for the same territory, that science *is* the modern religion par excellence, or that theology is not just queen but sole authoritative source for the sciences, remains prominent in education as in the public realm. But this view typically rests on mistaken assumptions about the nature of both science and religion. What we call religion and science in the modern era, and specifically since the mid-nineteenth century, are best understood as social practices that require the virtues for their perfection.

Beyond Barbour

Ian Barbour's fourfold typology for understanding the relation between science and religion (conflict, independence, dialogue, and integration), while it moves beyond the mere conflict thesis, does not offer much help (Barbour 2000). All four models depend on the same epistemological assumptions that undergird the conflict thesis. The main assumption is that science and religion are primarily characterized by distinct epistemologies. Science enables us to know facts, whereas religion is a source of values, beliefs, or superstitions, which do not provide such reliable knowledge about the world. Or so the story goes. Given this epistemological focus, the question frequently becomes: how do science and religion, facts and values, relate? Too often, this focus reduces both science and religion to bad epistemologies from the outset.

Consider briefly how this assumption of the distinct epistemologies underwrites all four models. The conflict model presumes that science and religion make

E. Dumler-Winckler (✉)
Department of Theological Studies, Saint Louis University, St. Louis, MO, USA
e-mail: emily.dumlerwinckler@slu.edu

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_5

mutually exclusive claims about the same domain. The object of inquiry is the same—for instance, how did the Earth become a place hospitable to human beings?—but because of their distinct methodologies, science and religion arrive at rival conclusions. The independence model assumes that, given the distinct domains, methods, questions, and even objects of each, science and religion work best when they work independently of one another. According to the dialogue model, any number of things (from similarities in presuppositions, methods, or concepts) may serve as the basis for a shared dialogue between science and religion. This model is an improvement on the others but leaves open the question of the similarity and the distinction between science and religion. One can embrace the dialogue model while maintaining a strict epistemological distinction between the two. Indeed, some contend for the necessity of dialogue because each needs the other: religion needs the facts of science; science needs the values of religion. The integration model holds that the insights of science and religion can be fully integrated, and yet, each type of integration (whether natural theology, theology of nature or process philosophy) depends on the assumption that one or the other of these two distinct epistemologies are primary. Integration is achieved by giving precedence to one and then incorporating the relevant insights of the other.

Each model, in different ways, depends on the assumption that science and religion are primarily characterized by distinct epistemologies—one more or less empirical or rational the other traditional or spiritual—that yield distinct epistemic products, the one being facts and knowledge and the other being values, beliefs, or superstitions. But, as we will see, there is a distinguished legacy of modern thinkers, including scientists or natural philosophers, theologians, and philosophers, who rightly resist distinguishing religion and science along these lines. Before we turn to this legacy below, we would do well to consider a quite different effort, by a more recent Gifford lecturer, namely, Peter Harrison's attempt to remap the *The Territories of Science and Religion* (Harrison 2015).

Beyond Harrison

Harrison has a tentative Wittgensteinian agenda.[1] His project seeks to liberate us from a certain picture of modern religion and science, namely, the conflict myth, which holds us captive. In this sense, he improves upon Barbour's narrowly

[1] (Harrison 2015, pp. 184–186) In a methodological note in the Epilogue, Harrison indicates the Wittgensteinian ambitions of his project. But what he tentatively gives with one hand, he immediately withdraws with the other. He doubts that these concepts will change or that the conflicts between them will go away. Of two influential approaches to intellectual history, this book seeks to offer a conceptual history [*Begriffsgeschichte*] rather than a contextual history (an approach advocated by Quentin Skinner and John Pocock). He sees certain advantages in this approach but seems less aware of the attendant dangers and weaknesses of the *Geistesgeschichte,* such as MacIntyre's and his own. Richard Rorty elucidates these dangers in "The Historiography of philosophy, four genres" (Rorty et al. 1984).

epistemological notions of science and religion, by seeking to provide a historical account of how such conceptions emerged in the first place. I wholly endorse this therapeutic effort. But if his project frees us from one picture, it holds us captive to another, equally mistaken and hopeless. It is a picture, moreover, that has captivated modern moral philosophers and theologians and now historians and philosophers of science for the past several decades.[2] For this reason, it deserves extended consideration. If Harrison is right (and I think he is) that the way forward for religion and science education depends on a better grasp of the history of these practices, then we will need a better historical narrative of these practices and their virtues than the one he provides.

Harrison charts a conceptual history from *scientia* and *religio* in the medieval period to the modern notions of science and religion (Harrison 2015, see Ch. 1). The former, which he characterizes as interior virtues, gave medievals dominion over their interior lives, whereas the latter which he characterizes as systems of propositional beliefs and exterior practices give moderns dominion over nature and the external world. But this narrative, which explicitly adopts Alasdair MacIntyre's story of the virtues' modern demise, rests on a mistaken understanding of medieval virtues, the persistence of virtue in the modern period, and the uses of these terms in both eras.[3] In his laudable attempt to portray modern science and religion as social practices, he creates new false dichotomies between the pre-modern and the modern eras and between virtues and practices, which ultimately do not illuminate the nature of or the relationship between science and religion. Specifically, Harrison's narrative rests on three mistaken claims: first, that *religio* and *scientia* are only or primarily understood in the medieval era as personal attributes or virtues (understood in Harrison's terms); second, that virtue is primarily a matter of interior dispositions rather than inextricably connected to exterior acts or expressions; and third, that modern religion is primarily characterized by propositional beliefs and practices devoid of virtue.

Harrison's claim that, in the medieval period, *scientia* and *religio* were understood primarily as virtues is a bit too constrained, especially according to Thomas Aquinas's account on which he draws heavily. Though no less true for both terms, it is especially striking in the case of *scientia*.[4] Harrison begins his account of "the

[2] See footnotes and the rest of this section for more about this prominent picture or narrative, which has its inception in Alasdair MacIntyre's story of the virtue modern demise. Harrison's extension of this narrative to the practices of religion and science remains unchallenged. Since the publication of his book, Harrison has been invited to lecture twice at the University of Notre Dame by the Notre Dame Institute for Advanced Studies, the Reilly Center, the Center for Theology, Science, and Human Flourishing, and is one the most prominent philosophers and historians of science.

[3] (Harrison 2015, pp. 184–85)

[4] (Aquinas 1981, p. II–II, Q. 81, A. 1–3) In Question 81, Article 1, Aquinas draws on Cicero's use of 'religio,' or 'relegit' meaning to read over again the things that pertain to the worship of God, Augustine's 'reeligere,' meaning to choose over again rather than neglect God, and "religare" [to bind together] whereby we are bound to God. Aquinas does not so much care which meaning of the term we adopt, since all of them properly denote a relation to God. In the following article he clarifies that *religio* may also be understood as the virtue whereby we pay due honor to God.

history of 'science'" with Aquinas, but not where Aquinas himself begins—namely, with a consideration of *scientia dei* and its relation to other *scientiae* (including *scientia divina* or natural philosophy and theology in *Summa Theologica* I.1). Rather, he begins with what Aquinas calls the virtue of *scientia*. "The parallel with *religio*," Harrison contends, "lies in the fact that we are now used to thinking of both religion and science as systems of [propositional] beliefs and practices, rather than conceiving of them as personal qualities… For Aquinas, however, both *religio* and *scientia* were, in the first place, personal attributes."[5]

But this is not quite right. "*Scientia*, for the medieval theologian," Victor Preller explains, "signifies both an immanent act or disposition of the knower, and an expression of that intentional state in intelligible propositional terms, unified under common principles of understanding. In human [as opposed to divine] terms, a 'science' is both a dispositional state of the scientist, and, by extension, the written or spoken expression of that state" (Preller 2005, p. 233). Harrison creates a division at precisely the point where Aquinas insists on a connection. It is only by contending that *scientia* is primarily a personal attribute, somewhat disconnected from propositional beliefs and practices, that Harrison can draw a contrast along these lines between the medieval and modern conceptions of science. But if the virtue of *scientia* is at least to some extent intrinsically connected to propositional expression, then Harrison's contrast between the pre-modern and modern eras will not do.

Not only is the depiction of *scientia* and *religio* as virtues too narrow, Harrison's account of these virtues creates additional false dichotomies which undergird the mistaken story of the virtue's modern demise. He draws too stark a contrast between virtue's interior dispositions and exterior acts or expressions. As we have seen, the two are more closely related in the case of *scientia* than Harrison conveys. Consider his depiction of Aquinas's virtue of *religio* and its relation to modern notions of religion:

[Aquinas] explains that in its primary sense *religio* refers to interior acts of devotion and prayer, and that this interior dimension is more important than any outward expressions of this virtue. Aquinas acknowledges that a range of outward behaviors are associated with *religio*—vows, tithes, offerings, and so on—but he regards these as secondary…. There is no sense in which *religio* refers to systems of propositional beliefs, and no sense of different religions (plural). Between Thomas's time and our own, *religio* has been transformed from a human virtue into a generic something, typically constituted by sets of beliefs and practices. It has also become the most common way of characterizing attitudes, beliefs, and practices concerned with the sacred or supernatural.[6]

Notice, the contrast between medieval *religio* and modern religion depends on opposing a moral virtue (annexed to justice) to sets of beliefs and practices. This is

[5] (Harrison 2015, p. 11) I added the term "propositional" before belief, because Harrison describes the contrast this way at several other points, and the Preller quote reveals the inadequacy of drawing the contrast between the medieval and modern use of these terms along these lines (7). As an afterthought to his consideration of the virtue, Harrison concedes that in the Middle Ages there were "sciences (*scientiae*), thought of as distinct and systematic bodies of knowledge" (13).

[6] (Harrison 2015, pp. 7–16)

the first clue that something in this description is amiss. For Aquinas, the moral virtues have everything to do with perfecting our beliefs and practices. More specifically, he contrasts *religio,* the virtue for Aquinas whereby we give God due honor (through *both* internal and external acts, as we will see) with attitudes, beliefs, and practices concerned with the sacred or supernatural. It is difficult to imagine how one could worship God, even if only through acts of devotion and prayer, apart from attitudes, beliefs, and practices.

It will help to consider each bit in turn. Harrison's claim, that "in its primary sense *religio* refers to interior acts" and that the interior dimension is "more important than any outward expressions of this virtue," draws the line between what Aquinas calls internal acts and outward expressions too starkly. Aquinas calls devotion and prayer "internal acts" because they direct the heart and mind to honor God, and as such these "belong to religion essentially" *(ST II-II* 81.7). But even these may entail outward expressions. For instance, common or corporate prayer is often vocal, and though individual prayer is not essentially vocal, Aquinas commends the practice (*ST II-II* 83.12). Still, internal acts take precedence over "external acts," which are secondary or subordinate in the sense that these—adoration, vows, tithes, sacrifices, and so on—are signs of the internal acts. Apart from proper devotion, tithes and sacrifices would be empty signs. That is, they would not honor God. And yet, the external act of adoration, whereby we humble our bodies before God, can inspire inward devotion, inciting our affections to worship and adore God. The internal and external acts of *religio* and the outward expressions of each are much more interrelated and interdependent than Harrison conveys.

Moreover, Aquinas makes clear at the outset of his consideration of *religio* that *both* the internal and external acts of religion are what he calls its "proper and immediate acts… by which man is directed to God alone" (*ST II-II* 81.1). And *religio* includes still other acts by commanding all of the virtues concerned with means toward the end of worshiping and serving God (*ST II-II* 81.1, 81.2.3, 81.3.1–2). Here Aquinas refers to James 1:27, "Religion that is pure and undefiled before God, the Father, is this: to care for orphans and widows in their distress, and to keep oneself unstained by the world."[7] At this point, it should be clear that even though the internal acts are essential to the virtue of *religio*, the outward expressions are by no means superfluous (*ST II-II* 81.7). Indeed, "*every deed*, insofar as it is done in God's honor, belongs to *religio*" (*ST II-II* 81.2.3, 81.3.2, emphasis mine).

Likewise, the claims that *religio* does not refer to a system of propositional beliefs and entails no sense of a plurality of religions, which he takes to characterize modern conceptions of religion, conceal more than they reveal. In a sense, both are true. But the first ignores the sense in which *religio* is, for Aquinas, intimately connected—through the theological virtue of faith (*fide*)—to propositional beliefs

[7] (*Bible NRSV* 2010) The contrast here is between the worthless religion or worship (θρησκεία) of those who consider themselves religious but do not keep a tight rein on their tongues and the true religion of those who worship God by caring for orphans and widows. The contrast is not between true interior religion and secondary exterior expression but rather between the outward expressions which serve as signs of the impious or devout heart.

about God. By *fide*, we participate in the *scientia dei* or "knowledge of God" which finds expression in propositions through "theological reflection on the 'cognitions of God' available to man on the basis of revelation (*sacra scriptura*)" (Preller 2005, p. 3). *Religio*, a moral virtue, and *fide,* an intellectual virtue, unite the mind of the believer with God, and so conform the believer to God's likeness (*ST II-II* 81.7).

Is Harrison on more solid ground when he claims that *religio* entails no sense of religions (plural)? Well, yes and no. In fact, *religio* assumes plurality in objects and manner of worship and perfects proper worship of the one true God. Its vice by excess is superstition whereby one "offers divine worship either to whom it ought not, or in a manner it ought not" (*ST II-II* 92.1). Thus, the distinction that moderns would later draw between true and false religion is quite similar to Aquinas's distinction between *religio* and superstition and proper and improper worship, albeit by different names.

We have seen that for Aquinas *scientia* and *religio,* considered as virtues, are not primarily or only interior dispositions disconnected from exterior acts in the ways Harrison suggests. In this light, consider the curious picture that he paints of the distinction between medieval and modern eras. "Whereas for Aquinas it was the 'interior' acts of religion that held primacy," he writes, "the balance now shifted decisively in favor of the exterior" (Harrison 2015, p. 11). Again, he repeats, "Between Thomas's time and our own, *religio* has been transformed from a human virtue into a generic something typically constituted by sets of [attitudes], beliefs and practices. *Scientia* has followed a similar course…" (Harrison 2015, p. 16). It is a decline narrative. The medieval virtues of *religio* and *scientia* are nowhere to be found in the wasteland of modernity. They have been displaced by propositional beliefs and attempts to gain dominion over nature.

Of course, the determinate content of the terms *religio* and *scientia,* considered *as* virtues, is distinct from their modern counterparts, "religion" and "science." That is, at some point, moderns stopped *using* these terms to refer to the virtues that perfect these activities, namely, giving honor to God and attaining demonstrable knowledge. But this does *not* mean that these virtues (habits) or the practices they perfect disappeared altogether.[8] Quite the contrary! The practices and virtues remain, even if by other names. If *religio* is a virtue that perfects those attitudes, beliefs, and practices, whereby we duly honor God, modern religion refers more generally to the attitudes, beliefs, and practices (whether characterized by virtues or vices, whether true or false, by whatever name) that pertain to the worship of God (the sacred or supernatural). I am suggesting that there is a certain continuity between the premodern and modern eras at precisely the point Harrison draws the contrast—namely, in the practices of natural philosophy, science, and divine worship and the virtues needed to perfect each.[9]

[8] It seems that the virtues Aquinas describes as *religio* and *pietas* (giving due honor to the sources of one's being— parents, country, teachers, etc.) are collapsed into the virtue of piety in the modern era. That is, piety was used to refer to proper honor of both God and parents, political community, etc.

[9] Arguing, rather than merely suggesting this point, is not something I can do in the scope of the present piece.

If Harrison's portrait misleads, in the epilogue, it takes on a more despairing hue. He is no apologist for re-conceptualizing science and religion. Far from moving beyond Barbour's typology, he reluctantly uses it to map the territories of science and religion, the current options for conceiving of their relationship. In his view, the integration model is an antiquated feature of the pre-nineteenth century period, one in which natural philosophy and natural history were subsumed by natural theology (Harrison 2015, p. 175). The conflict model is no better, for it depends on the sort of historical amnesia his work seeks to overcome (Harrison 2015, p. 19). The remaining two models—independence and dialogue—reinforce the assumptions animating the conflict myth. Given a different conceptual history, the conflict myth and its more compatibilist counterparts might have been (and might yet be) otherwise. Nonetheless, he doubts that we will be able to move beyond the territorial metaphor and provides no alternative for doing so.[10]

Instead, he borrows MacIntyre's famous analogy between modern moral discourse and the monks in Walter Miller's dystopic science fiction classic, *A Canticle for Leibowitz*. Harrison likens contemporary scholars, including philosophers and historians, but especially natural scientists, to the monks who have long lost the theoretical justification for the content of the disciplines they go on using. But whereas MacIntrye commends a return to a pre-modern conception of the virtues, Harrison offers no remedy whatsoever. We are left with a somewhat mistaken picture of how things got to be so bad and no reason to hope they might be better.

Harrison's narrative of the virtues' demise in modern science and religion threatens to reinforce two unfortunate trends in contemporary scholarship and education. Some think, as Harrison seems to in the epilogue, that a consideration of the virtues of modern science is simply a lost cause. If modern science and religion are no longer understood as virtues, they must be beyond the virtues' reach. Or so this story goes. Others are keen to consider the virtues of modern science. But, with Harrison, they assume that medieval reflection on the virtues can be of little assistance for this distinctly modern task.[11] Too much has changed. Indeed, our very notions of science and religion have changed. It is better to start anew. Both trends obscure the nature of science and religion and the virtues needed for their perfection. If rather science and religion (by whatever name) have always been socially embedded practices that require the virtues for their perfection, things are not so hopeless after all. One of the primary tasks of educators of science and religion today, as ever, is to help students cultivate the virtues of each. How, then, do we move beyond Barbour and Harrison?

[10] (Harrison 2015, pp. 177–79) See note 4 above on methodology and the limits of his approach.

[11] As of late there has been a growing interest in virtue epistemology, the intellectual virtues of science, and virtues in science education. But most of these thinkers give little sustained attention to the medieval scholastic consideration of the virtues, particularly that of Thomas Aquinas. In my view, these fields are impoverished for this lacuna. Prominent contemporary virtue epistemologists include Linda Zagzebski, Jason Baehr, Robert C.

Roberts, and Jay Wood. See Zagzebski 1996; Baehr 2012; and Wood 2015.

From Territories to Maps and beyond

To begin, I should say that I am not naive to the contemporary debates about what constitutes either science(s) or religion(s). They are disputed terms. But unlike some contemporary scholars, I do not think that their disputed status means that we should avoid all talk of religion and science, eschew any use of these terms whatsoever.[12] My own approach is to acknowledge this plurality and then clarify how I intend to use the terms and why I commend this use.

Modern or natural science[13] and religion, I suggest, are best understood as social practices with distinct aims and distinct means for achieving those aims.[14] As such, participants perfect the activities of either practice (or both practices) insofar as they cultivate the virtues needed to achieve the external ends and enjoy the internal goods those practices are designed to attain. For Aquinas, following Aristotle, a virtue is a habit "which makes its possessor good, and [her] work gook likewise" (*ST* I-II 55.3, 56.1). I will call those external and internal goods inherent to each practice innate goods. The internal goods and certain external goods of natural science and religion can only be attained and enjoyed through their respective practices.[15]

[12] Ristuccia contends that "If a historian plans to investigate cultural phenomena that are sometimes classified as religions… that historian has three choices. (1) Avoid the words 'religion,' 'religions,' 'religious' altogether." (2) "Supply a fiat definition at the start, in order to render the concept usable for one specific purpose… (3) Begin with an excursus… on all the possible meanings for 'religion' that existed in the time and place under consideration" (Ristuccia 2016, p. 75). He opts for the first in his own work but then argues that we might seek better, more accurate and useful, classifications. My own approach will be to acknowledge that there are contested usages and then clarify how I intend to use the terms and why I commend this use.

[13] I will use the term science throughout in a narrow sense to refer to the modern practices of natural science. Aware of the plurality of sciences that fall under the natural sciences, and the wide diversity of activities that comprise the practices of science so broadly conceived, I nonetheless us this term (and "scientist") to indicate the natural sciences broadly conceived.

[14] (MacIntyre 2007, p. 187) In using the terms "social practice" and "internal good," I follow MacIntyre's description of each when he writes, "By a 'practice' I am going to mean any coherent and complex from of socially established cooperative human activity through which goods internal to that form of activity are realized in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of, that form of activity, with the result that human powers to achieve excellence, and human conceptions of the ends and goods involved are systematically extended." But there are also goods external to the practice of science, for instance, that are also goods that can only be achieved through the practices themselves, such as control, prediction and explanation of natural phenomena. These external goods cannot be had through other practices, and yet they are not goods strictly internal to the practice of science itself. They are the ends at which scientific practice aims.

[15] (MacIntyre 2007, pp. 188–89) Internal goods are goods that cannot be specified or attained apart from a given practice. MacIntyre calls these goods internal because (1) "we can only specify them in terms of" the given practice and examples from that practice and (2) "they can only be identified and recognized by the experience of participating in the practice in question." I agree with the first point. As a non-scientist, I certainly do not presume to name all of the internal goods of modern science, and those I do name will have no great degree of specificity. For I will bump up against the precise limitations that kept MacIntyre from describing the internal goods of chess with greater specificity. Nonetheless, I disagree that internal goods can only be identified *by* practitioners of a

One of the chief aims of natural science is a particular sort of knowledge about ourselves and the world we inhabit. This particular sort of knowledge can only be attained through the various observational and interpretive practices of the sciences or by taking it on trust from those who do practice science.

The object of the natural sciences is knowledge about the natural world including human beings. What sets the practices of natural science apart from other contemporary practices and disciplines is its particular way of attending to nature and the particular sort of knowledge this activity yields. To some extent, scientific knowledge enables us to control, predict, and explain certain aspects of nature. For this reason, like a good road map, scientific knowledge can be quite useful for helping us to find our way about the universe we inhabit. But it can also inspire awe, wonder, and appreciation for beauty and a sense of the whole. In this way, scientific knowledge can be both an intrinsic and an instrumental good—a good in itself as well as one that we can put to various uses, some better, some worse than others.

But the practices of the natural sciences do not provide the only sort of knowledge we attain about ourselves and the natural world.[16] The practices of religion—which include philosophy, theology, and a host of communal practices—provide another. Religion has as one of its many innate goods a certain sort of knowledge about and disposition toward God or the sacred, ourselves, and the world we inhabit. Its end is to help practitioners live the good life, in right relationship with God, self, and others, by cultivating the virtues needed to make a home of the world. Natural science maps certain features of our world, but it does not acquaint us with many others. The knowledge it provides—whether geological, biological, or astrophysical—and the dispositions it cultivates do not necessarily help us discern how to live as moral agents in *all* aspects of our lives, within and beyond the laboratory. Participation in its activities and communities may help to cultivate a certain range of virtues, but not the full range, which enable a life of holistic flourishing. It may help us to navigate particular aspects of the world we inhabit, but it does not thereby make it entirely habitable. At its best, the practice of religion does the latter. Broadly speaking, its innate goods consist in learning to live as moral agents in right relation to the divine, ourselves, our fellow creatures, and the natural world.

We would do better, I suggest, to conceive of the natural sciences and religion as practices whereby the scientist and (or as) religious practitioner, as cartographers and fellow inhabitants of the landscape, map the natural world, than as distinct territories to be charted. This is not too far afield, we will see, from how the distinguished legacy I mentioned at the outset has conceived of modern science and religion. Because the map metaphor has a long controversial history, a disclaimer is

given practice. I concede that there are certain internal goods that a non-practitioner could not likely identify, but at a general level I do not see the difficulty. I will name certain internal goods of science and religion and encourage practitioners to augment these with greater specificity or reject them altogether.

[16] When I refer the practices of science throughout, I have in mind the natural sciences specifically as these are most often compared to religion and theology in contemporary debates. I do not then have in mind the broader notion of science and its comparison with the arts more broadly, though this distinction is certainly relevant to the contemporary debates as well.

in order. My use of the map metaphor has nothing to do with the correspondence theories of truth with which it is often associated.[17] I am not interested in the representative nature of maps, so much as the social practices that lead to their creation and use. Neither is my use of the metaphor meant to signal a vulgar relativism or constructivism. Indeed, the map metaphor is helpful insofar as it is not beholden to the realist and anti-realist epistemological concerns that animate defenders and detractors of the correspondence theory in the first place.

To achieve excellence in their respective aims, the natural scientist and religious practitioner will need a host of virtues. First and foremost, each will need the virtues that help her to identify and value the innate goods of each practice, the external goods and aims as well as the internal goods of the practice. Some will be practitioners of each, namely, religious scientists, in which case they will need to cultivate the virtues of both practices. The intellectual and moral virtues are necessary to perfect practitioners of each.[18] It is one thing to have the intellectual and moral virtues needed to attain scientific knowledge, but another to have the virtues needed to use that knowledge and power well. We might hope that scientists will attain the moral virtues required to refer the goods of science to the goods of the global community. The virtues that help the religious practitioner to properly identify and value innate goods are more intimately bound up with considerations of the common good from the start.

What virtues will the natural scientist need to achieve excellence in this practice, to attain scientific knowledge and enjoy its internal goods? They will need host of virtues, many of which may be more or less obvious. First and foremost, the scientist will need the virtues that help her to properly recognize and desire the internal goods of her practice, as well as the virtues needed to attain them, and finally, we might hope, the virtues required to refer those goods to the common good. Mistake fame or power for the innate goods of science and one is likely to care little about corrupt means, inaccurate publications, or the ends to which scientific knowledge is referred.

Ralph Waldo Emerson, an excellent, if unlikely, source for reflection on the virtues of science, considers self-trust the virtue in which all the virtues are comprehended and the chief virtue of genius.[19] In the case of science, self-trust assembles the virtues needed to resist temptations to abandon the goods proper to science: patience to do the slow thankless work of observation with no guarantee of honor; perseverance to endure obstacles long after others have quit; courage to pursue knowledge at the risk of personal sacrifice or against scholarly consensus; justice and affability needed for collaborative research; hope that one's work will contribute to the interests of humankind and that resists the despair of perceived failure;

[17] (Gardiner and Engler 2010) By "naive correspondence theory of truth" I have in mind the view that language corresponds to something non-linguistic and that truth should be understood in terms of accuracy of that representation.

[18] For more about the distinction and relation between the moral and intellectual virtues specifically in the practice of science see, Emily Dumler-Winckler (2018).

[19] (Emerson 2006, vols. 1, 2) See his lecture "The American Scholar" and essay "Self-Reliance" in essays first series.

trust that one's best inquiries and investigations will bear fruit in season. The point is not to provide an exhaustive list. Certainly, we should include the virtues of science, which perfect the intellect with regard to this or that genus of knowable matter. Acknowledging this diversity, Aquinas indicates that, "according to the different kinds of knowable matter, there are different habits [or virtues] of scientific knowledge" (*ST* I-II 57.2). In other words, *scientia* is not one but many virtues or habits that perfect the intellect's knowledge of various matters.

Because scientific knowledge is the object of the practice of science, its attainment will require the intellectual virtues that help scientists to attain that particular knowledge. Yet, because science is a social and communal practice and because all knowledge is mediated by culture, language, and the agents who know, its perfection will also require various moral virtues for its perfection. The point here is simply to show how the virtues, intellectual and moral virtues alike, enable scientists to achieve the ends and enjoy the internal goods of science.

With respect to religion, we might, following Aquinas, call the habit whereby one rightly honors, worships, and serves God, the virtue of religion. Some such virtues would be central to achieving excellence in the practice of religion. So too, for Aquinas, are the theological virtues—faith, hope, and love—whereby we are directed to God and to supernatural happiness (*ST I-II* 62.1–2). Most striking, perhaps, is the fact that many of the virtues required for excellence in science are the same virtues that the religious practitioner must cultivate with respect to the activities of religion. It may come as no surprise that, for Emerson, the virtue of self-trust also assembles these virtues.

In his Address at Harvard Divinity School in 1838, Emerson urges the graduates to "love God without mediator or veil," to remember that the incarnate "God speaketh, not spake" (Emerson 2006, vol. 1144). The virtue of self-trust, whereby one cultivates faith in one's best intuitions, is of a piece with faith in God or the divine. Indeed, it is the virtue whereby the soul begins the ascent through the moral sentiment to the heights of the religious sentiment in all its sublime beauty. So too, the virtues of "justice, temperance," "courage, piety, love, and wisdom," among others, will be needed for the ascent (Emerson 2006, vols. 1, 124). The last is of particular interest. For where *scientia* perfects the intellect for "this or that genus of knowable matter," it is wisdom for Aquinas, that perfects the intellect to consider the highest causes, judge all things, and set them in order (*ST I-II* 57.2). Much more could be said on this theme. Again, my purpose here is to suggest that there are many virtues that enable religious practitioners to perfect the activities and enjoy the internal goods of the practice of religion and that some of those virtues are shared by practitioners of science.

How then are science and religion and their respective practitioners related? There is no simple answer. One response might be, in as many manifold ways as their proximate and final ends, internal goods, objects and methods of inquiry, communities of practice, and specific practitioners may be variously related. Of course, many persons are practitioners of both! To return to the map metaphor, Emerson suggests that, "Engineer, broker, jurist, physician, moralist, theologian, and every man, inasmuch as he has any science – is a definer and mapmaker of the latitudes and longitudes of our condition" (Emerson 2006, vol. 4). If we think of every person who has any knowledge as a cartographer of our condition, we might think of the practitioners of religion and science as mapping particular aspects of that condition. Note, these different aspects are not distinguished by the old divide between facts and values. Rather, the scientist and religious practitioner alike, provide us with more or less reliable knowledge about the world: knowledge about deep space and forgiveness, about physical and spiritual healing. Topographic, topological, tube, and road maps orient us to different aspects of our environment. "Genius," for Emerson, "is the naturalist or geographer of the supersensible regions, and draws their map" (Emerson 2006, vol. 4). The genius of whatever stripe, whether the poet (a religious sage of sorts for Emerson and his Romantic forbearers) or the "Man of science" (he would never adopt the neologism "scientist"), acquaints us with the supersensible regions.

The legacy of scientists-natural philosophers-poets-prophets-divines to which I have alluded suggests that the practices of science and religion have a special relation insofar as they have a shared object. William Wordsworth, in the second edition of the "Preface" to *Lyrical Ballads*, considers the question "What is a Poet" by comparing the poet and the "Man of science" (Wordsworth 2013). By the time he appends this section in 1802, it seems, Wordsworth has become convinced that both the poet and the "Man of science" are interpreters of nature, whose shared object is truth.[20]

David Bromwich convincingly suggests that Wordsworth came to this idea of the scientist under the sway of Sir Humphrey Davy's 1802 introductory lecture on general chemistry at the Royal Institution.[21] Davy suggests that "The study of nature, under any aspect whatever, 'must always be more or less connected with the love of the beautiful and sublime'" (Bromwich 1989, p. 29). The more connected it is with this dimension, at once aesthetic and moral, the more "science may become a source of consolation and of happiness" by purifying the imagination and attaching the affections to important objects "intimately related to the interest of the human species" (Bromwich 1989, p. 30). It is no wonder that Wordsworth finds this portrayal of science immensely appealing. At a time when the divorce between poetry and science was beginning to appear all but settled—poetry understood as "an aesthetic language without truth," science as "an objective truth without language"—these poet and scientist reconcile the two by seeing the likeness of each in the other, by understanding one another as smitten interpreters of the Book of Nature. Both men question the presumption that nature can ever be read without such an interpreter or mapmaker, whether scientific, relgious, or both.

Despite the increasingly widespread belief in the finality of the divorce, Davy and Wordsworth cleared the way for a distinguished legacy including the likes of William Whewell, Charles Darwin, and Emerson, to avoid this mistaken view and effect the happy partnership in their own time. Whewell famously coined the term

[20] (Bromwich 1989, p. 20) With David Bromwich, we might identify the define an interpreter as, "a persuasive observer whose theory of a family of objects may acquire the authority of fact."

[21] (Bromwich 1989, p. 30) Bromwich credits Roger Sharrock with this discovery. All citations of Davy herein are from Bromwich.

"scientist" in 1833 at a meeting of the British Association for the Advancement of Science, when Samuel Taylor Coleridge forbade those gathered to dignify themselves with the term "philosopher." But Whewell was not so interested in the distinction. For him, scientists and philosophers alike are set apart from their fellow interpreters in that "most men are unconscious of this perpetual habit of reading the language of the external world and translating as they read."[22] Darwin followed suit when he applauded T.H. Huxley for having articulately written what Darwin had "often said and thought," namely "that the process of scientific discovery was identical with every day thought, only with more care."[23] In fact, Laura Dassow Walls observes that "influential scientists like Michael Faraday and T.H Huxley rejected the term scientist because they 'preferred to think of their work as part of broader philosophical, theological, and moral concerns" (Walls 2003, pp. 62–63, 85). Emerson did so, presumably for similar reasons. These preeminent scientists happily thought of themselves as interpreters, and their work as intimately connected to the concerns of humanity.

Science and religion, I have suggested, are best understood as social practices whereby practitioners seek knowledge about human beings, the natural world, and the universe, in order to inhabit it well. According to this view, scientific and religious knowledge comes by way of inheritance and interpretation, within particular communities from which we inherit a set of interpretive lenses—a set of beliefs, values, and knowledge about the world (natural and supernatural, physical and metaphysical, visible and invisible)—that we take to be true largely on trust. Practitioners of each can only question so much of this received knowledge at any one given time, and tend to question most those aspects that do not help them to make sense of their lived experience or observations. By these lights, what we come to value as a fact in both practices is always to some extent a product of the culture in which it acquires that status. Science and religion depend on inherited interpretations of the Book of Nature and provide more or less reliable knowledge about ourselves and the world we inhabit. Moreover, various virtues perfect practitioners of each.

What distinguishes them is not primarily epistemological method or the object of their study broadly conceived, but the practices themselves and their respective aims and internal goods— those goods that can only be had by practitioners themselves. Though the epistemological method will look different in practice, we might say both science and religion are practices of *fides quaerens intellectum*, faith seeking understanding. One of the aims of natural science, I have suggested, is knowledge that enables us to predict, control, and explain certain aspects of the natural world. One of the internal goods of science is the awe, wonder, or satisfaction that comes with gaining knowledge about some particular aspect of our world. The aims of religion include attaining the knowledge and dispositions that enables us to use

[22] (Bromwich 1989, p. 36) 35. Bromwich explains that scientific knowledge understood as interpretation, "can still have the character of fact because the book of nature has been with us a long time, and in order to carry weight any revision must have preserved some part of its inheritance" (35).

[23] (Bromwich 1989, p. 35) (Darwin 1862).

scientific knowledge well and to live well in light of precisely those aspects of our world that are unpredictable, uncontrollable, or beyond explanation. Rather than ask after the relationship between science and religion or their respective territories, we would do better to think of them as mutually perfecting practices that provide distinct maps of the same landscape which help us to make a home of the world.[24] The task for educators of science and religion/theology, now as ever, is to help students cultivate the virtues of each.

Works Cited

Aquinas, T. (1981). *The Summa Theologica of St. Thomas Aquinas*. (− Fathers of The English Dominican Provinc, Trans.). New York: Benziger Brothers and Christian Classics.

Baehr, J. (2012). *The inquiring mind: On intellectual virtues and virtue epistemology* (Reprint edition). Oxford: Oxford University Press.

Barbour, I. G. (2000). *When science meets religion: Enemies, strangers, or partners*. San Francisco: HarperOne.

Bible: New Revised Standard Version. (2010). Abingdon Press.

Bromwich, D. (1989). *A choice of inheritance: Self and community from Edmund Burke to Robert Frost*. Cambridge, MA: Harvard University Press.

Darwin, C. (1862, December 7). *Correspondence to T.H. Huxley*. Retrieved August 3, 2016, from http://www.darwinproject.ac.uk/letter/DCP-LETT-3848.xml

Dumler-Winckler, E. (2018). The intellectual and moral virtues of scientific practice. Philosophy, Theology, and the Sciences, 5(1), 80–103.

Emerson, R. W. (2006). *Complete works of Ralph Waldo Emerson*. Retrieved June 30, 2016, from http://quod.lib.umich.edu/e/emerson/

Gardiner, M. Q., & Engler, S. (2010). Charting the map metaphor in theories of religion. *Religion, 40*(1), 1–13.

Harrison, P. (2015). *The territories of science and religion*. Chicago: University Of Chicago Press.

MacIntyre, A. (2007). *After virtue: A study in moral theory* (3rd ed.). Notre Dame: University of Notre Dame Press.

Preller, V. (2005). *Divine science and the science of god: A reformulation of Thomas Aquinas* (Reprint edn). Eugene, OR: Wipf & Stock Publishing.

Ristuccia, N. J. (2016). Peter Harrison, Ludwig Wittgenstein, and the problem of pre-modern religion. *Zygon, 51*(3), 718–728.

Rorty, R., Schneewind, J. B., & Skinner, Q. (Eds.). (1984). *Philosophy in history: Essays in the historiography of philosophy* (1st ed.). Cambridge: Cambridge University Press.

Walls, L. D. (2003). Emerson's Life in Science: The Culture of Truth. Cornell University Press.

Wood, R. C. R. J. (2015). *Intellectual virtues: An essay in regulative epistemology*. Oxford University Press.

Wordsworth, W. (2013). In N. Halmi (Ed.), *Wordsworth's poetry and prose*. New York/London: W. W. Norton & Company.

Zagzebski, L. T. (1996). *Virtues of the mind: An inquiry into the nature of virtue and the ethical foundations of knowledge*. Cambridge/New York: Cambridge University Press.

[24] I am grateful for the excellent feedback I received from Daniel Pedersen and Emanuele Ratti on an earlier draft of this paper.

Emily Dumler-Winckler is an Assistant Professor of Christian Ethics and Constructive Theology in the Theological Studies Department at Saint Louis University. Her areas of research include virtue theory (ancient and modern), Christian ethics and moral theology, religious methods, constructive theology (including historical, moral, philosophical, systematic, and political theology), and women and gender studies. She has published articles and chapters in edited volumes on Aquinas, Mary Wollstonecraft, Ralph Waldo Emerson, and American Transcendentalists, as well as on the virtues and their significance for debates in feminism, science, and philosophy. She is currently completing a book with the working title "Modern Virtue: Mary Wollstonecraft and a Tradition of Dissent" and has begun a second book project on the virtues of the practices of science and religion in the modern era.

Chapter 6
The Mediated Nature of Knowledge: Paul Ricoeur's Philosophy as a Means of Teaching Students About Science and Religion

Nathan H. White

Introduction

Within modern Western culture, a narrative dominates understandings of science and religion, namely that these disciplines inhabit widely disparate sectors with competing views of the world and varying ways of coming to knowledge of truth (Barbour 1997, p. 77).[1] In terms of reliability, veracity and insight into the true nature of the world, science invariably is deemed 'objective', thereby valued above religion, which, alternatively, is considered 'subjective' and experiential (Barbour 1974, p. 2, 1997, p. 77). This dichotomy is bound up in an epistemology that separates out scientific,[2] supposedly more veracious, thinking from other ways of knowing (Barbour 1997, p. 78).[3]

While this worldview is beneficial in many instances, it can become problematic when it is seen as the *only* valid epistemological approach, suggesting that other ways of viewing the world must be subject to its presuppositions, assumptions and methodologies. What is one to do when these worldviews come into apparent conflict with

[1] Ian Barbour suggests that some of this conflict is brought about due to a failure 'to distinguish between *scientific* and *philosophical* questions…These are alternative belief systems, each claiming to encompass all reality' (1997, p. 81). Emphasis in quotations here and throughout is original unless otherwise noted.

[2] My use of the term 'science' refers to the general contours of the discipline as understood in everyday parlance. In reality, the field to which it refers is widely diverse with varying epistemologies and methodologies. In this instance, it is expedient to refer to science as it is understood by the average student in Western culture.

[3] For proponents of the conflict thesis, Barbour proposes that '[a]s a rough approximation, we may say that religion asks *why* and science asks *how*' (1997, p. 82). He notes that this distinction requires clarification, yet his assessment remains broadly within a modernist framework.

N. H. White (✉)
Institute for Faith and Resilience, Lafayette, LA, USA

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_6

one another—as in Ian Barbour's 'conflict' relation between science and religion? Do other alternatives exist for understanding the science-religion relationship? Further, what common ground, if any, do these disciplines and epistemologies share?

Ian Barbour's Four Models

Ian Barbour proposed in his seminal Gifford Lectures, published as *Religion in an Age of Science* (1990) and later revised and expanded in *Religion and Science* (1997), that science and religion may relate to each other in four primary ways: conflict, independence, dialogue and integration (1997, pp. 77-105). These are merely a 'broad sketch of alternatives' in relating the two disciplines (1997, p. 77) and, as such, they provide a useful starting point for discussion.[4]

But Barbour's categories do not portray all possible relationships between these disciplines. By staying within modern understandings of the boundaries of science and religion, including the possibility of a neutral non-ideological space for evaluating truth claims, Barbour cannot fully depict the vast variegation in possible relations. Here, modern presuppositions of the relationship between science and religion subsume possible alternatives. Yet, Barbour's earlier work suggests potentially helpful directions for further enquiry.

Barbour on the Mediated Nature of Knowledge[5]

Drawing upon Max Black, Barbour argues for the centrality of metaphor and the mediation of language in both science and religion (1974, pp. 11-12). He writes, 'I will try to show that science is not as objective, nor religion as subjective, as these two opposing schools of thought both assumed' (1974, pp. 5-6). For Barbour, this equanimity is founded upon the use of models, in both science and religion, that are analogical in nature (1974, p. 7).[6] Yet, attention to similarities between ways of knowing in science and religion must not dismiss differences between the two (Barbour 1997, p. 95).[7] Still, the shared mediation afforded by human experience is itself the basis for dialogue that maintains both similarity and difference in the pursuit of truth. While

[4] Significantly, Barbour's model makes use of typology, a way of grouping ideas based on conceptual models and hermeneutic reasoning. As will become clear, this type of reasoning is founded upon semiotic structures of communication.

[5] This emphasis is clear in Barbour's earlier work (1974) and reiterated, though less strongly, later (1997, pp. 106–136).

[6] Barbour defines a model thusly: 'Broadly speaking, a model is a symbolic representation of selected aspects of the behaviour of a complex system for particular purposes. It is an imaginative tool for ordering experience, rather than a description of the world' (1974, p. 6).

[7] Substantial differences exist between ways of knowing in these disciplines, but rather than rehearsing the well-trodden ground of dissimilarity, I will here focus on similarities in their epistemologies that enable beneficial cross-disciplinary dialogue. These are significant considerations to which we will later return.

not all epistemologies are equally ideologically driven or have equal propensity toward veracious inferences, all human thinking entails some level of analogical reasoning and ideological situatedness, thereby leading to similarities across disciplines in the process of knowing, categorising and relating various types of knowledge.

In Barbour's thought, models may provide one such epistemological constant by enabling the interpretation of data and experience: 'As [scientific] models…are later used to interpret other patterns of observation in the laboratory, so models of an unobservable God are used to interpret new patterns of experience in human life' (1974, p. 50). For Barbour, models, akin to paradigms,[8] are metaphorical schemata for understanding and interpreting the world. Thus, the mediation of metaphor is primary to scientific and religious understanding, enabling meaningful engagement with the world.

Moving Beyond Barbour

The inevitability of the mediation of human knowledge suggests that the human condition offers no neutral space, free from ideology, in which to consider knowledge. Therefore, we may gain further clarity regarding science and religion through attention to these disciplines' historical and contextually bound nature and the hermeneutical reasoning that undergirds them. Peter Harrison (2015) provides just such an analysis of the contingency of modern understandings of these constructs and their relationship to one another.

Conceptual Confusion

Harrison displays the provisional nature of the modern paradigm of the science-religion relation by tracing the historical development of these constructs. He proposes that the modern standoff between these disciplines is derived not from the core subject matter itself but from the modern Western concepts that have come to denote these two areas of knowledge (2015, p. 194).[9] Harrison's in-depth historical analysis suggests that new understandings of the relationship between these disciplines are possible.[10] His argument primarily consists of conceptual clarification of the constructs, which itself is dependent upon the linguistic conventions of naming and categorising.

[8] Barbour suggests that a paradigm is '*a tradition transmitted through historical exemplars*' (1974, p. 9).

[9] Further, Harrison proposes that this is a product of 'the distorting projection of our present conceptual maps back onto the intellectual territories of the past' (2015, p. 4).

[10] Harrison suggests that it is the conceptual and linguistic misapplication of these terms that has precipitated confusion (2015, pp. 183–185).

Harrison's argument reframes Barbour's models by situating the subject matter of 'science' and 'religion' within particular contingent historical and cultural contexts. His historical overview displays how these terms and the concepts they denote have histories that themselves are subject to interpretation. Such mediation is inherent to human experience because language, whose semiotics are metaphorical in nature, is constitutive of the ability to communicate.[11] Similar reasoning is critical for Harrison's argument: indeed, in the first place, Harrison uses analogical description as a means of outlining his argument (2015, pp. 1-3), thus showcasing the utility and effectiveness of this method of communication.

Despite the diversity of epistemological commitments associated with these constructs in the past, current understandings of the relationship between science and religion are based upon conceptions of each as being primarily concerned with knowledge rather than as also having a moral component.[12] Yet, any assessment of the relation between science and religion must take into consideration the moral underpinnings of the constructs, which lie beyond the boundaries of the concepts as currently understood.

Here we must be careful not to fall into the trap of reinforcing the structures that promoted the 'conflict' hypotheses between science and religion in the first place. We may unknowingly do this by reaffirming presuppositions such as the 'cultural authority of the sciences, the propositional nature of religion, and the idea of a neutral, rational space in which dialogue can take place' (Harrison 2015, p. 198). Such assumptions further problematic modern understandings of science and religion. Can something constructive be made from a renewed understanding of methods of scientific and religious enquiry?

Here, the philosophy of Paul Ricoeur may provide a useful means of evaluating the claims of science and religion, including their epistemologies.[13] Ricoeur's ability to hold in dialectical tension disparate and, at times, seemingly contradictory constructs can assist in the discussion at hand.[14]

[11] To be clear, we must note with Janet Soskice that '[m]etaphor is by definition a figure of speech' (1985, p. 16). Its basis in language, however, does not preclude extension of such reasoning into the 'world' of the individual, as Paul Ricoeur (1973) argues. Here, perhaps, we diverge from Soskice's view.

[12] Cf. (Harrison 2015, p. 177). This is predominantly a modern viewpoint that hides the moral import understood by many premodern thinkers to be inherent in the subject matter that has come to be termed 'science' and 'religion'. The moral framework that underlies both scientific and religious enquiry, Harrison argues, is the true source of the supposed conflict at hand (2015, pp. 178, 197).

[13] No unique epistemology is inherent to either science or religion; however, as Harrison aptly displays, each discipline has come to be associated with specific ways of knowing.

[14] Others have also found Ricoeur's philosophy fertile ground for such enquiry (Gerhart and Russell 1984; Reynhout 2013). Ricoeur himself had fruitful dialogue with a neuroscientist regarding questions of theology, philosophy and science (Changeux and Ricoeur 2002).

An Alternative Through Mediated Knowledge

Ricoeur provides an alternative to Barbour's models through highlighting the influence of ideology on all approaches to truth. He asks: 'The question…is whether there exists a point of view on action which is capable of extricating itself from the ideological condition of knowledge engaged in praxis' (1991b, p. 248). In answering, Ricoeur follows Jürgen Habermas, claiming that 'all knowledge is supported by an interest' and therefore is mediated through the situated nature of human existence (1991b, p. 268). For Ricoeur, there is no disinterested knowledge, and therefore no disinterested pursuit of knowledge.

Because no place of disinterested objectivity exists, Ricoeur suggests that understanding of the world is necessarily mediated: 'there is no self-understanding that is not *mediated* by signs, symbols, and texts; in the last resort understanding coincides with the interpretation given to these mediating terms' (1991a, p. 15).[15] This mediation may take place through various means: through language, conceptual model, picture or other method of communication. Although for Ricoeur, language is 'the primary condition of all human experience' (1991a, p. 16),[16] his insights may analogically be applied to other semiotic means of mediation.[17] In terms of language, Ricoeur writes that the 'linguistic sign can *stand for* something only if it is *not* the thing' (1981c, p. 116). Thus, distance is created between the symbol and referent, necessitating some form of hermeneutical reasoning. A disjunction between metaphor and referent always exists—there is more behind the medium of communication, a 'surplus of meaning' that cannot fully be communicated (Ricoeur 1981d, p. 101). Thus, hermeneutical description—including the use of metaphor, paradigm and model—not only presupposes the mediation of knowledge but also serves to bridge the divide of knowledge created by that mediation.

Mediation in Religion and Science

Using Ricoeur's understanding of the mediated nature of knowledge enables us to speak of the relationship between science and religion in different terms. No longer are science and religion to be understood as existing on different planes, operating

[15] Certainly, this also could be seen as a claim to a different sort of ideological metanarrative. For Ricoeur, a paradigmatic ideology is inescapable, but the mediated nature of knowledge does not mean that truth is inaccessible. Ricoeur maintained that the mediation of language in knowledge does not devolve into utter subjectivity (1973, p. 108). In fact, the tension between the truth described by a metaphor and the referent of the metaphor is emblematic of the dialectic nature of human existence more generally (Ricoeur 1978, p. 247).

[16] Other scholars, such as J. Wentzel van Huyssteen (2006, p. 225), have suggested that language is a fundamental part of human uniqueness. Others see the structure of existence itself as metaphorical in nature (Lakoff and Johnson 1981).

[17] Cf. (Ricoeur 1973).

according to differing sets of rules and varying levels of neutrality in the pursuit of truth. Instead we may see both science and religion as approaches to knowledge that inherently are mediated.

Mediation in Religion

Religion does not escape from the mediation of knowledge that is intrinsic to human-lived experience. Even in religion, a critical realist position acknowledges the possibility of grasping the truth of reality, albeit in an imperfect manner.[18] Thus, Janet Soskice argues that, in the Christian tradition, metaphor is integral to the ability to speak of God:[19]

> …the Christian [has a] seemingly paradoxical conviction that, despite his [*sic*] utter inability to comprehend God, he is justified in speaking of God and that metaphor is the principal means by which he does so (1985, p. x).

Indeed, the finite human can only speak of an infinite God in a qualified and metaphorical manner due to the inadequacy of human language to describe God—in linguistic terms, the divide between symbol and referent.[20] Thus, Soskice concludes, it is 'necessary that in our stammering after a transcendent God we must speak…metaphorically or not at all' (1985, p. 140).

Furthermore, the influence of social forces on religion is substantial. Religious communities have a common paradigm (Barbour 1997, p. 93) wherein they 'are bound by shared assumptions, interests, and traditions of interpretation, and share a descriptive vocabulary' in the same way as scientific communities (Soskice 1985, p. 150). Belonging to a community, whether religious or secular, exerts considerable influence on worldview.[21]

Thus, the use of model and metaphor in science and religion cannot be separated into an easy dichotomy wherein scientific models are explanatory while religious models are affective (Soskice 1985, p. 108). This does not treat models in the same manner in each discipline. Rather, Soskice argues that the ability to use metaphor

[18] Soskice (1985, p. 137) as well as Barbour are proponents of critical realism, which Barbour suggests 'avoids naive realism, on the one hand, and instrumentalism, which abandons all concern for truth, on the other' (1974, p. 11). Cf. (Barbour 1997, p. 89). Care must be taken to preserve the ontology of the relationship between the metaphor and its referent, however. The reality of this relationship is significant for the compatibility of scientific and religious knowledge and is foundational for many within both scientific and religious communities. See (Ricoeur 1984, p. xii).

[19] Francis Bacon posits: '*there is no proceeding in invention of knowledge but by similitude*: and God is only self-like, having nothing in common with any creature, otherwise than as in shadow and trope' (Vickers 1968, p. 153) as cited in (Soskice 1985, p. 63).

[20] Cf. (Soskice 1985, p. 66).

[21] Ricoeur proposes that 'all objectifying knowledge…is preceded by a relation of *belonging* upon which we can never entirely reflect. Before any critical distance, we belong to a history, to a class, to a nation, to a culture, to one or several traditions. In accepting this belonging that precedes and supports us, we accept the very first role of ideology…the mediating function of the image' (1991b, p. 267).

comparably in both science and religion relies primarily on the reality depicting nature of both (1985, pp. 106-107).

Mediation in Science

The mediated nature of knowledge is often recognised in the case of religion, but not always in the case of science. The effect of language and societal influences upon human knowledge acquisition in both disciplines, however, is significant. In Ricoeur's thinking, science, beyond merely being a means of enquiry, also can become an ideology. Ideology is an inescapable part of human existence in this world, yet naturalistic science can claim to make judgements from the place of a non-ideology (Ricoeur 1991b, p. 255).[22] This is the basis of the supposed conflict between science and religion (Ricoeur 1991b, p. 256), yet this tension cannot totally be done away with since no place of disinterested objectivity exists (Ricoeur 1991b, pp. 263-264). Because human knowledge is necessarily mediated, the contextual nature of exploration for truth, including the experience of the explorer herself, is relevant to the pursuit of truth.

Ricoeur's claim that access to knowledge of the world is mediated (Ricoeur 1981d, p. 106) finds its origin in the metaphorical nature of knowledge that lies at the base of all thought (Ricoeur 1978, p. 22). For Ricoeur, the metaphor serves to bridge the supposed conflict between interpretation and explanation, that itself is the basis for science's claim to non-ideological neutrality (1981b, p. 166).[23] This bridging is possible due to the work of discourse in which the subject and object interact, an engagement that itself is a part of the contextual milieu in which this action takes place (Ricoeur 1981b, p. 166).[24] The mediation of knowledge in science and religion, then, is metaphorical in shape and dynamically affected by discourse between the subject, object and audience.[25] Hence, all knowledge acquisition

[22] Alister McGrath suggests that secularity is itself a mediated, narrated interpretation of reality (2002, p. 107). In this understanding, the natural sciences are a tradition wherein scientific methodology, community and even output is influenced by social forces (2002, p. 114). Hence, McGrath argues that '[a]llegedly neutral, transcendent or "objective" disciplines—such as the social sciences—are in reality no more than *narrated interpretations of reality* which possess no privileged status permitting them to judge or police others' (2002, pp. 118–119). Thomas Nagel (2012) further compellingly argues that a natural materialist position is not fully explanatory of human experience.

[23] Even within the sciences, an opposition between explanation (physical science) and interpretation (social science) could be understood to exist. Ricoeur does not maintain this distinction and, in fact, sees his work as mediating between the two (Ricoeur 1981a, p. 36).

[24] For Ricoeur, the relationship between metaphor and discourse is founded upon the polysemic nature of language in which words derive meaning contextually. Thus, just as the meaning of a word is determined through its context, so too the metaphor derives its meaning as a part of the discourse between symbol, referent and context (Ricoeur 1981b, p. 169).

[25] For Ricoeur's assessment of the reference of discourse, see (Ricoeur 1981b, p. 168). In Ricoeur's thought, 'reference' is both 'the intentional orientation towards a world and the reflexive orientation towards a self' (Ricoeur 1981b, p. 171).

includes dynamic and reflexive actualities whereby the metaphor, referent, 'speaker' and 'audience' are all alike engaged in the mediation of knowledge. This interaction, termed the 'hermeneutical circle', 'remains an unavoidable structure of interpretation' (Ricoeur 1981b, p. 178).[26]

Beyond the significance of metaphorical communication in mediation, metaphor can create greater meaning than would be possible in direct, unmediated communication. Ricoeur suggests that 'metaphor is more than a simple substitution whereby one word would replace a literal word…[if this were the case] [n]o new meaning emerges and we learn nothing' (1981b, p. 172). Instead, metaphor is 'a momentary creation of language, a semantic innovation which does not have a status in the language as something already established' (Ricoeur 1981b, p. 174). This creation brings about new meaning, suggesting new actualities in the world of the individual. Thus, 'understanding a metaphorical statement…is a question of "making sense", of producing the best overall intelligibility from an apparently discordant diversity' (Ricoeur 1981b, p. 175). To accomplish this, hermeneutical thinking is deployed on a number of different levels—from the semiotic representation of language itself to larger structures of paradigms and models—each making use of hermeneutical reasoning to convey meaning.

Ricoeur situates his reflections within larger discourses of the philosophy of science. In particular, he draws upon Max Black[27] (1978, p. 22) and Mary Hesse[28] (1978, p. 242) for their conceptions of the foundational nature of metaphor to scientific enquiry. For Ricoeur, 'metaphor is to poetic language what the model is to scientific language' with the result that 'in scientific language, the model is essentially a heuristic instrument that seeks, by means of fiction, to break down an inadequate interpretation and to lay the way for a new, more adequate interpretation' (1978, p. 240). Here Ricoeur's thinking is in line with Thomas Kuhn's philosophy.[29] Regarding this relationship Kevin Vanhoozer writes:

> What Kuhn means by paradigm is not far removed from what Ricoeur and others mean by metaphor…The shift from Newtonian physics to relativity could be construed as a shift in metaphors, and Einstein might well be regarded as a master poet, inventing new metaphors in order to discover more about the universe (1990, p. 81).[30]

Hermeneutical reasoning, then, instead of being foreign to science, is integral to it. In fact, Soskice argues that 'the vagueness of metaphorical terms, rather than rendering metaphors unsuited to scientific language, is just what makes them indispensable to it' (1985, p. 133).[31] Such reasoning is explanatory for individual

[26] Ricoeur suggests that the hermeneutical circle 'entails a sharp opposition to the sort of objectivity and non-implication which is supposed to characterise the scientific explanation of things' (1981b, p. 165).

[27] For example, Black (1962).

[28] For example, Hesse (1966).

[29] See Kuhn (1962).

[30] Citing (Ricoeur 1982, p. 16).

[31] McGrath, too, emphasises the importance of metaphorical conceptualisation in both science and religion (1998, pp. 165–206).

concepts as well as for larger philosophical shifts. Peter Harrison highlights this type of reasoning through emphasising the societally conditioned and historically bound nature of the constructs of science and religion. This understanding frees the terms from the constraints of meanings they have accreted, thereby disclosing a way through the apparent conflict.

Conclusions on Mediation

No place of non-ideology in the pursuit of knowledge exists; therefore, hermeneutical reasoning is necessary to facilitate human knowledge.[32] Ricoeur's philosophy provides insight into the mediated nature of knowledge, highlighting the effect of belonging and ideology on contingent understandings of the world. Here, science and religion are seen as mediated pursuits of truth that are facilitated through hermeneutical reasoning. Because the influence of ideology is unavoidable, problems arise when suggestion is made that such mediation is not present.

Moving to practical implementation of these ideas, this epistemological approach is suggestive of beneficial teaching strategies. Significantly, for our purposes, Ricoeur argues that the 'model belongs not to the logic of justification or proof, but to the logic of discovery' (1978, p. 240). This understanding lends itself to utility in the learning environment where the goal of instruction is precisely *discovery*. Ricoeur's thinking, then, coherently suggests the possibility of application in useful pedagogical methods.

Teaching Science and Religion

In addition to aiding in understanding the relationship between science and religion, Ricoeur's philosophy provides several significant advantages for teaching about this relationship. In particular, the use of metaphor, itself a basis for mediated ways of knowing, is suggestive of beneficial pedagogical strategies in both the disciplines of science and religion.

There are certain strengths implicit in styles of education that incorporate metaphor. Pedagogical strategies that use metaphor recognise that a student is not merely a *tabula rasa* but rather is inherently influenced by self-conception, prior experiences and desires (Fensham 2006, p. v). Additionally, metaphorical methods of instruction appeal to the innate interests and motivations of students that are integral to an effectual learning process, resulting in corresponding positive learning outcomes (Harrison 2006, p. 52). This is because '[a]nalogical thinking accesses useful structural and relational information from a learner's repertoire of familiar instances

[32] In Ricoeur's thought, the mediation of human knowledge introduces both distortion and possibility. Some potential distortions will be considered shortly.

or events (the *analog*) and maps structural and relational knowledge onto the unfamiliar science concept (the *target*)' (Harrison 2006, p. 52).

For some time, metaphor and analogy have been understood as useful for teaching students about science (Duit 1991; Harrison and Treagust 2006).[33] Indeed, '[t]he use of analogies and metaphors is important in science itself and their use in teaching science seems a natural extension' (Fensham 2006, p. v). These tools enable students to appropriate new information into a paradigm that makes sense of the information, create new schemata and concretise this information (Duit 1991, p. 652).[34] Thus, the use of analogy, in addition to aiding learning, can provide a new paradigm for students to see and re-envision the analog (Duit 1991, p. 653). This process enables two-way interaction in learning as students not only receive information but also engage in the creation of new understandings. Thus, metaphors enable more than the transference of knowledge, they involve 'a process of constructing the analogical relation the teacher aims at' (Wilbers and Duit 2006, p. 37). Significantly, students may not be aware of this dynamic and therefore must be pointed towards the analogies themselves as a part of this process (Duit 1991, p. 656). This may be, in part, because a good deal of 'epistemic insight' is required on the part of students to understand competing claims and the models upon which such claims are based (Billingsley et al. 2013).

Students are taught (whether they realise it or not) using *representations* of the world. The letter 'a' *represents* the sound it denotes, it is not the *actual* sound. Further, the word 'apple' *represents* the object, that is, an apple, but it is not the thing itself.[35] Moving further afield, a model of the solar system, taught pictorially, depicts the actual planets and their relation to one another and the sun. This logic is not new and can be applied in more complex cases, yet the presuppositions and implications of this knowledge are not always fully drawn out.

Even at its most precise point, science is still in need of means of semiotic communication for its investigation of truth and its subsequent portrayal to others. This introduces an element of mediation into the scientific quest and suggests that abstracted enquiry devoid of context or bias is not possible. As Ricoeur indicated, individuals belong to a distinctive community and context, and approach the world through a particular ideology. Individuals use past experience and knowledge in the interpretation and creation of metaphors (Harrison and Treagust 2006, pp. 11-12). Rather than being eschewed, this rootedness ought to be explored and utilised through the 'hermeneutic circle' of discourse in learning. Allan Harrison suggests that '[w]hen teachers and students co-construct analogical explanations using the students' shared experiences, effective learning often results' (2006, p. 62).

[33] I will not here be able to address specific teaching strategies for the use of metaphor and analogy; I only highlight some beneficial aspects of this type of teaching and their philosophical underpinnings.

[34] Significantly, Duit cites Kuhn's understanding of scientific paradigms as the theoretical basis for the construction of new schemata in learning.

[35] Cf. (Ricoeur 1981b, p. 167).

This presents distinct possibilities for teaching about science and religion. The use of metaphor, conceptual models and other semiotic means of communication should be encouraged in classroom settings. These types of knowing are already intuitively grasped by students who learn effectively through combining new insights with familiar concepts (Harrison and Treagust 2006, p. 12). Thus, this approach draws upon strengths that are already implicit in learners.

In a culture that increasingly uses virtual means of interacting with the world, the strategic use of mediated means of communication is all the more important and should be viewed as an invitation to freedom in creative teaching. Teachers should use their own experiences and expertise to communicate their understanding of the relationship between science and religion. For example, a story about how sailors use the stars to navigate the oceans or a description of the teacher's experience of looking into the night sky in the remote wilderness can be just as informative, and perhaps conveys a type of knowledge that is as significant as what is expressed by a textbook.

Furthermore, this method of teaching is directly linked to epistemologies implicit within the subjects themselves. The close connection between methodology of teaching and the actual subject matter can further be beneficial to the comprehension and retention of knowledge.[36] This advantage is based upon the connection between epistemology and teaching methodology and provides a philosophical foundation for pedagogical strategies already implicit in the discipline.

Cautions

Despite the potential positive benefits in the approach I have described, some caution is required. While many epistemological commonalities between science and religion exist due to the shared starting point of mediated human experience, there are also very real distinctions between the disciplines that do not allow them to be collapsed into one. Each 'voice' should be 'at once distinct and complementary' (Ricoeur 1984, p. xi), though neither one should be seen as occupying the place of non-ideology. This complementarity is enabled, not through the enactment of a novel epistemology but rather through the practical work of lived human experience (Ricoeur 1984, p. xi).

Care must be taken in the use of analogies in teaching, however, because the relationship between an analog and its reference is imprecise. Because this imprecision can lead to wrong conclusions by students, a degree of structured facilitation is needed on the part of the teacher (Duit 1991, pp. 666–667; Harrison and Treagust 2006, pp. 11, 22; Wilbers and Duit 2006, p. 37).

[36] See also Midgley et al. (2013).

Conclusion

Ricoeur suggests:

> Knowledge is always in the process of tearing itself away from ideology, but ideology always remains the grid, the code of interpretation…nothing is more necessary today than to renounce the arrogance of critique and to carry on with patience the endless work of distancing and renewing our historical substance (1991b, p. 269).

The modern 'conflict' theory of the relationship between science and religion sets the two disciplines at odds with one another, in large part due to a claim of non-ideology by some. Ricoeur enables us to move beyond Barbour's models, including the 'conflict' theory, through affirming the mediation of knowledge and suggesting that no place of non-ideology exists. Acknowledgement of the mediated nature of knowledge not only makes a way for the possible integration of insight from science and religion, it also is suggestive of beneficial teaching methodologies in both fields. The mediation of knowledge that enables dialogue between science and religion through the shared medium of language—to include concomitant hermeneutical reasoning through model and metaphor—also promotes beneficial teaching strategies for describing this relationship through the continuity between epistemology and teaching methodology.

Barbour suggests that '[a] more systematic integration can occur if both science and religion contribute to a coherent world view elaborated in a comprehensive metaphysics' (1997, p. 103). What has been proposed here aims toward a coherent, yet critical, view of the world. Such a view allows for disciplinary distinctiveness while also providing a meaningful and purposive understanding of reality (Barbour 1997, p. 105). Beyond merely being a proposal for another variant of Barbour's models of relationship, this essay attempts to show that any narration of the relationship between science and religion must take into account the mediated nature of human knowledge that brings into question the modern notion of a neutral space of enquiry. This starting point is instructive in many ways but also provides insight into theoretically informed methods of instruction that build upon strengths in students' methods of reasoning.

Ricoeur's philosophy provides helpful perspective on the relationship between science and religion and on teaching methodology in these disciplines. The mediated nature of human understanding, rather than being a barrier to knowledge of science and religion, can in fact be a means of providing beneficial insight into each—individually and in their relationship to one another. As Ricoeur has shown, interpretation is a necessary aspect of human experience, not an ancillary matter. Metaphorical reasoning serves as one way of addressing the interpretive gap inherent to mediated experience—one that is explanatory alike in the disciplines of science and religion because it serves as a bridge between interpretation and explanation, thereby creating meaning. Because hermeneutical reasoning is foundational to the mediation of knowledge, it is primary to knowledge transmission in teaching. Thus, understanding science and religion through the lens of mediation commends methods of teaching that arise from and work within the constraints of the types of knowledge and epistemologies found in each of these disciplines. In these ways, the mediated nature of knowledge suggests distinct possibilities for what Ricoeur terms 'a genuine interconnection of science and religion, on the edge of mystery' (1984, p. xi).

References

Barbour, I. G. (1974). *Myths, models, and paradigms: A comparative study in science and religion*. London: SCM Press.

Barbour, I. G. (1990). *Religion in an age of science*. San Francisco: HarperCollins.

Barbour, I. G. (1997). *Religion and science: Historical and contemporary issues*. San Francisco: HarperCollins.

Billingsley, B., Taber, K., Riga, F., & Newdick, H. (2013). Secondary school students' epistemic insight into the relationships between science and religion—A preliminary enquiry. *Research in Science Education, 43*(4), 1715–1732.

Black, M. (1962). *Models and metaphors*. Ithaca: Cornell University Press.

Changeux, J.-P., & Ricoeur, P. (2002). *What makes us think? A neuroscientist and a philosopher argue about ethics, human nature, and the brain* (DeBevoise, M.B., Trans.). Princeton: Princeton University Press.

Duit, R. (1991). On the role of analogies and metaphors in learning science. *Science Education, 75*(6), 649–672.

Fensham, P. (2006). Foreword. In P. J. Aubusson, A. G. Harrison, & S. M. Ritchie (Eds.), *Metaphor and analogy in science education* (pp. v–vi). Dordrecht: Springer.

Gerhart, M., & Russell, A. M. (1984). *Metaphoric process: The creation of scientific and religious understanding*. Fort Worth: Texas Christian University Press.

Harrison, A. G. (2006). The affective dimension of analogy. In P. J. Aubusson, A. G. Harrison, & S. M. Ritchie (Eds.), *Metaphor and analogy in science education* (pp. 51–63). Dordrecht: Springer.

Harrison, P. (2015). *The territories of science and religion*. Chicago: University of Chicago Press.

Harrison, A. G., & Treagust, D. F. (2006). Teaching and learning with analogies: Friend or foe? In P. J. Aubusson, A. G. Harrison, & S. M. Ritchie (Eds.), *Metaphor and analogy in science education* (pp. 11–24). Dordrecht: Springer.

Hesse, M. B. (1966). The explanatory function of metaphor. In *Models and analogies in science* (pp. 157–177). Notre Dame: University of Notre Dame Press.

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Lakoff, G., & Johnson, M. (1981). *Metaphors we live by*. Chicago: University of Chicago Press.

McGrath, A. E. (1998). *The foundations of dialogue in science and religion*. Oxford: Blackwell Publishers.

McGrath, A. E. (2002). *A scientific theology: Volume 2: Reality*. Edinburgh/New York: T&T Clark.

Midgley, W., Trimmer, K., & Davies, A. (Eds.). (2013). *Metaphors for, in and of education research*. Newcastle: Cambridge Scholars Publishing.

Nagel, T. (2012). *Mind and cosmos: Why the materialist neo-Darwinian conception of nature is almost certainly false*. Oxford/New York: Oxford University Press.

Reynhout, K. A. (2013). *Interdisciplinary interpretation: Paul Ricoeur and the hermeneutics of theology and science*. Lanham: Lexington Books.

Ricoeur, P. (1973). The model of the text: Meaningful action considered as a text. *New Literary History, 5*(1), 91–117.

Ricoeur, P. (1978). Rule of metaphor: Multi-disciplinary studies of the creation of meaning in language (trans: Czerny, R., McLaughlin, K., Costello, J.). London: Routledge & Kegan Paul.

Ricoeur, P. (1981a). A response by Paul Ricoeur. In J. B. Thompson (Ed.), *Hermeneutics and the human sciences: Essays on language, action and interpretation* (pp. 32–40). Cambridge: Cambridge University Press.

Ricoeur, P. (1981b). Metaphor and the central problem of hermeneutics. In J. B. Thompson (Ed.), *Hermeneutics and the human sciences: Essays on language, action and interpretation* (pp. 165–181). Cambridge: Cambridge University Press.

Ricoeur, P. (1981c). Phenomenology and hermeneutics. In J. B. Thompson (Ed.), *Hermeneutics and the human sciences: Essays on language, action and interpretation* (pp. 101–128). Cambridge: Cambridge University Press.

Ricoeur, P. (1981d). Toward a hermeneutic of the idea of revelation. In L. S. Mudge (Ed.), *Essays on biblical interpretation* (pp. 73–118). London: SPCK.

Ricoeur, P. (1982). Poetry and possibility: An interview with Paul Ricoeur. *The Manhattan Review, 2*(2), 6–21.

Ricoeur, P. (1984). Foreword. In M. Gerhart & A. M. Russell (Eds.), *Metaphoric process: The creation of scientific and religious understanding* (pp. xi–xiii). Fort Worth: Texas Christian University Press.

Ricoeur, P. (1991a). On interpretation. In *From text to action: Essays in hermeneutics, II* (Blamey, K., & Thompson, J.B., Trans.) (pp. 1–20). Evanston: Northwestern University Press.

Ricoeur, P. (1991b). Science and ideology. In *From text to action: Essays in hermeneutics, II* (Blamey, K., & Thompson, J.B., Trans.) (pp. 246–269). Evanston: Northwestern University Press.

Soskice, J. M. (1985). *Metaphor and religious language*. Oxford/New York: Oxford University Press.

van Huyssteen, J. W. (2006). *Alone in the world?: Human uniqueness in science and theology*. Grand Rapids: Eerdmans.

Vanhoozer, K. J. (1990). *Biblical narrative in the philosophy of Paul Ricoeur: A study in hermeneutics and theology*. Cambridge/New York: Cambridge University Press.

Vickers, B. (1968). *Francis bacon and renaissance prose*. Cambridge: Cambridge University Press.

Wilbers, J., & Duit, R. (2006). Post-festum and heuristic analogies. In P. J. Aubusson, A. G. Harrison, & S. M. Ritchie (Eds.), *Metaphor and analogy in science education* (pp. 37–49). Dordrecht: Springer.

Nathan H. White is an Executive Director of the Institute for Faith and Resilience in Lafayette, Louisiana. He holds a PhD in theology from Durham University and has written on the application and integration of theological and scientific knowledge for Oxford University Press and in his most recent work, *Biblical and Theological Visions of Resilience: Pastoral and Clinical Insights* (edited with Christopher C.H. Cook) (Routledge, 2020).

Chapter 7
The Moral Impact of Studying Science

Sally Riordan

Introduction

Science and religion are most usually compared on epistemic grounds: what do they tell us about the natural world and what methods do they use to determine those truths? The suggestion here is that the two fields should be compared on moral grounds: how do scientific and religious experiences affect the way a person lives his or her life? A hypothesis is presented in this vein: engaging in scientific work or education alters a person's moral outlook on everyday matters. In this chapter, I articulate and motivate this claim by framing it against both theological and philosophical debate. I explore how it might be tested as a claim in moral psychology. The resulting vision presented here is of science and religion engaged in dialogue—at times necessarily embroiled—not only about the nature of the world but regarding how best we navigate our way in it.

The Problem of Polarisation

In his 1989 Gifford lectures, *Religion in an Age of Science,* Ian Barbour presented a categorisation of theories that was to become the standard in the field of science and religion: a theory might portray the relationship between science and religion as one of conflict, independence, dialogue or integration (1990). Barbour's purpose was to give an overview of the prominent positions of the time in order to create a backdrop for his own narrative, which contained elements of both dialogue and integration.

S. Riordan (✉)
University of Wolverhampton, Wolverhampton, UK
e-mail: s.riordan@wlv.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_7

For almost 30 years, the resulting fourfold classification has set the scene for further discussion; it remains the prominent meta-theory in the field, despite acknowledgement of its weaknesses and suggestions for modification, clarification and alternative models, scholarship which has been both summarised and enriched by Mikael Stenmark (2004). One widely accepted criticism of Barbour's classification is its epistemic bias: the relationship between science and religion is only analysed by comparing the truth claims made by each (Cantor and Kenny 2001; Evans and Evans 2008). Because the generation of knowledge is plausibly a more complete description of science than of religion, the concern is that the resulting classification unfairly ignores the many other roles that religion plays in society, including its rituals, prayers and ceremonies. Barbour's work itself heeds the richness of religious experience; the problem is usually located in the influence and application of his classification. John Evans and Michael Evans have gone further, arguing that an epistemological focus has permeated Western academic thought in its entirety, including the entire field of sociology, long before Barbour's contribution to the debate regarding science and religion (2008).

The criticism is true as far as it goes, but instead of clarifying and improving our understanding of the relationship between science and religion, it exacerbates what may in fact be a more pressing issue resulting from the hold of Barbour's work upon the field. Accepting the existence of non-epistemic roles for religion in society provides reasons for holding onto religion in the face of conflict with science, but it only does so by emphasising a division of labour between the two. If we suppose that science (and only science) deals with metaphysical truth, whereas religion (and only religion) deals with moral truth, there is much less space for the two fields to interact. This results in a polarisation of the options available, encouraging either theories of conflict or those of independence. A prominent view that rose in influence in the decade after Barbour's work, for example, was the hypothesis that that science and religion, if pursued properly, are independent domains of knowledge (Gould 1999).

For Barbour himself, the purpose of his classification was to prepare for the consideration and development of positive narratives about the relationship between science and religion. Given this aim, its greatest failure would be the encouragement of viewpoints of independence and conflict at the expense of those of dialogue and integration. Although the literature shows that most scholars in the field assume that science and religion can—and should—be in dialogue, the community also acknowledges that this viewpoint is not shared in wider academic and public circles. As Colin Russell puts it, the existence of conflict between science and religion has been "unconsciously assimilated as part of the growing wisdom of our day" (2002, p. 10). Amidst growing concerns of how the science/religion debate is perceived and reflected in public spaces, most particularly schools, the most pressing concern is not merely that Barbour's classification does not depict the logical space in which theories can exist sufficiently accurately—which is, after all, to be expected from an early and pioneering systematisation of the field—but that, as a result of its inherent simplification, it fails to achieve its ultimate purpose, to encourage positive narratives about the interaction between science and religion.

Despite his own intentions, Barbour's classification has perhaps itself encouraged polarisation of the field because there lies a deep assumption about the division of labour within it. This is most clearly seen in his examples of positive interaction between science and religion. The communication between the fields is largely one-directional: scientific research papers land on the desks of theologians for them to work into a natural theology, systematic synthesis or wider metaphysics. Scientific progress, on the other hand, does not need the resulting worldview to be fed back to the laboratory: Barbour acknowledges that scientists need not raise wider questions about the order of the universe in the course of their work (1990). This means that the dialogue that is identified does not occur in the very midst of scientific practice, but at its outskirts. From the outset, Barbour's vision of dialogue was not of the most deeply entwined interaction between science and religion.

It is in the application and use of Barbour's classification, however, that the problem is greatest. Its four categories can too easily be unwittingly treated as mutually exclusive. Making this error forces a student, once encountering any conflict between science and religion, to choose between a position of conflict or of independence. Yet, in many areas of life, dialogue is most critical exactly when and where conflict exists. Mikael Stenmark's alternative classification thus has an important advantage over Barbour's: Stenmark gave less prominence to the factor of conflict when distinguishing the ways in which science and religion may relate (2004). He was careful to ensure that the existence of conflict between science and religion does not necessarily lead to the view that the fields are irreconcilable.

Although Stenmark's classification is more sophisticated than Barbour's, however, we may begin to suspect that it is the very concept of a classification that is the source of the problem of polarisation. If our real concern is the development and portrayal of positive narratives regarding the interaction between science and religion, perhaps our best course of action is to get on with exactly that. I pause before doing so only to argue that this starting point can (and should) be accepted by believers and non-believers alike.

The Unimportance of Conflict

The concern that public opinion is polarised into positions of conflict or independence is most usually raised by those with religious affiliations, but there are many reasons to bring an atheist to accept that dialogue is possible and desirable between the two fields, even if he or she believes them to be in insurmountable epistemic conflict. In the first place, it seems a reasonable position to take, if one accepts the widely acknowledged point that Barbour's classification is, understandably, philosophically unsophisticated (De Cruz 2017; Stenmark 2004). It won't do to close off debate because of the existence, in some quarters, of conflict.

Given that there are profound conflicts between different sciences (or religions), between parts of the same science (or religion), between members of the same laboratory (or place of worship), it would be remarkable to find an absence of conflict between science and religion as a whole. Stenmark is right: conflict isn't so important in determining the relationship between science and religion. A humble atheist might also accept Alain de Botton's argument that there is much for non-believers to learn and take from religious practices, because there are many elements of religion which people find helpful and alluring (2012). The atheist earns the title 'humble' by respecting public opinion. Such humility is called for because secularisation has not spread as rapidly nor as globally as expected by the early sociologists of the twentieth century (Stark 2015). Whether wanting to restrict it or promote it, secularisation thus demands public engagement about science from all sides. Third and finally, there is a growing concern that public acceptance of the conflict thesis deters the religiously minded from studying science. This is, indeed, one of the reasons for the 2009 founding of the Learning About Science and Religion (LASAR) project. Enthusing young people about science, regardless of their religious affiliations, is something we should all be concerned with.

Both atheist and believer should be troubled then, if the epistemic bias and simplicity of Barbour's classification has encouraged a polarisation of public views. Criticisms have failed to keep this, the ultimate purpose of Barbour's work, in mind: they do not explain the failure of the classification to encourage narratives of rich, two-way communication. I have suggested that this failure is, at least in part, a result of assuming a sharp division of labour between science and religion. For many, the assumption that science and religion have very different work to do is a fair one. A difference must be presumed, after all, for the fields to be compared at all. But we should perhaps wonder why we are so concerned to compare the two fields, if our real purpose is to communicate. The existence of conflict is to be expected and makes the need for interaction between the fields more urgent, not less. If we accept that dialogue is possible and desirable, the debate regarding science and religion should be extended beyond classification and be reoriented to deepen and enrich dialogue where it exists and to encourage it where it does not. It is against this background that I propose to entertain the idea that science contributes to more than a collection of facts to moral decision-making. The criticism of epistemic bias made of Barbour's work can be taken one step further: instead of merely pointing out the neglect of religious experiences such as ritual, prayer and ceremony, we can go on to compare the moral consequences of participating in such activities with the moral consequences of participating in science. The suggestion here is that science and religion can conflict on moral grounds: *engaging in scientific practice and education alters a person's everyday moral outlook*.

Although it is true that recent debate has not sufficiently acknowledged the importance of religious experience, it has perhaps acknowledged scientific experience even less. It has been assumed that scientists, *qua* scientists, have nothing to add to moral decision-making other than facts. Exploring an alternative hypothesis promises to open new ground for dialogue between science and religion. I have argued so far that atheists and non-believers alike should bypass the question of classification and take the possibility of dialogue as a starting point for the debate regarding the relationship between science and religion. Whether this can be done by approaching the debate on moral terms, however, remains to be seen. The idea that science doesn't just raise moral questions but takes part in answering them contrasts sharply with the commonsense view that science tells us what we can do, but not what we should do. We shall see that historic attempts to deliver an ethics from science have largely been unsuccessful. I turn now to distinguish the hypothesis at hand from these failed projects of the past and, by doing so, to articulate it more clearly.

A Return to an Ethics of Science

More than 30 years ago, Bernard Williams rallied against the apparent goal of modern philosophers to generate codified systems of morality, taking particular aim at Kantian ethics and utilitarianism (1985). In a perfectly codified system, the role of moral reasoning appears be restricted to the choice of initial axioms, from which all else follows by the application of logic. The principal variants of utilitarianism have customarily been interpreted in this way, resulting in a theory that has felt, even by its first critics, barren, dry and soulless (Macaulay, 1860). Some utilitarian thinkers have gone further, rejecting the need for any moral kick-start to their system: J. S. Mill (1861) believed that humans ought to strive to maximise happiness because it was in their nature to desire happiness; today, Sam Harris (2004) takes a similar view when he argues that the right thing to do can be worked out entirely from fact. In its most extreme form, then—as exemplified by the logical positivists—the aim of deriving an ethics from science goes as far as denying that there is any such thing as moral knowledge at all. Public intuition, on the other hand, has been on Williams' side, resistant to the idea of grounding morality in science. The commonsense view has been that science reveals how things are, but we must then, independently of science, decide what to do about those facts. For many philosophers, the commonsense view is supported by a compelling philosophical argument that is famously traced back to David Hume (1739). The *naturalistic fallacy* is a modern presentation of Hume's argument: it is a mistake to derive moral principles (about what there ought to be) from factual ones (about what there is). Set against the naturalistic fallacy, any attempt to derive ethics from science appears naïve, possibly including the hypothesis presented here that scientific experience alters a person's moral outlook.

On the other hand, the hypothesis can appear entirely trivial. We take it for granted that experiences—including education of all kinds—bring about changes to our characters. If this is to mean very much, it should at least mean that experiences affect a person's reactions when faced with ordinary decisions that have a moral flavour. As absurd as it may seem to generate ethics from science, it may seem equally absurd to assume that study merely adds to a person's knowledge, as if a person remains exactly as they were before learning, but with access to additional information in their memory. In the last 60 years, a series of philosophical arguments for the subjective nature of science has challenged the correctness of making a sharp distinction between what a person knows to be true and what a person believes to be right (Barnes and Bloor 1982; Kuhn 1962; Longino 1990). In particular, philosophers have suggested that scientists must turn to values, in addition to factual data, when making a choice between two competing theories (Kuhn 1962). They have also suggested that values are necessary to interpret scientific data and reach scientific conclusions (Douglas 2009). Note that philosophical work in this vein has identified particular situations where values play a role in scientific work, and this is what philosophers are referring to when they report that, "Science is subjective." A statement of this kind should not immediately be taken to mean, therefore, that science is irrational, that values permeate all areas of the sciences equally and universally or that science is subjective to the same extent or in similar ways to other fields.

Against the philosophical literature of recent times, then, the hypothesis that science alters moral outlook is an unsurprising one. However, the philosophical arguments to date have emphasised the ways in which science relies upon values and thus challenged the idea that science has a special status as the primary source of reliable and objective knowledge. The blurring of lines between science and religion has yet to be explored in the opposite direction: if values play a more profound role in generating facts, might not facts play a more profound role in generating values? In this way, the hypothesis that science alters moral values is a logical step forward from the current philosophical discussion regarding the relationship between fact and value.

It nevertheless remains to distinguish the hypothesis that science alters moral outlook from its failed (and extreme) predecessors in the history of ethics. I do so in three ways, by emphasising the empirical nature of the hypothesis, its mundane focus and its attention to change. In the first place, there is no derivation here of statements of value from statements of fact, as Hume argued was impossible. It is not suggested that a logical connection exists between the two. The statement 'we should not eat meat' cannot be derived from our scientific theories. Yet, it is plausible that certain scientific practices increase (or decrease) the chances that a person becomes vegetarian. If those scientific practices are widespread, it will have an impact on the moral outlook of our society. An ethics resulting from science need not, then, be a top-down, logical system of morals. This means that the causal connections between scientific experience and moral outlook may be difficult, even with hindsight, to explain. It has been common in moral psychology to make this assumption, since Simone Schnall et al. reported that being asked to wash your hands before entering an interview room affects your moral judgements during the interview (2008). Even in cases where the causal connection is plausible, it remains an empirical result that requires testing to demonstrate. It is possible, for example, to present plausible explanations of why conducting medical research on rats is more likely to bring a scientist to vegetarianism, if research were to reveal this causal connection. It is equally possible to provide plausible explanations of why conducting medical research on rats has the opposite effect. The rationale takes secondary place, after empirical research has ascertained the conclusion to be drawn.

Second, the focus here is on the moral decisions that are met with when going about the ordinary business of living. Should a lover who no longer wishes to be in a relationship wait until her partner has completed a course of chemotherapy before revealing her feelings? Should the able-bodied childminder leave the buggy outside the toilet cubicle or go instead with the buggy into the disabled cubicle? Should a parent allow a five-year-old to become a vegan? Situations of this kind cannot be easily solved by logic because they are not simple exemplifications of general moral principles. Furthermore, conducting empirical research into the relationship between scientific experience and everyday moral outlook will not reveal high-level claims regarding how we should act. What is being sought is evidence of the impact of a particular scientific experience upon a particular aspect of a person's beliefs, inclinations, judgements, behaviours or dispositions that are demonstrated in everyday life. (I generally use 'outlook' to avoid prioritising between these qualities and to thus avoid making assumptions regarding the metaphysics of mind; I also leave the question open regarding what counts as a scientific experience and do not claim that there is any profound or meaningful distinction between this and any other kind of experience.) There is no assumption made here about what characterises morally good behaviour, but it is assumed that we can distinguish moral decisions (in which we can respond more rightly or more wrongly) from non-moral ones (in which there is no right thing to do). A person's moral outlook is then understood to be the collection of their reactions when faced (possibly counterfactually) with such decisions.

Finally, the hypothesis is framed to consider *changes* to a person's moral outlook. From this perspective, there is no seeking of the ultimate source of morals. Because the focus is on everyday living, there cannot be a moral void into which science steps: we are forced to make these kinds of moral decisions by living our lives, and in doing so, we demonstrate a moral outlook. As a result, even if scientific experience is found to alter morality, it is not the only generator of value.

The resulting claim is still a challenging one for some believers, especially for those who believe that their religious institution provides the only guidance on moral matters. But if a believer accepts that family, friends and many other influences can help a person to live a better life, it is plausible that learning about the natural world may do so too. What is more, there is no assumption here, as has been associated with historical attempts to derive ethics from science, that an alteration to morality brought about by science is necessarily an improvement. It is because of this that the hypothesis presented here provides a new platform for the debate between religion and science: once an effect of scientific (or religious) experience is revealed, it remains to be debated whether the change is desirable or not.

This sketch of how a modern ethics from science should differ from those of the past has implications for a theory of morals required to support it. It requires a moral philosophy that allows for progress in morality, that focusses on the mundane, that is open to many moral sources, that has an empirical aspect and that looks to experience as well as belief. These are stringent and high demands to place upon a theory of morals, and much philosophical work is yet to be done to provide such a framework. The philosophical motivation for doing so would be to take the argument for the subjective nature of science to its logical ends. In addition, there is a theological motivation for this work, to steer between the polarising position of conflict and independence in the science/religion debate and to encourage richer dialogue between the two fields. I see the primary purpose of this work, however, to be in education: how does the study of science impact upon the moral outlook of children? In the penultimate section of this chapter, "Testing the moral impact of scientific education", I assess the most relevant research completed in this area to date and explore how best it might be continued in the future. Before that, I reveal some evidence that indicates that bypassing the problem of polarisation may be more difficult than I have so far suggested.

Evidence of Changing Attitudes in Children

There is no assumption here that scientific experience is superior to religious experience for the development of a person's morality. Yet, it does challenge members of religious communities in a new and potentially difficult way, to open the debate on how we become better people to sources other than religious authorities. On the face of it, the research envisaged does not answer the question of what it is to be good but, once goodness is agreed, how to go about embodying and implementing that goodness in everyday life. Because the many believers and nonbelievers alike, for example, can agree that it is a good thing to regularly donate to charity, a discovery of the kind that studying chemistry brings people to give more to charity than listening to sermons does would be worth analysis and debate. A fundamental disagreement between atheists and believers may well remain in the ensuing conversation regarding the ultimate source against which morality is measured. Those without religious commitments are more likely to assume that moral judgements can only be made by the lights of previous experience. From this perspective, scientific and religious experience may make an equal contribution towards our moral judgement. Those with religious commitments, however, are more likely to assume that they should, at least in part, assess the impact of scientific experience against moral requirements revealed through religious practice, tradition and teaching. From this perspective, science and religion cannot have an equal impact on moral judgement. The religious community may sense a deeper and more threatening challenge here, then, to the priority of religion in matters of value.

The situation echoes, perhaps, the challenge felt, from the time of Thomas Kuhn's work onwards, by some scientists to the priority of science in matters of fact. As a result of Kuhn's work, it is more readily accepted by the philosophical community today that our commitment to the rationality of science is based on conviction. Indeed, Gary Gutting has argued that this no longer remains an argument but is an example of knowledge secured by philosophers in the latter half of the twentieth century (2009). (This is not to say, as Gutting emphasises, that philosophers have concluded that science is irrational or based on personal prejudice.) I suggest that the growing appreciation for how science makes use of values has not reduced public confidence in the institutions of science. Similarly, I propose that exploring its subjective aspects further, to consider the possibility that it generates values, need not reduce public confidence in the equally robust institutions of religion.

The persistence of public attitudes, however, casts doubt on the theological motivation for this work. I have suggested that viewing science as an influencer of values, and thus, permitting the two fields to debate on a more equal footing regarding moral questions, will offset the unintended polarising consequence of Barbour's classification. One reason for thinking that this line of reasoning may be overly optimistic is that viewing science as a consumer of values does not appear to have a similar effect. The conflict thesis—the idea that science and religion are irreconcilable—remains strong, despite the increasing acceptance within the philosophical community, and possibly wider communities, that science has subjective elements.

My own experiences with undergraduates of philosophy of science over the last 20 years suggest that there has indeed been a growing acceptance in the UK of the subjectivity of science, although this has not obviously reduced the popularity of the conflict thesis. I have conducted a pilot study in two Cambridgeshire secondary schools to test this hypothesis further. It indicates that children today may indeed be more aware of the subjective nature of science than they were 20 years ago.

In 2015–2016 academic year, I administered a questionnaire to Year 7 students (aged 11–12 years) at a co-educational state secondary school (serving 1400 students aged 11–18 years). I administered the same questionnaire in the 2016–2017 academic year to Year 8 students (aged 12–13 years) at a second co-educational state secondary school (serving 1300 students aged 11–16 years). The "Large Scale Exploration of Pupils' Understanding of Nature of Science" questionnaire (LSE) was developed and validated by Joan Solomon, Linda Scott and Jon Duveen (1996). It consists of five multiple-choice items. The fifth item of the questionnaire (shown in Fig. 7.1) asks students why old scientific theories are replaced by new ones.

Q5. Many of the old theories of science have been replaced by new ones. Is this because:

(a) We have better technology now?

(b) More evidence has become available?

(c) People living at different times have had different ways of explaining?

(d) We have now proved the old experiments were wrong?

Fig. 7.1 Item 5 from the LSE questionnaire administered in 2016 and 2017 at two Cambridgeshire secondary schools, originally published by Solomon, Scott and Duveen (1996). Solomon et al. considered (a), (b) and (c) to be adequate responses to the question

Solomon et al. presented four options for students to choose from and accepted three of these as adequate responses. An old theory might be replaced as a result of (a) newer technology, (b) new evidence or (c) because people at different times have a different way of explaining. They took the fourth option, (d), that scientific theories are replaced when older experimental results are proved wrong by newer ones, to indicate a less developed view of scientific progress.

The item addresses one particular aspect of the subjectivity of science. In the first half of the twentieth century, logical positivists promoted an objective view of the progression of scientific theories: a clear-cut distinction was made between theories that had been falsified and those that had not; the decision to replace one by another was a purely logical one, which was (at least theoretically) computable. Students who select the fourth option (d) are demonstrating a viewpoint of this kind. In contrast, Thomas Kuhn, following a long line of others, argued that scientists do not choose theories in an algorithmic way (1962). Students with a more subjective view of science, along the lines of Kuhn's, are more likely to respond to this item with option (c). It should be noted, however, that the item does not address the role that values play in theory change directly and therefore we label option (d) as a 'more objective' view than option (c) with caution.

Solomon and her colleagues administered the LSE to 126 British students in Year 8 in 1996. In 2016, I gave it to 31 students in Year 7; in 2017, I gave it to 30 students in Year 8. The results are shown in Fig. 7.2. The results show a statistically significant decrease ($p < 0.001$) in the number of students opting for option (d) in the recent tests (4%) compared with the original test (17%). (The p value has been calculated by applying Pearson's chi-square test.)

This is an intriguing result from a pilot study but one which cannot be readily generalised to a wider population. In particular, post-questionnaire interviews

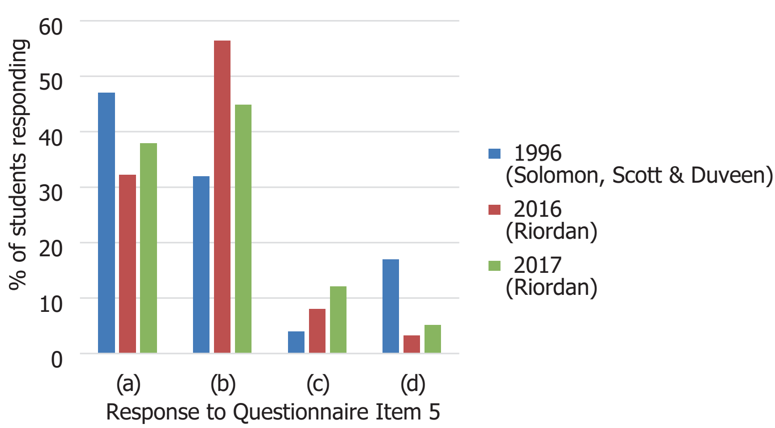


Fig. 7.2 Responses of students to the fifth item of the LSE (shown in Fig. 7.1). The comparison shows that students were more likely to give the answer (d) 20 years ago, indicating a more objective view of science. The numerical data from 1996 were interpreted from a graph (1996). When students in 2016 and 2017 responded with two options, each was given a score of 0.5

conducted with Year 7 students demonstrated that these students held a much more nuanced understanding of science than had been captured by the LSE. These interviews therefore revealed the limitations of this research method. Indeed, since this questionnaire was developed there has been a growing understanding of the complexities of eliciting students' views on the nature of science; research has suggested that students' attitudes on this matter are better elicited by open-ended methods (Lederman et al. 1998). This pilot study was restricted because it required data from the past, a more thorough study of children's current attitudes to the subjectivity of science would use improved elicitation tools.

Further research is also required to discover whether children who view science as more subjective are less likely to accept the conflict thesis. Perhaps the conflict thesis is becoming less entrenched in public thought as Russell took it to be in 2002. If so, we may be more optimistic about the growth of dialogue between science and religion and of the path I am advocating of how to move the science/religion debate beyond Barbour. It is also possible, however, that children are continuing to accept the conflict thesis despite (and even because of) their growing recognition of the more subjective elements of science. It may be easier to discard scientific ideas that disagree with one's own if science is too lazily labelled 'subjective'. Such a conclusion would cast doubt on the idea that recognising the similarities between science and religion can reduce the problem of polarisation.

Testing the Moral Impact of Scientific Education

So far, I have presented a claim—that practising or studying science alters a person's moral outlook—and attempted to make it at least palatable. I have situated this claim in an old debate regarding the conflict between science and religion, arguing that it provides a new platform for a richer dialogue. I have then articulated it against philosophical literature by distinguishing it from historical attempts to generate ethics from science. One way in which it differs to the claims of the philosophical literature (and requires a nonstandard theory of morals) is that it is empirical in nature. It is, indeed, perhaps best tested as a claim of moral psychology, by administering of questionnaires and by conducting psychological tasks to measure scientific experience and moral outlook.

To date, the largest study broadly of the kind envisaged here was undertaken by Jean Decety and his colleagues, who investigated the correlation between the religiosity of households and the altruism of children in those households (2015). The study was of 1170 children aged between 5 and 12 years, living in six countries (Canada, China, Jordan, Turkey, USA and South Africa). The religiosity of each child's household was measured by a questionnaire completed by parents and guardians. The altruism of the children was measured by psychological testing. A version of the 'dictator game' was played: the children were shown 30 stickers and allowed to choose 10 stickers to keep; on being informed that not everyone in their school could take part, they were then given the option of giving some of their stickers away. The study found a negative correlation between the religiousness of a child's household and the number of stickers the child donated. If a further correlation is then accepted between atheism and the practice of science, a conclusion can be drawn regarding the correlation between science and altruism that is very broadly of the kind under consideration here: scientific practice is positively correlated with altruistic behaviour.

The truth of this claim is not of immediate importance here. It is useful to us only as a point of comparison. There is no work that I know of that directly supports the hypothesis of this chapter. The work of Decety et al. differs from what is needed because it is not a causal claim of the kind we are looking for: the kindness of the children could not be attributed to their own scientific experience and education. Furthermore, this research did not measure changes in the children's kindness. Nevertheless, the psychological tasks of the kind used by Decety et al. would be suitable tools to compare the changes in moral outlook of students undertaking scientific study with those who are not. In the UK, the most obvious point to administer such tests would be when students begin specialised 2-year courses of study at the age of 16 years. Students with previously similar educational backgrounds are able at this point to take very different paths, some continuing with formal scientific education (following a timetable that is mostly or entirely composed of science) and others dropping it entirely. The testing would then be retaken at the end of these specialised courses, providing the opportunity to discover if students' moral outlooks have diverged according to their choice of study.

Another difference with the work of Decety et al. is that we cannot yet identify what kinds of moral outlook we are interested to measure. We are considering the possibility of causal connections between scientific experience and morality that are not easily recognised and reasoned for. It is not clear at the beginning of the research, therefore, what psychological tests should be selected. Before psychological tests are conducted, it will be necessary to identify plausible relationships between areas of scientific study and moral outlook. This would perhaps best be achieved with a large-scale series of questionnaires designed to track the moral outlook of students through their specialised studies. Questionnaires of this kind have been designed and validated by researchers for similar purposes, most notably the Moral Foundations Questionnaire, developed by Jesse Graham, Jonathan Haidt and Brian Nosek (2009). Adaptations could be made to tailor such questionnaires for teenagers and the specific moral decisions they face, covering topics of social media, relationships, animals, environment and responsibility. The advantages of such an approach are that it is possible to address a wide range of topics and to reach many students, studying different sciences. On the other hand, it will not directly test students' moral outlook but only their self-reported moral beliefs. Having identified potential causal connections, it would then be necessary to back up such research with smaller scale psychological testing.

A Vision of Dialogue on Non-epistemic Grounds

I have attempted to articulate the hypothesis, in a way that avoids both triviality and absurdity, that engaging in scientific practice and education alters a person's everyday moral outlook. I have considered how this claim can be tested empirically. Evidence that scientific experience impacts upon a person's morality would call for richer dialogue between two great pillars of society, those of science and religion. Such research has the potential, then, of taking the science/religion debate beyond Barbour's delineation of the field. Instead of classifying how science and religion can or should interact with each other, the vision presented here is of how we should get on with that interaction. In particular, it raises the question of how we live our lives above that of what there is in our world. It is, after all, a question for all of us, in all our capacities, to consider.

References

Barbour, I. G. (1990). *Religion in an age of science*. San Francisco: Harper & Row.

Barnes, B., & Bloor, D. (1982). Relativism, rationalism and the sociology of knowledge. In M. Hollis & S. Lukes (Eds.), *Rationality and relativism*. Blackwell.

Cantor, G., & Kenny, C. (2001). Barbour's fourfold way: Problems with his taxonomy of science-religion relationships. *Zygon, 36*, 765–781. https://doi.org/10.1111/0591-2385.00395.

De Botton, A. (2012). *Religion for atheists: A non-believer's guide to the uses of religion*. London: Hamish Hamilton.

De Cruz, H. (2017). Religion and science. Stanford Encyclopedia of Philosophy. Spring 2017 Ed.

Decety, J., Cowell, J. M., Lee, K., Mahasneh, R., Malcolm-Smith, S., Selcuk, B., & Zhou, X. (2015). The negative association between religiousness and children's altruism across the world. *Current Biology, 25*, 2951–2955. https://doi.org/10.1016/j.cub.2015.09.056.

Douglas, H. (2009). *Science, policy, and the value-free ideal*. Pittsburgh: University of Pittsburgh Press.

Evans, J. H., & Evans, M. S. (2008). Religion and science: Beyond the epistemological conflict. *Narrative Annu Rev Sociol, 34*, 87–105. https://doi.org/10.1146/annurev.soc.34.040507.134702.

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

Graham, J., Haidt, J., & Nosek, B. (2009). Liberals and conservatives rely on different sets of moral foundations. *Journal of Personality and Social Psychology, 96*, 1029–1046. https://doi.org/10.1037/a0015141.

Gutting, G. (2009). *What philosophers know: Case studies in recent analytic philosophy*. Cambridge: Cambridge University Press.

Harris, S. (2004). *The end of faith: Religion, terror, and the future of reason*. New York: W.W. Norton &.

Hume, D. (1739). *A treatise of human nature: being an attempt to introduce the experimental method of reasoning into moral subjects*. Printed for J. Noon, London.

Kuhn, T. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Lederman, N. G., Wade, P. D., & Bell, R. L. (1998). Assessing the nature of science: What is the nature of our assessments? *Science Education, 7*, 595–615. https://doi.org/10.1023/A:1008601707321.

Longino, H. E. (1990). *Science as social knowledge: Values and objectivity in scientific inquiry*. Princeton: Princeton University Press.

Macaulay, T. B. (1860). *The miscellaneous writings and speeches of lord Macaulay*. London: Longman, Green, Longman and Roberts.

Mill, J. S. (1861). *Utilitarianism*. Son & Bourn, London: Parker.

Russell, C. A. (2002). The conflict of science and religions. In G. B. Ferngren (Ed.), *Science and religion: A historical introduction*. JHU Press.

Schnall, S., Haidt, J., Clore, G. L., & Jordan, A. H. (2008). Disgust as embodied moral judgment. *Personality and Social Psychology Bulletin, 34*(8), 1096–1109.

Solomon, J., Scott, L., & Duveen, J. (1996). Large-scale exploration of pupils' understanding of the nature of science. *Science Education, 80*, 493–508. https://doi.org/10.1002/(SICI)1098-237X(199609)80:5<493::AID-SCE1>3.0.CO;2-6.

Stark, R. (2015). *The triumph of faith: Why the world is more religious than ever*. Wilmington: ISI Books.

Stenmark, M., 2004. *How to Relate Science and Religion: A Multidimensional Model*. By William B. Eerdmans Publishing Company, Grand Rapids, MI/Cambridge.

Williams, B. (1985). *Ethics and the limits of philosophy*. Fontana Press.

Dr. Sally Riordan is a senior research fellow at the Education Observatory, at the University of Wolverhampton. She previously taught physics in various secondary state schools in Cambridgeshire and supervised undergraduate students in history and philosophy of science at the University of Cambridge. Her publications include 'The Objectivity of Scientific Measures' in *Studies in History and Philosophy of Science* and 'And How Experiments Begin: Defining the Kilogram by the Planck Constant', in *Journal for General Philosophy of Science*. Her research interests include social justice in education, science education and the ethics of science.

Chapter 8
Autonomous Self and Inter-Processual Self: Two Ways of Explaining How People "See" and Live Relationships and the Resulting Dialogue Between Science and Faith

José Víctor Orón, Kleio Akrivou, and Germán Scalzo

Introduction

Debate on the relationship between science and religion has long flourished, as seen in two key reference books (Brooke 1991; Harrison 2010). In 1966, Ian Barbour presented a milestone for the dialogue between science and religion, postulating that both are part of the same spectrum and share subjective and objective reasons such that *critical realism* is needed because, in some aspects, they converge and, in other aspects, they diverge (Barbour 1966). Barbour accordingly suggested four different understandings for the relationship between science and religion, as follows: conflict, independence, dialogue and integration (Barbour 2000). This classification has been broadly accepted, although it has also been subject to modifications and alternatives; for example, John Haught proposes conflict, contrasts and convergence (Haught 2012). Stenmark, in an earlier work, suggests that several different kinds of relationships end up being of the same posture because conflict could be expressed in different ways, but, in the end, science and religion are understood as terms in opposition to one another (Stenmark 2010).

J. V. Orón (✉)
Mind-Brain Group: Biology and subjectivity in philosophy and contemporary neuroscience, Institute for Culture and Society (ICS), University of Navarra, Navarra, Spain

UpToYou Foundation

K. Akrivou
Business Ethics & Organizational Behaviour, University of Reading, Reading, UK

University of Navarra, Pamplona, Spain
e-mail: k.akrivou@henley.ac.uk

G. Scalzo
School of Economics and Business, Universidad Panamericana, Mexico City, Mexico

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_8

We do not think that the conflict between science and religion is between two disciplines or indeed that it is a conflict at all because of the vast number of esteemed people with scientific and religious/theological educations that share common views on the issue. Of course, there are differing positions among people with a religious/theological education, just as there are differing positions among scientific scholars, regarding the relationship between science and religion (Stenmark 2010). This leads us to argue that the key to relate science and religion is not the degree to which they objectively have some conflict. It may be better to take a step back altogether from the assumption of science (fact-based knowledge) and religion (faith-based knowledge) as two separate domains. One may essentially ask, "What are both science and religion for; why do we need them?" One may also wonder, "Why answer the question about the relationship between science and religion?"

Thus, the more important inquiry becomes the purpose that both scientific and faith-based systems of knowledge serve. Asking this question means emphasizing first how science and faith (and all their attendant questions) may be understood and experienced by different people and, second, more or less mature and ethical ways of understanding and acting in human affairs (Akrivou and Bradbury-Huang 2011). The philosophical and psychological postures of how a person understands or experiences the science–religion relationship define how they are integrated into human action. This assumption is congruent with the fact that the foundations of science are philosophical rather than scientific (Haught 2012). For religion, philosophy is also the key instrument in theology because *the faithful need to show the reason of their faith* (first Letter of St Peter).

If we revisit various traditional models and how they approach the faith/religion–science problem – for example, Barbour (2000); Haught (2012) and Stenmark (2010) – they do not really appear to be as opposed in their epistemological assumptions as these authors argue, including Barbour's divergent models/positions. This is in line with E. Dumler-Winckler (in the same volume). In fact, all the authors who have developed literature on science and religion try to advance the "project of reconciliation" between science and religion, understanding them a priori in conflict. For instance, Ian Barbour received the Templeton Prize in 1999 for Progress in Religion.

We have researched the dialogue between neuroscience and faith (Orón 2014) and different kinds and qualities of human beings, as well as the quality of our knowing and action, which all help define two contrasting paradigms of understanding and living (Akrivou and Orón 2016). Accordingly, in this chapter, we aim to show how philosophical/psychological perspectives that can be assumed by all, independent of preferences about religion and science, can explain the posture that these two paradigms take on when facing this issue. In our previous research, based on consolidating a number of theoretical perspectives across a diverse disciplinary orientation (mainly philosophy, psychology and neuroscience), we suggested that there are two contrasting paradigms for conceiving of the self and human development, namely, **autonomous self (AS)** and **inter-processual self (IPS)** (Akrivou and Orón 2016; Akrivou et al. 2018). We suggest here that, depending on which of these two corresponding paradigms characterizes a person, *how* he or she "sees" and lives the relationship–dialogue between science and faith emerges as directly related.

For the AS, the subject is defined in confrontation with and opposition to any (human or other) object, understood as external and unrelated to the self. This is because AS understands the human being as an autonomous subject that strives to grow in increasing autonomy. Individualist growth in AS occurs based on the maintenance of self-control and accumulated expertise. For the other model of self and human development, namely, IPS, the human being is a person, that is, an open dynamic relationship that always maintains a distinct uniqueness and who is not exhausted in her presence as such. IPS values the personalist way whereby every human being maintains their uniqueness and internal quality of relating with another/others. In IPS, personal growth is not possible unless it happens through improving the quality of relationships between a person and other persons, as well as other beings and nature.

These two background positions, AS and IPS, can find support from proponents and opponents of both religion and science because, as noted, the emphasis is on how the relationship between the two is lived and understood. Even more importantly, we suggest that the IPS and AS mind-sets possess different understandings of the **quality of dialogue** itself. We therefore suggest that the quality of dialogue between science and religion differs when comparing AS and IPS.

We suggest that people who support an understanding of the human being modelled upon the AS or the IPS are more likely to understand and experience the relationship between science and faith in different qualitative ways, and we critically discuss this theoretical perspective. Human beings modelled upon the AS are more likely to understand and experience science and religion as separate "domains", and they relate to it in terms of conflict or a mental problem to be solved. Based on the AS, requiring the separation between the subject-knower (and mind) and all other objects as external, science and faith will then be understood as two independent "cognitive" object-domains that at some ideal moment or point may be integrated. The AS subject is entitled to *autonomously* decide which of the two to "value" more and individualistically decides how to act in the face of a perceived "conflict" separating these two domains.

Instead, people who support an understanding based upon IPS are more likely to experience and value the relationship between science and religion as an interrelated notion. Simply put, for an IPS mind-set, it is meaningless to understand this issue by separating the two constituent parts. People who live out IPS are more likely to experience and wish to grow their personal being and identity between science and religion; thus, they perceive the two in genuine integrative terms, namely, as part of an inseparable whole and a perpetual union whereby each part completes the other, while maintaining their distinctiveness. Therefore, the IPS position promotes integrated dialogue in the science–religion relationship, while the AS model understands that relationship is a conflict and is thus less likely to sustain dialogue.

Autonomous Self (AS) and Inter-Processual Self (IPS) Paradigms

As stated above, we propose two contrasting paradigms of conceiving the self and human development, which we term the **autonomous self (AS)** and the **interprocessual self (IPS)** (Akrivou et al. 2018).

Despite the fact that psychologists and philosophers have diverse models of the self, human action, human integrity and development, they all focus on human development that occurs across a number of different aspects, stages or domains. For instance, one focuses on social aspects, while another focuses on cognitive aspects. According to our research, these conceptualizations have more in common than it at first appears. Thus, depending on which of these two corresponding backgrounds characterizes **the person**, people will "see" and live the relationship–dialogue differently in response to other persons, things and the entire notion of human knowing and action. The AS model has its philosophical foundations in Descartes, Kant and German idealism, and its psychological foundations in Kegan, Ryan and Loevinger/Cook-Greuter.

The IPS model has its philosophical foundations in Aristotle, Leonardo Polo, Alfred Whitehead and Wang Yangming, while its psychological foundations are found in Erik Erikson, Carl Rogers and Viktor Frankl (Akrivou and Orón 2016).

The starting point of the AS model is the affirmation of a (taken for granted ontology of) division between the subject and the object as a priori distinct, while how to bring them closer together relies on the autonomous will of the subject agent. Modernism has emphasised the strength of the self as the epitome of agency (Düsing 2002). We suggest that this meaning-making quality of the AS reflects the "modern" paradigm of human beings, action and knowledge, whereby the object-world and human relationships are understood as separate and independent.

Indeed, the modernist self is the platform by which to access the world and to harness and master it by the Cartesian mind. This self loves to define substances, i.e. entities that exist by themselves; once a given substance is defined, it is possible to establish relationships or not based on the autonomous free will of each subject agent (Akrivou et al. 2018). In this case, the self grows because she rationally expands her mastery domain after domain. This process ends up being governed by the ideal of total self-determination (with the last instance of what is good or wrong being the self). In the first part of its development, the self rests more on the mastery of various social aspects or domains, but in higher states of mature growth, the self becomes increasingly autonomous and independent. The loneliness of that (AS) self is that, in the end, the self knows almost nothing about itself because it is not a person, but rather a mere logical necessity based on the fact that there must be someone to support activity (Düsing 2002 p. 12). But since the self only knows objects, the self can only know itself as an object and through objects rather than as a distinct subject.

There are some unintended educational implications of AS's understanding of science and religion as separate domains. Attempts have been made to resolve the problem of their relationship as a technical issue by adding separate individual pedagogical tools/interventions (Akrivou and Bradbury-Huang 2015) to help address various cognitive components included in a scientific or religious epistemology. They, however, fail to enable a long-lasting formula for human action with a focus on ethics and sustainability. Because of this, learners' development following the "autonomous self" paradigm is limited and only succeeds in the short term.

On the other hand, the starting point of the IPS model is personalism and the affirmation of its dynamic and relational unity. For IPS, personal growth is only possible through improving the quality of relationships between a person and other persons, as well as other beings and nature. This starting point reveals a very different attitude before life itself and its different aspects because IPS has confidence in life. IPS asserts the relational unit that gives people confidence to approach the other(s) without the need to master because it is driven by the wonder of mutual learning and growing in relation to the other(s) (Akrivou et al. 2018). However, this wonder is respectful of the other's uniqueness and allows the person to discover that individual growth is both personal as well as a *sine-qua-non* for the growth of the system. Improving the quality of our relationships is the best and only way towards overall development, which is what constitutes personal growth.

In the case of the IPS model/mind-set, personal differentiation, integration, growth and identity are different conceptualizations of the same event (as opposed to being seen as different processes). If, in AS, the self is the subject above all, in IPS, the self is a person, meaning that at the core of each human being, we find uniqueness, intimacy and individuality; this self balances the nature-subject and the personal fundamentals that shape being and acting (Akrivou and Orón 2016). So the person could be a subject, but only insofar as one is a person and maintains one's humanity by how one acts and ethically relates within a vision of mutual growth whereby all parts in a growing relationship maintain and enhance their distinctive identity and purpose. Thus, IPS does not reject AS's offer (individuality and the energy to create), but rather incorporates the best parts of AS. IPS does not, however, need to grow through individual mastery as AS does.

IPS also has several educational implications. Related to our topic, when we work with students at any age, we should not assume that science and religion are two different domains. The reality is one complicated domain and we ought to strive for students to understand reality both as an integrated whole and in its complexity (Akrivou 2009) rather than in a simplistic (reductionist) way. Thus, we must start by discovering the complexity of this united reality. Little by little, in the learning process, students will discover the different aspects of reality because they are in relation to one another. At the same time that they differentiate them, they integrate and identify them, increasing knowledge, including as related to the identity, differentiation and integration happening all at the same time. We find that the differences between science and religion are only a point of view that we use to contemplate reality, but, in all its complexity, there is only one reality and it is not possible to disaggregate science from faith. Science and religion offer different pathways for answering key questions about reality itself. If we want to know reality and to intervene in it in a way that enables the good, we need not just take into account science (in all of its different disciplines, including psychology, mathematics, sociology, etc.) and religion (in all of its complexity), but also other various pathways that involve literature, history, etc.

The fact that each person holds either an AS or IPS mind-set does not mean that each governs a subjective opinion one holds about science or religion. **Rather, each of these two mind-sets (AS or IPS) enables a contrasting corresponding existential, anthropological and metaphysical perspective.** The corresponding existential difference is between trusting (in IPS) or searching for security (in AS). The corresponding anthropological difference is between the fact that for human beings it is possible to recognize human nature, the subject agent and personal references (in IPS), versus uniquely relying on the subject agent's characteristics (in AS). Finally, the corresponding metaphysical differences between IPS and AS are between considering the universe as a relational and intertwined unit (in IPS) or as made up of various substances (in AS).

It is not at all the same thing to aim towards and to reach an "integral reality", or an "ordered totality" (Altarejos and Naval 2000 p. 86). We suggest that while IPS aims to reach an "integral reality" through the growth of the relational unit(s) involved, with the AS mind-set, it is only possible to reach an "ordered totality" through a hierarchical logical sum of parts. Our way of understanding to integrate "*entails a maturation in which different aspects and relationships differentiate and optimize to the same extent that they place themselves in relation to one another*" (Orón 2015 p. 114).

Integration is a key word, as it helps distinguish the notion of moral maturity for IPS in opposition to AS. Integration, in IPS, happens via personal-systemic growth since the person is always understood as a unity-respecting entity. Integration in the IPS model entails a maturation that requires differentiation, but differentiation and integration are two interrelated dynamics/sides relevant to the integrity of the person (Akrivou 2009) because "*integration is the dynamic that explains how growth or human maturity happens; even more, integration is the dynamic that describes the evolution and functioning of open, free systems*" (Orón 2015 p. 114). However, for AS, integration is nothing more than a kind of internal coherence and something to achieve. In IPS, integration constitutes the activity of growth from the very beginning, while in AS, it is a characteristic to be reached, or not, at the end (Akrivou and Orón 2016).

Relationship Between Religion and Science in Light of AS and IPS Paradigms

As mentioned, Ian Barbour offered the first conceptualisation between science and religion, which has received a variety of interpretations. Among them, two major different approaches emerged, namely, conflict <u>or</u> integration. The conflict position incorporates several cognitive domain sub-divisions, such as independent fields, submission of one field to another (religion under science or science under religion, religion A under religion B, etc.) or a more explicit confrontation. We consider that this paradigm of conflict belongs to the assumptions inherent in the AS model. In contrast, the paradigm of integration belongs to assumptions in the IPS model. For the AS model, the conflicting relationship between science and faith comes from considering them as two independent "cognitive" domains. Instead, people whose way of being/understanding is premised upon IPS are more likely to experience and value the relationship between science and religion in genuinely integrative terms.

IPS understands the science–religion relationship as part of an inseparable whole and an a priori union, whereby each part completes the other, while maintaining their distinctiveness. They have a variety of possible ways and qualities for growing this relationship further (in positive or negative terms). Therefore, a key question for IPS emerges as to whether each of these integrally related parts (in our case, science and religion) could be utilized in a higher order by mature persons who collaborate, catalysing action in service of the good (Akrivou et al. 2016, 2018). Clearly, science (scientists) that serves bad or evil ends is impermissible irrespective of one's position on the science and religion problem. And religion (persons practicing a faith) that serves bad or evil ends is also intolerable irrespective of the position or epistemological stance that one takes on the science and religion relationship problem. This is so because the IPS paradigm undertakes action with an orientation towards a good, purposeful existence and relationships. The IPS mind-set asks how all involved parties might contribute to each other's growth in the service of a more humane world.

It is worth recalling each model's existential differences regarding their underlying assumptions and approaches. AS seeks security, while IPS trusts and wonder drives its approach to learn more about the world. When AS finds discrepancies between science and religion, it tends to understand and approach them with *a conflict* mind-set, while IPS tends to explore the tensions that make up the science–religion relationship with an approach *of wonder*. In the end, their corresponding approaches and difference(s) are a matter of basic trust. It is thus of interest that every human being is faced with resolving the challenge of basic trust or basic mistrust in the first 2 years of life (Erikson 1959, 1963, 1997), as opposed to dealing with it all one's life as if it were an irresolvable personal challenge.

The conflictive mode and the integration mode share something that respectively underline AS and IPS's approach to life, relationships and, in this case, the science–religion matter; they need to understand both deeply and in qualitative terms, and it does not matter in the end if one understands them as two alien poles or two realities that coexist on peaceful terms. The fact that some people do not take the time to think about or reflect on this issue because they have already rejected any relationship between science and religion actually demonstrates one possible understanding of the issue. Human beings cannot flee from their existential struggle and task of trying to understand a very complicated and potentially unfathomable world in all its depth. It is possible that all systems have sufficient epistemological resources for understanding the world because all systems can be understood better when one tries to understand them from within, but every system also has external considerations. This very affirmation could be supported on a different level by mathematics, quantum physics, neuroscience, philosophy and psychology (Orón and Sánchez-Cañizares 2017). This fits very well in the issue of science–religion and their common dependence on philosophy.

When a human being wants to know, it is because he assumes that the world is not chaotic and that studying without some sort of meaning is pointless. In the debates surrounding science and religion, some have argued that people who completely reject the relationship between science and religion must then prove how it is possible that the human mind could develop two irreconcilable systems of knowing (Harrison 2010).

There is another meeting point between science and religion, namely, *purpose*, and it is meant to invoke **the intentionality perspective** rather than a teleology perspective. While the study of subjects such as math may be driven by an end of pure knowledge, it seems obvious that studying mathematics ought to also and primarily aim at developing a good or excellent tool in our quest for a better world. The *telos* of having a better world means allowing all who inhabit it to live together better. The same could be said regarding religion itself, its knowledge, study and experience. If religion does not serve the purpose of improving quality of life (together as a species, with other species and the planet) it is quite difficult indeed to understand it as a religion. Thus, in the end, science and religion both aim at the same end. This is another commonality in philosophical terms between the two that supports the need to acknowledge and intentionally put them in the service of a moral purpose.

Tension between science and religion does not have to be thought of in negative terms; indeed, tension can be thought of as an opportunity (Harrison 2010 p. 283). It all depends on one's existential position. If this position refers to the desire for control and mastery, this tension is certainly a problem, but if it refers to trusting, tension awakens wonder and deepens life-enhancing possibilities.

Regarding dialogue, it is obvious that AS and IPS understand dialogue from two strikingly different perspectives. Although both use the same word dialogue, just as they understand personal integration differently, they use it in very different ways. Dialogue is defined *as a conversation between* two or more parts, groups, persons, etc., and it is oriented towards mutual exploration or resolution of a problem (Oxford, Dictionary of English), which relies on the shared, responsible use of reason. Yet, *dialogue* is meaningless, and its ends unreachable without participation; thus, the process of being in dialogue is necessary as a means for understanding something at the end of the dialogue process.

Based on this, we suggest that **genuine** dialogue is only possible from within the IPS mode (Akrivou et al. 2016; 2018). For AS, dialogue is in fact either a transactional exchange or a political negotiation; there, it is mistakenly understood as a *dialectic* whereby it corresponds to the art of discussing the truth of two or more opinions with the aim that one should prevail since each side is understood as dichotomous and potentially irreconcilable. In the same way, the goals of commercial companies or political parties are defined previous to the dialoguing process and are external to it, while each autonomous party defines their interests perfectly, a priori and independently. Dialogue is then something that has to be endured in order to promote one's agenda, points and interests above those of others. If the dialogue process requires one party to give up something at some point for consensus, it is seen as a sacrifice in order to secure something more important.

By contrast, and taking into account that "the idea of person expresses in its origin the idea of dialogue" (Ratzinger 1990 p. 443), for IPS, there is a real readiness and a humanistic, benevolent willingness to hear the other and partake in dialogue (Akrivou et al. 2016) because the I-person assumes that the other-person has the same willingness to take part and mutually participate in discovering a way of resolving a challenge that satisfies the common good and each party's good beyond what could be individually imagined. Since "there is neither the pure 'I,' nor the pure 'you,' but on both sides the 'I' is integrated into the greater 'we'" (Ratzinger 1990 p. 453), the goal is not therefore individual, but rather is shared and oriented towards a higher purpose that increases the good of all involved. These perspectives thus present the experience and process of dialogue, as well as its progress and potential outcomes, as fundamentally different.

Conclusion

This chapter discusses that the relationship between science and faith is not a given or objectively defined one but rather depends on personal ways of understanding/seeing and living this relationship. In order to show this, and drawing from our previous research, we approached the matter from two contrasting paradigms of conceiving the self and human development, namely, the "autonomous self" (AS) and the "inter-processual self" (IPS) to conclude that, depending on the corresponding background that characterizes the human being, people "see" and live the relationship–dialogue between science and faith differently.

As shown above, an understanding of the human being and action in the AS mode makes persons more likely to experience this relationship between science and faith in terms of conflict or a mentally unresolvable dialectic where science or religion have to win out over the other and dominate the person's overall worldview. Instead, people who display an understanding based upon the IPS paradigm are more likely to experience and value the relationship between science and religion as an interrelated notion and an inseparable union across different ways of understanding. IPS does not try to understand these constituent parts in terms of dichotomy and duality, as two separate domains, but rather perceives the two in genuine integrative terms and always in relationship, while the AS mode centres on which one is true and which one has a fallacious understanding of reality.

Simply put, this means that AS ultimately falls short of the task of promoting genuine dialogue between the two, whereas IPS has the capacity to promote a genuine dialogue between science and religion premised upon its understanding of the self, human beings, action and understanding of the dialogue itself.

Bibliography

Akrivou, K. (2009). *Differentiation and integration in adult development: The role of self-complexity and integrative learning in self-integration*. Munich: VDM Verlag.

Akrivou, K., & Bradbury-Huang, H. (2015). Educating integrated catalysts: Transforming business schools toward ethics and sustainability. *Academy of Management Learning & Education, 14*(2), 222–240.

Akrivou, K., & Bradbury-Huang, H. (2011). Executive catalysts: Predicting sustainable performance amid complex demands*. The Leadership Quarterly, 22*(5), 9951009.

Akrivou, K., & Orón, J. V. (2016). Two kinds of human integrity: Towards the ethics of inter-processual self (IPS). In K. Akrivou & A. J. G. Sison (Eds.), *Challenges of capitalism for virtue and the common good: Inter-disciplinary perspectives*. Cheltenham: Edward Elgar.

Akrivou, K., Bolade-Ogunfodun, O., & Adewale, A. A. (2016). Integrated habitus for the common good of the firm: A radically humanistic conception of organizational habitus with systemic human integrity orientation. In K. Akrivou & A. J. G. Sison (Eds.), *Challenges of capitalism for virtue and the common good: Interdisciplinary perspectives*. Cheltenham: Edward Elgar.

Akrivou, K., Orón, J. V., & Scalzo, G. (2018). *The inter-processual self. Towards a personalist virtue ethics proposal for human agency*. Cambridge: Cambridge Scholars Publishing.

Altarejos, F., & Naval, C. (2000). *Filosofía de La Educación. Tercera*. Pamplona: EUNSA.

Barbour, I. (1966). *Issues in science and religion*. Washington: Prentice-Hall.

Barbour, I. (2000). *When science meets religion: Enemies, strangers or partners*. New York: Harper Collins.

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

Düsing, K. (2002). La Subjetividad En La Filosofia Clásica Alemana de Kant a Hegel. Una Panorámica a Modo de Programa. *Azafea Revista de filosofia, 4*, 97–121.

Erikson, E. (1959). Identity and the cycle of life: Selected papers. *Psychological Issues, 1*(1), 5–165.

Erikson, E (1959. 1963). *Childhodd and society*. 2nd ed. New York: W.W: Norton.

Erikson, E. (1959. 1997). *El Ciclo Vital Completo*. Española. Barcelona: Paidos.

Harrison, P. (Ed.). (2010). *The Cambridge companion to science and religion*. Cambridge: Cambridge University Press.

Haught, J. F. (2012). *Science and faith: A new introduction*. New York: Paulist Press.

Orón, J. V. (2014). Neurociencia y Fe : El Sistema de Creencias Como Lugar de Encuentro Interdisciplinar. *Scientia et Fides, 2*(2), 213–270.

Orón, J. V. (2015). Leonardo Polo's integrative dynamic as a philosophical framework for understanding neuroscience. *Journal of Polian Studies, 2*, 109–133.

Orón, J. V., & Sánchez-Cañizares, J. (2017). ¿Es Posible La Reducción Epistemológica? Todo Sistema Necesita Presupuestos Extra-Sistémicos. *Anuario filosófico, 50*(3), 601–617.

Ratzinger, J. (1990). Retrieving the tradition. Concerning the notion of person in theology. *Communio: International Catholic Review, 17*(fall), 439–454.

Stenmark, M. (2010). Ways of relating science and religion. In P. Harrison (Ed.), *The Cambridge companion to science and religion*. Cambridge: Cambridge University Press.

José Víctor Orón Semper is dedicated to research for the improvement of education after 15 years of school educational practice. His basic training is very varied: Civil Engineer, Philosophy and Theology, Master in Cognitive Neuroscience and Master in Bioethics and Doctor of Education. His central research field is emotional education, but it complements it with other topics all related: educational neuroscience and human development psychology. This allows its approach to always be interdisciplinary combining philosophy, psychology and neuroscience. He created an educational program, UpToYou, which he directs (www.uptoyoueducacion.com).

Dr. Kleio Akrivou is an Associate Professor of Business Ethics and Organisational Behaviour (Moral Psychology) at the University of Reading's Henley Business School in the United Kingdom. She is also a Visiting Scholar at the University of Navarra's institute for Business and Humanism, and Culture and Society in Spain. She has a Doctor of Philosophy (PhD) degree with a cross-disciplinary focus on Moral Psychology/Philosophical Psychology and Behavioural Science from Case Western Reserve University (USA). Previous to her PhD in Moral Psychology and OB, she also completed cross-disciplinary bachelors and Masters of Science degrees with a focus on management and economics and international commerce and relations.

Dr. Germán R. Scalzo is a Professor of Business Ethics at the Universidad Panamericana (Mexico) and a member of the Mexican National Research Institute. He received a degree in Business Administration from Universidad Austral (Argentina) and his MA and PhD in Government and Organizational Culture at the Institute for Business and Humanism, University of Navarra (Spain). Previously, he was a Professor at the Universidad Austral (Argentina) and has worked at Johnson & Johnson of Argentina and Openware-Globant as head of HR and CSR. He served on the board of Global Compact in Argentina and founded a civil association for the promotion of CSR in the region, of which he was CEO until mid-2008, when he traveled to Spain to continue his studies.

Chapter 9
'About' and 'Of' Languages: A New Way of Framing Religion and Science

Ben Trubody

The Conflict Thesis: Science vs. Religion

Barbour (2000) presents four possibilities for how 'science' and 'religion' interact. Whilst the thrust of this chapter is to argue that it takes a fundamentalist reading of science and religion to understand them as being in conflict and that science and religion do deal with completely independent domains, the more controversial claim is that objectivity has its origins in subjectivity meaning both the 'dialogue' and 'integration' models are possible.

The strong 'conflict thesis' (Barbour 2000) is an overly dogmatic or fundamentalist commitment to a version of reality. On the one hand, there is 'scientism' that takes only empirical claims as meaningful, where statements about God or the soul are at best unfalsifiable and at worst meaningless. On the other hand, there is 'creationism' that only takes as meaningful a certain theocentric interpretation of reality that places central to its validity the objective truth of their beliefs. This gives a straightforward either/or between evolutionary biology and creationist science, if one is to retain the young earth hypothesis, for example. Put like this then; they do appear to be in conflict, but how accurate and honest a representation is this? Some of the ways the seemingly disparate practices of science and religion can be made to conflict is firstly by competing over the same fundamentalist notion of 'Truth' and secondly, conflating what those practices do and what they are about. So, what is a fundamentalist notion of 'Truth'? Capital 'T'.

'Truth' is a metaphysical abstraction that posits reality as it *really* is. Here science aims at 'a culture free description of how reality is' (Weinberg 2001, p. 238). Equally for the religious fundamentalist, 'Truth' means they have access to reality as it really is, including the objective truth of their religion. Not only are they

B. Trubody (✉)
Independent Researcher, Cheltenham, UK

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_9

competing over the same representation of ‘Truth’ but in claiming that science can explain experiences usually reserved for religion, art or philosophy or that religion can explain phenomena usually reserved for physics, biology or chemistry; antagonism then is not far away. Not only does commitment to ‘Truth’ mean that all facets of existence, experience and human meaning are included, but also it has come to be synonymous with a particular representation, which is the ‘objective-explicit’ form of ‘truth’. Rather than concede that science has things to tell us about the material, physical world and that religion (and its secular variants) has things to tell us about the non-material, ethical concerns of human existence, the fundamentalist subsumes all ways of experiencing and interpreting reality. Before addressing why the ‘objective-explicit’ form of ‘truth’ has come to be its dominant representation amongst fundamentalists, it must be clarified what is meant by it.

Since the Enlightenment and the proliferation of science, one representation of the ‘truth’ that has come to dominate all other representations is its ‘objective-explicit’ image. The received view is that science is its method and its method is objective. Not only that but this objective, self-correcting method of science allows it to state explicit things about reality that can be tested. If science does one thing, it is its ability to generate explicit scientific statements that can be peer-reviewed, cross-interrogated, replicated and ultimately written down in the body of knowledge scientific. This ability, however, does not come overnight or without cost, and it is the overrepresentation of science as its method during periods of normal science, as opposed to the historical messiness of science and its methodological pluralism and anarchism, that creates a powerfully seductive image of what science is and can do (Feyerabend 1993). If then it is science that gets to say what is ‘real’ in the sense of actual, empirical existence, and your religion is committed to a literalistic interpretation, where what it says is objectively-explicitly ‘True’ then, knowingly or not, we have crept into the metaphysics of science, where we start asking about ‘proof’ or ‘evidence’ for such claims. This has led to the development of Creationist science with its own technical research journals such as *Answers Research Journal* (2017) that offer proof for the Biblical account of events and why orthodox science is in error.

This critique, however, goes both ways. In privileging the ‘objective-explicit’ form of ‘Truth’ it becomes incomprehensible to scientism that there are areas of human experience that do not or cannot be dealt with scientifically, where what is foundational to ethics or existential angst is not genetics, neurology or evolutionary dispositions, but subjective-tacit awareness of being. What I have called the ‘subjective-tacit awareness of being’ are those things that are beyond objective-explicit representation and maybe best dealt with through symbolism, metaphor, doubt and even faith. Thus what separates science from religion or scientific concerns from religious ones is simply that they are not the same practice, attempting the same sorts of things. They speak, as it were, different languages, which will be discussed as ‘about’ and ‘of’ languages. It will be part of this chapter to argue that religion, at its most meaningful, has nothing or very little to say about the objective-explicit, empirical aspects of reality. If one thinks this is what religion should be doing, such as debating with biologists over the veracity of evolutionary theory, then one is just doing poor science. Similarly, if scientism thinks that concerns over death/existence and questions of value or ethics are really just brain states or evolutionary dispositions, then one has ceased to be a scientist and is instead doing bad moral-ethical philosophy-theology. In the terms of this chapter, one would have confused two types of language which I have call 'about' (AL) and 'of' (OL) languages. Here, improper or uncritical use of either language creates the apparent conflict experienced at the linguistic and conceptual level. Moreover, if one sticks to a strong Kierkegaardian (1941, 2006) interpretation of the 'self', it could be argued that the objective ways in which we deal with the world has its origins in the subjective. That without concern or care for things which we take upon ourselves (why things matter to me), there would be no need to ask questions from which an objective worldview comes, i.e. it matters to me to know the way the world really is. This gives space for both the 'dialogue' and 'integration' models of Barbour's (2000) typologies. Next it will be argued that fundamentalists in privileging the 'objective-explicit' representation of 'Truth' have to deny or reject the value and importance of their own subjectivity, which Kierkegaard found to be of central importance in the process of *becoming* religious.

Rejecting and Reclaiming Subjectivity

Here we begin with a question: even if science could tell us how things *really* are in the objective sense should this make a difference to anyone with a religious faith?[1] The two views to be considered that necessitate conflict over this question are 'religious fundamentalism' and 'scientism' (Voegelin 1948). For Kierkegaard (1941) the answer was 'no'. 'Faith' and 'science' not only deal with completely different spheres of existence, but more unsettling still is that the objective mode of representation we have within science may have its origins in the subjective. That to ask any question what-so-ever, scientific or otherwise, is predicated on the idea that a question is asked because it matters to someone. Without the desire to know, to be unhappy with the state of things or to work out one's relationship with the world around them, how does science get going?

Backing up for a moment, why are science and religion not in conflict? Science is predominantly about the physical-material world prohibiting the supernatural. If we want to know the objective description of natural phenomena then we consult the appropriate scientist. So, when might we want to consult a religious authority? At the risk of dodging the question and offering up a definition of religion and what it does, this author would like to draw the reader's attention to the problem of working from definitions. Whilst it could be pointed out that a religion is a difficult concept to define explicitly (Smart 1968), so too is science. The 'problem of demarcation' is exactly this, ways of telling science and non-science apart (Chalmers 2010). The lack of success here should not lead one to conclude that there is no difference between science and magic, but that there may be a fault with the question. For any explicit definition of science we could offer a historical counterexample can be found (Feyerabend 1993; Kuhn 1996). This does not mean there is no such thing as science or that it is the same as religion; rather, it reveals the limitations of trying to work from definitions. So rather than say what science and religion objectively-explicitly are, maybe we are better off looking at what they *do*.

Religion then for Kierkegaard is about *becoming* religious, rather than *being* religious. Becoming religious is to never arrive. It is fraught with doubt in addressing whether one is

1. Whilst I talk about 'religious faith' this also applies to its secular variants, where an atheist may also be dealing with ethical or existential concerns.

morally justified relying on faith. Being religious, however, is to have a concrete grasp on the issues of right and wrong. The certainty of following a prescribed set of rules or unquestioningly obeying an authority figure does not require faith as long as there is rational justification. It is in becoming religious or ethical that faith has its most meaningful expression according to Kierkegaard. Becoming religious here is not primarily about the physical-material world at all and certainly not an objective conception of what it means to be religious. Whilst people have to be in the physical world to act ethically, ethical concerns do not come from the physical world but rather how we are tacitly involved with it. Ethics comes from our subjective – what it means to be a 'self' in a world where as humans it is easy to exist like everything else and where as humans we have the unique capability of objectifying ourselves. Scientism, however, wants to say that such ethical-subjective concerns and even the *choice* to think of oneself as merely a biped or bundle of neurological wires are the products of evolution or neurological synapses. That 'ethics' or 'existential choice' is somehow in the brain or part of an evolutionary disposition (Tallis 2012).

Whilst the received view is to have a concrete or definite grasp of one's own faith, for Kierkegaard, the concerns and doubts wrestled with in becoming religious are all subjective, that is to say, there can be no objective criteria for becoming religious, which is what the fundamentalist requires. To say that one *is* moral, in the same way someone might say they *are* Christian, is for Kierkegaard to give up on 'faith'. To know that one is a Christian or righteous can be done by appealing to knowledge or some objective criteria for justification. It is this certainty that gets abused in religious and secular fundamentalism by appealing to objective sources for confirmation, rather than the dealing with the subjective doubt that one might be wrong. What we find in the philosophical confusion between these different discourses is that one is essentially seeking objective answers to subjective questions due to the objective representation of 'truth' coming to dominate what we mean by 'real' or 'exists'. This cuts both ways when people project subjective answers to objective question, such that it is not a matter of opinion or belief whether vaccines cause autism or whether the law of energy conservation can be violated. In trying to extrapolate from objective descriptions to subjective experience we are implying that 'meaning' can be accounted for empirically, as if the 'meaning' of *Hamlet* is contained in the objective structure of language or play manuscripts. In the same way, how does a brain scan inform me about what my life or parents mean to me? If

I want greater insight into the human condition, I am probably better off listening to a musician or reading a great work of literature than speaking to a cognitive scientist. 'Meaning' then is a public, socio-historical network that contextualises ways-of-being or practices; it is not found in my head or in the objective structures of the brain. This is not to say that an objective scientific description is necessarily less beautiful or meaningful than a poem, as bad poetry exists. For some the elegance, simplicity or universality of an equation definitely has an aesthetic quality (Dirac 1939). It is that quality, however, that is not present in the objective content of scientific descriptions; there is no symbol or placeholder for beauty or meaning; it is something that comes from our subjective-tacit understanding of being in the world. Show Dirac's equation to a layperson and they will not get the deeper meaning of what those symbols represent or what they imply. Here one has had to undergo extensive training in order to 'see' the world from the perspective of mathematical symbols, which means being in the 'world' of mathematics and physics. This 'world' is not a physical location but a culture of practice that is acquired tacitly (Collins 2010). It is not just to learn *about* science, but to live out the discourse *of* science, which is to have its aesthetic, qualitative aspects guide one's work. When scientists lapse into metaphor or artistry in explaining what they think they are doing or what there is it is not because what they are doing is unscientific, but because they have exhausted the AL. They can say no more *about* what they are doing. What grounds this ability to know that one has exhausted the AL is the doing *of* science, the OL. This distinction between the 'explicit' (objective) and 'tacit' (subjective) aspects of a practice is one of the central problems of the strong artificial intelligence programme. A computer can be instructed to play chess and beat a grandmaster (as chess can be reduced to explicit rule following), but it cannot be instructed on what it means to play a game, as 'play' is an absence of rules, it is the 'desire to be' (Sartre 1984, p. 742). 'Play…releases subjectivity' and is 'an activity of which man is the first origin…sets the rules and has no consequence except according to the rules posited' (Ibid., pp. 580-581). 'Play' is also about things such as fair-play, cheating or competitiveness, values which have a socio-historical dimension. Yet, this does not prevent scientism from overstating the role of the explicit-objective description of humanity. Where subjectivity eludes objective description, it can be signposted through things like metaphor or symbolism. However, as soon as we try and reduce ethics, art or play to physics, genetics or algorithms as the deeper, more foundational 'Truth', we begin to deny the importance of our own subjectivity leading to statements such as Francis Crick's (1994, p. 3) where:

> 'You', your joys and your sorrows, your memories and your ambitions and your sense of personal identity and free will are in fact no more than the behaviour of a vast assembly of nerve cells and their associated molecules.

This is not to say that neuroscience cannot tell us about how our brains work, but such descriptions and explanations are not the entire story of who we are. If religious claims should be viewed sceptically when making empirical statements, then by the same measure, science should also be held accountable when proclaiming on concerns of the subjective. So, as informative as the cognitive sciences are, they are nowhere near close to answering some of the fundamental questions about the mind or consciousness, let alone why someone should be religious (Tallis 2012). In arguing for the importance of the subjective-tacit it has to be conceded that: *there can never be an objective description of subjective meaning,* and *the tacit cannot be accounted for in terms of the explicit*. However, what we find is that scientism is compelled to give up subjectivity as a lesser, second-order experience, where actual reality is found at the neural-genetic-quantum level. The religious fundamentalist rejects subjectivity by thinking that their faith gets its 'truth' from the explicit-objective structure of their religion, such as knowledge about what a book says, empirical evidence for the resurrection or that evolutionary theory is flawed. As soon as we make the leap to understanding God, ethics or existence as non-trivial subjective phenomena, then science and religion cease to be in conflict. Yet for the religious fundamentalist, whoever controls the objective-explicit meaning of a sacred text is the one who is closer to God. Paradoxically, in the quest for religious conservatism one has to ignore the traditions of exegesis, hermeneutics and scholarly debate practised by religion, where the further one moved away from the literalism of words to the esoterica of symbols, the closer to the divine one was getting (Armstrong 2005).

Søren Kierkegaard

The theologian-philosopher Søren Kierkegaard argued that to *become* a Christian was more important than *being* a Christian. The 'becoming' was a process of doubt, whereas 'being' was an abstraction that begat certainty. Why this troubled Kierkegaard is that ultimately there can be no objective empirical criteria for being a person of faith (Kierkegaard 1941). If there were there would be no need for faith as one would simply follow a set of rules or perform certain rituals at the right time, where fidelity to the system would remove any doubt whether one were religious, ethical, good or not. Kierkegaard, however, understood being religious as a personal commitment, an accomplishment of sustained engagement with the world through self-reflection, when one has exhausted all rational justification. Humans, like all things, can be described objectively, in terms of DNA sequences, chemical composition or geometrical points, which is what science does. This aspect of our existence is identical to that of other objects. For science this is the most important aspect of humans, to understand them as abstracted natural objects. This, however, is not the only way humans exist. Kierkegaard argued there is another way humans exist which stands them apart from all other objects, where in order to be religious, this has to take precedence. This was the role of our subjectivity, which is what allows us to understand things, including ourselves, as objects. Moreover, this for Kierkegaard meant that the objective mode required for science has its origins in the subjective. This would suggest that Barbour's 'dialogue' and 'integration' models for science and religion are possible.

Kierkegaard says that what is at stake in subjectivity that is not risked in objectivity is that we are able to lose who we are – lose ourselves. A desk either is or is not – it does not have the capacity to lose itself, whereas our subjective existence is under constant threat if we cease to be ourselves, which means if we decide to think and act like everyone else or be like everything else. For without any subjective concerns, we cease to exist in any meaningful sense. To exist objectively is easy for both the desk and a human as they both are, but to exist subjectively is a constant battle to not slip into merely existing as an object or passively take up everyone else's views. So when Kierkegaard talks about *becoming* a Christian, it is in this sense that he means it, how one decides to live their life (or not) and not just follow what some book or someone tells them. Most of us do not like dealing with this aspect of our existence, which is inherently uncertain as there are no objective criteria or manuals to appeal to, yet that is exactly what most of us seek in those deeply personal, challenging and troubling questions. What should I do now with my life? Am I a good person? The fundamentalists on both sides of the religion and science debate will defer to their criteria, ultimately both seeking *objective answers to a subjective question*.

Why then do we struggle with subjective questions more than objective ones? It is not because it requires a greater amount of knowledge, but rather the opposite. The question and the answer can only be given and understood in doubt. Here becoming religious is a matter of faith and not knowing, living in, with and through doubt. Some have called this position 'fideism' (Plantinga, 1983). Kierkegaard says that no one should become Christian as a result of a rational argument or on the presentation of evidence, as is done in the proofs for the existence of God debate, for one would have completely missed the point of what it means to be a Christian. An 'objective acceptance of Christianity is paganism or thoughtlessness' (Kierkegaard 1941, p. 108).

In *Fear and Trembling*, Kierkegaard (2006) retells the story of Abraham's sacrifice of Isaac. Viewed from the outside, objectively, Abraham appears a criminal or madman. Yet Kierkegaard argues that no matter what we think of him, our rational judgement of him comes from a totally different place to the inner ethical, subjective torment of Abraham's acceptance or rejection of God's command to kill his son. Abraham knows that there is no rational reason to obey this command. In that moment he acts in faith, in the compete uncertainty that what he is about to do may be terribly wrong. It was Abraham's decision ultimately whether to listen to the angel or to God's command. In emphasising the subjective, however, Abraham's actions concern someone else, another subjective being. It is this relation that was crucial for people like Buber or Levinas.[2] Rather than explain what faith is Kierkegaard (1941) can only present it as a kind of paradox, which we are invited to make sense of. Positivists and rationalists like the new atheists would dismiss this as sophistry or absurd in appealing to paradoxical reasoning and equally the religious fundamentalist will find this too philosophically troubling as it will oppose their objective conception of faith. Here it is completely possible that two atheists or theists may arrive at their belief or non-belief in completely different ways, one looking to objective empirical evidence to inform their decisions, the other working entirely from their subjective experience of existing.

‘About’ and 'Of’ Languages

Just as Kierkegaard distinguished between the noun of being *Christian* and the verb of *becoming* a Christian, we also find an analogue in the AL/OL. An AL is simply anything that is *about* something else. For example, mathematics is *about* quantities and their relationships, classical physics is *about* objects and motion, soccer is *about* a sport, and Christianity is *about* the resurrection and salvation through Christ. Traditionally, philosophy has fixated upon ‘being’ by asking after ‘essence’ or ‘thing-ness’: what is justice, beauty, the good? This way of thinking about the world is arguably what science and religion inherited from natural philosophy. This shared inheritance has become gradually contested with the rise in the explanatory power of science. At its most confused we get Christian scientists trying to explain how it is scientifically possible that Christ could have turned water into wine, as if there were no other deeper, symbolic-cultural interpretation to the miracle stories. This leads the scientist Frank Tipler to consider why Christianity may be a ‘possibly true theory of physical reality’ (2007, p. 267). This would be completely incomprehensible to Kierkegaard, that Christianity had anything to say about the external world. Rather, it is science which explicitly states possible theories of physical reality. If anything can be said with certainty or probability it is here – the chemical composition of matter, natural physical constants, the classification of species and so on. In this sense science is *about* an external reality, nature or world, and religion is *about* historical, cultural and social phenomena. The OL is the conceptually more difficult discourse to communicate. It refers to the tacit-subjective aspects of reality. Unfortunately, even writing or speaking *about* the OL is an AL. Due to OL being beyond propositional language it is confined to the AL for illustrative and pedagogic purposes. Put another way, the tacit can only be communicated through the explicit. Arguably this has its equivalence in Wittgenstein’s (2001) difference between *saying* and *showing* that if one is dependent on explicit language, on grammatical and logical rules, then one can only definitely state a very small number of things, but by presenting the argument and making it conflict with

2. It is central to Levinas’ interpretation that Abraham did not sacrifice his son but was willing to. He took himself to the point of killing and then backed down, becoming receptive to the ‘other’ (Katz, 2001). This is important as our subjective-being is bound up with other people; our actions, even if they just concern ourselves, are always about other people.

our tacit understanding of how the world is, we can show the argument to be weak or faulty. The OL is concerned with the meaning of actions and historical process, not just the actions of individuals, but how such practices are contextualised socially and historically. So, the formal rules of chess can be written down or coded (they are about chess), but why people play games in the first place or what they mean, which has a long socio-history, is something that is beyond explication. The language *of* chess then is its playing, which incorporates the significance of 'play' – fairly, competitively, sportingly, humorously, spontaneously and so on. As soon as we begin to describe and codify chess, we have lapsed into a language that is *about* chess. No amount of objective description as to what chess is about is itself chess. The pieces, the board, the tactics and so on are all about chess, but none are the game. One can code explicit rules to follow, decision trees and probabilistic algorithms, but this leaves untouched the tacit understanding required to contextualise any action or statement (Dreyfus 1979; Katz 2012). 'Meaning' then is not reducible to 'information', which is what explication relies on. Asking whether a computer can play chess may be like asking whether a submarine can swim. They are both socially grounded experiences that are not reducible to rules, where one cannot make explicit the social elements that contextualise gaming, let alone being scientific or religious. It is in this wider social context that OL are not just actions but the socio-historical contexts within which they occur.

As humans are historical beings our AL and OL change over time. Some languages cease to hold the same meaning; others cease to exist at all. We can track this with any human activity where the AL and OL of soccer, for example, has changed. Shoulder charging the goal-keeper use to be *of* soccer, but is now no longer legal. That action is now *about* foul-play, becoming part of the language *of* cheating or poor sportsmanship. Equally, campaigns like 'kick racism out of football' are trying to make what were normalised elements of soccer cease to be of and eventually about soccer altogether. Another route to the tacit maybe to ask what does it *mean* to be. The question that Kierkegaard ruminated upon was what does it mean to be Christian? Today we could equally ask what does it mean to be a white, black, male, female, queer, elderly, European and so on. Here, feminist and black existentialist methodologies have tried to elevate the status of the subjective as a source of evidence and resource for truth (Gordon, 2008; Harding, 1987). Again, when we ask what does it *mean* to be 'black', 'female', 'Christian' and so on, we can always produce an objective-explicit definition, which is what the politics of identity rely on, where we can single out the 'other'. Race or hereditary behaviour historically being a very powerful tool for social division where science states that 'race' is *about* skin colour, anatomical shape and geographical location, all objective criteria utilised by slavery, apartheid or eugenics programmes (Gould 1981). Of course, one could argue those were examples of bad science, but science is only what humans do with it, good and bad. It does not exist outside of human practice. Here philosophers such as Putnam (2004) have come round to the idea that facts and values may not be mutually exclusive as statements about reality. What Putnam (2004) identified in the economists and scientists of the early twentieth century is that they clung to a distinctly logical positivist view of knowledge and 'Truth' that only statements that can be shown to be true or false by way of logical inference or deduction are meaningful, where claims about love or welfare have no analogue. This is to overlook the fact that the justification itself is not the product of science, nor can it be shown to be true or false by logical analysis, but is rather a principle or value by which science is conducted.

Wittgenstein, who was influenced by Kierkegaard (Schönbaumsfeld 2007), said that 'doubt can only exist where a question exists, a question only where an answer exists, and an answer only where something can be said' (Wittgenstein 2001, p. 88). Here Wittgenstein is saying that where we can say anything at all, in the respect that we would only say something meaningful, as opposed to nonsense, is the precursor to questioning that gives rise to things like answers and doubt. A background of tacit meaning is required before we even begin to ask questions, as how would we know what we were asking after? Before we can explicitly talk about objects or ideas those ways-of-talking, or 'forms of life', have to already be tacitly meaningful. In the absence of any prior tacit-meaning we are simply unable to communicate. In short, a background of practices, discourses and tacit-meaning have to be in place before we can abstract to a metaphysics about how things are and how we know it. Another way of stating this is to say that an OL always precedes an AL historically, so that talk *about* chess is preceded by the game *of* chess, explicit talk *about* science is preceded by forms-of-life that make acting scientific meaningful, and the same goes for religion. However, the OL can also be understood retrospectively in light of an AL. That is, we can understand the past in terms of the present. We are less inclined to this with games as they rarely make 'truth' claims, but amongst science and religious fundamentalists, this is commonplace – that what there is has always been the case, and it exists independently of any tacit background meaning or practices of discourse. This allows fundamentalists to say things like science is converging on the 'Truth' or prophecies are being fulfilled from the Bible. Here reality has always been about the Christian version of events or whatever will unify quantum and relativistic physics. We get into this conundrum if we think the AL is more fundamental to science or religion than the OL, that what they both communicate and make explicit is more important to how science-religion works than the actual doing of those practices. What happens if we do think the AL is more important that the OL in how those practices work is something like the 'problem of demarcation'. Ultimately, we say that science is *about* nature or the world, but all those things we could say about nature from science (knowledge-facts) or even about science itself (method) are themselves not science. They are the products, artefacts and tools of science. The physicist Richard Feynman (2001, pp. 177-187) made a similar point, stating that science is not its equations, terminology, theories or even the knowledge it produces as these all change:

> It is not science to know how to change centigrade to Fahrenheit […] learn from science that you must doubt the experts […] the belief in the ignorance of experts […] When someone says science teaches such and such, he is using the word incorrectly. Science doesn't teach it; experience teaches it.

Science is simply whatever scientists do and to try and codify it into an objective-explicit criterion or definition is to limit what it could be. Instead, what can be given are values, principles, heuristics and models for how science has worked at any one time, but no criteria for how science should be at all times. This is Feyerabend's

(1993) point in *Against Method* that there is no scientific method – only approaches that have worked, which if systematised and generalised become self-defeating. The historical movement between the AL and OL means that some things may not be *about* science because it is no longer *of* science. This is where the anachronistic approaches of creation scientists falls down that what they are doing is no longer of science. This is not to say that religion cannot talk about scientific things and science cannot talk about religious things. Religion can comment on the need for ecological preservation or the ethics of stem cell research, and science can carbon-date religious artefacts or investigate the health benefits of meditative prayer. Problems arise, however, when both types of claims are regarded as equal in the sorts of truths or aspects of reality they reference. If they are understood as being the same, in that they share the same AL and OL, then they will appear to be in conflict. For example, when someone claims that communion wine empirically changes into the blood of Christ, we either have to side with science and say this is highly unlikely, or we side with religion that gains its knowledge and proof via other means. Kierkegaard's point here is that it should not matter whether the transubstantiation is literal or not, for neither is evidence for the 'truth' of religion. Being religious may require evidence or rational justification, but becoming religious is done in doubt and faith. Similarly, religion or its secular variants that deal with the concerns of living ethically and the meaning of one's life have no grounds in explicit-objective description. Problems arise, however, when an objective-explicit claim is regarded as the same as or more superior than a subjective-tacit one. Where these do become confused someone like Sam Harris (2010) argues that 'moral questions' will have objectively right and wrong answers, which are grounded in empirical facts about the causes of well-being. Scientifically trained theologians, like John Polkinghorne, use the wonder and mysteries of the universe to signpost the transcendental, to get people to search for greater understanding (Polkinghorne 1988). There are also historians, anthropologists and scientists who are invested in talking about religion, be it its historical origins, the provenance of manuscripts or even possible scientific explanations for religion or the experience of God (Alper 2008). When, however, the religious person falls back onto scientific arguments for the 'Truth' of their religion, or the scientist falls back onto metaphysics for asserting the superiority of objective-explicit scientific claims over subjective-tacit ones, one has produced a pathological version of each.

Conclusion

If one concedes that science and religion are not the same practice, addressing the same aspects of human existence, in the same way, then they cannot be in conflict. How they may come into conflict is through a conflation concerning two discourses that I have termed AL and OL. Based upon Kierkegaard's critique of religion it was argued that the practices of science and religion both address different aspects of reality. However, for the fundamentalist, 'Truth' has become associated with the 'objective-explicit' representation of reality as being the only representation of 'truth'. To this end, both reject or under-value the role of subjectivity. Scientism believes there to be a more foundational explanation for the subjective, be it ethics or sense of existence, found in genes, neurology or base physical matter. Not only does this explain the existence of the subjective, but it also can inform us on matters of values such as how one should live (Harris 2010). Concurrently, the religious fundamentalist denies their own subjectivity by basing the value or 'Truth' of their religious beliefs in the objective structures of their religion, be it what a text says or the evidence for their beliefs, e.g. the scientific basis for miracles (Tipler 2007). Paradoxically, where one has gone so far beyond the evidence as to be doing speculative philosophy or appealing to evidence or standards of justification when none are required as to be doing anachronistic science, one is being neither honestly scientific nor religious. Expressed in the terms of this chapter one has either confused or misused the AL (objective-explicit) and OL (subjective-tacit) of science and religion. Where humans and nature can be represented as objects science has been paramount in discovering objective-explicit truths *about* them. This is done via the language *of* science, a process, an activity, a practice that is socio-historical, tacitly connected to the world it attempts to abstract into 'aboutness'. Falling objects are about gravity and not natural dispositions or esoteric forces. The diversity of species is about evolution and not created kinds. When, however, we want to know about the 'truths' of the human condition or the socio-historical conditions for knowledge the AL and OL of 'science' may well not be suited to addressing such questions. Science cannot teach us about science, science does not teach anything, as Feynman (2001) says; rather, it is the experience of what science has been that is what guides judgement. It is the failure of science to investigate itself scientifically that has led to the intractable problem of demarcation. When we do find ourselves asking such questions as to the meaning of existence or about the ethical uncertainty of our actions, rather than lapse into the OL and AL of science, which seeks to determine the 'Truth' of such matters in the objective structures of the brain, in our biology, or even the theoretical possibility of miracles, we might be better placed to consult the OL and AL of religion (or its secular variants). This is where Kierkegaard's insight is most crucial. There can never be an objective-explicit account of the subjective-tacit. To seek the 'Truth' of religion in either the objective aspects of religion or what science says about human beings is a wholly mistaken endeavour with regard to the value or 'truth' of religion. Whilst religion may be about a number of things at the empirical level, for Kierkegaard, it is in wrestling with doubt over the morality of one's actions, to not know and act in pure faith; to try and become ethical is the language *of* religion. To stand up for social justice, to fight for equality or religious tolerance in the absence of any certainty as to whether one is in the right or not and never have that let up is the language *of* religion. Under this understanding it makes no sense to ask for proof as to the veracity of one's belief system. To give 'scientific' (objective-explicit) reasons for why one *should* be ethical is just a mistake, as if the truth of moral decisions lay in neural synapses or our evolutionary past. Rather, ethics and existential concerns are best approached through things like metaphor, poetics, art, symbolism or philosophy, all tacit to the religious experience that refuses to be reduced to the 'knowable', 'epistemic' or 'propositional'. Those phenomena that do may be *about* religion, e.g. revelation or the numinous, but as soon as it moves into the realm of objective-explicit representation of 'truth' it ceases to be *of* religion. The significance for Kierkegaard (1941) is that those ways of objectively representing the world have their origins in the subjective, which in the negative sense makes the conflict model impossible (i.e. religion and science cannot be in conflict), but in the positive sense make Barbour's 'dialogue' and 'integration' model possible (i.e. the metaphysical origins of science in human concern for their own existence).

References

Alper, M. (2008). *The god part of the brain: A scientific interpretation of human spirituality and god*. Naperville: Sourcebooks.

Answers Research Journal: Building the Creation Model (2017). http://answersingenesis.org/answers/research-journal/. Accessed 12 Jan 2017.

Armstrong, K. (2005). *A short history of myth*. Edinburgh: Canongate.

Barbour, I. G. (2000). *When science meets religion: Enemies, strangers, or partners*. New York: Harper Collins.

Chalmers, A. F. (2010). *What is this thing called science ?* Maidenhead: Open University Press.

Collins, H. (2010). *Tacit and explicit knowledge*. Chicago: Chicago University Press.

Crick, F. (1994). *The astonishing hypothesis: The scientific search for the soul*. London: Simon and Schuster.

Dirac, P. (1939). The relation between mathematics and physics. *Proceedings of the Royal Society, 59*(1938–1939), 122–129.

Dreyfus, H. (1979). *What computers can't do*. New York: MIT Press.

Feyerabend, P. (1993). *Against method* (3rd ed.). London: Verso.

Feynman, R. (2001). What is science? In J. Robbins (Ed.), *The pleasure of finding things out: The best short works of Richard P. Feynman* (pp. 171–188). London: Penguin Books.

Gordon, R. L. (2008). *An introduction to Africana philosophy*. Cambridge: Cambridge University Press.

Gould, S. J. (1981). *The mismeasure of man*. New York: Norton.

Harding, S. (1987). *Feminism and methodology: Social science issues*. Bloomington: Indiana University Press.

Harris, S. (2010). *The moral landscape: How science can determine human values*. London: Bantam Press.

Katz, E. C. (2001). The voice of god and the face of the other. *The Journal of Textual Reasoning* 2 (1). http://etext.lib.virginia.edu/journals/tr/volume2/number1/katz.html. Accessed 22 Sept 2016.

Katz, Y. (2012, November 1). Noam Chomsky on where artificial intelligence went wrong. *The Atlantic*. http://theatlantic.com/technology/archive/2012/11/noam-chomsky-on-where-artificalintelligence-went-wrong/261637/?single_page=true>. Accessed 19 Aug 2016.

Kierkegaard, S. (1941). *Concluding unscientific postscript* (Swenson, D. F. & Lowrie, W., Trans.). Princeton: Princeton University Press.

Kierkegaard, S. (2006). *Fear and trembling* (S. Walsh, Trans.). Cambridge: Cambridge University Press.

Kuhn, T. (1996). *The structure of scientific revolutions* (3rd ed.). Chicago: University of Chicago Press.

Plantinga, A. (1983). Reason and belief in god. In A. Plantinga & N. Wolterstorff (Eds.), *Faith and rationality: Reason and belief in god* (pp. 16–94). Notre Dame: University of Notre Dame Press.

Polkinghorne, J. (1988). *Science and creation: The search for understanding*. London: SPCK.

Putnam, H. (2004). *The collapse of the fact/value dichotomy and other essays*. Cambridge, MA: Harvard University Press.

Sartre, J. (1984). *Being and nothingness* (Barnes, H. E., Trans.). New York: Washington Square Press.

Schönbaumsfeld, G. (2007). *A confusion of the spheres: Kierkegaard and Wittgenstein on philosophy and religion*. Oxford: Oxford University Press.

Smart, N. (1968). *Secular education and the logic of religion*. New York: Humanities Press.

Tallis, R. (2012). *Aping mankind: Neuromania, dawinitis, and the misrepresentation of humanity*. Durham: Acumen.

Tipler, F. J. (2007). *The physics of christianity*. London/New York: Doubleday.

Voegelin, E. (1948). The origins of scientism. *Social Research, 15*(4), 462–494.

Weinberg, S. (2001). Peace at last? In J. Labinger & H. Collins (Eds.), *The one culture? A conversation about science* (pp. 238–242). Chicago: University of Chicago Press.

Wittgenstein, L. (2001). *Tractatus logico-philosophicus* (Pears, D. F., & McGuinness, B. F., Trans.). London: Routledge Classics.

Ben Trubody (PhD, University of Gloucestershire; MA, University of Exeter) is a part-time Lecturer in religion, philosophy and ethics at the University of Gloucestershire and an independent researcher. He is also a tutor for the WEA engaged in public philosophy. He is the author of a variety of papers ranging from the *Synthese Library Series* to *Philosophy Now*. His current research focus is on the nature and structure of scientific fraud.

Part II
Beyond Bare Statistics

Chapter 10
Beyond Bare Statistics

Michael J. Reiss

Much of the science and religion debate has focussed on statistics. There have been many national surveys on people's views about science and religion in general or the compatibility of religious faith and an acceptance of evolution in particular. In a small number of cases, the scope of such surveys has been international. One of the best known of these is Miller et al. (2006), in which data on the acceptance of the theory of evolution in 34 countries are compared.

While statistical studies are valuable and can often draw attention to questions and issues that can otherwise be neglected, they are far from the whole story. Indeed, there can be a number of problems with such surveys – and these problems are only compounded when issues of translation arise as they do in most international studies. Aside from the usual statistical issues to do with representativeness, a particular problem is how to phrase the questions. It is all too easy for surveys to presume one or more of the possible relationships between science and religion (see Solderer in this volume). Both Baker (2012) and McCain and Kampourakis (2016) have criticised the ways in which surveys in the evolution-religion field may fail to capture data of high validity.

The chapters in this section go beyond bare statistics by examining more nuanced studies of science, religion and education with the aim of developing a deeper understanding of the issues at play when attempting to deal with the issues of science and religion in the classroom.

Christina Easton in her chapter looks at data collected during hour-long focus groups. The students she interviewed saw religious claims as subjective opinion, 'true for the person' and immune to counterevidence. This view was sometimes defended with an appeal to something like the verification principle: students used the empirical criterion of science to judge *all* types of statements. Religious state-

M. J. Reiss (✉)
Institute of Education, University College London, London, UK
e-mail: m.reiss@ucl.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_10

ments fail to pass the test of empirical verifiability because they lack physical proof and, consequently, were seen as 'mere opinion'.

In their chapter, Berry Billingsley and Mehdi Nassaji begin by showing that in their large sample of 15- to 16-year-old students in secondary schools in England, the majority of students felt that science and religion have conflicting views about what it means to be human. They found that many of these students had a scientistic, reductionist and determinist view of science. Interesting, though, just over half of the students believed in some form of soul, and just over half believed that 'life has an ultimate purpose'. Based on these findings, Billingsley and Nassaji designed a workshop with the aim of extending students' epistemic insight in order to appreciate that science has both power and limitations in explaining what it means to be human. Findings from this workshop suggested that the comparison between a humanlike machine and a human being proved to be an engaging and insightful topic for students.

A fundamental question is what principles should guide the teaching of controversial and value- or ideology-oriented topics in science education. Jostein Sæther addresses this question in his chapter, arguing that an answer may provide a frame of reference for the science-religion-worldview issue in school contexts. He ends by proposing ten principles for handling the science-religion issue in science education. Sæther emphasises that his proposal is definitely not the last word on this matter. Testing his proposal in classroom contexts should help science educators and classroom science teachers handle discussions in this area better than what is currently often the case.

One of the shortcomings of studies of students' views about and understandings of the relationship between science and religion has been the static nature of such studies. In his chapter, Christian Hoeger shows the benefits of collecting rich data (drawings and interviews) over a number of years from the same German secondary school students about their understandings of creation, the big bang and evolution. The richness of these data shows how much is lost by trying to force the findings into the categories of either Barbour (1997) or Piaget (1971).

The number of countries where work has been undertaken on the significance of students' religious beliefs for their learning in science is gradually increasing. In her chapter, Ann Cameron shows how South Africa's colonial history has had a profound influence on its religious and educational character. Over the last 200 years, Christianity has been adopted by the majority of its people and has become indigenised, with the Bible often being interpreted in a literal way. African students studying science typically find themselves caught between their indigenised Christian belief systems and those aspects of science that appear to conflict with their religious beliefs. Through a case study which investigated the learning difficulties of students in an astronomy course, Cameron found that students are trapped between having their belief systems undermined and rejecting the scientific knowledge that offers a means to a better future.

Finally, Berry Billingsley and Sharon Fraser report on a small study of year 6 students in Australia drawn from four private Christian or Independent schools. Responses from surveys and interviews indicated, perhaps unsurprisingly for children of this age, that their ideas about both the nature of science and the nature of religion are still forming. The majority of children recognised science and religion as being different, although they talked about these differences solely in terms of the explanations they provide rather than the questions they ask or purposes they serve.

References

Baker, S. (2012). The Theos/ComRes survey into public perception of Darwinism in the UK: A recipe for confusion. *Public Understanding of Science, 21*, 286–293.

Barbour, I. G. (1997). *Religion and science*. San Francisco: HarperOne.

McCain, K., & Kampourakis, K. (2016). Which question do polls about evolution and belief really ask, and why does it matter? *Public Understanding of Science*. https://doi.org/10.1177/0963662516642726.

Miller, J. D., Scott, E. C., & Okamoto, S. (2006). Public acceptance of evolution. *Science, 313*, 765–766.

Piaget, J. (1971). *The child's conception of the world*. London: Routledge & Kegan Paul.

Michael J. Reiss is a Professor of Science Education at UCL Institute of Education, Visiting Professor at the Universities of Kiel, York and the Royal Veterinary College, Honorary Fellow of the British Science Association and of the College of Teachers, Docent at the University of Helsinki, a Fellow of the Academy of Social Sciences and a Priest in the Church of England. He is the President of the International Society for Science and Religion and of the International Association for Science and Religion in Schools and has research and consultancy interests in science education, bioethics and sex education.

Chapter 11
Truth in Science and ‘Truth’ in Religion: An Enquiry into Student Views on Different Types of Truth-Claim

Christina Easton

Introduction

‘I don’t believe in God because of science’. ‘Everyone’s entitled to believe what they want’. These two views were often voiced during student discussions that took place when I was a secondary school Religious Education (RE) teacher. They represent two common tendencies that I observed in students. Firstly, students would cite a lack of scientific evidence as a reason for not believing in God. Secondly, they would see religious opinions as subjectively true and specially protected from criticism.

These two tendencies may be in conflict. *If* my students are right that ‘God exists’ is true for the believer, then (according to their reasoning) this belief should be untouched by objective evidence from science. Yet at the same time, my students think that science *does* have a bearing on the truth of (some) religious opinions. This is something of a puzzle, meriting further investigation and reflection.

The second tendency has been reported anecdotally by teachers elsewhere. Trevor Cooling has argued that teaching about religion poses a ‘unique epistemological challenge’, because students regularly dismiss content as ‘just an opinion’ (Cooling 2012, p. 88). Cooling found that whilst his scholarly knowledge was generally respected when teaching Science, this was not the case in his RE lessons.

The difference in student views towards science and religion is examined in this chapter, which reports the findings from a small-scale, qualitative study. The study was initially undertaken with the primary aim of exploring how students conceive of religious and moral truth-claims as compared to other types of truth-claim. There was no explicit mention of science in the research aims or the interview schedule. However, an emerging theme of the study was the clear tendency amongst the

C. Easton (✉)
London School of Economics and Political Science, London, UK
e-mail: C.E.Easton@lse.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_11

student participants to hold scientific knowledge as authoritative and to characterise science as giving certain, indisputable 'facts' that contrast with the 'opinions' of religion.

Background

The Disputed Role of Truth in RE

There has been a longstanding debate in RE over what the aims of the subject should be and how this should inform pedagogy.[1] Rather than survey the various pedagogies, here I draw on aspects of the debate which bear on the role that truth should play in RE.

Pluralism

Some thinkers have been worried by 'religious exclusivism' (the belief that only one particular set of religious truth-claims is true), seeing it as a dangerous threat to social cohesion in multicultural societies. Instead, they advocate a pluralist approach to RE, which encourages students to view different religious truth-claims as equally valid.

One prominent example is John Hull, who thinks of exclusivist views as 'religionist'. He criticises these views for promoting that 'We are right, they are wrong' (1992, p. 70). He advocates an 'anti-religionist curriculum' (2000, p. 84) which promotes the *universal* nature of religion (1992, p. 71).

Hull's view is best described as a *pluralist* approach to religion, since it accepts more than one belief-set as true. However, it is a quick move from Hull's pluralism to an anti-realist perspective which denies objective truth in religion. Hull implies that it is unacceptable to say that the beliefs of others are wrong. If none are wrong, then either all are right, or all lack a truth-value (i.e. are neither true nor false, like 'chocolate is the best flavour of ice cream'). Since claims made by different religions are sometimes in conflict, we are forced towards the second part of this dichotomy.

Andrew Davis (2010), who advocates a 'moderate pluralism' for RE, thinks the problem of conflicting truth-claims can be avoided. According to Davis, contentious truth-claims (such as 'Jesus is the Son of God') should be interpreted in a non-literal, metaphorical way. But this will not do, for we should represent religion in an authentic light to students, and many religious believers *do* hold their beliefs literally. For example, approximately 40% of Americans believe that Jesus was God living amongst men (Gallup 2002), and 73% of US adults believe that Jesus was

[1] See Grimmitt (2000) for a survey of RE pedagogies.

born of a virgin (Gallup 2013). We cannot say of *all* believers that they interpret contentious claims metaphorically, simply to avoid conflict with the truth-claims of other religions. It is both unjustified and patronising to refer to exclusivist approaches as 'primitive' (Davis 2010, p. 198).

Anti-realism

Some thinkers have abandoned objective truth in religion entirely. For example, Erricker and Erricker (2000) describe their RE pedagogy as a 'narrative' education which 'draws on a philosophical basis derived from relativist and postmodernist thinking' (p. xiv). Clive Erricker criticises current approaches to RE for focusing on 'religion', a category that is intrinsically ideological (p. 29) and therefore exclusive. This motivates Erricker to advocate a radical transformation of RE, including a departure from looking at religions (p. 30). Since there are no objective truths about religion, RE should completely avoid talk of truth.

Critical RE

In contrast to the pluralist and relativist approaches summarised above, a critical approach to RE places examination of truth centre-stage. The founder of this approach, Andrew Wright, argues for a pedagogy where the key aim is to 'enable students to engage with questions of ultimate truth, and attend to the task of living truthful lives in an informed, critical and literate manner' (Wright 2007, p. 3). Three key assumptions of critical realism underlie the pedagogy: that there is a reality which exists independently of our knowledge of it (ontological realism), that our knowledge of this reality is limited (epistemic relativity) and that, despite this, we are able to make sensible judgements about what this reality is (judgemental rationality).

Adopting this pedagogy would go some way to addressing the following concern raised by Billingsley et al. (2016, p. 477–8):

> the RE classroom is seen by students as a space in which a range of ideas can be presented but there are no criteria to say whether one idea is better than another. This lack of a critical framework means that the choice to reject science seems to students to be acceptable within the epistemological framework that they suppose exists in their RE lessons.

Critical RE aims to explore with students what tools are on offer for exercising their judgemental rationality, i.e. what criteria should be utilised when making judgements about truth. It encourages students to seek truthful answers to ultimate questions, without imposing on students a view of what these answers are.[2]

[2] For a simple explanation of the conceptual framework underlying this pedagogy, as well as lesson resources and schemes of work exemplifying critical RE pedagogy, see Easton et al. (2019).

Student Views on Truth in Science and Religion

The previous section looked at scholarly opinion on the role that truth should play in RE. In this section, I give an overview of research into what *students* think about truth in science and religion. Knowing 'where students are at' is important, for it should be informing the pedagogical approach we adopt, as well as shaping curriculum content.

Evidence suggesting that students conceive of religious and moral truth-claims differently from other types of truth-claim has mostly been anecdotal. For example, Stephen Law provides evidence of what he describes as 'rampant relativism and non-judgementalism' amongst university students (Law 2006, p. 77). However, studies investigating student views on the relationship between science and religion have indicated that students think about these two disciplines in very different ways.

Billingsley et al. (2016) found that many students contrasted the 'facts' of science with the 'opinions' of religion. Students often associated science with certainty, with one student saying that 'science is just anything that's proven right' (p. 471). In contrast, they saw religion as consisting of unprovable opinions that all have equal status.

Similarly, Hanley et al. (2014) found that their student participants saw a clear divide between 'belief' and 'evidence'. 'Belief-based' knowledge systems privilege what is known by faith and expressed through scripture and personal experience. 'Evidence-based' knowledge systems are those backed up by facts, observations, and experimental evidence. Students tend to perceive scientific theories such as the Big Bang as based in fact, in contrast to religious views of creation which are based in faith and teachings (p. 1221).

The Verification Principle

In the last two sections, we have seen a tendency amongst both scholars and students to view religious claims as distinct from what they see as the provable, objective facts of science. This tendency can partly be explained by the desire for peaceful co-existence in multicultural societies. By seeing religion as a personal preference (like different tastes in flavours of ice cream), conflict is reduced. However, there is an important epistemic motivation as well, which has its roots in Logical Positivism.

The eighteenth century philosopher David Hume made the dramatic assertion that we should 'commit … to flames' statements that do not fit neatly into his 'fork' of 'analytic a priori' and 'synthetic a posteriori' (1999, p. 211). In the twentieth century, the Logical Positivists sought to apply Hume's ideas to the study of language. This culminated in the work of A. J. Ayer, who proposed the verification principle: a statement is only meaningful if it is either a tautology or is (in principle) empirically verifiable. (A statement is 'empirically verifiable' when it can be checked by means that are accessible to the senses. For example, the statement 'this book is 50 pages long' is meaningful (but false) according to the principle, since you can check its truth-status by looking at the page numbers or by counting.) The verification principle implies that religious language should be dismissed as 'nonsensical'; religious statements do not assert facts (Ayer 1990, p. 24).

Criticisms of the verification principle have been widespread. Most scholars now agree that the Logical Positivists failed to properly attend to how we use language, especially the meaning that we clearly do see in poetry, art and moral discourse. However, Logical Positivism has left a lasting legacy on our thinking about the difference between science and religion: scientific knowledge is now seen as the 'benchmark' by which to judge factual claims. According to this view, whilst scientific statements are in principle testable, religious and moral statements are not even testable in principle and therefore are consigned to 'mere opinion'.

Scientism

Scientism can be seen as both a cause and an effect of Logical Positivism. Scientism is the view that the scientific method is the only way to establish knowledge. Where gaps in knowledge exist, these will be filled by future scientific discovery. Scientist views have been popularised by a number of prominent scientists, including Peter Atkins, who argues for the 'universal competence' of science (Atkins 1995, p. 97).

Many scientists reject scientism and exercise caution over expanding the realm of science. The American Association for the Advancement of Science has stated that 'there are many matters that cannot usefully be examined in a scientific way' (AAAS 1989, p. 26). Indeed, Hugh Gauch (2009) argues that it is a pillar of science to understand it as limited. He points out that the 'powers and limits of science are consistently identified by position papers as an essential component of scientific literacy' (p. 67).

Science is not only limited in terms of its *scope*. We should also see science as limited in terms of the *certainty* it can deliver. Hypotheses are tested by empirical investigation. The more support there is for a hypothesis, the more probable it is. But these inductive arguments can never achieve absolute certainty in the way that a deductive proof can. As Hume pointed out, inductive arguments suffer from the 'problem of induction'. They rely on the premise that:

> instances of which we have had no experience, must resemble those of which we have had experience, and that the course of nature continues always uniformly the same. (Hume 1992, p. 89)

Since we only have past instances to rely on to support the claim that 'the future will resemble the past', this is a circular argument. As a result we are 'never able to prove' the general claims made by science (Hume 1992, p. 92), such as 'metals expand when heated'. Thus we should not see scientific knowledge as absolutely certain; although science can show us that a claim is highly probable, such knowledge will always have less certainty than the deductive knowledge of mathematics and logic.

Science and Religion as Non-overlapping Magisteria

Partly as a response to scientism, and partly as an attempt to rescue religion from the dismal fate dealt by the verification principle, some have suggested that there should be different principles for the distinct realms of science and religion. According to this view, Ayer was mistakenly trying to apply scientific criteria to other realms. Gould (1999, p. 6) talks of the realms of science and religion as 'non-overlapping magisteria', arguing that:

> The … magisterium, of science covers the empirical realm: what is the universe made of (fact) and why does it work this way (theory). The magisterium of religion extends over questions of ultimate meaning and moral value. These … do not overlap.

Talk of different realms for science and religion (often followed by talk of different 'truths') is problematic. Since most people view scientific truths as objective, the kind of 'truth' reserved for religious claims lacks metaphysical importance and is more akin to an expression of preference. Religious statements become 'expressions of subjective preference devoid of any purchase on reality', generating 'a fact-value divide in which reality is limited to facts and stripped of all value' (Wright 2013, p. 13).

Research Aims and Methodology

The primary aim of the study was to explore how students conceive of religious and moral truth-claims as compared to other types of truth-claim. A subsidiary aim was to investigate whether students appeal to something like the verification principle when discussing religion.

The data was collected during 3 hour-long focus groups, with the researcher taking the role of interviewer. Focus groups were opted for over individual interviews because this gave opportunities for participants to challenge each other to express *reasons* for their beliefs, enabling a deeper level of understanding and explanation. To minimise group effects, students worked individually to give written answers before the group discussions took place. These written answers became important data alongside the interview transcripts.

The approach to the interviewing was semi-structured. The interview schedule allowed for cross-case comparability (across the different participants and different focus groups). However, the sequence could be varied, the emphasis and timings could be altered, and the follow-up questioning was flexible.

The study took place at an independent, all-girls school in South-West London. The school has a broadly Christian ethos, although students come from a range of religious and non-religious backgrounds. The majority of students were of white racial origin.

The participants were Year 9 students, chosen because they were the only students in the school that had not been taught by the researcher. This was important so that the students were not biased towards particular responses that they felt the interviewer wanted. Year 9 were also the only year group that had not completed a Year 7 scheme of work introducing RE taught with a critical pedagogy, which explicitly raises the issue of the nature of religious truth.[3] To ensure a spread of characteristics, students were selected from the classes of three different RE teachers and from a range of abilities (two low, two middle, two high, based on their RE teacher's judgement in conjunction with MIDYIS scores).

The focus group size was six, allowing for a dynamic and energetic discussion. Morgan (1998, p. 70) suggests that a small group size is better where topics are controversial or complex. Clearly both conditions applied in this study. One student was unavailable on the day and so in total the sample size was 17 students.

The focus groups were audio-recorded and transcribed first-hand. The transcriptions were written verbatim, so that the participants' responses were captured in their own terms. Using thematic analysis, the data was coded according to themes. Some of these themes arose from the research aims, but the majority were in vivo codes, arising fluidly alongside the data analysis. To avoid fragmentation of the data (Bryman 2008, p. 553), the codes were kept within the transcript text. This way, data was never seen apart from its original context.

Since the research was undertaken with some preconceived ideas on the research questions, particular attention was paid to negative evidence in the analysis of the transcripts. Each code had an opposite, and the transcripts were revisited to look for these negative codes.

Analysis

Students engaged in lively discussion in their focus groups, for the full hour. This resulted in an abundance of rich data. From the various constructs that arose from the data, key themes were identified. In this section, I summarise only the themes that are of relevance to understanding how students conceive of scientific claims in comparison to how they conceive of religious claims.[4]

Quotes from the transcripts are in italics. 'T' refers to the interviewer. Bold has sometimes been used to draw the reader's attention to specific parts of quotations.

[3] See Easton et al. (2019) for this scheme of work and accompanying lesson plans and resources.

[4] In Easton (forthcoming), I discuss a number of other important themes, including the complex position taken by students over the truth-status of moral statements.

The pseudonyms used to replace student names indicate which focus group the student was in (X, Y or Z), followed by the ability range that they represented (A for high, B for medium and C for low), followed by a random number from 1 to 6. The quotes are best understood in relation to the interview schedule (see Appendix).

Student Approaches to Religious Truth-Claims

All the students made comments that indicated that they saw religious statements as *subjectively* rather than *objectively* true. The following example comes from a discussion of where to place the statement ‘God loves everyone’ (Question 5):[5]

ZC2: *I did put* [side] *B to start with, but then I realised it was wrong.*
T: *I don’t necessarily think it is wrong. I think you could put it on side B and say I think it is totally true that God loves everyone.*
ZC1: *I think* ***it depends on who you are*** *though.*
ZB4: *Cos* ***they are all opinions*** *in the end.*

ZC1’s comment implies that whether the statement is true depends on who is making the claim; it is subjective to the person.

All students designated the two religious statements in Question 5 as side A (which all students labelled as ‘opinion’).[6] The only negative evidence against religious statements being subjective opinion came in the form of a challenge to YC2’s comment that ‘*God is what you make of him or her*’. YA5 says:

> *I think some people would find it disrespectful. Like the idea that if you could make up God in your own head, you could say that he looks like a human.*

Similarly, YB4 challenges by saying

> *you shouldn’t be able to just make up God in your head… Because if something’s just made up by different people then it doesn’t make it particularly realistic.*

These two quotes are the only evidence of realist views about religion in the three transcripts.

Students also talked about moral claims as subjectively true, although their position here wavered when it came to statements that they felt absolutely sure were true, such as statements of racial equality.

[5] There were two ‘sides’, each made up of a different set of statements. Side A contained statements which are commonly viewed as ‘opinion’, such as ‘chocolate is the best flavour of ice cream’. Side B contained statements that are usually viewed as ‘fact’ such as ‘copper conducts electricity’. Students had to make a decision over which side to place new statements on.

[6] The two sides were labelled only as ‘Side A’ and ‘Side B’ on the student handout. However, since all students spoke of side A as ‘opinion’ and side B as ‘fact’, I will now adopt these labels.

The Need for Empirical Verification

One motivation for students viewing religious statements as subjective was the thought that these statements cannot be proven empirically (i.e. via the senses or by scientific means). This requirement for empirical verification was an issue that arose in all focus groups. For example, in this dialogue, students are discussing Question 2:

T: *XB3 said about 3 and 4 that* ***they can't be true or false****. So let's just take one particular example, so 'There is no God', so it's an atheist's point of view… Would the rest of you agree that this isn't either true or false?*

XC1: ***Yeah****.*

XA5: ***Yeah, cos it can't be proved.***

XB2: ***Yeah cos you would have so many different answers.*** *Like everyone would have a different opinion on that…*

XB3: *Yeah cos some people like believe that God does everything… some people believe he doesn't exist. Others believe he's there but doesn't really do anything.*

XA5: *Also God is supposed to be spiritual – so* ***it is not like you can get material proof of God****. Like a photo or something. Because* ***most facts are proven either through photos*** *or… Like water and hydrogen and oxygen – if you zoom in really close you could learn about…****most things you could scientifically prove through like material****…like* ***what you can see****.*

XA6: *So* ***we all go with the fact that you can see it or touch it or hear it****.*

XB3: *Like with* ***our senses****.*

XA5: *Or due to* ***scientific proof****.*

XA6: ***Whereas with God you can't use your senses so that's why… I think maybe that's what differentiates things that are facts and things that are opinion.***

Since the statement 'There is no God' is not amenable to scientific testing, it is the subject of disagreement, cannot be assigned a truth-value and therefore cannot be a 'fact'.

Students made frequent references to 'proof', which became an in vivo code. From studying the context of these references, it is clear that students meant *empirical* proof. For example, ZC2 says about the issue of whether there is a God that '*it can't be proven in any way*', despite the fact that she will have discussed at least some arguments for and against the existence of God in her RE lessons.

In response to Question 4, most students appealed to 'the facts'. These were examples of empirical evidence, such as '*scientists have gone into space and taken pictures of the earth*' (ZB4). The evidence here was viewed by most students as so great that the flat earth belief was simply not a legitimate opinion; YC1 says '*that's not an opinion*' and ZC2 says '*she's just going to have to accept it whether she likes it or not*'. Here there was some evidence of viewing science and religion as distinct types of truth-claim; whereas it is legitimate to have different opinions on religious and moral matters, this is not acceptable on (at least some) scientific matters.

The discussion of empirical verification of God's existence that spontaneously arose in Group X bore an uncanny resemblance to twentieth century discussions about Logical Positivism. The group concluded that the claim that 'God exists' is '*opinion till death*' (XA6), for only then can it be verified.

The Authority and Certainty of Science

Although there was no explicit reference to science in the interview schedule, 55 references to science were made across the focus groups. The authority that science held for the students became an emergent theme, worthy of discussion in and of itself.

Students appeared to think that it was so obvious that science has an especially authoritative epistemic status that this needs no further argumentation.

T: *So it's basically ended up being like Bible verses science. They could say that they don't trust science.*
YC1: *Yeah I know but science is like…* [long pause] *science.*

And again, with a different group:

T: *But what makes science so special though?*
ZC2: *Because it's right!*

In these statements, students did not attempt to justify science's authoritative status. However, more generally, science was viewed as reliable because it has *evidence* (which was another frequently used word); '*I believe that science is correct because they have real hard evidence to back their statements up with…*'(XB3).

Unlike with religious statements, students felt that it was safe to say that (some) scientific statements were definitely true. Whereas religious claims are uncertain, '*It's quite a different thing to believe that the earth is flat cos it's just like not*.' (ZC2) The word 'science' was sometimes even misused to designate certainty. For example, some students designated the first two statements in Question 2 as 'scientific', even though one is a mathematical statement. Of the two statements, ZC2 says that they '*can be…scientifically proven*' and XB3 says '*no one really has a different opinion because science has like proved it so much*'. It is not clear how science can prove '3+3=6', and so it appears that here the students are misusing 'science' to express their confidence in the certainty of the statement.

There was little evidence of students viewing science and religion as 'non-overlapping magisteria' (see section "Science and religion as non-overlapping magisteria"). Instead, students perceived a requirement for all knowledge to conform to the standards set by science. For example, in the following conversation, it is implied that the Bible needs scientific proof:

YC1: *Science is proven. They haven't proven the Bible yet. How do we know whether God is alive? Or dead?*

YA5: *But according to some Christians they'd say that it was.*
T: *But when you say that they haven't proven the Bible, don't you mean 'by scientific means'?*
YC1: *Exactly so science…*
YA5: *But you might say that science is contradicted by the Bible, if you believe that it is true.*
YC1: *No no no. Cos **the Bible and religion is like belief.** Science is like…*
YA5: *But that's your opinion.*
YC1: ***If the Bible people, like the religious people want to contradict science then they need some Bible science proof.***

Facts Versus Opinions

The concern with the distinction between 'fact' and 'opinion' was another emergent theme of the study. The distinction was brought up in every focus group and discussed by every student. 'Fact' and 'opinion' became in vivo codes, with 129 references to 'fact' and 182 references to 'opinion'. The strong division present mirrors the research findings described in section "Student views on truth in science and religion".

Facts

Facts were identified as being '*100% true*' (ZB4) but most frequently by their 'provability'. Facts are '*proven*' (ZB4, YB3, ZB3) and '*definite*' (ZA5). YA5 said in discussion of Question 4:

> *We're saying that there's a lot of proof of it* [the world] *being round. Like **enough proof that we can call it a fact**.*

More specifically, facts have *empirical* proof.

> ***You can't use your senses** so that's why… I think maybe **that's what differentiates things that are facts and things that are opinion**.* (XA6)

Most students saw a sharp divide between fact and opinion. The exception was one student who indicated that these concepts could overlap. XA6 said:

> *You could have an opinion that is also a fact. Like I think that 2 + 2 = 4, but that's a fact as well.*

Opinions

Students showed a great deal of concern with showing respect for opinions. It was common to hear students say that '*Everyone is entitled to believe what they want*' (YB4). However, students stepped away from this view when it came to statements that are clearly contradicted by scientific evidence. For example, ZC2 says of the flat-earther that '*she's just going to have to accept it whether she likes it or not*'. YC1 says '*that's not an opinion*' and (faced by lots of disagreement from her peers) justifies this by saying '*It's proven that it's round you know*'. Evolution was brought up by students as another example of something that religious people just *have* to accept. For these students, where opinions were perceived to conflict with scientific evidence, people are *not* entitled to believe what they want. The 'entitlement' only extends to beliefs that can be interpreted as subjectively true and making no claims about the physical world.

One factor that motivated students to designate certain statements as 'opinion' was the lack of consensus over the truth of these statements.

> *once it can be split into two views then it must be an opinion.* (ZA5)

> *some people agree with him and some people don't. And because there's two viewpoints it then goes on side A.* (YA5)

This is perhaps why 'the world is flat' cannot be an opinion; according to these students, *everyone* knows the world is round. The lack of consensus was important for these students in motivating the perceived gulf between 'scientific facts' and 'religious opinions'. This suggests that it would be helpful to give students tools and content to aid their understanding that there is disagreement in some areas of science too.

Implications for Curriculum Content and Teaching Pedagogy

Emphasis on Truth in RE

Cooling's (2012) report of students dismissing religious content as 'just opinion' was strongly supported by this study, with all students viewing religious statements as 'opinion'. 'Exclusivist' or 'religionist' attitudes were not present in this sample of students. Instead, the students' views were closer to the relativist approach championed by Erricker.

This suggests that those advocating pluralist or relativist approaches to RE are unjustified in assuming that students adopt a realist attitude that needs countering. Instead, the findings suggest that a pedagogical emphasis on religion as (at least sometimes) making objective truth-claims may be justified. This points towards adopting a critical RE pedagogy, since this pedagogy asks that students examine religions as making objective claims about reality.

Reflection on the Scientific Method

The students in this study were inclined to view science as having supreme epistemic authority. Rather than viewing science and religion as 'separate realms', religious statements were judged against the epistemic standards set by the scientific method.

In RE Lessons

A good RE curriculum will include an exploration of the nature of religious truth and discussion of the extent to which religious claims conflict with science. But this study suggests that more than this is required.

Firstly, RE teachers should provide opportunities for assumptions held by students (such as a version of the verification principle) to be questioned. For example, one activity could ask that students look at how various non-religious statements fare according to the verification principle.

Secondly, teachers need to work to dispel the myth of unanimity in science, by highlighting that disagreement can be an important feature of scientific discourse. Although this is most relevant to scientific knowledge in the making, even supposed 'laws' have been the subject of disagreement. For example, scientists supposed for centuries that Newton's law of gravity was universally applicable, yet Einstein was to later argue that this does not apply in extreme gravitational situations. To help students understand this aspect of science, teachers could simply flag an example in the media of scientific disagreement. (Examples at the time of writing include a disagreement over the dinosaur family tree[7] and over the amount of fruit and vegetables that we should be eating.[8]) Alternatively, teachers might point to the historical disagreement within the scientific community over Big Bang Theory.[9]

Thirdly, teachers need to dispel the myth of certainty by encouraging students to reflect on science as providing inductive arguments and thus probabilistic conclusions. To aid students in understanding this, they can be taught about the difference between inductive and deductive arguments. Learning about the so-called problem of induction (see section "Scientism") helps students to understand the difference between proof, inductive argument and empirical evidence. Even conclusions that are so probable that they are taken to be 'certain knowledge' in common parlance are not *guaranteed* to be true in the way that the conclusion of a sound deductive argument is. Scientific conclusions always face the possibility of revision in light of new evidence or as a result of reinterpretation of existing evidence.

---

[7] https://www.theguardian.com/science/2017/mar/22/scottish-fossil-may-cause-radical-shakeup-of-dinosaur-family-tree-saltopus (accessed 23/03/17)

[8] https://theconversation.com/do-you-really-need-to-eat-ten-portions-of-fruit-and-veg-a-day-74477 (accessed 23/03/17)

[9] Bagdonas and Silva (2015) give a detailed exploration of teaching this debate.

The subject content suggested here sounds hard, but lessons covering these topics have been tried and tested with Year 9s in a variety of contexts. For an exemplar scheme of work on 'Science and Religion', including lesson plans that address these issues, see Easton et al. (2019).

In Science Lessons

To avoid RE being seen as the critic of science, Science lessons should also involve some reflection on the scientific method. The importance of discussion about the nature of science has increasingly been recognised by educators (Matthews 2009). Indeed, reflection on the nature and limitations of science now features on many Science curricula internationally (Billingsley et al. 2016, p. 464).[10] However, there has not been widespread take-up by teachers (Lederman et al. 2014), suggesting that more needs to be done to incorporate reflection on the nature of science into classroom teaching.

At the very least, Science teachers could do more to make clear to their students the existence of scientific disagreement and the uncertain nature of some scientific theories. Students should be taught to understand that in some areas of science there is a lack of consensus and a lack of certainty. Not only would this lead to the realisation that these are not unique features of RE topics, it would also result in a more authentic understanding of science itself.

Limitations

The interview questions drawn up as part of this study provide a useful tool to draw on in further research into the way that students think about the truth-claims made by science and religion. Since this was a small study, the implications drawn out above cannot confidently be generalised to other contexts. To do so would require additional studies, involving more focus groups in a wide variety of school contexts.

Notably, the participants were all female. There is some evidence to suggest that 'female peer culture values harmony' and that women experience more negative emotions when competing (Lee et al. 2016). This supports the stereotype that

[10] For more on the nature of science in Science Education, see the journal 'Science & Education', which has numerous articles on this topic. It is the official journal of the International History, Philosophy, and Science Teaching Group, which also sponsors national and international conferences addressing the teaching of the nature of science. As part of their 'Project 2061', the American Association for the Advancement of Science provided a guide to their various educational resources that aim at 'understanding the nature of science and developing the habits of mind needed to use that understanding for personal and social purposes' (AAAS 2010).

women prefer co-operation and avoid direct conflict. If this stereotype is true, it may have increased the likelihood of participants seeing religious views as subjective opinions that cannot be the subject of disagreement. In light of this, undertaking a similar study with a mixed-gender group or all boys would be of significant interest.

Conclusion

The tendencies reported as anecdotes at the start of this chapter were seen amongst the participants in this study. The students saw religious claims as subjective opinion, 'true for the person' and immune to counter-evidence. This view was sometimes defended with an appeal to something like the verification principle: students used the empirical criterion of science to judge *all* types of statements. Religious statements fail to pass the test of empirical verifiability because they lack physical proof and consequently are 'mere opinion'.

A clear tendency was observed for students to see scientific statements as contrasting with opinion: they are objectively true, certain and authoritative. Where an opinion conflicts with a 'fact' of science, some students dropped their view that opinions cannot be questioned and cannot be wrong. According to these students, where science conflicts with an opinion, this shows either that the opinion is wrong, or it shows that the opinion is *neither* right nor wrong (i.e. subjective).

The findings suggest that a pedagogical concern with truth is appropriate in RE, in order to counter-balance student tendencies towards relativism about religion. Additionally, RE and Science schemes of work should include more reflection on the scientific method, in order to make clearer to students that science does not always involve complete consensus and unwavering certainty.

Appendix: Selected Parts of the Interview Schedule

Discussion Question 2

Here are four statements. **How are the first two statements different from the second two statements?**

1. 3 + 3 = 6.
2. Water is made up of hydrogen and oxygen.
3. There is no God.
4. God wants everyone to pray five times a day.

Discussion Question 4

Angela believes that the earth is flat. Scientists think it is round. **What would you say to Angela if she told you that the earth is flat?**

Discussion Question 5

Side A	Side B
Chocolate is the best flavour of ice cream.	2 + 2 = 4
Cats are the nicest animals.	Copper conducts electricity.
Blue is the best colour for decorating bedrooms.	Vitamin C is good for you.

Would you put these statements on side A or side B?
Hitler is an evil man.
God loves everyone.
Cheetahs can run faster than lions.
White and black people are of equal value.
The world was created by God.

References

American Association for the Advancement of Science (AAAS). (1989). *Project 2061: Science for all Americans*. Washington, DC: AAAS.

American Association for the Advancement of Science (AAAS). (2010). *Exploring the nature of science*. http://www.project2061.org/publications/guides/science.pdf. Accessed 4 Jan 2019.

Atkins, P. (1995). Science as truth. *History of the Human Sciences, 8*(2), 97–102.

Ayer, A. J. (1990). *Language, truth and logic*. London: Penguin.

Bagdonas, A., & Silva, C. C. (2015). Enhancing teachers' awareness about relations between science and religion the debate between steady state and big bang theories. *Science and Education, 24*, 1173–1199.

Billingsley, B., Brock, R., Taber, K. S., & Riga, F. (2016). How students view the boundaries between their science and religious education concerning the origins of life and the universe. *Science Education, 100*(3), 459–482.

Bryman, A. (2008). *Social research methods* (3rd ed.). Oxford: Oxford University Press.

Cooling, T. (2012). Faith, religious education and whole school issues. In L. Philip Barnes (Ed.), *Debates in religious education* (pp. 88–97). Oxon: Routledge.

Davis, A. (2010). Defending religious pluralism for religious education. *Ethics and Education, 5*(3), 189–202.

Easton, C. (forthcoming). *Looking for answers? A qualitative study examining relativism about religious and moral truth amongst secondary school students* [Working Paper].

Easton, C., Goodman, A., Wright, A., & Wright, A. (2019). *Critical religious education in practice: A teacher's guide for the secondary classroom*. London: Routledge.

Erricker, C., & Erricker, J. (2000). *Reconstructing religious, spiritual and moral education*. London: RoutledgeFalmer.
Gallup. (2002). *Who is Jesus?* http://www.gallup.com/poll/7471/who-jesus.aspx. Accessed 27 Mar 2017.
Gallup. (2013). *Most Americans believe in Jesus' virgin birth.* http://www.pewresearch.org/fact-tank/2013/12/25/most-americans-believe-in-jesus-virgin-birth/. Accessed 27 Mar 2017.
Gauch, H. G. (2009). Science, worldviews, and education. *Science and Education, 18*, 667–695.
Gould, S. J. (1999). *Rocks of ages: Science and religion in the fullness of life*. New York: Ballantine.
Grimmitt, M. (2000). *Pedagogies of religious education*. Essex: McCrimmons.
Hanley, P., Bennett, J., & Ratcliffe, M. (2014). The inter-relationship of science and religion: A typology of engagement. *International Journal of Science Education, 36*(7), 1210–1229.
Hull, J. M. (1992). The transmission of religious prejudice. *British Journal of Religious Education, 14*(2), 69–72.
Hull, J. M. (2000). Religionism and religious education. In: M. Leicester and S. Modgil (Eds.), *Spiritual and religious education* (pp. 75–85). London: Falmer Press.
Hume, D. (1992). *Treatise of human nature*. New York: Prometheus.
Hume, D. (1999). *An enquiry concerning human understanding*. Oxford: Oxford University Press.
Law, S. (2006). *The war for children's minds*. Oxford: Routledge.
Lederman, N. G., Antink, A., & Bartos, S. (2014). Nature of science, scientific inquiry, and socio-scientific issues arising from genetics: A pathway to developing a scientifically literate citizenry. *Science & Education, 23*(2), 285–302.
Lee, S. Y., Kesebir, S., & Pillutla, M. M. (2016). Gender differences in response to competition with same-gender coworkers: A relational perspective. *Journal of Personality and Social Psychology, 110*(6), 869–886.
Matthews, M. R. (2009). Science, worldviews and education: An introduction. *Science and Education, 18*(6-7), 641–666.
Morgan, D. L. (1998). *Planning focus groups*. Thousand Oaks: Sage.
Wright A. (2007). *Critical religious education, multiculturalism, and the pursuit of truth.* Cardiff: University of Wales Press.
Wright, A. (2013). *Christianity and critical realism*. Oxon: Routledge.

Christina Easton is a Doctoral Researcher in Philosophy at the London School of Economics. Her thesis concerns the acceptability of teaching liberal values in schools. Prior to taking up the studentship at LSE, she taught Philosophy and Religious Studies at secondary schools for 8 years. She has recently co-authored the book *Critical Religious Education in Practice: A Teacher's Guide for the Secondary Classroom* (Routledge, 2019), which includes a scheme of work and resources on science and religion. For Christina's academic publications and blog posts, see http://personal.lse.ac.uk/DAVISCE2/.

Chapter 12
Developing a Workshop for Secondary School Students that Provides a Space to Explore Questions About Human Personhood Through the Context of Human-like Machines

Berry Billingsley and Mehdi Nassaji

Introduction

This chapter introduces and explains a workshop designed to give secondary school students an opportunity to discuss the interactions between science and widely held beliefs about personhood, including beliefs about the soul.

The workshop was constructed as part of the *Being Human* project conducted by the LASAR (Learning about Science and Religion) Research Project. LASAR was established in 2009 to look at how questions and themes bridging science and religion are managed in schools.

As we explain further shortly the motivation for designing and running this workshop for secondary school students was a concern that some students hold back questions in their science lessons that they perceive to be 'off-topic' and/or to have a religious aspect. With this in mind we wanted to design a workshop that could provide students with opportunities to voice their questions and to explore a range of perspectives on the relationships between science and widely held beliefs about human personhood. We chose the theme of human-like machines for the workshop in part because we anticipated that it is a topic that engages this age group and also as a way to open up a space for discussion about human personhood that can address issues associated with religious belief without setting them up explicitly.

The idea that a person has a spiritual aspect or soul is central to the teachings of many faiths and is also an idea that is frequently endorsed by popular culture. Whether or not someone believes in the soul as a religious concept, there are attributes of personhood which are widely associated with the concept of a soul that are

B. Billingsley (✉) · M. Nassaji
LASAR (Learning about Science and Religion), Canterbury Christ Church University, Canterbury, UK
e-mail: berry.billingsley@canterbury.ac.uk; mehdi.nassaji@canterbury.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_12

valued by people more generally. For example, in religious thinking and in popular perceptions of personhood more widely, it is believed that people have a capacity to choose how they behave and are sensitive to the moral consequences of their behaviour. Warren Brown (2004, p. 58) summarises the attributes of the soul in a way that illustrates its relevance to our area of interest in our research by saying:

> In many religious traditions, the concept of a soul has played a very important and meaningful role in the understanding of personhood. The soul has been thought to be the source of important aspects of human uniqueness, at various times including consciousness, intellect and free will. The soul is viewed as the point of interaction with God, and as necessary for maintaining belief in eternal life. It is the soul that is both corrupted by sin and the target of redemption. Most important the soul has come to encompass critical aspects of personhood. (Brown 2004, p. 58)

At the same time, scientific advances, particularly in evolutionary biology, genetics, neuroscience and artificial intelligence, present many challenges to religious and popular notions of human personhood. Common beliefs about human personhood have been challenged by Nobel Prize winner and biologist Frances Crick who argues that you, your joys and your sorrows, your memories and your ambitions, and your sense of personal identity and free will are in fact no more than the behaviour of a vast assembly of nerve cells and their associated molecules. As Lewis Carroll's Alice might have phrased it: 'you're nothing but a pack of neurons' (Crick 1994, p. 3).

While some commentators and some scholars argue that science is revealing a reductionist and, as such, atheistic picture of a person, this is only one of a range of positions that scholars today express.

We turn now to the context of human-like robots and explain why this became the focus we introduced for the workshop.

Alongside the question of what robots can do now and in the short term, there is also the question of what robots might do and one day become in the future. Ryan Dowell (2018, p. 305) is one of the many authors who are open to the possibility of thinking machines at some point claiming that:

> In the future, it is possible that humans will create machines that are thinking entities with faculties on par with humans. Computers are already more capable than humans at some tasks, but are not regarded as truly intelligent or able to think. Yet since the early days of computing, humans have contemplated the possibility of intelligent machines—those which reach some level of sentience. Intelligent machines could result from highly active and rapidly advancing fields of research, such as attempts to emulate the human brain, or to develop generalized artificial intelligence (AGI).

If, one day, there will be sentient, thinking robots, then what indicative steps might be expected over the coming years? A second prompt for the workshop was a headline by Yale News that is 'the first self-aware robot created' (Suterwala 2012). The body of the report states that 'A robot developed by computer science experts at the Social Robotics Lab may pass a landmark test by recognizing itself changing in a mirror'. The mirror test has become a widely used method to test for self-awareness in an animal which is usually selected as an example of its species. The same report then critiques its own headline by including a comment from a principal scientist at Honda Research Institute in California. The scientist gives a view that a robot could never be self-aware in the same way an animal can be. Instead, the kind of limited self-awareness for which the researchers plan to test is 'purely an image-processing program'. Other reports of the same advance also anticipate self-aware robots and attempt to varying extents to discuss the significance of this achievement in relation to the goal (see, e.g. 'Robot learns to recognise itself in mirror', BBC 2012).

The Yale article has a sensationalist headline and then critiques its own claim by quoting a scientist who calls into question whether a robot that can identify its own reflection in a mirror is self-aware in the human sense. In our view this makes it an interesting article to discuss with a class. Is a machine that can produce signs of self-consciousness necessarily conscious of itself? Philosopher Joel Feinberg (1994, p. 52) sees these signs as merely outward indicators of an inner mental life that is essential to what makes us conscious selves:

> It is because people are conscious; have a sense of their personal identities; have plans, goals, and projects; experience emotions; are liable to pains, anxieties, and frustrations; can reason and bargain, and so on—it is because of these attributes that people have values and interests, desires and expectations of their own, including a stake in their own futures, and a personal well-being of a sort we cannot ascribe to unconscious or nonrational beings.

School students are encountering news of advances in evolutionary biology, neuroscience and genetics both in formal lessons and via the media which may seem to challenge the notion of the person as an agent with moral responsibilities and a capacity for making choices. Headlines like 'it's all in your genes' or 'we're just a bundle of neurons' are not uncommon in media reports and suggest that human thought and behaviour can potentially be fully explained scientifically. Consider, for example, a media article which says that scientists have discovered the parts of the brain which become active when someone falls in love (see, e.g. Spencer 2015). How might reports that emphasise a biology of emotions be interpreted by a school student who believes each person has love that is associated with a core or soul which is distinct from the material body? An analysis of media reports of advances in neuroscience by Racine et al. (2010) concluded that neuroessentialism is an emerging trend in media interpretations of neuroimaging. The authors explain that neuroessentialism refers to depictions of the brain as the essence of a person, with the brain a synonym for soul. It seems reasonable to suppose that school students' perceptions of what it means to be human are influenced by such reports and also that some students may experience some of the puzzles and conundrums that scholarly literature discusses.

One of our central motivations for constructing the workshop was the possibility that secondary school students may not have access to the epistemic insight which enables scholars to articulate different positions on whether and why scientific and nonreductive (including religious) accounts of personhood may be compatible. This circumspection was in part prompted by the findings of a small-scale survey with students in upper secondary school which sought to discover students' positions on the power of science to explain aspects of human personhood relating to behaviour, thinking and personality. This found that there are some teenagers who believe that science has revealed a necessarily materialistic and deterministic picture of human personhood, yet were uncomfortable about accepting these ideas for themselves (Billingsley et al. 2016b). The survey included the statement, 'the brain is what makes you "you"', and invited students to add comments as well as show their level of agreement. Students' comments revealed the ways that some are struggling to make sense of the ideas that they had encountered as these examples illustrate:

> I'm unsure about this one. I suppose everything you do is a result of the brain, but I feel uneasy saying that I'm not a person – I'm just a brain in a shell.
>
> I am unsure whether humans have a soul and whether that affects you rather than your brain.
>
> I suppose so, if the brain is really where all decisions and thoughts come from but the ability to weigh out pros and cons and emotion I don't think comes from the brain.

How secondary school students reason about the relationships between scientific and religious ideas has been a concern within educational research for some time. Studies exploring students' perceptions of what science and religion say about the origins of life has shown that school students frequently hold narrow and even misconstrued perceptions of science and religion and as such are blocked from appreciating the range of positions that scholars take (Billingsley 2010; Billingsley et al. 2016a; Konnemann et al. 2016). Arguably, one of the reasons for this is the way that teaching is organised in secondary schools – which is mostly into single subject sessions.

Immersing students in the questions, methods and norms of thought of a single discipline at a time is important to help students get a feeling for how each discipline works and there is no intention here to suggest a move away from teaching disciplines through subject compartments. When, however, compartmentalisation becomes entrenched, it means that organisational, social and pedagogical practices have become habits and dictate students' and teachers' expectations about what happens in the classroom (Tyack and Tobin 1994).

Compartmentalisation affects students' opportunities to develop cross-disciplinary epistemic insight (Billingsley et al. 2018). In a strictly compartmentalised education system such as in England, children may have few opportunities to compare the questions, methods and norms of thought that characterise different disciplines. Our own research shows that interest in 'Big Questions' (i.e. questions about the nature of reality and human personhood) such as why there is a universe at all, what it means to be a person and the extent to which a person can freely direct the choices they make in life is widespread among young people but also that children typically have few opportunities to ask questions and engage in discussion (Taber et al. 2011). Our previous work found that that in science lessons teachers try to avoid questions and discussion that link with religion. We also found that children pick up on their teachers' resistance and hold back their questions believing them to be 'unwelcome' (Billingsley et al. 2013). Fourteen-year-old David (not his real name) was one of the many students who explained that students resist asking questions they perceive as 'off-topic': 'We don't ask science teachers questions any more at the moment, because we don't think that they'd answer them … they won't answer that because it's not on their topic'. Brenda (also aged 14) used the abbreviation RS to refer to religious studies/education when she told us:

> We don't really talk about RS in science, I don't think the teacher really brings it up, and no-one ever asks about it, so there's no need for her to bring it up. And the same with RS, no-one really asks the science questions because you'd really more ask your science teacher about that instead of asking your RE teacher. (Billingsley et al. 2013, p. 1726)

What we drew from this preliminary work was that many young people are wrestling with the implications of contemporary science when thinking about what it means to be human, and there is a tendency among upper secondary school students ages 14–17 to articulate scientific ideas about human personhood and character in reductionist and deterministic terms. We also concluded that school students are unlikely to have opportunities in school to raise and discuss any questions and concerns that they have.

Having indicated the motivation for developing the workshop, we will now explain the activities that were provided for students participating in the workshop.

Workshop Activities

Workshop Activity 1: Can a Robot Be an Electronic Person?

The facilitator asks participants to imagine that it is the year 2100 and that the field of robotics has made significant advances. Participants have an array of technologies to choose from at their local computing and robotics shop. They are asked to imagine that they are a keen amateur technician entering the annual 'artificial life' championships. With a £1000 budget, the objective is to build the machine that has what it needs to have the status of electronic person. The facilitator asks them to discuss how they will choose to spend their budget and why and to be ready to explain and defend their decisions. The figure below is a worksheet for this activity (Fig. 12.1).

Workshop Activity 2: Can a Robot Hear?

The facilitator asks students to give their opinions about whether we can design and build a robot that can hear. There is a work sheet with these two questions:

1. Suppose you were designing a robot that can hear – how would you address that challenge?
2. How would the robot demonstrate that it can hear (if it can hear)?

Then the facilitator demonstrates a robot that starts and stops moving on the sound of a clap and again asks the question, 'Can this robot hear?' The aim is to help

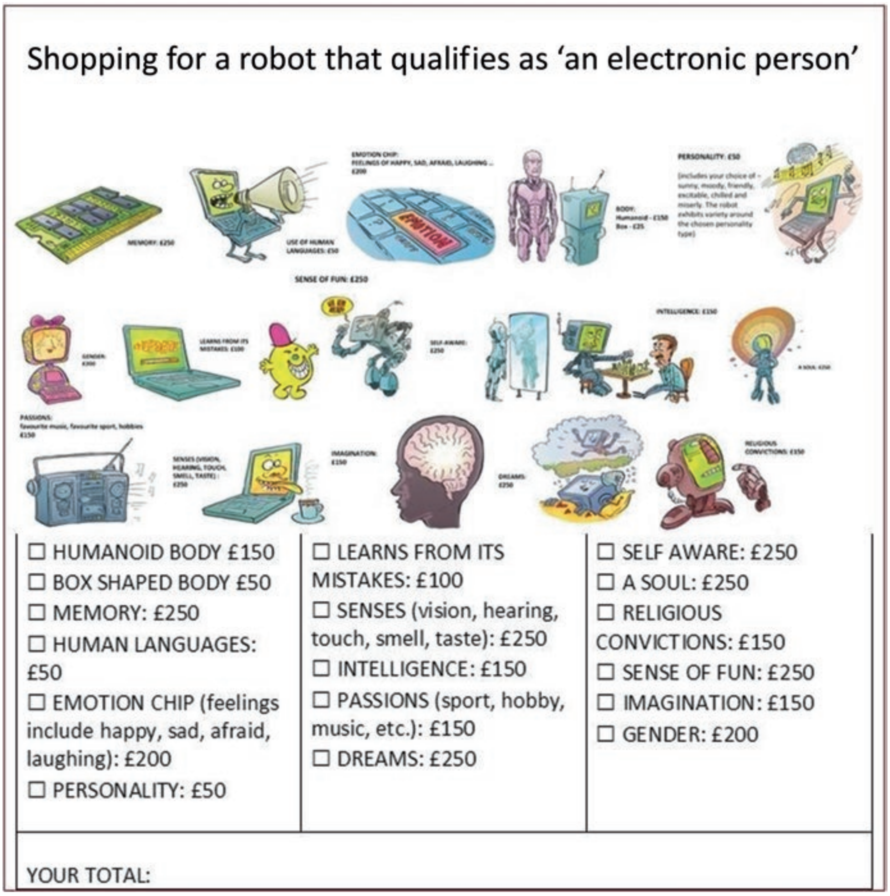


Fig. 12.1 Handout sheet for workshop activity 1

students consider whether there is a distinction between 'hearing' and 'responding to sound'. Students are asked whether there is a difference between a person hearing and a robot hearing. Pupils may suggest that 'understanding' or 'emotions' are involved in the person hearing. The list of differences between a robot hearing and a person hearing is written on the board by the facilitator. (Participants may suggest that hearing for a person is more complicated than just a responding to a clap. In that case, the facilitator may ask what about Siri (the voice recognition and response system on iPhones): Does Siri hear what the user says, and if this is hearing, how is this different from a person hearing?) During the discussion among students, the facilitator should try to highlight two different answers that students may give to the question of whether hearing is the same as responding to sound. One view is that 'hearing and responding to sound are the same', and the other is that 'a robot responding to sound is different from a human being hearing' (the facilitator refers back to this distinction later).

Workshop Activity 3: Comparing the Visible Behaviour of a Humanoid Robot and a Human Being

The facilitator explains what a humanoid robot is (perhaps showing some interesting photos or video clips). She/he asks the group of students to do a simple task (such as raising their hands a couple of times). Then the facilitator asks the students to imagine that there is a group of humanoid robots in one room and a group of students in another room and that both groups have been asked to follow the same instruction (raising their hand). The facilitator asks students to think about the similarities and differences between these groups in what they are doing. The point is to discuss the difference of 'rule following' between programmed humanoid robots and the human beings. These are the questions for thinking and discussion:

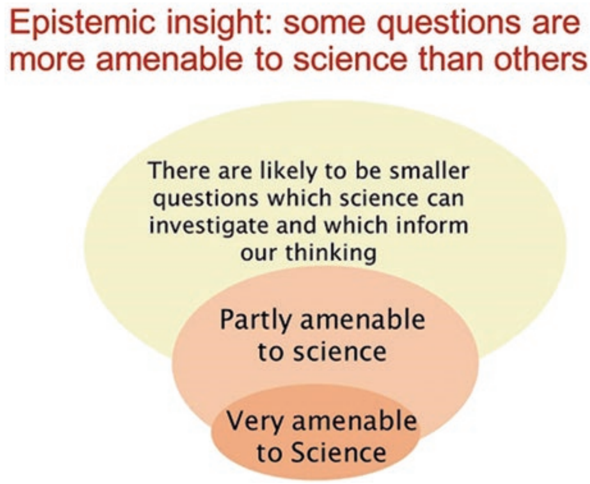
- Would the robot get tired if we asked them to do this many, many times? Would that be a difference between a humanoid robot and a human being? (If students say robots never get tired in the way that a human being gets tired, the facilitator may ask them to list the signs of tiredness in humans and say, 'How about if I give this list to an engineer and ask for a group of robots that show all these signs after repeating the job for a certain number of times? Does this reduce or even fill in the gap between the robots and the human beings?)
- Do you think that any of the humans or robots or both would start to get cross if they were asked to do this several times? (The facilitator can then say that the engineers will be asked to address this gap in their design.)
- Do you think that any of the humans or robots or both would refuse to follow the instruction after a while? (The facilitator can again say that this will be addressed in the design of the robots.)
- Does the robot group understand what they are doing?

The facilitator broadens the question and asks whether, in general, engineers can fill the gap between humanoid robots and human beings – by honing the robots' visible behaviour until they match the behaviour exhibited by people?

Workshop Activity 4: Ordering Questions from Amenable to Science to More Metaphysically Sensitive

The facilitator gives eight cards which each present a question and ask students to use the graphic below to categorise them into (a) very amenable to science; (b) partly amenable to science; (c) not very amenable to science – but there may be smaller scientific questions that we can usefully explore (see Fig. 12.2).

Fig. 12.2 Graphic to sort questions



Data Collection and Findings

We have run various versions of the workshop as pilot studies with different year groups, from Year 8 to Year 12 (12- to 17-year-olds) on different occasions. Here we highlight some of our findings drawn from this mostly exploratory work.

Many students commented on the impact of the workshop on their ideas about robots, being human and science. In explaining how her thinking had changed, Tara commented that 'I have realised the scientific potential … [of] advanced robots and have distinguished the difference between scientific and non-scientific questions'. Reyhaneh stated that although her thinking had not changed and she still believes that robots will not advance the level of humans, now she has 'a deeper understanding into some of the reasons for this'.

A version of the workshop was presented to 32 Year 8 students in a school in South England with a survey before and after the workshop. Analysis of the survey indicated that students had become more critical about the meaning of the terms that are commonly used for robots and human beings. For instance, before the workshop, nearly 70% of the students agreed or strongly agreed with the statement that 'One day there will be robots that are as intelligent as humans'; the level of agreement with this statement after the workshop fell to just over 40%. Similarly, while one in three of the students initially agreed or strongly agreed with the statement that 'One day there will be robots that have minds', this level of agreement reduced to less than 15% after the workshop.

We also found evidence that the workshop was an effective way to draw students' attention to the need to consider the power and limitations of science, and in some cases this consideration led some students to change their expressed positions on this statement. In response to the statement 'One day science will be able to tell us how our personalities are formed', nearly 50% of students agreed or strongly agreed before the workshop, while less than 10% agreed or strongly agreed with the same statement after the workshop.

At the end of each workshop, we also asked students how their thinking had changed; below is a sample of comments students who attended these workshops:

- I have questioned the difference between hearing and responding which is particularly significant in terms of understanding of robot.
- It has made me think more about what makes me a human – and what does/doesn't do the same for a robot.
- I can appreciate the difference between hearing and responding and it has developed my ethical views about robots.
- I am thinking more metaphysical. Science is not all about grades.
- Now I think there is a way bigger question and meaning to think about with robots and humans.
- It has enabled me to think about the source of our mental thoughts and if it is possible to implement senses and the power of thoughts into machinery/robots.

Conclusion

In this chapter we report on the design and delivery of a workshop that aimed to address some of the issues raised by research that explores how secondary school students make sense of the ideas they encounter about human personhood in the light of their understanding of science. Previous research indicated that there are some students in this age group who articulate scientific ideas in reductionist and deterministic terms and are troubled by what these ideas mean in relation to common beliefs such as that people have souls. Based on these findings, we designed a workshop designed to give school students an opportunity to make comparisons between human-like machines and human beings and to explore questions and issues around personhood. Comments and survey data gathered from participants suggested that the workshop engaged secondary school students. We also noted that the workshop helped to develop participants' epistemic insight and encouraged students to examine their own and other stances on the power and limitations of science.

References

BBC. (2012, August 23). *Robot learns to recognise itself in mirror*. Retrieved from http://www.bbc.co.uk/news/technology-19354994

Billingsley, B. (2010). *Secondary school pupils' thinking about Apparent Contradictions between science and religion*. Paper presented at the Association of Tutors in Science Education (ATSE) Annual Conference, Manchester.

Billingsley, B., Taber, K. S., Riga, F., & Newdick, H. (2013). Secondary school students' epistemic insight into the relationships between science and religion; A preliminary enquiry. *Research in Science Education, 43*(4), 1715–1732. https://doi.org/10.1007/s11165-012-9317-y.

Billingsley, B., Brock, R., Taber, K. S., & Riga, F. (2016a). How students view the boundaries between their science and religious education concerning the origins of life and the universe. *Science Education, 100*(3), 459–482. https://doi.org/10.1002/sce.21213

Billingsley, B., Nassaji, M., Costa, A., & Chappell, K. (2016b). What do teenagers believe about the soul? Findings from a survey and interview study with upper secondary school students. In N. Spurway (Ed.), *Science and religion forum 40th anniversary book*. Cambridge, UK: Cambridge scholar publishing.

Billingsley, B., Nassaji, M., Fraser, S., & Lawson, F. (2018). A framework for epistemic insight. *Research in Science Education, 48*(6), 1115–1131. https://doi.org/10.1007/s11165-018-9788-6.

Brown, W. (2004). Neurobiological Embodiment of Spirituality and Soul. In M. A. Jeeves (Ed.), *From cells to souls, and beyond: Changing portraits of human nature* (pp. 58–77). Grand Rapids: Wm. B. Eerdmans Publishing.

Crick, F. (1994). *The astonishing hypothesis*. London: Simon & Schuster.

Dowell, R. (2018). Fundamental protections for non-biological intelligences or: How we learn to stop worrying and love our robot brethren. *Minnesota Journal of Law, Science & Technology, 19*, 305.

Feinberg, J. (1994). *Freedom and fulfillment: Philosophical essays*. Princeton: Princeton University Press.

Konnemann, C., Asshoff, R., & Hammann, M. (2016). Insights into the diversity of attitudes concerning evolution and creation: A multidimensional approach. *Science Education, 100*(4), 673–705. https://doi.org/10.1002/sce.21226.

Racine, E., Waldman, S., Rosenberg, J., & Illes, J. (2010). Contemporary neuroscience in the media. *Social Science & Medicine, 71*(4), 725–733.

Spencer, B. (2015, March 15). Scan that says it's true love: Brain experts say they can tell what stage of romance someone is at by looking at MRI results. *Daily Mail*. Retrieved from http://www.dailymail.co.uk/sciencetech/article-2995741/The-scan-says-s-true-love.html

Suterwala, A. (2012). *First self-aware robot created*. Retrieved from https://yaledailynews.com/blog/2012/09/25/first-self-aware-robot-created/

Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2011). To what extent do pupils perceive science to be inconsistent with religious faith? An exploratory survey of 13-14 year-old English pupils. *Science Education International*, (2), *22*, 99–118.

Tyack, D., & Tobin, W. (1994). The grammar of schooling: Why has change been so hard? *American Educational Research Journal, 31*(3), 453–479.

Prof. Berry Billingsley specialises in Science Education and leads the LASAR (Learning about Science and Religion) research team at Canterbury Christ Church University. Her interests include students' ideas about the nature of science and, more broadly, developing strategies to support the development of epistemic insight, young people's engagement in science, artificial intelligence, Big Questions bridging science, religion and the wider humanities and the communication of science and technology news in the media. Equipped with a physics degree, Berry's first career was with the BBC where she produced and presented television and radio programmes including BBC World Service's 'Science in Action', BBC TV's 'Tomorrow's World' and BBC Education's 'Search out Science'. She then travelled to Australia, to become a senior project manager with the Department of Education. She regularly publishes in science education.

Dr. Mehdi Nassaji is working with the LASAR centre as a Research Fellow. His BSc was in Control Engineering and then completed an MA degree in Education and another MA in Philosophy of Science. His focus in his PhD at the University of Hull was on the idea of Plurality of Truth, arguing that there can be a number of different true claims, including religious truths that are not necessarily reducible or translatable to science.

Chapter 13
Three Perspectives on the Science-Religion Issue in Science Education: Interdisciplinarity, Value or Ideology Orientation and Responsible Personalization

Jostein Sæther

What principles should guide the teaching of controversial, value- or ideology-oriented topics in science education? An answer to this question may provide a frame of reference for the science-religion-worldview issue in school contexts, as well as a necessary background for my main question: Is interdisciplinarity the way to go, and how important is responsible personalization (subjectification) in this context? References to selected sources aim to build connections between the literature on science education and educational theory of a more general character. This chapter is not simply one more contribution from the perspectives of theology, philosophy and science on the relationship between science, worldviews, ideologies etc. However, in the introduction, I summarize a knowledge base for the following discussion. The purpose is to highlight challenges and dilemmas by discussing a didactic model combined with ten theses, which relate to the claim that interdisciplinarity, value or ideology orientation and responsible personalization are necessary preconditions in science education. To concretize, I refer particularly to the debate on methodological versus metaphysical naturalism.

Introduction

What is the nature of reality and the human being? In the context of the science – religion issue, this big controversial question may be a starting point for a discussion about the identity of science education as a school subject. Terms such as 'controversy' and 'controversial' indicate that 'significant numbers of people argue

J. Sæther (✉)
NLA University College, Bergen, Norway
e-mail: Jostein.Saether@NLA.no

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_13

… without reaching a conclusion' (Oulton et al. 2004, p. 411). But, as Reiss adds, 'there are degrees of controversy', and 'what is controversial for one group may not be controversial for another' (Reiss 2011, p. 403 in reference to Hand).

Four groups of questions give examples of value or ideology aspects in science and science education in which religion also has something to say:

- Does the human embryo have a certain value different from the embryos of other species, regardless of its genetic equipment (e.g. with or without predispositions to impairments and diseases)?
- Does the description of the human being as a hominidae exclude specific human characteristics or values such as dignity, freedom and responsibility?
- Does nature, with all of its different areas and components, habitats and species, have value in its own right?
- Should theories from the natural sciences about the origin and development of the cosmos and of life exclude the idea that reality may include more than the natural sciences can study?

Obviously, different values and ideologies (idea systems) will open up premises for discussion on such issues, to which worldviews and religious views may also connect (Säther 2003). In an educational context, Eisner says that ideologies are 'beliefs about what schools should teach, for what ends, and for what reasons'. Ideologies are 'belief systems that provide the value premises from which decisions about practical educational matters are made' (1992, p. 302). He also underlines that ideologies can be 'tacit rather than explicit' and therefore need to be analysed, detected and perhaps criticized. Ideologies in education can therefore be 'located on a continuum from the most obvious, public and articulate statement of purpose, content and rationale to the most subtle, private, and latent view' (p. 305).

Science and its activities are ideology or value related in different ways, by practising (or not) research ethics, prioritizing certain themes and perspectives, providing new technological opportunities (e.g. gene technology) and giving people new self-understanding (Douglas 2009; Matthews 1999; Säther 2003). Science is characterized by certain methods, which are supposed to give scientific knowledge (i.e. beliefs that are true and reasoned). Examination of an introduction to the philosophy of science opens up the debate on what characterizes scientific knowledge. See, for example, the National Science Teacher Association (2000) and the American Association for the Advancement of Science (1990), for a short description. My very simplistic conclusion, based on such references brought into our context, is that the scientific underpinnings are usually quite solid, providing satisfactory scientific knowledge such as in cosmology, the theory of evolution and many socio-scientific issues. The fact that science is fallible and builds on a range of presuppositions, and sometimes even undergoes changes of a paradigmatic character, usually does not threaten the scientific knowledge basis of issues that also have political, religious, worldview or value aspects.

However, huge problems have arisen in the debate between methodological and metaphysical naturalism (Fishman and Boundry 2013). An example from a biology textbook can illustrate this point: 'You are an animal' (a reference to Sjøberg 2014,

p. 48). From a biological perspective, this is true (methodological naturalism/reductionism). Seen from a certain existential and metaphysical perspective, however, if the human being is nothing more, then this is a deeply controversial metaphysical stance. On the other hand, methodological naturalism/reductionism is a modest claim that acknowledges the possible limitations of science. The opposite view and its 'scientism' is an approach that does not see such possible limitations.

A recent example is Mahner's claim that '…science and religion … are metaphysically, methodologically, and attitudinally incompatible' (2014, p. 1829). This view is (of course) contested. Reiss, for example, says 'I embed scientific knowledge entirely within religious knowledge'. However, '[i]f there is any conflict about scientific knowledge between the teachings of science and those of religion … I am nearly always on the side of science. … 'nearly always' … because … science is fallible and it is not inconceivable, though most unlikely nowadays, that a particular instance of scientific conflict between science and religion might subsequently, and scientifically, be resolved in favour of the religious reading' (2010, p. 96). In his view, religious knowledge is indeed knowledge, but not scientific knowledge; it does welcome science, however.

The controversy of metaphysical naturalism is illustrated in the abovementioned references (Mahner 2014; Reiss 2014). In my view, this metaphysical naturalism represents metaphysical reductionism, which is highly problematic. Methodological naturalism, on the other hand, is a kind of methodological reductionism that is necessary in science; this is a broadly accepted principle among the central spokespersons of most Christian congregations worldwide. The classification of the human being as a species in the animal kingdom, seen from a biological perspective (methodological reductionism), is therefore not a problem. However, a deeply problematic and controversial stance is that of seeing the human being exclusively as an 'animal' to be understood only from the perspective of the natural sciences by rejecting other possible realms of meaning or dimensions in existence. For further references on the discussion on values, ethics, ideology, worldview and religion in science education, see, e.g. Matthews (1999, 2009), Reiss (2014, p. 1640), Säther (2003) and Zeidler and Sadler (2008).

To integrate values or ideological issues in science teaching we need a broader platform of educational theory, philosophy of science education (e.g. Schulz 2014) and, from the literature on teaching topics of a controversial, ethical or dilemmatic character (e.g., Geddis 1998; Levinson 2006; Nielsen 2013; Oulton et al. 2004; Patry et al. 2013; Saunders and Rennie 2013). In this context, the idea of interdisciplinarity is important, for example, in the fields of genetics and society (Kampourakis et al. 2014, p. 257).

However, Albert et al. claim that the humanities are not emphasized in interdisciplinary natural science research (Albert et al. 2017, p. 85). A look into the literature on science education discussing the nature of science (Lederman and Lederman 2014), socioscientific issues (Zeidler 2014) and interdisciplinarity (Czerniak and Johnson 2014; Develaki 2008) gives the same impression. Possible connections to the humanities are not emphasized. However, there are exceptions (e.g. Billingsley et al. 2018).

In this study, I emphasize the science-religion issue by focusing on three questions: What principles should guide the teaching of controversial value- or ideology-related topics in the context of science education? Is interdisciplinarity the way to go, and if so, is it the only way? How important is responsible personalization ('subjectification') in this context?

Three General Perspectives on Science Education

The content of school subjects depends on decisions about 'curriculum emphasis' (Roberts 1998, p. 5). In education, someone teaches something to someone else in some setting (Schwab, referring to Berliner 2006, p. 5–6), in an interaction between ideological, formal, perceived, operational and experiential curricula (Goodlad et al. 1979, pp. 59–64) to which external factors also connect. In this complex landscape, I would like to highlight three very general principles:

1. *Science education needs educational theory.* The knowledge base of science education comes from science, the philosophy of science, the literature on science education and 'education as an academic discipline in its own right' (Biesta 2011, p. 175).

2. *Particularly in teaching controversial issue, science education needs a balance between responsible personalization (subjectification), socialization and qualification*, as illustrated in Fig. 13.1.

According to Biesta, education is primarily about what he calls 'subjectification', i.e. prioritizing the enhancement of autonomy and independence in order to

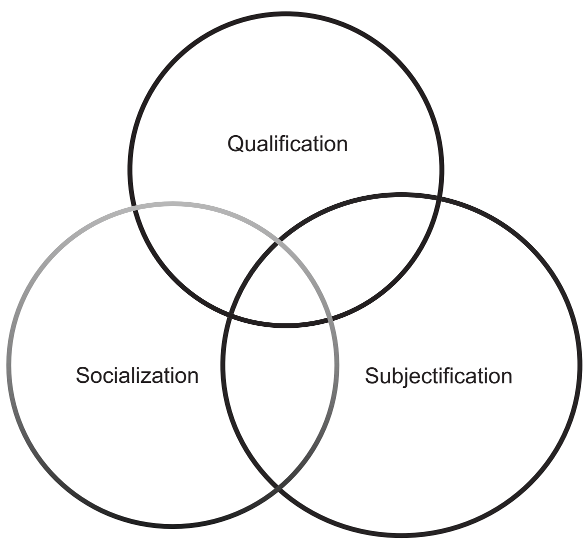


Fig. 13.1 Three educational domains. (Adapted by permission from Springer Nature. From Biesta (2017, p. 443). ©Springer Nature Singapore Pte Ltd. 2017)

strengthen a child or a student (2010, p. 21) and viewing pupils as 'subjects of action and responsibility' (2014a, p. 64). At the same time, certain knowledge, skills, attitudes and norms (qualification and socialization) are necessary:

> Because education is multidimensional, teachers constantly need to make judgements about how to balance the different dimensions; they need to set priorities – which can never be set in general but always need to be set in concrete situations with regard to concrete students – and they need to be able to handle tensions and conflict and, on the other hand, be able to see possibilities for synergy (2013, p. 40).

Parallel to this is Pring's focus on the 'whole person' in education, although it seems like Pring is mostly arguing for socialization with an emphasis on the range of qualities necessary for an activity to be called 'educational', i.e. not only promoting knowledge, understanding and intellectual skills but also intellectual virtues, imagination, moral virtues and habits, social and political involvement, integrity and authenticity (Pring 2004, pp. 19–20). A third reference in this context is Reindal's critique of the qualification framework of the Bologna Process, which seems to accept knowledge acquisition (competence) as sufficient for the claim that education has occurred without personal, i.e. 'subjective' commitment (Reindal 2013).

3. *In practice, education is a compromise between different traditions.* Therefore, the search for principles to guide the teaching of controversial issues should be enlightened by an interplay between various curricular traditions (e.g. Biesta 2014b; Eisner 1992; Klafki 1998; McNeil 2009).

Models for Teaching Controversial Issues in Science Education

Figure 13.2 illustrates three selected dilemmas or possible choices in the teaching of science-religion-worldview issues.

Figure 13.2 displays three dimensions of dealing with controversial topics in science education, that is, *interdisciplinarity* (A) combined with various degrees of focus on *values or ideological aspects* (B) and *the personalization dimension* (C). By talking about (C), i.e. *the personalization dimension*, I make reference to Biesta's concept of subjectification, the overlapping idea of personal commitment and meaning (Reindal), and a focus on 'the whole person' (Pring).

How, then, can the complexity of the science-religion-worldview issue demonstrated in Fig. 13.2 be taken into science teaching? To illustrate different options in educational contexts, I combine both interdisciplinarity and value or ideology orientation into one dimension by showing four positions, see Fig. 13.3. According to Fig. 13.3, the science-religion-worldview issue may be handled on a continuum, with different weights placed on interdisciplinarity and collaboration between teachers or school subjects, value or ideology aspects.

The general picture may look like this: In some cases, a lack of resources, competence, time and willingness prevents movement towards interdisciplinarity.

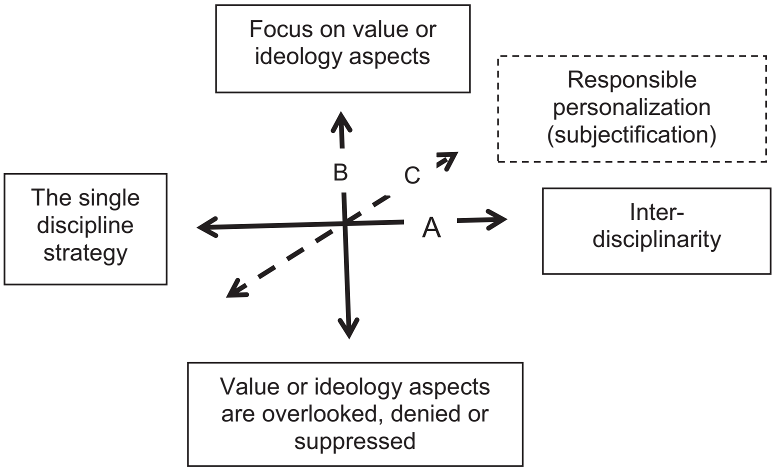


Fig. 13.2 Interdisciplinarity, value or ideology orientation and responsible personalization. (Adapted from Sæther et al. 2018, p. 54. By permission of ©UOWM, Faculty of Education, Greece)

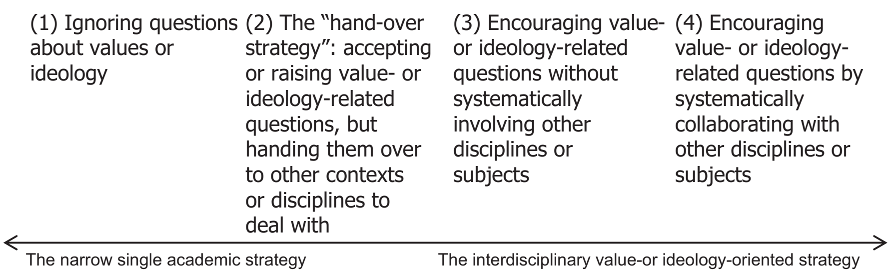


Fig. 13.3 Four strategies in science education for the handling of value or ideology issues in teaching and learning processes. (Adapted from Sæther et al. 2018, p. 50. By permission of ©UOWM, Faculty of Education, Greece)

Curricular constraints of various kinds, i.e. the complexity of the topic; the character of the controversy with various and sometimes conflicting expectations of colleagues, administrators and parents; the lack of an ideal speech situation, etc. make it difficult to defend strategy 3 or 4. The 'ideal speech situation' (Habermas), which is to some extent necessary for these strategies, can be achieved only partially in educational contexts. Wikipedia's presentation may summarize a popular understanding of Habermas' 'utopian' dialogue:

> In an ideal speech situation, participants would be able to evaluate each other's assertions solely on the basis of reason and evidence in an atmosphere completely free of any nonrational 'coercive' influences, including both physical and psychological coercion. Furthermore, all participants would be motivated solely by the desire to obtain a rational consensus. (Wikipedia 2017)

The aim and structure of different programmes give various opportunities for collaboration with other subjects, and it is often not realistic to expect much from integrative approaches (Sæther et al. 2018): Science educators often lack degrees or university credits in fields such as ethics, philosophy, the social sciences or religion, any of which could help them to discuss the ideology- and value-related questions raised in their science courses. Therefore, if Strategy 4 is unrealistic, how could one lay a foundation for honest intellectual discussions? The most radical answer is to say that Strategy 2 is the only alternative to guarantee that teachers do not stray from their areas of competence in their teaching. Science education should therefore indicate what other disciplines, subjects or realms of meaning are relevant when value- or ideology-related questions are raised. A minimum claim is that science education should explicitly indicate what science primarily is and is not about, and which questions science cannot answer by itself. Strategy 4 expresses an ambitious idea about collaboration and integration that is seldom realistic. I therefore contend that Strategy 2 should not be categorically abandoned. Nevertheless, Strategy 2 does represent a narrow approach that seems to veer too far away from giving students opportunities for spontaneous discussion and gathering information from various perspectives. Is Strategy 3 best, then? Perhaps, this approach best reflects actual teaching conditions. Furthermore, the literature on scientific literacy and socio-scientific issues in science education seems to correspond largely with this strategy. However, by practising this strategy, the teacher may lack the competence necessary to contribute relevant knowledge. Therefore, science teachers need an understanding of the limits of their competence, because such an insight is necessary to understand when to deploy a 'hand-over' strategy (Sæther et al. 2018).

We should also problematize the idea of responsible personalization, combined with a focus on education as personal formation 'in its widest sense' (Pring 2015, p. 30). For example, in a situation where students, teachers and parents have competing ideologies, I suggest that the best strategy in some cases might be to withdraw to a certain extent from existential discussions laden with religious aspects.

Theses on Handling the Science-Religion Issue in Science Education

To fill the models (Figs. 13.1, 13.2 and 13.3) with more content, I will introduce 10 rather normative and common sense theses by presenting an idealistic image. Each of them contains issues for further discussion. It is not possible to present a final list, and my proposal is definitely not the last word in this context. My claim is that practitioners should discuss the principles and attitudes necessary for handling controversial issues in science education. An example from Stephen Hawking (1942–2018) may give a point of reference for our reflection, and I therefore refer to this quote in the following discussion:

> When people ask me if a god created the universe, I tell them that the question itself makes no sense. Time didn't exist before the Big Bang, so there is no time for God to make the universe in. It's like asking directions to the edge of the earth; The Earth is a sphere; it doesn't have an edge; so looking for it is a futile exercise. We are each free to believe what we want, and it's my view that the simplest explanation is; there is no god. No one created our universe, and no one directs our fate. This leads me to a profound realization; There is probably no heaven, and no afterlife either. We have this one life to appreciate the grand design of the universe, and for that I am extremely grateful. (Hawking 2017).

The first thesis presents a general and obvious basis:

1. Although influenced by and embedded in values or ideologies, science education should always be knowledge-informed

The debate in the fields of philosophy and science education on criteria for talking about knowledge and truth is ongoing. Although incomplete, the clarification efforts of the National Science Teacher Association (2000) and the American Association for the Advancement of Science (1990) may provide a summary that teachers could refer to. The above paragraph on Hawking's thought process should challenge us to discuss what science is, and what it is not, as well as Hawking's personal stance on the matter. As has been said, science education should be knowledge-based in science and knowledge-informed by educational theory. At the same time, science education is value- or ideology-laden in many ways: in its rationale as a teaching subject, in the selection of topics, in the provision of new opportunities to understand and handle complex personal and social issues and in the formation of young people as individuals. However, science education should not be a school subject with its primary focus on worldviews, values, ethics, ideologies and religion. A minimum claim is that science education should explicitly indicate what science primarily *is about* and *is not* about, and which questions science is unable to answer (by itself). The concept of knowledge has to be discussed in the light of criteria for scientific knowledge, without rejecting possibilities for other realms of meaning. Methodological naturalism/reductionism should therefore be promoted and metaphysical naturalism rejected as a scientifically based approach. However, at the same time, 'the new atheists' and creationism could be introduced where appropriate (according to age level, the student group and the situation) to demonstrate the nonscientific basis these approaches have.

2. In a particular school system, the values and ideologies of science education should be clarified in light of the relevant regulatory documents (school laws, curriculum documents, etc.)

Educators should ask: how can a holistic view of the aims and values of science education be described that also includes the overarching ideas in national and local regulatory documents? '[A]ll subjects need to relate to the full spectrum of educational goals', Holbrook and Rannikmae say (2007, p. 1351). These fundamental ideas and aims may to a certain extent be integrated into one harmonious entity, or be seen as a collection of more or less conflicting discourses, etc. (Bybee and DeBoer 1994; Pedretti and Nazir 2011; Roberts 1998, 2007), named as different ideologies (Eisner 1992; Säther 2003). Educators should, as far as possible, aim to interpret curriculum guidelines as holistic units expressing ideas and intentions that are not necessarily in conflict with one another but instead complementary. For example, the Hawking excerpt mentioned above could raise the opportunity to discuss metaphysics and science: what is science and what personal ideological claims have scientists published (i.e. Hawking's metaphysical naturalism)?

3. The science teacher should be challenged to reflect on various value and ideology traditions in the curriculum guidelines, educational resources and science education practices

Parallel with the struggle to identify and practise holistic thinking, we should acknowledge that educational guidelines, resources and practices might represent different traditions, which either are in tension with each other or complement each other fruitfully. In the vast literature on this issue, there have been many examples of efforts to name traditions and aims (see, e.g. Pedretti and Nazir 2011; Roberts and Bybee 2014; Reiss 2007). The science teacher should have elementary (not advanced academic) competence in describing traditions as, for example, Bybee and DeBoer (1994) have done. They differentiate between three major goals in the history of science education, mentioned as 'understanding scientific knowledge', 'understanding and using scientific methods' and 'promoting personal-social development'. Throughout the history of science education, 'a balanced program has been difficult to achieve' (1994, p. 385). For example, the quote from Hawking above would challenge teachers to discuss the fundamental aims of science education from these three perspectives.

4. The science teacher should be familiar with and able to discuss the strengths and weaknesses of at least one method used in teaching controversial issues

There is broad agreement in the literature on science education that contested topics should be handled by stimulating dialogues and reasoning processes. But dialogues may also have affective components: 'to suggest that a person's stance may be changed by rational argument is simplistic' (Dewhurst 1992 in Oulton et al. 2004, p. 417). A look into an introductory book on the social psychology of attitudes easily shows that a change in attitude depends not only on academic arguments and persuasion, but on a range of factors, for example, whether one likes and trusts the person with whom one is in dialogue. The science teacher should know some principles in the teaching of value- or ideology-related topics, e.g. Kolstø (2006), Levinson (2006), Oulton et al. (2004), Patry et al. (2013), Sadler and Zeidler (2004), and Saunders and Rennie (2013).

5. The teaching of controversial issues should be based on principles that strengthen students' participation

There are several reasons for this: it may enhance learning outcomes; it reinforces children's right to speak; it stimulates personal development and prepares students for future participation in society. However, the provision of equal opportunities to participate is not easy to practice for many reasons, including the inequality of power, status and roles along with differences in speech competence, motivation, self-confidence and feelings of safety. To promote participation, the science teacher should establish trust and strengthen the possibility of an emotional climate in order to stimulate participation in dialogues, particularly supporting 'the weak voices' in the classroom. We should be aware of the intellectualism that might be embedded in dilemma- and dialogue-oriented education. However, I still claim it to be self-evident that our heritage from the Enlightenment focusing on knowledge, rationality and autonomy should be emphasized. This message has consequently the obligation to allow students to participate in efforts to discuss and decide on value or ideology issues.

6. The science teacher should have an appropriate understanding of the rights of children, parents, the authorities and the teacher as a professional agent in education

Our focus on subjectification, existential meaning and responsibility, versus a more restricted view, emphasizing academic learning isolated from focusing on values, ideologies and personal involvement, challenges our thinking, not only on what aims education should have but also on how to give proper attention to the rights and obligations of the different groups involved:

(a) Children's right to education and their right to speak, participate and be involved
(b) Parents' rights to choose the kind of education that should be given to their children, which may imply a right to organize private schools
(c) Teachers' rights and their obligation to not violate their professional knowledge and ethos
(d) States' rights and their obligation to organize educational institutions.

See The Universal Declaration of Human Rights and the Convention on the Rights of the Child, e.g. Article 29.

A challenge is to find the proper balance between home and school in cases of value or ideology conflicts. Engen argues for what he calls 'integrating socialization', which 'cannot correspond fully with the preference of any single group' and in which 'only a partial commonality of interests will be functional' (Engen 2009, p. 260).

7. Science education should promote the critical investigation of knowledge and value claims without falling into the trap of relativism and scepticism

Some values are thought to be universal, such as freedom, equality, dignity, respect for the natural environment, the full development of the human personality in education, peace, tolerance, friendship, responsibility, cultural identity and children's and parents' rights (thesis 6). The concrete implications of these values may be disputed. Value claims should be investigated in a dialectical process of collaboration and exchange between different disciplines or fields of knowledge, where none are excluded from contributing (Afdal 2004; Føllesdal 2005). They should not be deemed irrational, even though they do not have any direct scientific basis.

Despite different philosophical convictions and worldviews, diverse groups may (often) reach agreement on fundamental values.

8. *It is not appropriate to expect students to take a stand in every value or ideology conflict*

I have argued for the criterion called ‘subjectification’, or ‘responsible personalization’, as a fundamental characteristic of education. However, personal involvement should not be overemphasized. If necessary, a disinterested approach taken by students should be respected and might even be encouraged in certain cases. Because of the complexity of the issues under discussion, conflicts of interest between the school and parents, and the fact that not every topic is attractive to all students, it should not be expected that every controversial issue will result in a personal stance.

9. The fact-value issue: science education should discuss the naturalistic fallacy

There is no direct link from ‘is’ to ‘ought’ (‘the naturalistic fallacy’). On the other hand, this traditional view is disputed by the idea that values indeed can be discussed rationally by bringing the whole range of beliefs and knowledge based on sciences, the humanities and human experiences into the discussion (Afdal 2004; Føllesdal 2005). However, different value or ideology convictions may result in disagreement, which dialogues may be unable to solve.

10. The science teacher should, if possible, promote interdisciplinarity and collaboration between school subjects and be able to see when ‘hand-over’ strategies are necessary in areas of value- or ideology-laden controversies

Interdisciplinarity and responsible personalization are necessary if education aims to meet students’ existential need for meaning and wholeness. My stance is that interdisciplinary collaboration and engagement should, if realistic, be an ideal of science education. However, it is not always possible or desirable to reach common decisions in areas of controversy.

Conclusion

It is not possible to present a final list of principles capable of leading science education out of all dilemmas in the handling of controversial issues, to which the science-religion-worldview debate belongs (at least sometimes). In this context, I have presented some fundamental ideas that need further clarification in concrete situations, e.g. the quote above from Hawking.

Although influenced by and embedded in values or ideologies, science education should always be science-based and informed by educational theory. Honest science education should not overlook topics related to religion, without any primary focus on worldviews, values, ideologies and stances influenced by religion. Science education should indicate what other disciplines, subjects or realms of meaning exist when these domains are discussed. A minimum claim is that science education should explicitly indicate what science is (or is not) primarily about, and which questions science cannot claim to be able to answer by itself. In a given school system, the values and ideologies of science education should be clarified in light of the relevant regulatory documents in respect for the child's right to speak and be educated, parents' rights to choose the education of their children and teachers' rights to practise according to their professional ethos. Interdisciplinarity and responsible personalization are necessities if education is to meet students' existential need for meaning and wholeness. There is no exact answer as to how much interdisciplinarity and personal existential development there should be in the science education classroom. This depends on teachers' competence, available time and resources, the degree of tension caused by the issue at hand, etc.

This normative and common-sense conclusion should be further discussed, e.g. by asking the following questions. What are the aims and values of education? What is scientific knowledge compared to other realms of meaning? In what sense are science and education value- or ideology-laden activities? Where does/should the knowledge, values and ideologies in education come from? How should educators promote critical thinking while avoiding relativism and scepticism? How can the rights and authorities of different interest groups in education be described? When is interdisciplinarity a useful principle? How should the principle of participation be applied in education, and what are the preconditions? How can the teacher manage to combine traditions in teaching controversial issues?

The science-religion-worldview issue, and its bearing on metaphysical and value aspects in science education, necessitates a renewed focus on the importance and limitations of interdisciplinarity, value or ideology orientation and responsible personalization. I think that teachers' attitudes towards the principles sketched above would give some directions for practice. The next step should be an illustration of these principles by discussing more cases from educational practice. However, to prescribe the didactical consequences in detail without contextualizing them seems, to me, impossible.

Acknowledgements Thanks to my colleagues Solveig Magnus Reindal, Njål Skrunes and Geir Olav Toft. The models we have developed originate from The Linnaeus International Project on Integrative Approaches within Teacher Education initiated by Lena Fritzén and Anna Tapola, Linnaeus University, Sweden, with financial support from The Swedish Foundation for International Cooperation in Research and Higher Education (STINT), Riksbankens Jubileumsfond (RJ), Linnaeus University, and NLA University College (Norway). Thanks also to the editors and reviewers.

References

Afdal, G. (2004). Facts, values and moral education. *Nordic Studies in Education, 24*(3), 195210.

Albert, M., Paradis, E., & Kuper, A. (2017). Interdisciplinary fantasy. In S. Frickel, M. Albert, & B. Prainsack (Eds.), *Investigating interdisciplinary collaboration. Theory and practice across the disciplines* (pp. 84–103). New Brunswick: Rutgers University Press.

American Association for the Advancement of Science (1990). *The nature of science*. http://www.project2061.org/publications/sfaa/online/sfaatoc.htm. Accessed 27 Mar 2017.

Berliner, D. C. (2006). Educational psychology: Searching for essence throughout a century of influence. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 3–27). Mahwah: Erlbaum.

Biesta, G. (2010). *Good education in an age of measurement: ethics, politics, democracy*. Boulder, Colo: Paradigm Publishers.

Biesta, G. (2011). Disciplines and theory in the academic study of education: A comparative analysis of the Anglo-American and Continental construction of the field. *Pedagogy, Culture and Society, 19*(2), 175–192.

Biesta, G. (2013). Becoming educationally wise: Towards a virtue-based conception of teaching and teacher education. In A.-L. Østern, K. Smith, T. Ryghaug, T. Krüger, & M. B. Postholm (Eds.), *Teacher education research between national identity and global trends* (pp. 29–51). Trondheim: Akademika Publishing.

Biesta, G. J. J. (2014a). *The beautiful risk of education*. Boulder: Paradigm Publishers.

Biesta, G. (2014b). Pragmatising the curriculum: bringing knowledge back into the curriculum conversation, but via pragmatism. *Curriculum Journal, 25*(1), 29–49.

Biesta, G. (2017). The future of teacher education: Evidence, competence or wisdom? In M. A. Peters, B. Cowie, & I. Menter (Eds.), *A companion to research in teacher education* (pp. 435–453). Singapore: Springer.

Billingsley, B., Nassaji, M., Fraser, S., & Lawson, F. (2018). A framework for teaching epistemic insight in schools. *Research in Science Education, 48*(6), 1115–1131.

Bybee, R. W., & DeBoer, G. E. (1994). Research on goals for the science curriculum. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 357–387). New York: MacMillan.

Convention on the Rights of the Child. (2017). http://www.ohchr.org/en/professionalinterest/pages/crc.aspx. Accessed 27 Feb 2017.

Czerniak, C. M., & Johnson, C. C. (2014). Interdisciplinary science teaching. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research in science education vol II* (pp. 395–411). New York: Routledge.

Develaki, M. (2008). Social and ethical dimension of the natural sciences, complex problems of the age, interdisciplinarity, and the contribution of education. *Science & Education, 17*(8–9), 873–888.

Douglas, H. E. (2009). *Science, policy, and the value-free ideal*. Pittsburgh: University of Pittsburgh Press.

Eisner, E. W. (1992). Curriculum ideologies. In P. W. Jackson (Ed.), *Handbook of research on curriculum* (pp. 302–326). New York: MacMillan.

Engen, T. O. (2009). Socialization, literacy, and empowerment. In J. A. Bank (Ed.), *The Routledge international companion to multicultural education* (pp. 252–262). New York: Routledge.

Fishman, Y. I., & Boudry, M. (2013). Does science presuppose naturalism (or anything at all)? *Science & Education, 22*(5), 921–949.

Føllesdal, D. (2005). The emergence of justification in ethics. *European Review, 13*(2), 169182.

Geddis, A. N. (1998). Analyzing discourse about controversial issues in the science classroom. In D. A. Roberts & L. Østman (Eds.), *Problems of meaning in science curriculum* (pp. 115–129). New York: Teachers College Press.

Goodlad, J. I., Klein, M. F., & Tye, K. A. (1979). The domains of curriculum and their study. In J. I. Goodlad et al. (Eds.), *Curriculum inquiry. The study of curriculum practice* (pp. 43–76). New York: McGraw-Hill.

Hawking, S. (2017). *[Hawking on religious beliefs]*. http://www.goodreads.com/quotes/551152-when-people-ask-me-if-a-god-created-theuniverse. Accessed 28 Mar 2017.

Holbrook, J., & Rannikmae, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education, 29*(11), 1347–1362.

Kampourakis, K., Reydon, T. A. C., Patrinos, G. P., & Strasser, B. J. (2014). Genetics and society – Educating scientifically literate citizens: Introduction to the thematic issue. *Science & Education, 23*(2), 251–258.

Klafki, W. (1998). Characteristics of critical-constructive Didaktik. In B. B. Gundem & S. Hopman (Eds.), *Didaktik and/or curriculum* (pp. 308–330). New York: Peter Lang.

Kolstø, S. D. (2006). Patterns in students' argumentation confronted with a risk-focused socio-scientific issue. *International Journal of Science Education, 28*(14), 1689–1716.

Lederman, N. G., & Lederman, J. S. (2014). Research on teaching and learning of nature of science. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education vol II* (pp. 600–620). New York: Routledge.

Levinson, R. (2006). Towards a theoretical framework for teaching controversial socioscientific issues. *International Journal of Science Education, 28*(10), 1201–1224.

Mahner, M. (2014). Science, religion, and naturalism: Metaphysical and methodological incompatibilities. In M. R. Matthews (Ed.), *International handbook of research in history, philosophy and science teaching* (pp. 1793–1835). Dordrecht: Springer.

Matthews, M. R. (Ed.). (1999). Values in science and in science education [Special issue]. *Science & Education*, 8(1).

Matthews, M. R. (Ed.). (2009). *Science, worldviews and education*. Dordrecht: Springer.

McNeil, J. D. (2009). *Contemporary curriculum in thought and action*. Hoboken: Wiley.

National Science Teacher Association (2000). *The nature of science*. http://www.nsta.org/about/positions/natureofscience.aspx. Accessed 27 Mar 2014.

Nielsen, J. A. (2013). Dialectical features of students' argumentation: A critical review of argumentation studies in science education. *Research in Science Education, 43*(1), 371–393.

Oulton, C., Dillon, J., & Grace, M. (2004). Reconceptualizing the teaching of controversial Issues. *International Journal of Science Education, 26*(4), 411–423.

Patry, J.-L., Weinberger, A., Weyringer, S., & Nussbaumer, M. (2013). Combining values and knowledge education. In B. J. Irby, G. Brown, R. Lara-Alecio, & S. Jackson (Eds.), *The handbook of educational theories* (pp. 565–579). Charlotte: Information Age Publishing.

Pedretti, E., & Nazir, J. (2011). Currents in STSE education: Mapping a complex field, 40 years on. *Science Education, 95*(4), 601–626.

Pring, R. (2004). *Philosophy of educational research* (2nd ed.). London: Continuum.

Pring, R. (2015). *Philosophy of educational research* (3rd ed.). London: Continuum.

Reindal, S. (2013). Bildung, the Bologna process and Kierkegaard's concept of subjective thinking. *Studies in Philosophy & Education, 32*(5), 533–549.

Reiss, M. (2007). What should be the aim(s) of school science education. In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), *The re-emergence of values in science education* (pp. 13–28). Rotterdam: Sense Publishers.

Reiss, M. J. (2010). Science and religion: implications for science educators. *Cultural Studies of Science Education, 5*(1), 91–101.

Reiss, M. J. (2011). How should creationism and intelligent design be dealt with in the classroom? *Journal of Philosophy of Education, 45*(3), 399–415.

Reiss, M. (2014). What significance does Christianity have for science education? In M. R. Matthews (Ed.), *International handbook of research in history, philosophy and science teaching* (pp. 1637–1662). Dordrecht: Springer.

Roberts, D. A. (1998). Analyzing school science courses: The concept of companion meaning. In D. A. Roberts & L. Østman (Eds.), *Problems of meaning in science curriculum* (pp. 5–12). New York: Teachers College Press.

Roberts, D. A. (2007). Scientific literacy/Science literacy. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729–780). Mahwah: Lawrence Erlbaum Associates.

Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, science literacy, and science education. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. II, pp. 545–558). New York: Routledge.

Sæther, J., Reindal, S. M., Skrunes, N. & Toft, G.O. (2018). A model for analysing genetics and values in biology textbooks with focus on teacher education. *MENON: Journal of Educational Research*. Third thematic issue, pp. 46–57. Open access: http://www.edu.uowm.gr/site/system/files/menon_issue_3rd_special_112018.pdf

Säther, J. (2003). The concept of ideology in analysis of fundamental questions in science education: A review with selected examples from Norwegian curricula and textbooks. *Science & Education, 12*(3), 237–260.

Saunders, K. J., & Rennie, L. J. (2013). A pedagogical model for ethical inquiry into socioscientific issues in science. *Research in Science Education, 43*(1), 253–274.

Schulz, R. M. (2014). Philosophy of education and science education: A vital but underdeveloped relationship. In M. Matthews (Ed.), *International handbook of research in history, philosophy and science teaching* (pp. 1259–1316). Heidelberg: Springer.

Sjøberg, S. (2014). *Naturfag som allmenndannelse [Science education as "Bildung"]*. Oslo: Gyldendal Akademisk.

Universal Declaration of Human Rights. (1948). http://www.un.org/en/universal-declarationhuman-rights/. Accessed 4 Apr 2017.

Wikipedia (2017). *The ideal speech situation*. https://en.wikipedia.org/wiki/Ideal_speech_situation. Accessed 20 Feb 2017.

Zeidler, D. L. (2014). Socioscientific issues as a curriculum emphasis: Theory, research, and practice. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education vol II* (pp. 697–726). New York: Routledge.

Zeidler, D. L., & Sadler, T. D. (Eds.). (2008). Social and ethical issues in science education [Special issue]. *Science & Education*, *17*(8–9).

Dr. Jostein Sæther is a Professor Emeritus at NLA University College in Bergen, Norway. He is a former school teacher with undergraduate studies in Biology and Education, which led to postgraduate studies at the University of Oslo and a Doctorate on Educational Psychology as an integrated part of teacher education programs. His research interests also include the ideological aspects of science education. Examples of articles relevant for this book are: '*The concept of ideology in analysis of fundamental questions in science education*' (2003), and '*Moral and democratic education in the context of science education*' (2012).

Chapter 14
Changes and Stabilities in the Views of German Secondary School Students on the Origin of the World and of Humans from the Ages of 12 to 14 and 16: First Results of a Qualitative Empirical Longitudinal Study

Christian Hoeger

Research Problem, Questions, Design, Sample, and Method

Research Problem

For many decades, there has been a broad public and academic international debate on the relations of the theology of creation and of science concerning the origin of the world and of mankind: Some emotional discussions about neo-Darwinian theories of evolution in particular have caused quite a stir (e.g. Behe 1996; Schoenborn 2005; Dawkins 2006; Kutschera 2008).

Playing theology off against science (biology or physics) leads to conflicts, which appear from a meta-level only as one of at least four possible relationships (Barbour 1997): conflict, independence, dialogue, and integration; Shane et al. (2016, 167–169) speak about harmony and complexity instead of the last two models. Such conflicts might be expected to have been clarified some time ago—at least in theology (e.g. Lueke 2016). On the one hand, religiously motivated followers of creationism and intelligent design try to attack the empirically very well-based theory of evolution (Behe 1996; Junker 2010; Junker and Scherer 2013). On the other hand, books and bestsellers by some famous scientists, e.g. Hawking (1998), Hawking and Mlodinow (2010), and Dawkins (2006), show an atheistic criticism of religion on the basis of naturalistic arguments presented as scientific. Both assaults appear out of a special theoretical scientific point of view as frontier crossings, in

C. Hoeger (✉)
Catholic Theology, Institute of Theologies, University of Education Freiburg, Freiburg im Breisgau, Germany
e-mail: christian.hoeger@ph-freiburg.de

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_14

which the terrain of the other discipline is hurt beyond its own methodical competence.

What does this theoretical discussion mean for the fields of religious and science education in schools (e.g. Reiss 2008), especially in Germany?[1]

The actual debate on the theology of creation and natural science implicates urging challenges: In order to update didactics of religious education orientated by the individual development of students' attitudes on creation, big bang, and creation (e.g. Schweitzer 1999), some new empirical longitudinal data would be very useful. By their analysis, interdisciplinary religious learning (Schreiner 2012) could be improved by means of a focus on thematic intersections with education in biology and physics (Benk and Erb 2008, 333). But there are only dated and locally restricted (longitudinal) data available (Reich et al. 1994; Rothgangel 1999; Fetz et al. 2001; Reich 2002; Worsley 2013; Schweitzer et al. 2016), which have to be scrutinized (Dieterich and Imkampe 2013; Hoeger 2016).

Since unfortunately most studies are solely cross-sectionally drafted, you will not get dependable information on how individuals have changed in their lives in specific aspects of their attitudes. By means of a cross-sectional design, which is more economic in doing research, solely based on averaged data of different age cohorts, asked at the same period of time, conclusions are drawn on developments of single persons. This is a logic conclusion, however unmasked in developmental and educational psychology as a "central systematic error" (Valsiner 2000, 77; Schick 2012, 22). In order to get valid findings on actual developments and processes, one, however, has to use a more laborious and time-consuming longitudinal design. This is the ideal solution which in most cases allows only a smaller number of test persons to be explored in depth over a considerable period of time.

Therefore, it is largely unclear to what extent and in what respect contemporary students change in their knowledge and attitudes on the big bang, evolution, and the creator (e.g. Barnes et al. 2017).

[1] In the Federal Republic of Germany, each of the 16 states decides on its own educational system. This has led to a very complex overall situation. In 14 federal states, pupils attend primary schools for 4 years (in Berlin and Brandenburg for 6 years). Then the students have to choose between three (or two) different types of secondary schools: They attend secondary modern schools in order to graduate after the 9th form. Otherwise, they go to junior high schools and graduate after the 10th form. (In some states, secondary modern and junior high schools have merged.) Or they attend grammar schools/high schools until graduating after the 12th or 13th form. In several federal states, students also attend comprehensive schools.

Religious Education (RE) normally takes place in every state school and form in conformity with the German Constitution (article 7,3). About 60% of German students belong to a Christian church, in Eastern Germany; however, undenominational students often are in the majority. In most states in Germany, the religious communities work together with the state which has to organize RE. This results in schools in diverse offers of confessional RE, e.g. of the Protestant, Roman Catholic and meanwhile in some places of the Islamic type (about 5% of the students are Muslim). Most students have to attend RE in their own religion and confession with a teacher of the same confession or choose the subjects ethics or philosophy as a neutral alternative. In some regions, Roman Catholic and Protestant RE cooperate (from time to time). In three federal states (Berlin, Brandenburg, Bremen), RE is substituted by a neutral subject. An interreligious RE for all the students is offered by Protestant teachers in Hamburg.

The state of the art and recent research on the three domains "theology of creation", "astrophysics", and "Evolutionary Biology", however, reveal the following incomplete picture in adolescents' intuitive thinking.

Domain Intuitive "Theology of Creation"

An early study from Switzerland brought to light that Piaget's concept (1971, 259–388) of "making" the world and their elements by God, understood as an anthropomorphic figure working like a craftsman, changes at the following levels in adolescents' world views (Hoeger 2013a, 92):

> "Four cosmogony levels emerged from analysis of the responses by the religious believers, the first three involving (decreasingly) unreflected Piagetian artificialism […]. At Level 1 (about 5 to 8 years), God makes everything, including human artifacts; at Level 2 (7 to 9 years, and less frequently up to 15 years), God still 'makes' (most of) nature, but no longer artifacts; at Level 3 (mainly 10 to 13 years, some older subjects), nature functions very much on its own and human beings are largely autonomous, but nevertheless God acts somehow behind the scene; finally, at Level 4 (15 years and up), scientific and theological concepts are reflected and coordinated". (Reich et al. 1994, 152).

At the age of about 15–16 years, young persons get new possibilities to reflect their ways of thinking about God and the world because of the so-called means-reflection or epistemic cognition. Thus, they are after careful consideration furthermore able to believe in a creator, if God still has existential meaning for them (Fetz et al. 2001, 247, 265).

The topic of creation has remained a vital, important, and up-to-date theme in (German-speaking) academic and practical discourses on RE (Altmeyer et al. 2018; Hoeger 2018).

Domain Intuitive "Astrophysics"

The great significance of astrophysical theories, of the big bang theory especially, for the explanation of the origin of the world on the part of adolescents in Germany is illustrated by several quantitative studies (e.g. Ziebertz and Riegel 2008, 48–51). Thereby, the respondents believe at a ratio of one third in a divine creator of the world and consider scientific theories of the beginning of the world to be more plausible (Gensicke 2006, 218–219; Feige and Gennerich 2008, 183; Klose 2011).

In a qualitative empirical focus, adolescents' cosmological concepts of the origin of the world (Eikermann 2012, Hoeger 2008, 180–189) seldom function without and mostly with the big bang, which can be traced back to very different natural causes or is related to the Earth in a geocentric way or to the whole universe in a cosmocentric manner and is accompanied by diverse images of its process (Hoeger 2014, 128–135; Hoeger 2015b, 209–211).

In addition, I have been able to work out a matrix of explanations of the world on the basis of the following six types by interviewing 14 adolescents[2] (aged about 18 years old) (Hoeger 2008, 193–276; 2011, 111–115; 2013a, 95–98):

1. In the "natural belief in creation", the creation of the world as well as the big bang theory or something like it is supported.
2. In "creationism", adolescents believe in the creation of the world, but negate the big bang theory.
3. Followers of the "naturalistic agnosis of creation" call God as creator of the world in question and accept the big bang.
4. In "universal doubt", the creation of the world as well as the big bang theory is held in abeyance.
5. The "exclusive naturalism" exclusively assumes a purely natural origin of the world.
6. The "negation of a creator in a critical natural science view" denies a divine act of creation of the world and is sceptical about astrophysical models of the world.

Billingsley et al. (2013) show that 12 students (aged 13–14 years old) from England interviewed on the origin of universe (and life) held the following four views of relationship between science and religion: "contradictory", "negotiated", "unexplored", and "unknowable".

Domain Intuitive "Evolutionary Biology"

Quantitative surveys from Germany demonstrate that adolescents are generally quite positive about the theory of evolution (Klose 2011, 148–149; Konnemann et al. 2013, 59). In addition, about 60% of persons beyond the age of 16 considered evolution and about 20% a creator to be a better answer to the question concerning the origin of humans (about 20% were unsure) (EARSandEYES 2009; IfD Allensbach 2009, 147).

Among the preconceptions about evolution on the part of students, we find teleological ones and concepts of a Lamarckian or anthropomorphic kind (Johannsen and Krueger 2005, 32–34; Kattmann 2013; Hammann and Asshoff 2015, 228–255). There also exists a widespread misconception (not only) among many American college students of biology that man has descended from apes (like the chimpanzees of today) (Robbins and Roy 2007, 463).

The 12 students interviewed by Konnemann et al. (2013, 56) from the 5th, 8th, and 11th forms judged the issue "evolution" to be more important than "creation". Sciences were rated highly with regard to their potential of explanation, without making the provable an absolute of a universal answer to every question concerning meaning in life.

[2] A quantity of 14 persons is sufficient and quite normal for qualitative research, because it is aimed at gaining a theoretical saturation of a theory or a typology (Strauss and Corbin 1996; Kelle and Kluge 2010, 41–55) instead of reaching representativeness.

Besides creationism also attracts much interest (e.g. Fulljames and Francis 1988; Francis and Greer 2001; Klose 2009; Rothgangel 2011). Creationist adolescents are convinced of the idea that nothing but religion gives the right answer to the question about the origin of humans, whereas they reject evolutionary theory. This attitude is not common among German adolescents (Retzlaff-Fuerst and Urhahne 2009, 175–176; Konnemann et al. 2013, 59–60). Factors of influence which promote creationism lie in socialization by school and family. This is indicated by a US study (Evans 2001, 222–223, 243).

Aims and Research Questions

My empirical study is based on these theoretical and practical targets:

1. The theoretical aim is to establish a new qualitative empirically grounded theory on stabilities and processes of change in the thinking of German secondary school students about the three core concepts of creation, the big bang, and evolution.
2. The practical aim of the project lies in a better advancement of religious, physical, biological, and interdisciplinary learning processes of secondary school students. This advancement will be reached by teachers in forms 5 to 9 by means of connecting useful topics to the attitudes of students in an accurately fitting way. Such a timely offering of subject-based learning issues has generally been adopted in didactics of Religious Education (RE) in Germany. Englert (1985) called it “punctuality” or “kairology” (Hoeger 2015a).

The study tries to give answers to the following four research questions:

1. How do students think about the origin of the world and how do they combine their concepts on the big bang and creation in classes 5, 7, and 9?
2. How do students think about the origin of humans and how do they combine their concepts on evolution and creation in classes 5, 7, and 9?
3. Which changes and stabilities of attitudes can be described concerning the questions of the origin of the world from classes 5 to 7 and to 9?
4. Which changes and stabilities can be described concerning the questions of the origin of humans from classes 5 to 7 and to 9?

A further research question aiming at explaining potential changes is:

5. How do changes in knowledge and attitude within the domains have effects on the interdisciplinary answers to the questions concerning the origin of the world and of humans?

Design, Sample, and Method of Analysis

In order to answer the research questions, the design lent itself to a qualitative empirical longitudinal study (Doering and Bortz 2016, 210–213), since hardly any actual longitudinal data are available in this research perspective.

Especially due to enormous expense and the risk of panel mortality, it is understandable that many researchers prefer to refrain from applying a longitudinal design and make use of other methods which allow an easier handling (Flick et al. 2017, 256; Doering and Bortz 2016, 213). Therefore, new empirically grounded concepts, typologies, or first hypotheses have to be developed by means of a small sample in a more explorative way.

As Table 14.1 shows, the collection of data started in July 2010, when I invited 24 11-year-old Catholic pupils (attending the fifth form in one Religious Education class in a grammar school in Pforzheim, a town of 120,000 inhabitants in South-Western Germany) in seven small groups to draw a picture and write a text to show their ideas of the origin of the world. At that time, I worked as their teacher for RE. So the collection of data took place during lessons at the end of the term. I left the school at the end of this term in order to work at the University of Education in Freiburg.

Two years later from May to July in 2012, I came back to interview the same students now attending the seventh form. At that time, 15 students with a mean age of 13 years were reached again. Eight interviews in groups or with a single subject were conducted.

From May to July 2014, I got the chance to perform seven interviews with 11 15-year-old students a third time: 10 persons attended the ninth form, one the eighth form.

The fourth and last point of measurement took place in July 2016, when I could reach two 17-year-old students attending the 11th grade in an interview.

Meanwhile, all the interviews have been transcribed and fed into the program MAXQDA 11. Using some elements of the methodology of Grounded Theory (Strauss and Corbin 1996; Corbin and Strauss 2015), the open coding and some sort of selective coding is still in progress. Some cases have already been analysed, so I

Table 14.1 Longitudinal design and sample

Points of measurement	1	2	3	4
Time	July 2010	May–July 2012	May–July 2014	July 2016
Number of students	24	15	11	2
Mean age (years)	11	13	15	17
Grade	5	7	9	11
Forms of data	8 pictures and texts in groups	8 interviews in groups or single	7 interviews in groups or single	1 interview

will present two individual cases of students: Their pseudonyms are Nico and Lena, respectively, whose attitudes have undergone some interesting changes.

Nico's Views on the Origin of World and Humans (12, 14, and 16 Years Old)

Nico's Views (2010; 12 Years Old)

Nico, a boy aged 12 years and 4 months, and two other female pupils attending religious education in the fifth grade (secondary education first stage) drew the picture in Fig. 14.1 in order to explain how the world might have originated:

The three pupils wrote the following text:

> How the world has come into being: There was a big ball, on which was nothing except water: no light, no living beings, no sky… In these circumstances God reflected on the situation: 'Things can't go on like this.' Then he created light (the sun) for the day and less light for the night (the moon and the stars). He divided the waters and blew air into the hollow. He meant: 'Creatures shall get into the water!' Thus it happened. 'But not every creature can swim and adapt to the water! Solid ground is needed between the waters!' Little angeldwarfs came on the earth. They planted the solid soil with grass and sundry other things. Then he created life on earth: the dinosaurs. Through thousands of years all the animals have changed, including the apes, but the dinosaurs died out long ago. We (the humans) are direct descendants of apes. At the seventh day God looked on the earth and was happy

Fig. 14.1 Picture drawn by Nico and two girls about the origin of the world (published in Hoeger 2012, 46)

Origin of the World Concerning this issue, Nico is convinced of God as the creator of the world, which means the Earth. The big bang is not mentioned.

Biblical View The student's ideas are strongly influenced by the first creation narrative in Genesis 1, 1–2, and 4a. We can find historical understanding of the bible.

Origin of the Plants "angeldwarfs" are helping God with the plants.

Evolution In the developmental steps 5 and 6—according to days 5 and 6 of the creation narrative—we can find a preconcept of evolution in the picture, because the pupils are convinced of the process of changing dinosaurs to human in one million years. There is an "adaption" of some creatures to the water. We can also see a changing of species: dinosaurs turn to apes and in the end to human beings.

Evolution and Creation God created the first species. Then followed a kind of natural evolution of animals to humans which had been initiated by God. (Hoeger 2012, 46–47; 2013b, 359–362).

Nico's View on the Origin of the Earth (2010)

Below in Fig. 14.2, Nico's view on the origin of the Earth will be presented. Here, four possible views are differentiated:

- "exclusive creation of the Earth" means that God has generated or formed the Earth directly and without any natural auxiliary means.
- "natural creation of the Earth" stands for an origin of the Earth by the creator with some natural auxiliary means, e.g. the big bang.
- "naturalistic emergence of the Earth" describes the attitude of a totally natural formation of the Earth without any divine action.

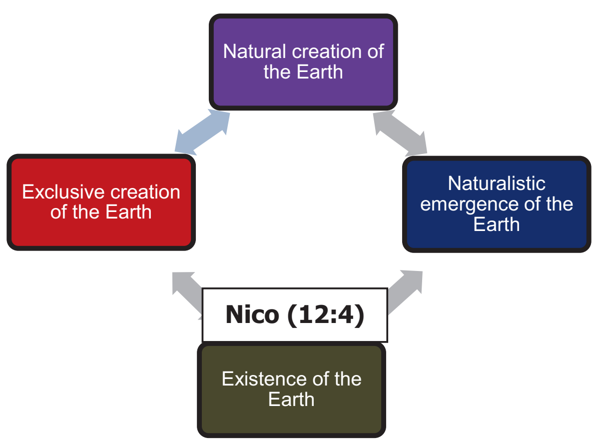


Fig. 14.2 Nico's view on the origin of the Earth in 2010

- "existence of the Earth" denotes that the Earth always existed without a religious or scientific explanation of its origin.

Analysing Nico's picture and text, it is obvious that his view conforms to the category *existence of the Earth*, because the origin of the "big ball" is not explained and the creator just finds it.

Nico's View on the Origin of Humans (2010)

Quite similar to the conceptualization of the origin of the Earth, the empirical data on Nico's views about the origins of humans can be assigned to three categories:

- The "exclusive creation of humans" marks the view of adolescents being convinced of the idea that humans did not arise from apes by a natural process of evolution, but were directly created by God, as it is suggested in the creation narratives in a literal interpretation of the Old Testament. Typical of such an attitude, often labelled creationism, is the individual opinion of having to choose between evolution and creation of man as two competitive answers to the same question on the origin of man. The conflict is solved in favour of a religious view.
- The "natural creation of humans" marks an attitude in which adolescents have an "as well as" position, so that scientific theories, as, e.g. the theory of evolution, are right, and we present-day humans owe our existence to a natural evolutionary process as well as to a creation by God. Typically in this connection the individual does not see a conflict between a theology of creation and natural science (e.g. evolution theory), but prefers a dialogue or integration as making more sense.
- "Naturalistic human evolution" is the view in which adolescents are convinced that scientifically grounded theories, e.g. the evolution theory, are the one and only explanation of the origin of humans, which means that the idea of a divine creation of humans must be wrong. Typical of this attitude is the opinion of having to decide between natural processes (e.g. according to the neo-Darwinian theory of evolution) and creation of man as two competitive answers to the same question on the origin of man. The conflict is solved in favour of a naturalistic view.

After analysing Nico's text and picture at the age of 12 years and 4 months, I ascribed his view in Fig. 14.3 to the *natural creation of humans*, because he is convinced of a direct creation of the dinosaurs by God. This creation follows a natural process of evolution of animals and humans.

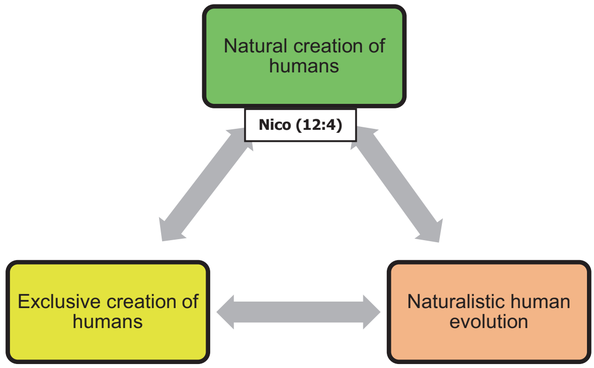


Fig. 14.3 Nico's view on the origin of humans in 2010

Nico's Views (2012; 14 Years Old)

When Nico was nearly 2 years older, aged 14 years and 2 months, he gave an interview in 2012 resulting in these answers:

Origin of the World Relating to this question, we find two different views in 14-year-old Nico's mind. The adolescent most consistently takes the position of a natural creation of the Earth through the big bang, when he says that God perhaps created the big bang. Previously, he had expressed the assumption of a biblical perspective, which was sceptical concerning the big bang.

Biblical View Nico says that "not everything is to be taken literally".

Origin of the Plants He does not believe any longer that small "angeldwarfs" came to the Earth in order to plant the grass. But he has got no better explanation.

Evolution There was evolution from dinosaurs to apes and to humans.

Evolution and Creation He thinks that God allowed evolution free play and did not plan everything exactly and beforehand.

Nico's Views on the Origin of the World (2012)

When Nico is in the seventh form, he refers to the question of the origin of the world to the origin of the Earth (and not of the universe) as he did it in 2010.

As Fig. 14.4 shows, 14-year and 2-months-old Nico gives two different answers: Nico 1 stands for the biblical perspective which he had taken at first. This is to be coded either as *exclusive creation of the Earth* or as *existence of the Earth*. Both views, however, remain questionable because of Nico's short biblical credo, which does not go into detail. Nico 2 shows in the interview a more dominating view of a *natural creation of the Earth*.

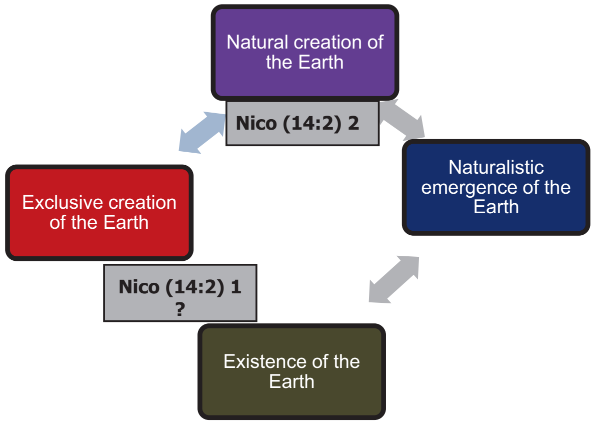


Fig. 14.4 Nico's views on the origin of the world in 2012

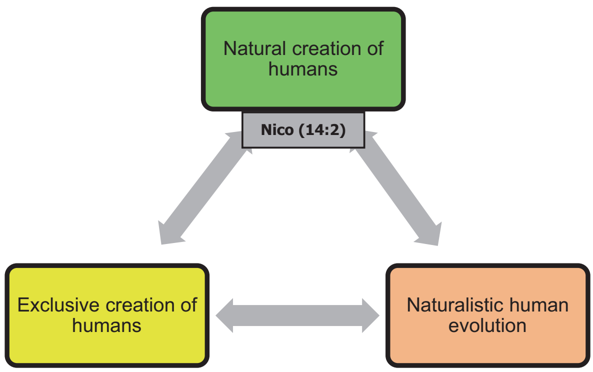


Fig. 14.5 Nico's view on the origin of humans in 2012

Nico's View on the Origin of Humans (2012)

After analyzing the interview with Nico, Moni, and Karin at the age of 14 years and 2 months, I ascribed Nico's view to the *natural creation of humans*, because he thinks that God allowed evolution up to the arrival of human's free play and did not determine everything beforehand in detail. Figure 14.5 illustrates Nico's view about the origin of humans.

Nico's Views (2014; 16 Years Old)

Two years later, I performed an interview with Nico (16 years and 4 months old) alone, where he gave the following answers:

Origin of the World Nico imagines the origin of the world firstly as the beginning of the universe and secondly as the emergence of the Earth. Nico means that God probably created first the universe, then the Earth in 7 days, where every day stands for a step in a sequence. God created the world, which is supposed to develop further on its own. In this process, God helped a little bit from time to time.

Biblical View Nico believes that you should interpret the bible in a metaphorical way. He does not believe in the existence of two first human beings called Adam and Eve.

Evolution Life on Earth arose from microorganisms. In Nico's view, it is proved that dinosaurs had existed, because their bones have been found, and that humans have evolved from apes.

Evolution ***Versus*** *Creation (Mostly)* In Nico's mind, natural science and religion primarily harmonize in regard of the origin of the world. This, however, is not applicable to the origin of humans: For Nico, there exists an objection: Either humans had existed at the beginning as told in the creation narrative or humans evolved slowly from the apes. Because of this direct and magical understanding of creation, in Nico's eyes, evolution and creation do not fit with one another. There is in the interview in addition a weaker position of natural creation of man, which will be described below.

Nico's Views on the Origin of the Universe (2014)

When the 16-year-old Nico was asked about the origin of the world, he made a clear difference between the beginning of the universe and of the planet Earth. Because of this I have to present two figures: Fig. 14.6 on the origin of the universe and Fig. 14.7 on the origin of the Earth.

The world began with the big bang. In Nico's view, the universe emerged either by accident or through God. That is why you cannot state its deeper origin with

Fig. 14.6 Nico's views on the origin of the Earth (2014)

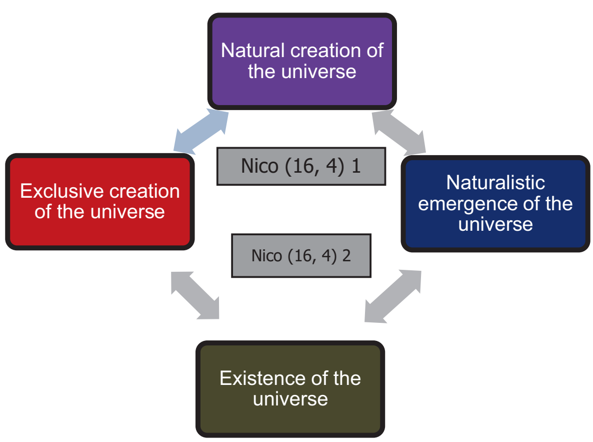
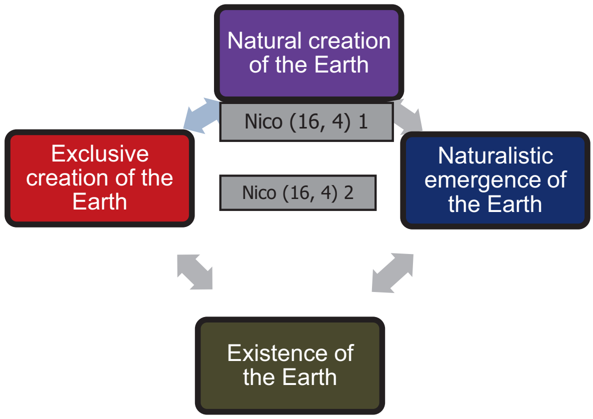


Fig. 14.7 Nico's views on the origin of the Earth in 2014



certainty. Finally, the 16-year-old decides in favour of a world that was probably created by God through the big bang, which could not have arisen totally by chance, but had to originate from God.

So we can point out two views of the 9th former: Dominating is the *natural creation of the universe* (Nico 1). Moreover, we find an *agnostic position* that locates the beginning of the cosmos in the middle between divine creation and naturalistic emergence by chance (Nico 2). Figure 14.6 illustrates Nico's (16;4) dual answers to the question about the origin of the world.

Nico's Views on the Origin of the Earth (2014)

We equally find this dual structure of the answers which contains both an *agnostic position* and a *natural creation* in the 16-year-old's attitude to the beginning of our blue planet. On the one hand, the origin of the Earth proceeded in an *uncertain way*, as the world might have originated by pure chance—like the universe as well—and because we are not sure how God could have made the Earth and many other things which remain unknown to us (Nico 2). On the other hand, Nico finds for himself the stronger religious answer that God initiated the origin of the Earth by the big bang, whereupon the world had to develop further on its own ("Nico 1"). For this reason, that there was a *natural creation of the Earth* is obvious—as Fig. 14.7 shows.

Nico's Views on the Origin of Humans (2014)

The 16-year-old Nico gives a double answer to the question about the origin of humans, depending on the concept of creation used.

On the one hand (shown in Fig. 14.8 as Nico 1), Nico uses the word "creation" explicitly as a sudden appearance of human beings as a result of a supernatural

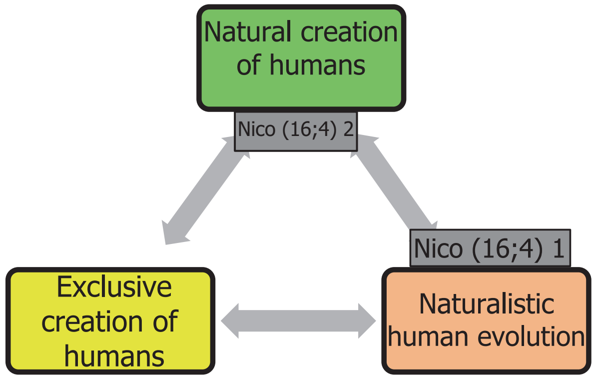


Fig. 14.8 Nico's views on the origin of human in 2014

divine power, which he negates definitively and believes, on the contrary, totally in the evolution of man from apes. Because of this, Nico's first and stronger view lies completely within that of a *naturalistic human evolution*.

On the other hand, Nico 2 is not convinced of the development of the world and of the origin of life totally without the help of God, which makes a difference to (atheistic) people with a naturalistic opinion and no belief in creation. So the 16-year-old emphasizes that the world in its independent history (also of the creatures in the world) was created by God in the beginning and that the world benefits from some additional divine help from time to time. On these grounds, we see here a notion of a *natural creation of humans* still shining through, because Nico still seems to be convinced of a divinely initiated and permitted evolution towards man—as he had been 2 years before. This second position, however, seems to be weaker than the first naturalistic one.

Changes and Stabilities of Nico's and Lena's Views on the Origin of Humans

The following part presents the changes and stabilities of Nico's and Lena's views on the origin of humans in a diachronic view. After that they will be compared with each other in order to identify questions for further research.

Changes and Stabilities of Nico's Views on the Origin of Humans

In order to give an answer to research question 4 ("Which changes and stabilities are to be found concerning the questions of the origin of humans from classes 5 to 7 to 9?"), Fig. 14.9 brings the coded views at the three points of measurement from 2010, 2012, and 2014 into a diachronic synopsis.

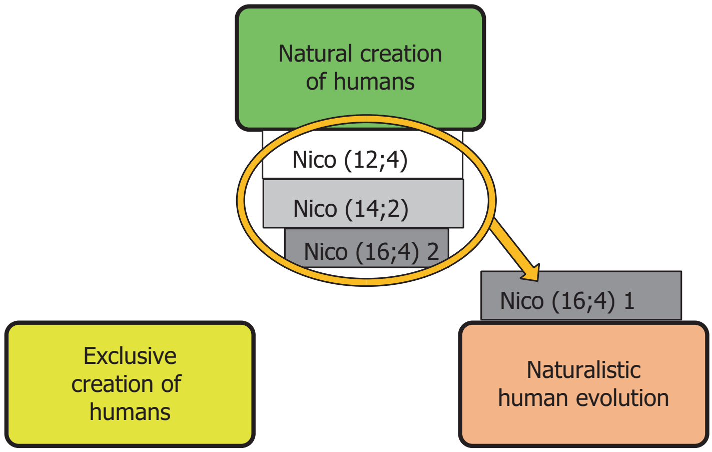


Fig. 14.9 Changes and stabilities of Nico's views on the origin of humans

How can we put Nico's answers to the diachronic question of the origin of humans in a nutshell?

A *complete stability* of the natural creation of man characterizes the period from the fifth to the seventh form, while Nico is aged between 12 and 14 years.

A *partial stability* of the natural creation of man stays until form 9, but it is overlaid with the new, dominant naturalistic human evolution of the 16-year-old, that is caused by a supernatural, miraculous concept of creation. This is not compatible with the evidently slow evolution of humans and therefore has been abandoned. So *a part* of the view changes in the sense of a *"naturalistic loss of theology"*.

Changes of Lena's Views on the Origin of Humans

To allow a comparison with Nico, I show in the light of Lena's views a further example from the same sample that is—in order not to go beyond the scope—focused on the changes of the view on the origin of humans.

As Fig. 14.10 shows, Lena started (aged 11;10) with a belief in the *creation of humans*; however, because of the lack of data, it is not clear whether she believes in an exclusive creation or a natural creation.

After 2 years, Lena (13;10) changed to an *almost purely naturalistic view* concerning the origin of mankind, because she became positive about the truth of evolution and does no longer believe in creation as told in Genesis 1.

Two years later, Lena (15;11) is convinced of the *natural creation of humans*: She believes in God as creator of humans by means of evolution (Hoeger 2016, 97,102).

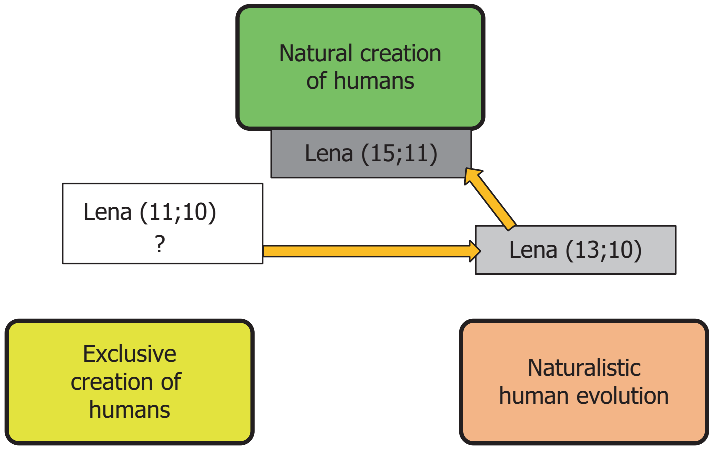


Fig. 14.10 Changes in Lena's views on the origin of humans

Comparison of Nico's and Lena's Cases in a Diachronic Perspective

By comparing the cases of Nico and Lena, we can point out a couple of identical traits: Both students being Roman Catholic and attending Catholic Religious Education—a possibility available to students in many state schools in Germany—give God as creator some significance at all times.

But we find important differences as well: While Nico stays relatively stable in his view about a natural creation of humans and tends to a naturalistic human evolution not before the age of 16, Lena changes her view from measure point to measure point. She starts from a possibly even exclusive belief in creation at an age of 11, arrives at the other extreme of a more naturalistic human evolution at the age of 13, and reaches the view of a natural creation of humans at the age of 15.

This outcome results in the following questions: How can we explain these findings? Where could we find the motives and the causes of these varying developments?

The current literature has so far led solely to the existence and development of an unreflected Piagetian artificialism. It starts at about 5 years and ends at the age of mainly 10–13 years. This is not of use relating to the adolescents of the age group in the study reported here. Additionally, relying on so-called means-reflection at about the age of 15–16 years does not provide sufficient criteria to explain in what direction an initial belief in creation might change.

Reich's (2003, 2004) theory of "relational and contextual reasoning" also does not go beyond tendencies of an increase in discrimination. It would consequently have to be rated as a cognitive factor of change. But such older studies into the development of thinking in complementarity do not always draw a clear distinction between different questions of origin: origin of the universe, the Earth, life on Earth, plants, animals, and humans (Rauch and Hoeger 2016). Perhaps the concept of "epistemic insight" (Billingsley et al. 2013; Konnemann et al. 2018) will lead to a fruitful explanation.

Furthermore, the kind of arguments used to prove or to deny specific attitudes might lead to a rewarding track in order to detect inner motors of development (Basel et al. 2014; Weiss 2016, 473–479).

Possibly, influences of socialization might also provide some further clues and points of departures: e.g. the extent and kind of increase of knowledge in the domains of theology of creation, astrophysics, geology, and biology of evolution. Not least, the differentiation between such cognitive aspects and more affective reasons would in addition have to be thought over in this respect (e.g. Fetz et al. 2001, 250,252; Konnemann et al. 2013, 56–59; Konnemann et al. 2016, 674–685).

These questions will be further examined in my postdoctoral research on the basis of all the cases and collected data. So I do hope that my new longitudinal approach will help teachers to understand better what their students know and believe and how their specific and potential views and changes in these could be described and explained.

The results will be important for religious as well as scientific education. They may help young people to combine religious and scientific paradigms of worldviews in a reasonable way.

References

Altmeyer, S., Englert, R., Kohler-Spiegel, H., Naurath, E., Schroeder, B., & Schweitzer, F. (Eds.). (2018). *Schoepfung*. Goettingen: Vandenhoeck & Ruprecht (Jahr*buch der Religionspaedagogik*, 34).

Barbour, I. G. (1997). *Religion and science*. San Francisco: HarperOne.

Barnes, M., Elser, J., & Brownell, S. (2017). Impact of a short evolution module on students' perceived conflict between religion and evolution. *The American Biology Teacher, 79*(2), 104–111.

Basel, N., Harms, U., Prechtl, H., Weiss, T., & Rothgangel, M. (2014). Students' arguments on the science and religion issue: The example of evolutionary theory and genesis. *Journal of Biological Education, 48*(4), 179–187.

Behe, M. J. (1996). *Darwin's black box: The biochemical challenge to evolution*. New York/London/Toronto/Sydney: Free Press.

Benk, A., & Erb, R. (2008). Religionsdidaktik und Physikdidaktik. *Theo-Web, 7*(1), 321–343.

Billingsley, B., Taber, K., Riga, F., & Newdick, H. (2013). Secondary school students' epistemic insight into the relationships between science and religion – A preliminary enquiry. *Research in Science Education, 43*(4), 1715–1732.

Corbin, J., & Strauss, A. (2015). *Basics of qualitative research. Techniques and procedures for developing grounded theory*. London: Sage Publishing.

Dawkins, R. (2006). *The god delusion*. London: Bantam Books.

Dieterich, V.-J., & Imkampe, M. (2013). "Es koennte doch sein, dass Gott der Natur geholfen hat, sich zu entwickeln" – Komplementaeres oder/und hybrides Denken? In V.-J. Dieterich, B. Roebben, & M. Rothgangel (Eds.), *Der Urknall ist immerhin, wuerde ich sagen, auch nur eine Theorie* (pp. 132–143). Stuttgart: Calwer.

Doering, N., & Bortz, J. (2016). *Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften*. Berlin, Heidelberg: Springer.

EARSandEYES. (2009). Umfrage zur Entstehung des Menschen. http://de.statista.com/statistik/daten/studie/5983/umfrage/beste-erklaerung-fuer-dieentstehung-des-heutigen-menschen/. Accessed 22 Mar 2017.

Eikermann, S.-L. (2012). *Weltbilder von Grundschulkindern heute*. Berlin/Muenster: Lit.

Englert, R. (1985). *Glaubensgeschichte und Bildungsprozess*. Muenchen: Koesel.

Evans, E. M. (2001). Cognitive and contextual factors in the emergence of diverse belief systems: Creation versus evolution. *Cognitive Psychology, 42*, 217–266.

Feige, A., & Gennerich, C. (2008). *Lebensorientierungen Jugendlicher*. Muenster: Waxmann.

Fetz, R. L., Reich, K. H., & Valentin, P. (2001). *Weltbildentwicklung und Schoepfungsverstaendnis*. Stuttgart: Kohlhammer.

Flick, U., Kardorff, E. V., & Steinke, I. (Eds.). (2017). *Qualitative Forschung*. Reinbek bei Hamburg: Rowohlt.

Francis, L., & Greer, J. (2001). Shaping adolescents' attitudes towards science and religion in Northern Ireland: The role of scientism, creationism and denominational schools. *Research in Science & Technological Education, 19*(1), 39–53.

Fulljames, P., & Francis, L. (1988). The influence of creationism and scientism on attitudes towards christianity among Kenyan secondary school students. *Educational Studies, 14*(1), 77–96.

Gensicke, T. (2006). Jugend und Religiositaet. In Shell Deutschland Holding (Ed.), *Jugend 2006* (pp. 203–239). Frankfurt a.M.: Fischer.

Hammann, M., & Asshoff, R. (2015). *Schuelervorstellungen im Biologieunterricht*. Seelze: Klett & Kallmeyer.

Hawking, S. (1998). *A brief history of time*. New York: Bantam.

Hawking, S., & Mlodinow, L. (2010). *The grand design*. New York: Bantam.

Hoeger, C. (2008). *Abschied vom Schoepfergott?* Berlin: Lit.

Hoeger, C. (2011). Kein Pauschalabschied vom Schoepfergott: Welterklaerungen von Abiturientinnen und Abiturienten. In H.-G. Ziebertz (Ed.), *Praktische Theologie – empirisch* (pp. 99–126). Berlin: Lit.

Hoeger, C. (2012). Analyse von sieben Kinderbildern zur Weltentstehung bzw. Welterschaffung. In I. R. P. der Erzdioezese Freiburg (Ed.), *Umgang mit Bildern im Religionsunterricht* (pp. 39–58). IRP der Erzdioezese Freiburg: Freiburg.

Hoeger, C. (2013a). Schoepfungstheologie der Jugendlichen und deren Konsequenzen fuer den Religionsunterricht. In V.-J. Dieterich, B. Roebben, & M. Rothgangel (Eds.), *Der Urknall ist immerhin, wuerde ich sagen, auch nur eine Theorie* (pp. 91–104). Stuttgart: Calwer.

Hoeger, C. (2013b). "Kaeseglocke" oder "blauer Planet"? In H.J. Riedl & R. Wunderlich (Eds.), *"Erwerbt euch Weisheit, …" (Sir 51,25)* (pp. 335–372). Frankfurt a. M.: Lang.

Hoeger, C. (2014). Was Kinder und Jugendliche vom Kosmos wissen und wie es sich wandeln kann. In V.-J. Dieterich & G. Buettner (Eds.), *Weisst du wieviel Sternlein stehen?* (pp. 121–136). Kassel: Kassel University Press.

Hoeger, C. (2015a). Lehrkraft, gib uns passende Inhalte zur rechten Zeit! In S. Pemsel-Maier & M. Schambeck (Eds.), *Keine Angst vor Inhalten!* (pp. 171–190). Freiburg: Herder.

Hoeger, C. (2015b). Einstellungen zum Ursprung von Welt und Mensch. In T. Faix & U. Riegel & T. Kuenkler (Eds.), Theologien von Jugendlichen (pp. 207–224). Berlin: Lit.

Hoeger, C. (2016). Schuelerwissen und -einstellungen zu Schoepfung, Urknall und Evolution in der Entwicklung. In C. Hoeger & S. Arzt (Eds.), *Empirische Religionspaedagogik und Praktische Theologie* (pp. 250–270). Freiburg: Salzburg. http://phfr.bszbw.de/frontdoor/index/index/docId/566. Accessed 22 Mar 2017.

Hoeger, C. (2018). Schachmatt für die Schoepfung? Empirische Befunde und religionspaedagogische Herausforderungen. In S. Altmeyer, R. Englert, H. Kohler-Spiegel, E. Naurath, B. Schroeder, & F. Schweitzer (Eds.), *Schoepfung* (pp. 30–44). Goettingen: Vandenhoeck & Ruprecht (Jahrbuch der Religionspaedagogik, 34).

IfD Allensbach. (2009). Glauben an Schoepfungsgeschichte oder Evolution des Menschen. http://de.statista.com/statistik/daten/studie/5171/umfrage/glauben-an-schoepfungsgeschichteoder-evolution/. Accessed 22 Mar 2017.

Johannsen, M., & Krueger, D. (2005). Schuelervorstellungen zur Evolution – eine quantitative Studie. *Berichte des Instituts fuer Didaktik der Biologie, 14*, 23–48.

Junker, R. (2010). *Spuren Gottes in der Schoepfung?* Holzgerlingen: SCM Haenssler.

Junker, R., & Scherer, S. (2013). *Evolution – ein kritisches Lehrbuch*. Giessen: Weyel.

Kattmann, U. (2013). Glaube an die Evolution? In H. P. Weber & R. Langthaler (Eds.), *Evolutionstheorie und Schoepfungsglaube* (pp. 201–227). Goettingen: Vandenhoeck & Ruprecht unipress.

Kelle, U., & Kluge, S. (2010). *Vom Einzelfall zum Typus*. Wiesbaden: VS Verl. fuer Sozialwissenschaften.

Klose, B. (2009). Kreationismus und Wissenschaftsglaeubigkeit – empirisch erfasst!? *Theo-Web, 8*(1), 75–79.

Klose, B. (2011). Kreationismus, Wissenschaftsglaeubigkeit und Werthaltung Jugendlicher. In H. Bayrhuber, A. Faber, & R. Leinfelder (Eds.), *Darwin und kein Ende?* (pp. 145–151). Seelze: Kallmeyer.

Konnemann, C., Oberleitner, E., Asshoff, R., Hammann, M., & Rothgangel, M. (2013). Einstellungen Jugendlicher zu Schoepfung und Evolution. In V.-J. Dieterich, B. Roebben, & M. Rothgangel (Eds.), *Der Urknall ist immerhin, wuerde ich sagen, auch nur eine Theorie* (pp. 49–62). Stuttgart: Calwer.

Konnemann, C., Asshoff, R., & Hammann, M. (2016). Insights into the diversity of attitudes concerning evolution and creation: A multidimensional approach. *Science Education, 100*(4), 673–705.

Konnemann, C., Hoeger, C., Asshoff, R., Hammann, M., & Riess, W. (2018). A role for epistemic insight in attitude and belief change? Lessons from a cross-curricular course on evolution and creation. *Research Science Education, 48*(6), 1187–1204.

Kutschera, U. (2008). Creationism in Germany and its possible cause. *Evolution: Education & Outreach, 1*, 84–86.

Lueke, U. (2016). Ergaenzung oder Widerspruch? Urknall, Evolution und Schoepfung. *Welt und Umwelt der Bibel, 21*(80), 10–17.

Piaget, J. (1971). *The Child's conception of the world*. London: Routledge & Kegan Paul LTD. https://ia800501.us.archive.org/30/items/childsconception01piag/childsconception01piag.pdf. Accessed 22 Mar 2017.

Rauch, T., & Hoeger, C. (2016). Naturdeutungen von GrundschuelerInnen. In C. Hoeger & S. Arzt (Eds.), *Empirische Religionspaedagogik und Praktische Theologie* (pp. 250–270). Salzburg: Freiburg. http://phfr.bsz-bw.de/frontdoor/index/index/docId/566. Accessed 22 Mar 2017.

Reich, K. H. (2002). *Developing the horizons of the mind. Relational and contextual reasoning and the resolution of cognitive conflict*. Cambridge: Cambridge University Press.

Reich, K. H. (2003). Developing the horizons of the mind. Reich's response to the commentators. *Zygon: Journal of Religion and Science, 38*(2), 459–466.

Reich, K. H. (2004). *The role of cognition in religious development*. http://dspace.library.uu.nl/bitstream/1874/1164/19/index.htm. Accessed 22 Mar 2017.

Reich, K. H., Oser, F., & Valentin, P. (1994). Knowing why i now know better: Children's and Youth's explanations of their worldview changes. *Journal of Research on Adolescence, 4*(1), 151–173.

Reiss, M. (2008). Should science educators deal with the science/religion issue? *Studies in Science Education, 44*(2), 157–186.

Retzlaff-Fuerst, C., & Urhahne, D. (2009). Evolutionstheorie, Religiositaet und Kreationismus und wie Schueler darueber denken. *Der mathematische und naturwissenschaftliche Unterricht, 62*(3), 173–183.

Robbins, J., & Roy, P. (2007). The natural selection. *The American Biology Teacher, 69*(8), 460–466.

Rothgangel, M. (1999). *Naturwissenschaft und Theologie*. Goettingen: Vandenhoeck & Ruprecht.

Rothgangel, M. (2011). Kreationismus und Szientismus: Didaktische Herausforderungen. In H. Bayrhuber, A. Faber, & R. Leinfelder (Eds.), *Darwin und kein Ende?* (pp. 154–169). Seelze: Kallmeyer.

Schick, H. (2012). *Entwicklungspsychologie der Kindheit und Jugend*. Stuttgart: Kohlhammer.

Schoenborn, C. (2005, July 7). Finding design in nature. *New York Times*.

Schreiner, M. (2012). Das Verhaeltnis des Religionsunterrichts zu anderen Faechern. In M. Rothgangel, G. Adam, & R. Lachmann (Eds.), *Religionspaedagogisches Kompendium* (pp. 191–206). Goettingen/Bristol: Vandenhoeck & Ruprecht.

Schweitzer, F. (1999). Kinder und Jugendliche als Exegeten? In D. Bell, H. Lipski-Melchior, J. von Luepke, & B. Ventur (Eds.), *Menschen suchen – Zugaenge finden* (pp. 238–244). Wuppertal: Foedus.

Schweitzer, F., Hardecker, G., Maaß, C. H., Ilg, W., & Lißmann, K. (2016). *Jugendliche nach der Konfirmation: Glaube, Kirche und eigenes Engagement – eine Laengsschnittstudie*. Guetersloh: Guetersloher Verlagshaus.

Shane, J., Binns, I., Meadows, L., Hermann, R., & Benus, M. (2016). Beyond evolution: Addressing broad interactions between science and religion in science teacher education. *Journal of Science Teacher Education, 27*(2), 165–181.

Strauss, A., & Corbin, J. (1996). *Grounded theory: Grundlagen qualitativer Sozialforschung*. Weinheim: Psychologie-Verl.-Union.

Valsiner, J. (2000). *Culture and human development*. London: Sage.

Weiss, T. (2016). *Fachspezifische und fachuebergreifende Argumentation am Beispiel von Schoepfung und Evolution*. Goettingen: Vandenhoeck & Ruprecht unipress.

Worsley, H. J. (2013). Seven years on: Insights from children's developing perspectives in interpreting the wisdom of the biblical creation narrative. *British Journal of Religious Education, 35*(1), 55–71.

Ziebertz, H.-G., & Riegel, U. (2008). *Letzte Sicherheiten*. Guetersloh, Freiburg: Guetersloher Verl.-Haus & Herder.

Christian Hoeger Since 2010, Dr. Christian Hoeger has worked as Catholic theologian at the University of Education Freiburg/Germany, where he teaches teacher trainees in RE, Old Testament, church history and systematic theology. From 2006 to 2010, he worked as a teacher of RE at academic high schools in Germany. Previously he wrote his dissertation at the University of Wuerzburg: 'Farewell to the creator?' examined how far adolescents dissociate from the Christian belief in a creator of the world. Prior to this, he graduated in Catholic theology and pedagogy. His finished habilitation analyses students' changing attitudes on Creation, Big Bang and Evolution. Since 2012, he has been a speaker of the Department "Empirical Research in RE" of Association of Scholars in Catholic Religious Education and Catechetics and a member of the International Society of Empirical Research in Theology.

Chapter 15
Cultural and Religious Barriers to Learning Science in South Africa

Ann Cameron

Introduction

In 1994, South Africa transitioned from White minority rule to a free democratic state under Black majority rule. This political revolution led to a number of challenges in education, and in particular, challenges to the prevailing dominant Eurocentric curricula that continue to be used in South African universities and schools. This challenge is complicated by global western dominance of the science curriculum and the fact that many African students have adopted a strong fundamentalist understanding of Christianity.

South Africa's history of colonization and 'missionization' has led to a nation characterized by large-scale subscription to Christianity in various forms. It has been so successfully indigenized and transformed that the majority of South Africans now ascribe to some form of Christianity in addition to, or in place of, African Traditional Religion, and there has been massive growth in the African Independent Church movement (Chidester 1992). These churches, and the charismatic churches which are also growing in number and following in South Africa, tend to follow a fundamentalist and literalist interpretation of the Bible (Mbiti 1969; Chidester 1992). For the many students who have been shaped by this conservative teaching, evolutionary science poses challenges that are very difficult to deal with.

Science was not offered as a subject to Black students during the apartheid years, but in the more than two and a half decades since 1994, many of the students choosing to take science continue to struggle with it. In trying to understand this, attention has been focused on the impact of African epistemology and ontology on learning in science, and it has been established that Black students are not only affected by

A. Cameron (✉)
Science Teaching and Learning Centre, University of the Witwatersrand, Johannesburg, South Africa
e-mail: Ann.Cameron@wits.ac.za

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_15

historic tensions between science and Christianity; they are also affected by deeply held indigenous belief systems. In 2015 and 2016, the student protests that were linked to the #RhodesMustFall and #FeesMustFall movements (Kamanzi 2016) exposed deep tensions regarding the nature and role of the curriculum as a whole, not just in science, where for many years there has been awareness of the epistemological challenges that exist. In a society where epistemic privilege remains persistently Eurocentric, the calls for decolonization of the curriculum have highlighted an emerging discourse that seeks to 'tackle and dismantle the epistemic violence and hegemony of Eurocentricism' (Heleta 2016).

This chapter draws on a case study to highlight the nature of 'epistemic violence' (Spivak 1994), which has been and continues to be suffered by many, but especially by Black students studying science in South Africa. The context of the study (Cameron 2007) was a university-level course in astronomy, where the students found themselves deeply challenged by theories such as the Big Bang and Solar Nebular Theory. The findings highlight the complexity of epistemic violence at several different levels, including conflicts between science, religion and indigenous knowledge systems, and most recently, challenges associated with calls for the decolonization of the curriculum in South Africa.

A Case Study of Barriers to Learning in Science

One of the most significant changes in education after the demise of apartheid, was the formal acknowledgement in the curriculum of the existence of indigenous knowledge systems (IKS) in South Africa. Despite more than a hundred years of suppression through the dominance in the formal schooling system of Eurocentric curricula, these knowledge systems have continued to exist in the hearts and minds of its indigenous peoples. In the new curriculum that was developed in the first decade after democracy, all academic disciplines, including Physical Science, were required to acknowledge IKS and include examples of indigenous knowledge (IK) (Department of Education 2002; Department of Education 2003). This served as a formal acknowledgement of South Africa's cultural diversity and was critical in the effort to address the imbalances and injustices of the past educational system.

South Africa's recent participation in international benchmark tests such as the Third International Mathematics and Science Study (TIMSS) has revealed, however, how poorly its students are performing in these subjects (Qobo 2017). Research indicates a complex array of challenges in relation to teaching and learning in South Africa, notably with regard to the language of teaching and learning and the allocation of resources (Spaull and Kotze 2015). In addition to these easily identified challenges, however, Morrow (2009) recognized the challenges related to what he termed 'epistemological access'. This concept highlights that for learners from traditional cultures, access to higher education institutions is only the first step to a qualification. Students also need access to ways of knowing and being that may be dissimilar to their home-based ways of knowing and being. This is especially pertinent in science, where the content is based on what is commonly referred to as 'western modern science' (Snively and Corsiglia 2000). The analogy used in the 1990s to highlight difficulties that learners from traditional or indigenous cultural backgrounds experience in learning science was that of 'border crossing', where 'crossing' into the 'culture' of science may be 'smooth', 'managed', 'hazardous' or 'impossible' (Aikenhead 1996; Aikenhead and Jegede 1999). In South Africa, the national matric exam results (Department of Education 2017), as well as results from TIMMS and other surveys, indicate that for many, but mainly Black learners, the learning journey into science is problematic. The epistemological challenges faced by these students, which may involve both cultural and religious beliefs, place them in a quandary that has largely been ignored by lecturers who are not conscious of the epistemic and symbolic violence that may be associated with their discipline.

Background to the Study

Prior to the arrival of white settlers and missionaries in South Africa, the African homestead was not only the central site of learning within the broader social, cultural and political authority of the chiefdom and tribe, it was also the 'nexus of symbolic and social relations between the living family members and their deceased ancestor spirits' (Chidester 1992, p. 5). The strength of this system meant that despite southern Africa being one of the most missionized regions of the world during the nineteenth century, missionaries had only limited success in gaining converts (Chidester 1992). The exponential growth of Christianity in South Africa in the twentieth century is thought to be due to the emergence of African nationalism and the creation of Independent Churches as centres of Black leadership and power, in response to the domination of white religious and political control (Ibid). The independent Church movement then led to the indigenization of the Christian faith and the development of an African theology (Mbiti 1969). Today, many sects continue to evolve under the leadership of self-proclaimed prophets.

South Africa's demography currently stands at about 55 million people, with Black people making up more than 80% of the population (StatsSA 2017). The last census that collected data on religious affiliation was that of 2001, where records show that almost 88% of the Black population belonged to Christian churches of one form or another (Hendriks & Erasmus 2005). In Africa as a whole, it has been projected that Christianity will remain the region's largest religious group, growing from 517 million in 2010 to more than 1.1 billion in 2050 (Pew 2015). Edwards (1998) explains this growth in terms of the 'resonance' that exists between certain aspects of Christianity, particularly in relation to the Old Testament, and the African worldview. Examples of this resonance include the role of community, the role of the spirit in African life and the practice of animal sacrifice (Arden 1996; Elion and Strieman 2001). Rapid urbanization has resulted in the disintegration of a traditional way of life for Africans, with many feeling very displaced in the cities. The

Independent Churches offer a sense of belonging and support that serves as a replacement for the traditional community base left behind in the rural areas. A notable feature of these Independent Churches is a tendency towards fundamentalism, with Mbiti (1969) pointing out that

> 'The literal interpretation of the Bible is common among these Churches. It is to be remembered … that some of their leaders cannot even read, and the majority are poorly educated, so that only a few of them have been to theological colleges or seminaries. There is a tendency among some groups to stick almost exclusively to the Old Testament and its precepts' (p. 229)

The large Christian following in South Africa and the tendency towards fundamentalism mean that a strong and widespread reaction can be anticipated in response to the 'different story' told by science. The issues that have historically resulted in conflict between science and Christianity, for example in Britain and the United States of America, also exist in South Africa. However, in South Africa, these issues are also affected by a deep-rooted respect of authority and the well-defined sense of community that defines African culture. While there can be no doubt about the impact of education, urbanization and industrialization on the indigenous people, their indigenous beliefs systems remain central:

> '(u)nless Christianity and Islam fully occupy the whole person as much as, if not more than, traditional religions do, most converts to these faiths will continue to revert to their old beliefs and practices for perhaps six days a week, and certainly in times of emergency and crisis' (Mbiti 1969, p. 3)

Ochieng'-Odhiambo (1995, p. 45) indicates that this reversion to a traditional way of life is because 'their forefathers and ancestors had left them with practical solutions (to) the great problems of humanity; the problem of life and death, of salvation or destruction'. In contrast to Western spirituality, which Edwards (1998, p. 86) describes as having been 'diminished through its run-in with Western science (and) relegated to the limbo of the unreal', African spirituality is growing, and it does not subscribe to dualism. For the African, even in the science classroom, 'to be, is to be religious, in a religious universe' (Mbiti 1969, p. 256).

The desire to be economically upwardly mobile is clearly linked to higher education, where the qualifications obtained provide access to well-paid jobs. In South Africa, this is enormously enhanced for those graduates who gain a degree in science. For many aspiring students, however, theories that are encountered in science courses may present challenges that lead to compliance learning, where they rote learn simply to pass. Others may feel compelled to replace their cultural and religious beliefs with scientism. For those who cannot cope with what has been termed epistemological 'violence', the likely outcome is failure or dropping out.

Teaching and Learning in Astronomy

With the notion of epistemic violence in mind, a research study was undertaken in one of South Africa's universities to investigate learning difficulties in a compulsory astronomy course taken by first-year students planning to major in Geology or Geography. Studies in astronomy education have shown that sociocultural factors combine with everyday lived human experience, thereby creating learning difficulties that are unique to the study of astronomy (Feigenberg et al. 2002). Astronomy is an ancient science, with knowledge of the heavenly bodies stretching back into the histories of past cultures. It is also an ultra-modern science, which has allowed for manned space travel and the means to explain the formation of the universe and solar system. The 'modern western science' of today has created a knowledge system that is very different to traditional knowledge systems that evolved over thousands of years. This modern understanding has been disseminated across the world as the canonical knowledge of science, but many of the conceptual models in astronomy that need to be developed by learners, are abstract and counter-intuitive, making teaching and learning in this field very difficult (Albanese et al. 1997). These difficulties are compounded when what is taught is seen to contradict or conflict with students' prior knowledge, especially when this knowledge is grounded in their religious beliefs.

The case study involved a mixed-methods research methodology over a period of three years, involving 191 students, the majority of whom were Black males. The study was based on two sociocultural constructivist theories of learning, viz. cultural border crossing (Aikenhead 1996) and collateral learning (Jegede 1995), which had become popular in South Africa as a means to understand the difficulties that students continued to experience in science. Data were obtained through the use questionnaires and interviews. At the start of each course during the time of the study, the prior knowledge of the students was sought in relation to a few key concepts that would have been covered in the high school Geography curriculum. The questions focused on students' understanding of the universe, the solar system and the consequences of the rotation and revolution of the Earth. These questions had the dual purpose of benchmarking South African students' knowledge in this field against international studies, and of establishing the prevalence of any cultural or traditional ideas that they held. Once the course had been completed, a post-instruction questionnaire was used to establish any conceptual changes that may have occurred in relation to these concepts. This questionnaire also sought to establish the nature of any learning difficulties that may have been experienced by the students. The data obtained from the questionnaires were analysed to establish the nature of students' understanding, as well as any conceptual shifts that may have occurred as a result of the course. This analysis was used to guide semi-structured interviews in order to probe students' beliefs and the learning difficulties they had experienced during the course. Over the time of the study, 25 students participated in the interviews, with 20 of them being Black male students. The other students who volunteered to be interviewed were two Black females, one White male and two Indian students, one female and one male.

Case Study Findings and Discussion

Data from the questionnaires and interviews highlighted the deeply religious nature of the students. It also highlighted how an unmediated presentation of science could achieve the opposite of the learning that was desired. Many of the students described how they struggled to deal with what they were being taught, and in the language of cultural border crossing, it was found that there were many for whom the crossing into science was hazardous, if not impossible.

However, the literature indicates that South African students are no different with regard to learning challenges in astronomy than their counterparts in other countries. Research shows that many students display misconceptions and poor levels of knowledge, and will offer brief descriptions of phenomena rather than give causal scientific explanations for events such as the seasons or moon phases (Lelliott and Rollnick 2010). This lack of scientific understanding has been ascribed to the fact that scientific explanations often run counter to normal daily experience and that higher-order thinking is required to develop the abstract conceptual models that are needed for full understanding. Concepts such as day and night are developed early on in life with people using themselves and their experience as their point of reference. It is difficult to ascribe these experiences to the earth turning on its axis and 'pre-scientific ideas' are therefore very difficult to change (Nussbaum and Novak 1976; Lemmer et al. 2003). It has also been found that misconceptions that arise from such self-referenced knowledge are actually preferred over the scientifically correct concepts, because the latter are so much harder to understand (Bailey and Slater 2003). Furthermore, it has been found that the development of a scientific understanding of cosmology has to proceed through a series of developmental stages, where the quality and timing of teaching is critical because the understanding of 'big ideas', like heliocentricity, requires comprehension of a range of interconnected phenomena (Nussbaum and Novak 1976; Summers and Mant 1995; Albanese et al. 1997). In South Africa, many teachers in the historically Black schools are under- or un-qualified in their teaching disciplines (Bot et al. 2000; Nkosi 2015), and as a result, it is not unusual to find a prevalence of misconceptions in students who have been taught by teachers who themselves carry these misconceptions.

Cultural Beliefs and Their Impact on Learning in Science

In contrast to the research in multiculturalism reported in the science education literature, one of the unexpected findings to emerge from the data in this study was the infrequent reference to what could be described as cultural beliefs. Such beliefs were rarely mentioned. It was far more common for students to respond to questions such as 'What is a star?' or 'Why does the moon appear to change its shape?' by providing simple descriptive answers that contained fragments of science vaguely remembered from school. The most common cultural belief to emerge was a connection that was made between stars and ancestors or ancestral spirits, where the stars were seen to be the 'eyes' of the ancestors. The understanding was that the stars/ancestors are present at night, when they will be 'watching out for you' while it is dark. During the day when it is light, you are expected to be able to look after yourself, 'so that is when they sleep and you can't see them'. A few students associated shooting stars (meteors) with the 'passing' (death) of people. The notion that a shooting star is simply a piece of rock burning up in space was unacceptable to these students, who understood this event as the process that connected the newly departed to their place with the ancestors' spirits. While there were few such specific examples of indigenous beliefs, many of the responses in the pre-instruction questionnaire hinted at animism, anthropocentricism, anthropomorphism and teleology, all of which are characteristic of a traditional worldview. Most of the students claimed, however, that such cultural beliefs would not serve as an impediment to their willingness or ability to learn and understand the scientific concepts. One of the students explained this by saying that while their grandparents, and their grandparents before them, 'only had their eyes to help them observe the world, we now live in a world full of technology that enables us to see differently'. However, another student (the names given are pseudonyms) expressed concern about how science had the power to erode his African worldview. During the interviews, he said:

> '… it's like we have to stay African… if you can change our tradition because of science, we gonna lose our culture. I'm proud of my culture. If I stay with science, it's like I will lose my culture…' (Meshack).

Most students managed to master the concepts that were taught in the course, but some simply used rote learning to pass. For many students, the cost of a 'western' education may be very high, because this can alienate them from their community and belonging to a community of people, who share a communal culture, is fundamental to African identity. This is because it is only within the community, which extends beyond the living members of the extended family to include the ancestors or 'living dead', that it is possible to be fully human (Mbiti 1969, p. 25). Mbiti explains that

> '… a person cannot detach himself from the religion of his group, for to do so would be to be severed from his roots, his foundations, his context of security, his kinships and the entire group of those who make him aware of his own existence… to be without religion amounts to a self-excommunication from the entire life of society, and African peoples do not know how to exist without religion' (Ibid., p. 2).

One of the students explained his experience as follows:

> 'When I am home, in the rural areas of Qwa Qwa, I actually believe that all these traditional things work, because I do not want to be ostracized. I mustn't even speak English, and that's very difficult because I've been speaking English so much. I must try to speak my own language. Sometimes it's difficult because they say "mmmm … snob!" and "… so now you think you are white!"' (Jabulani)

In their review of indigenous knowledge systems in South Africa, Vhurumukhu and Mokeleche (2009) describe IKS as the cultural matrix in which indigenous knowledge (IK) is enmeshed and stored. They point out that the components of this cultural matrix have been the subject of many discussions and contestation over what should constitute 'indigenous' and what should be counted as 'knowledge' (p. 98). Most definitions refer to folk knowledge as that developed over a long period of time and in a particular geographical context, where this deeply held knowledge is linked to the environment and to cultural beliefs, values and practices. In the context of science education, IK is most comfortably understood as traditional ecological knowledge (TEK) (Stanley and Brickhouse 2001), where the science within the indigenous knowledge can be explained. Examples of IK or TEK which have been given in the post-apartheid science curricula give no hint, however, of the religious nature of African epistemology. These examples tend to focus on things like the fermentation process in beer brewing, while ignoring the role of beer in the appeasement of ancestral spirits. For Africans, religious belief systems are part of the IKS matrix, and the dualism that is evident in how science deals with knowledge is foreign to them.

Religious Beliefs and Their Impact on Learning in Science

The history of astronomy shows a complex link between science and religion because the foundations of modern astronomy lie in religious beliefs and practices (Kudadjie and Osei 1998). In the global north, as science grew ever more powerful in explaining the physical universe, the beliefs and understandings offered by science came into conflict with those of the Christian church (Ross 2004).

These debates were brought to South Africa, where conservative fundamentalist interpretations of the Bible continue to dominate, especially in relation to beliefs about creation. African creation stories, which focus on the creation of human beings, resonate with the Biblical account in Genesis. In contrast to the Biblical version, however, African creation stories either give no account of a beginning or an end, or present an *ex nihilo* creation of the Universe by God, who is then believed to have withdrawn, leaving humans to communicate with him through the spirits (Van Dyk 2001). The New Testament teachings which give access to God through Jesus and the Holy Spirit support belief in spirit (*umoya*) and are greatly appealing in offering access to God through Jesus, rather than through local ancestors or spirits that can be offended and which then need to be appeased (Ibid.). For pragmatic converts, the mingling of Christian and African traditional beliefs results in what Shumba (1999) called an 'African product', where there is freedom to draw on different beliefs in different situations. However, the central evolutionary theories of astronomy (Big Bang Theory and Solar Nebular Theory) are doubly at odds with this African product. They conflict with both traditional African creation beliefs, and with the Genesis account, which is accepted in its literal form in South Africa's independent and conservative mainstream churches.

During the interviews, where students were given the opportunity to express their feelings about the course, many spoke passionately about the challenges they had faced in relation to their religious beliefs. Some found theories such as the Big

Bang to be so far-fetched as to undermine the credibility of science. Some could not afford to engage with science because of how it undermined their beliefs systems. Some were dazzled by the power and authority of the university, but were fearful about how their learning in science would affect their identity and their relationships with family and community. A few extracts from the interviews illustrate the nature of the difficulties that were experienced:

- 'the things I learnt began to interfere with my religion because they might be true. I decided to make a decision and stick to my religion (but) everything just seems to be so confusing' (Samson)
- 'you know, when I was growing up I believed in Christ, and I've tried not to forget whatever I was taught back there. But I've been struggling … I cannot try to replace what is in my heart by this knowledge that I have just got…' (David)
- 'when I heard about Big Bang, to me it was like a nightmare. It was really hard you see, because I am saved, I am born again…' (Xolani)

In the context of this study, the most significant finding was in relation to the number of students affected by what they perceived as conflict between science and religion. Mbiti makes the claim that 'Africans are notoriously religious' (1969, p. 1), and in South Africa, where most Black people belong to churches that are fundamentalist in their teaching, the common conflict between science and religion, particularly regarding evolution, is widespread. Fewer than 10% of the students reported that they had 'no problems' with what they were being taught in relation to their belief systems. For the majority, however, theories which have become the norm in science to explain the nature and existence of the universe were perceived as undermining their religious frameworks. Students wanted to know 'Where is God in all of this?'; 'Where is heaven?'; 'Where do Adam and Eve fit in?'

Kudadjie and Osei (1998) point out that African cultural practice includes respect of elders and not questioning anything that someone in authority says. In the universities, power is vested in the predominantly white lecturing staff, who in many cases lack awareness of their scientific positivism. The consequence, as Heleta notes in an article entitled 'Decolonization of higher education: Dismantling Epistemic Violence and Eurocentricism in South Africa', is that 'the curriculum remains Eurocentric and continues to reinforce white and Western dominance and privilege' (Heleta 2016, p. 1). Students tend to be silent about difficulties they may be experiencing because they don't want to be seen as stupid or different. They often cannot relate to what has been called 'mythical science' because it is so far removed from their everyday experience. They have no one to turn to who can understand the dilemmas they face. They are often the first in their family to attend university, so their parents are unable to help. Their religious leaders are also unlikely to have been schooled in the concepts the students find challenging. For lecturers, the questions that plague the students have no part in the curriculum and so they too remain silent, either because of lack of awareness of the students' cognitive stress, or because they don't know how to address the religious questions that students find so challenging.

In the same way that African Independent Churches have grown exponentially in urban areas to meet the need for community and offer a sense of belonging to those who have been displaced, in the university context students can find a new ‘family’ and sense of belonging through joining a campus religious society. The student demography in the university has changed radically since 1994, with Black students now making up more than 80% of the student body (AISU 2017). This demographic change has produced a conspicuous shift in faith-based student societies, where a few mainstream religious societies (Catholic, Anglican and Methodist), which have modest registration numbers, have been overtaken by independent church and charismatic church societies. By 2007 for example, there were 19 societies with a total registration of 1981 students. The highest registrations were in African Independent church societies such as the International Pentecostal Holiness Church and the Zion Christian Fellowship, followed by charismatic churches such as His People and RhemaDotGod@Wits. By 2015, registrations had more than doubled to 4837 students in 21 societies. Over this period, there was the loss of a few societies such as the Kingdom Heritage Society, as well as the creation of new ones, including ‘Uplifted Life’ and ‘Nazareth’. These societies have brought a significant Christian presence to the campus, through widespread advertising of prayer meetings and praise gatherings, and evenings and weekends on the campus are filled with the sounds of African worship. The presence of these groups and the support they offer to students serve to strengthen pushback to theoretical knowledge which is seen to undermine religious beliefs.

Epistemic Conflict in the Broader Education Context

The long-standing conflicts between science and religion, which remain difficult to resolve for those who hold strong fundamentalist views, are being mirrored in recent events in South Africa in the calls for decolonization of the curriculum. This call is based on the idea that

> ‘education must be free from Western epistemological domination, Eurocentricism, epistemic violence and worldviews that were designed to degrade, exploit and subjugate people in Africa’ (Heleta 2016, p. 5).

What the decolonization movement has brought to the fore is that the ‘epistemic violence’ (Spivak 1994) that has been suffered through colonization and apartheid, can no longer be ignored. The South African Council on Higher Education (CHE) has therefore called for curriculum transformation, based on the recognition that

> ‘it is clear that curriculum is connected with large and fundamental questions, and that the issue of its decolonisation involves tackling simultaneously and concertedly the question of the core purpose and goals of South African universities. It should also be clear that curriculum is connected with profound questions of values, epistemology, ontology and knowledge making and dissemination, in a context of unequal social relations’ (Badat 2017 in CHE 2017).

The complexity of what is required is linked to the understanding, drawn here from the science education literature, that 'the history of Earth and life is an emotionally charged subject' (Jackson et al. 1995 p. 594), and that strongly held beliefs can act as 'critical barriers' to learning (Sharp 1996 p. 686). However, the epistemological challenges that are now associated with the call for curriculum decolonization are not new. In 1998 for example, Kincheloe suggested that teaching astronomy without reference to other ways of knowing can be equated with 'unexamined scientism', and in a paper published in 2001, Cobern and Loving warned that around the world, science was being taught at the expense of indigenous knowledge. They said this was a 'move that precipitates charges of epistemological hegemony and cultural imperialism' (p. 52).

In South Africa, students are desperate to gain access to higher education which is internationally recognized, but this can be seen to come at a price. Their experience is one of ongoing epistemic violence associated with colonialism, which in science is exacerbated by the fact that Africans are deeply religious. Any teaching that disregards the spiritual or appears to displace the role of God is deeply offensive. The complexity of the situation is captured by Ramphele (1996), who 20 years before the student protests noted the

> '…dangers posed by the devastating combination of guilt and deep seated lack of respect shown by the white colonial authorities, and the role of victim adopted by the colonized. Coupled with this role is a glorification of indigenous culture which poses the greatest threat to the ability of indigenous people to transform their social relations. Modernity is a reality they cannot wish away, but engaging it creatively requires a critical appraisal of indigenous culture, and the retention of the good as well as the jettisoning of the bad' (p. 194).

While science initially grew out of a desire to reveal the work of God in the world (Hodgson 2002), for many scientists, belief in science has replaced belief in God. Lecturers who are fundamentalist in their relationship with science, i.e. those who ascribe to scientism, may be unaware of their unwitting prejudice, ignorance, thoughtlessness and even racist stereotyping in their dealings with students (Jackson et al. 1995; Gillborn 2002). Their reality is that as lecturers, they are science teachers with science to teach. However, Ogunniyi has warned that it is naïve to assume that 'students can be persuaded by a few hours of exposure to science to break with meaningful and tenaciously held cultural beliefs, for alien concepts they have just encountered in the science classroom' (1995, p. 26).

Conclusion

Students in South Africa, especially those studying science, are caught in the middle of a number of competing epistemologies that are linked to cultural, religious and political frameworks. The call for decolonization of the curriculum is moving the debate to a consideration of the core purpose of education in South Africa. If this purpose is to empower people to make choices for the betterment of all, and to enable them to live without fear and in peace with each other and the environment, then in the context of science, teaching needs to be invitational and find ways to create bridges rather than barriers, and lecturers need to support students to hold conflicting ideas in a world that exists in a state of epistemological tension.

References

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27*, 1–52.

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269–287.

AISU. (2017). *Academic information & systems unit*. Johannesburg: University of the Witwatersrand.

Albanese, A., Danhoni Neves, M. C., & Vicentini, M. (1997). Models in Science and in Science Education: A critical review of research on students' ideas about the Earth and its place in the universe. *Science & Education, 6*(6), 573–590.

Arden, N. (1996). *The spirits speak*. New York: Henry Holt and Company.

Bailey, J. M., & Slater, T. F. (2003). A review of astronomy education research. *Astronomy Education Review, 2*(2). http://aer.noao.edu/AERArticle.php?issue=4&section=2&article=2.

Bot, M., Wilson, D., & Dove, S. (2000). *The Education Atlas of South Africa 2000*. Pietermaritzburg: The Education Foundation.

Cameron, A. K. (2007). *Cultural and religious barriers to learning in basic astronomy: a South African study. Unpublished PhD thesis*. Johannesburg: University of the Witwatersrand.

Chidester, D. (1992). *Religions of South Africa*. London: Routledge.

Cobern, W. W., & Loving, C. C. (2001). Defining science in a multicultural world: Implications for science education. *Science Education, 85*, 50–67.

CHE (2017). *Council on higher education monitoring brief on decolonisation*, No. 3, November 2017. https://www.che.ac.za/sites/default/files/publications/BrieflySpeaking%20(3)%20Curriculum%20dec olonisation.pdf

Department of Education (2002). *Revised National Curriculum Statement, GETC, Grades R – 9*, Government Printer, Gazette No 23406, Vol 443.

Department of Education (2003). *National Curriculum Statement, FET, Grades 10–12*, Government Printer.

Department of Education (2017). National Senior Certificate Examination 2016 Diagnostic Report. http://www.education.gov.za/Portals/0/Documents/Reports/NSC%20DIAGNOSTIC%20REPORT%202016%20WEB.pdf?ver=2017-02-17-100126-000

Edwards, F. (1998). African spirituality and the integrity of science. In C. W. du Toit (Ed.), *Faith, science and African culture*. Pretoria: Research Institute for Theology and Religion, University of South Africa.

Elion, B., & Strieman, M. (2001). *Clued up on Culture*. Camps Bay Cape Town: One Life Media.

Feigenberg, J., Lavrik, L. V., & Shunyakov, V. (2002). Space scale models in the history of science and students' mental models. *Science & Education, 11*, 377–392.

Gillborn, D. (2002). *Education and Institutional Racism. Perspectives of policy and practice in England*. Paper presented at a School of Education Research Seminar, Education Campus. University of the Witwatersrand, Johannesburg, 12th November.

Heleta, S. (2016). Decolonization of higher education: Dismantling epistemic violence and Eurocentricism in South Africa. *Transformation in Higher Education, 1*(1), a9. http://dx.doi.org/10.4102/the.v1i1.9.

Hendriks, J., & Erasmus, J. (2005). Religion in South Africa: The 2001 Population Census Data. *Journal of Theology for Southern Africa, 121*, 88–111.

Hodgson, P. E. (2002). *Christianity and science*. Johannesburg: St Augustine College of South Africa.

Jackson, D. F., Doster, E. C., Meadows, L., & Wood, T. (1995). Hearts and minds in the science classroom: The education of a confirmed evolutionist. *Journal of Research in Science Teaching, 32*(6), 585–611.

Jegede, O. (1995). Collateral learning and the eco-cultural paradigm in science and mathematics education in Africa. *Studies in Science Education, 25*, 97–137.

Kamanzi, B. (2016). *#FeesMustFall: Decolonising education*. South African student protesters will not stop at freezing university fees. http://www.aljazeera.com/indepth/opinion/2016/10/feesmustfalldecolonising-education-161031093938509.html

Kincheloe, J. L. (1998). Critical research in science education. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education, Part Two*. Dordrecht: Kluwer Academic Publishers.

Kudadjie, J., & Osei, J. (1998). Understanding African cosmology: Its content and contribution to world-view, community and the development of science. In C. W. du Toit (Ed.), *Faith, Science and African Culture*. Pretoria: Research Institute for Theology and Religion, University of South Africa.

Lemmer, M., Lemmer, T. N., & Smit, J. J. A. (2003). South African students' view of the universe. *International Journal of Science Education, 25*(5), 563–582.

Lelliott, A., & Rollnick, M. (2010). Big ideas: A review of astronomy education research 1974 – 2008. *International Journal of Science Education, 32*(13), 1771–1799.

Mbiti, J. S. (1969). *African religions and philosophy*. Oxford: Heinemann Educational Publishers.

Morrow W. (2009). *Bounds of democracy: Epistemological access in higher education*. Cape Town, Human Sciences Research Council Press. ISBN (soft copy) 978-0-7969-2271-7.

Nkosi, B. (2015). *Most of our teachers' can't*. Mail & Guardian, 17 April. https://mg.co.za/article/2015-04-17-most-of-our-new-teachers-cant

Nussbaum, J., & Novak, J. D. (1976). An assessment of children's concepts of the earth utilizing structured interviews. *Science Education, 60*(4), 535–550.

Ochieng'-Odhiambo, F. (1995). *African philosophy: An introduction*. Nairobi: Consolata Institute of Philosophy Press.

Ogunniyi, M. B. (1995). *Race, culture, evolution and traditional worldview: Challenges for science education in Africa*. Inaugural Lecture, School of Science and Mathematics Education, University of the Western Cape, Bellville, 22nd September.

Pew (2015). *Pew research centre: The future of world religions: Population growth projections, 2010–2050*. http://www.pewforum.org/2015/04/02/religious-projections-2010-2050/. Accessed 17 Feb 2017.

Qobo, M. (2017). South Africa can compete globally without fixing its attitude to maths. *The Conversation*, 9th January, http://theconversation.com/south-africa-cant-compete-globally-withoutfixing-its-attitude-to-maths-70925

Ramphele, M. (1996). *A life* (2nd ed.). Cape Town: David Philip Publishers (Pty) Ltd.

Ross, H. (2004). *A matter of days*. Colorado: NavPress.

Shumba, O. (1999). Relationship between secondary science teachers' orientation to traditional culture and beliefs concerning science instructional ideology. *Journal of Research in Science Teaching, 36*(3), 333–355.

Snively, G., & Corsiglia, J. (2000). Discovering indigenous science: implications for science education. *Science Education, 85*, 6–34.

South African History Online (2017). *People of South Africa*. Origins, Language, Culture and Identity. https://v1.sahistory.org.za/pages/artsmediaculture/culture%20&%20heritage/culturalgroups/menu.htm

Spaull, N., & Kotze, J. (2015). Starting behind and staying behind in South Africa. The case of insurmountable learning deficits in mathematics. *International Journal of Educational Development, 41*, 13–24.

Spivak, G. C. (1994). Can the subaltern speak? In P. Williams & L. Chrisman (Eds.), *Colonial discourse and post-colonial theory: A Reader* (pp. 66–111). New York: Harvester/Wheatsheaf.

Stanley, W. B., & Brickhouse, N. W. (2001). Teaching sciences: The multicultural question revisited. *Science Education, 85*, 35–49.

StatsSA (2017). *Statistics South Africa*. http://cs2016.statssa.gov.za/

Summers, M., & Mant, J. (1995). A survey of some primary school teachers' understandings of the Earth's place in the Universe. *Educational Research, 37*(1), 3–19.

Van Dyk, P. J. (2001). *A brief history of creation*. Pretoria: Unisa Press, University of Pretoria.

Vhurumukhu, E., & Mokeleche, M. (2009). The nature of science and indigenous knowledge systems in South Africa, 2000 – 2007: A critical review of the research in science education. *African Journal of Research in Mathematics, Science and Technology Education, 13*(sup1), 96–114. https://doi.org/10.1080/10288457.2009.10740664.

Ann Cameron is an Associate Professor and Head of the Science Teaching and Learning Centre in the Faculty of Science, University of the Witwatersrand, where she has served in academic staff development for the past 15 years. Her focus is on developing intentional reflection on teaching and learning in the rapidly changing environment of higher education in South Africa. Her research interests include the impact of the socio-cultural context on learning in science, with specific reference to indigenous knowledge systems.

Chapter 16
Ways Children Reason About Science and Religion in Primary School: Findings from a Small-Scale Study in Australian Primary Schools

Berry Billingsley and Sharon Fraser

Introduction

Tensions between the domains of science and religion have been with us for centuries (e.g. Galileo 1615), with concord and conflict being the focus of numerous journal articles, books and websites (e.g. Davies 1983; Polkinghorne 2007a, b; Prideux and Pepper 2012; Reiss 2008; Straine 2014; Taber et al. 2011). Scholars from the extreme sides of the 'debate' critique the nature of their own discipline and how it compares with, relates to or is incompatible with the other. In more recent times, incompatible and in some circumstances immovable positions have been reiterated as promoting a public perception of religion-science duality: '… there are the fanatical atheists whose intolerance is of the same kind as the intolerance of the religious fanatics and comes from the same source' (Einstein 1941, cited in Jammer 1999, p. 97). There are many scholars, however, who argue for a way through the duality, proposing another way of thinking about the two domains and how they might be understood to relate to each other (Alexander 2007; Trigg 2007). While it may be rare for teachers to be exposed to the arguments posed by the advocates of the many positions that exist, it is possibly rarer still for them to have an in-depth understanding of how these positions relate to their teaching context or responsibilities towards their students.

Scientific study seeks to enhance our understanding of the physical world using reason, experiments, imagination and creativity (Straine 2014). Science is widely

B. Billingsley
LASAR (Learning about Science and Religion), Canterbury Christ Church University, Canterbury, UK
e-mail: berry.billingsley@canterbury.ac.uk

S. Fraser (✉)
College of Arts, Law and Education (CALE), University of Tasmania, Hobart, Australia
e-mail: sharon.fraser@utas.edu.au

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_16

understood to be a discipline that can provide a high level of certainty. Claims made by science are initially tentative (Bickmore et al. 2009) and open to contestation and revision in the light of new or reinterpreted evidence. There are, however, numerous well-established ideas in science (e.g. the earth rotates upon its axis and orbits the sun) which are no longer considered tentative in practice.

Scientific theories develop as data accumulate. The process by which this happens is sometimes summed by the phrase 'the scientific method'. However this simplistic representation of the scientific endeavour mirrors a narrow epistemology and has been the subject of critique for over 70 years. Concern has been raised about the extent to which science is perceived as a set of formulaic steps by both the general population and the science teaching community itself (Randolph 2005) as in reality there is not *one* method of 'doing science'. While science is undertaken in a systematic and logical manner, understanding in science has rarely been achieved by way of a straightforward path. Rather, it is not uncommon for many different people from different fields of study, using different sorts of tests undertaken over time, to provide multiple lines of evidence which are used to evaluate the accuracy of a scientific idea. Summarising the manner in which scientific knowledge is constructed in a step-by-step linear model is therefore flawed and stops learners thinking about and experiencing the messiness of scientific research.

Key to understanding science as a discipline is that it is both a product and a process – a body of knowledge *and* a way of knowing. Science epistemology, or the '… logical and philosophical grounds upon which scientific claims are advanced and justified' (Sandoval 2005, p. 635), may not be something that learners engage with in any direct sense during their schooling. However, grappling with the way in which knowledge claims in science are made and justified is important for learners and the general community as a whole if they are to understand and interpret many twenty first century issues such as climate change. Sandoval has suggested that science epistemology can be provided to learners in a manageable form through four epistemological themes:

1. *Science knowledge is constructed* by people by way of a dialectical relationship between observation (including creativity and interpretation) and theory. Scientific knowledge is constructed socially through collaboration and competition, and is accepted because people are persuaded of its usefulness to our understanding of the natural world.
2. *Diversity of scientific methods* is incorporated into the variety of investigations undertaken within the different scientific disciplines. Methods rely on standards (e.g. systematicity, care, fit with other data) for evaluating the fit between observations, scientific process and knowledge claims, and they include but are not limited to controlled experimentation.
3. *Forms of scientific knowledge* are different and vary in their ability to explain or predict the observable world (e.g. hypothesis, models, theory, law), and they are subject to change in the light of new data.
4. *Scientific knowledge varies in certainty;* all scientific knowledge is tentative, and some claims are more tentative than others (e.g. string theory versus force of

gravity). Absolute certainty does not exist in science, and current ideas may change as new ideas form from emerging data and their interpretation. Reasoning and argumentation, therefore, are key to the process of science.

By enabling learners of science to engage with these four epistemological themes, they come to understand about testing ideas and generating evidence, and to realise that there are types of questions, scientific questions, that lend themselves to being studied scientifically and others that do not. They are alerted to the strengths and limitations of the discipline in regards how it can contribute to our knowledge of the world.

Religion has its own nature and is defined by the Australian Bureau of Statistics as '…a set of beliefs and practices, usually involving acknowledgment of a divine or higher being or power, by which people order the conduct of their lives both practically and in a moral sense' (para 1). When viewed through evidentialism, however, whereby 'justified beliefs must be grounded in evidence' (Smith 2014, p. 135), some claims made by religious faiths can appear insupportable. The term 'evidence' is well understood in the discipline of Science, where it is generally of an empirical nature gathered in accordance with the scientific methods that are acceptable to the field of inquiry. However, the term means something quite different in the discipline of history, for example, whereby artefacts left over from the past (text, images or objects) are sources of information, which become 'historical evidence' when interpreted by historians using their own historical method. Whether or not all religious belief must be based in evidence is a fundamental question for those interested in religious epistemology. What is clear, however, is that theologians and other scholars in this field may refer to types of evidence that are quite different from that which is acceptable in science due to the nature of religion as a way of knowing. When talking about evidence in religion, some scholars point to the fact that theistic belief (belief in a God who interacts with people), referred to as the 'common consent' of the human race, as evidence that God exists (Kelly 2011). Others have argued that religious beliefs and theism provide a better motivation than other theories, social contract theory for example, for living a moral life (Clark and Samuel 2011). Religious people also refer to 'sources of faith' which in the Christian world, for example, include the Bible, reason, tradition and religious experience (Straine 2014). Finally, as described in Never Off Topic[1] website developed by LASAR (Learning about Science and Religion)[2] for schools: 'Some religious people see the existence of science itself as evidence for the idea that God exists. God created a universe which can be explored using science and He gave humans a passion for exploring …' (2011, para 4).

What is also highly pertinent when discussing science and religion with children is to give them a sense of what unites science and religion, and that is humankind's need to understand and make meaning of the world around them. As Dutch (2002, para 4) argued, both science and religion share some basic tenets within their own discipline,

[1] Never Off Topic: http://www.neverofftopic.com/re-topics/re-year-10-11/evidence-in-religion/

[2] LASAR: http://lasarcentre.com/

such as: '… an accepted canon of ideas, means of evaluating and responding to new ideas …, means of enforcing rules …, means of translating ideas into concrete action, and means of dealing with the claims of rival institutions'. Without understanding the nature of each discipline and its purpose, however, it is almost impossible to discuss how they relate and to develop an informed stance on whether that relationship is confrontational or complimentary. In this chapter, we report on a study undertaken in Australia which investigated the extent to which children perceive a relationship between science and religion and can discern the natures of each discipline.

The Study

Research conducted collaboratively by researchers from the University of Reading, UK, and the University of Tasmania, Australia, in the *Being Human* project (*Being Human: Discovering and Advancing School Students' Perceptions of the Relationships between Science and Religion*) has revealed ways in which primary (year 6) and secondary (years 10 and 11) school students and their teachers perceive science and religion and the relationship between them. The research is funded by the Templeton Foundation[3] which is a philanthropic organisation, interested in exploring big questions relating to human purpose and ultimate reality. To find out how children think about science and religion, particularly as it pertains to what it means to be human, the project has carried out surveys and interviews with over 600 primary school-aged children in the UK and Australia. The perspectives of Australian students from year 6, gained through a pilot project consisting of 64 surveys and supported by 20 interviews, are the focus here. Overall, the research has been informed by the following questions:

RQ1: How do primary children perceive the relationships between science and religion?
RQ2: What are primary children's perceptions of the nature of science including their perceptions of the scientific position on religion?
RQ3: What are primary children's commitments to religion and to what extent do they perceive that science conflicts with their personal beliefs?
RQ4: What are children's perceptions of the Christian position on how to interpret the Biblical creation story?
RQ5: What are primary children's perceptions of how questions and interactions concerning science and religion are addressed in school?

The data arising from the Australian pilot study will be presented here in relation to three emerging themes.

1. Science is proof and religion is belief
2. Science and religion are compartmentalised
3. Considering the perspectives of both science and religion

[3] The John Templeton Foundation: https://www.templeton.org/

Religious Education in the Australian Context

In Australia, children attend either fully funded government schools (state schools) or private schools (e.g. faith-based schools, independent schools) which receive some government funding but which also charge tuition fees of varying amounts. In Australia, religious education (RE) is not part of the taught curriculum; therefore, RE is only likely to be taught by classroom teachers in faith-based schools. The positioning of religion in secular education in Australia has been analysed in great depth in relation to ideologies, policies, pedagogies and practices (Byrne 2014), with discussion remaining ongoing. The religious content of the state-based education systems varies between jurisdictions, while in many states and territories, secular education (possibly including general religious education but not polemical theology) is protected by law. In state schools (and non-denominational private schools) in Australia, religious education if offered, is regulated to 30 min or less a week, and it is provided by religious professionals or volunteers. Student attendance at religious education instruction is not mandatory; rather, parents must give their permission for their child to participate and the school must provide alternative classes such as instruction in values or ethics. Faith-based schools provide their own religious education and/or instruction, and it is not uncommon for generalist primary teachers to teach both science and RE in those schools. Throughout Australia, therefore, students have varied opportunities to participate in discussions about religion and how it relates to science, depending upon the state or territory they live in and the school they attend.

Methods

The Australian aspect of the *Being Human* project reported here has drawn from the survey responses of 64 year 6 (aged 10–11 years) primary school students and 20 follow-up interviews in 4 schools from Victoria and Tasmania. Participants were drawn from private Christian or Independent schools as consent to participate in the research was not approved for government schools in these two states. The manner in which RE was taught varied across the schools, in regards the extent to which both it was taught, and the critical and/or inquiry-based manner in which it was addressed. Due to both the small number of schools and students involved, as well as the lack of breadth (religious, independent, secular) of the participant schools, any conclusions drawn should be considered as tentative.

Year 6 students participated in a survey consisting of 43 questions with the option to provide open-ended comments, which took them approximately 20 min to complete. The survey was provided online through Survey Monkey, and students completed the survey as a class group at the same time. Interested students were able to nominate their interest in participating in an interview, and these were undertaken subsequent to their completion of the survey. Both the survey and the interview explored the students' perceptions of what science and religion say about potentially topics shared between science and religion, such as the origins of the universe and evolution, and probed how formal education affects children's developing understanding of how science and religion relate.

Exploring where their views had come from and who it is that they talk to about them was also a clear focus of the interview. Students were asked about their understanding of science and its importance to them, and whether they had religious beliefs. They were questioned about who they talked to about science and/or religion, whether they talked about both together and if such discussions were had at school. Further questions aimed to elicit their understandings about the purpose of and relationship between science and religion, what each 'says' about particular phenomena and/or conundrums (miracles, prayer) and whether or not they saw a conflict between them. The data are reported as both percentages (from the survey item responses) and qualitative responses (from both the survey and interviews), with interview participants being quoted using pseudonyms.

Results

Of the students surveyed, almost 60% were boys, 88% identified as being Christian, and 81% indicated that they believed in God. Fifty-three per cent of those who completed the surveys were interested in being interviewed and further exploring the ideas raised. Students' responses to the survey questions pertinent to this paper are summarised in Table 16.1.

Science Is Proof and Religion Is Belief

Students indicated that they believe that science is dynamic, and all about facts that help us live in and impact upon the world, while religion is something you just believe in, as Peter summarised: '…I don't think it goes well with um religion and things. Like the rules don't exactly equal up to God…Science is right, and religion it's just what you believe'. Nearly all interview respondents expressed an opinion that science is important, as it makes the world a better place, as Jake explained: 'I think it matters because it gives us an understanding of how things work so that we can understand in certain situations how things can be improved or how things are as good as they could be, so yeah'. Overall, as evidenced by the children's responses to focused survey questions (Table 16.1), an understanding of both science concepts (see items 7–10) and the nature of science is still forming in children of this age. While they might have heard of particular science concepts, such as the Big Bang and Evolution, they may not have a deep understanding of what they actually mean. There was a belief that science 'proves' things, with 70.3% believing that theories become facts once they are proved (see Table 16.1). According to Esty, science will continue to prove more and more things as we keep asking questions and

Table 16.1 The extent to which students agree or disagree (%) with *Being Human* survey items

	% agreement/disagreement with the statement			
Survey item	Agree	Neither agree nor disagree	Disagree	I don't understand the question
7. I have heard of evolution	73.0	11.1	11.1	4.8
8. I know enough about evolution to explain it to a friend	50.8	17.5	30.2	1.6
9. I have heard of the Big Bang theory	88.5	4.9	6.6	0
10. I know enough about the Big Bang theory to explain it to a friend	53.1	17.2	29.7	0
11. I believe the universe was created by God (or a Greater Being)	76.6	10.9	12.5	0
12. Evolution and creation of humans by God (or a Greater Being) can both be true	35.9	21.9	32.8	9.4
13. The Big Bang theory fits with a belief that the universe is created by God (or a Greater Being)	15.9	27.0	36.5	20.6
14. I believe in miracles which break laws of nature	46.0	31.7	7.9	14.3
15. Science makes it hard to believe in God (or a Greater Being)	28.1	29.7	40.6	1.6
17. Science and religion disagree on so many things, they cannot both be true	28.1	39.1	23.4	9.4
19. Science and religion work together like friends	15.6	39.1	39.1	6.3
20. According to science, laws of nature determine everything that happens	27.4	24.2	30.6	17.7
21. Many scientists believe in God (or a Greater Being)	26.6	46.9	23.4	3.1
23. One day we may be able to explain the whole universe using science alone	27.0	28.6	42.9	1.6
24. The animals and plants on Earth evolved from simpler organisms	27.9	26.2	39.3	6.6
25. In my view humans did not evolve from simpler organisms	49.2	20.6	20.6	9.5
26. The scientific view is that God does not exist	23.4	42.2	29.7	4.7
27. The scientific view is that it is impossible for miracles to happen which break laws of nature	33.3	44.4	15.9	6.3
28. The scientific view is that prayers cannot change what happened in the future	41.3	25.4	33.3	0
29. In science, theories become facts once they are proved	70.3	17.2	7.8	4.7
30. The scientific view is that God (or a Greater Being) does not exist	30.2	36.5	31.7	1.6
34. It's wrong to challenge someone's beliefs	64.1	21.9	14.1	0

(continued)

Table 16.1 (continued)

Survey item	% agreement/disagreement with the statement			
	Agree	Neither agree nor disagree	Disagree	I don't understand the question
35. My teachers have talked about whether science and religion fit together	18.8	37.5	42.2	1.6
36. I am interested in whether science and religion fit together	47.6	31.7	20.6	0
37. I am interested in whether science and people's cultural beliefs fit together	47.6	27.0	17.5	7.9
38. In school we have learnt about scientists who believe in God (or a Greater Being)	30.2	15.9	52.4	1.6

technologies develop: '…since technology's getting smarter and stuff….because they have more definite, like, they could think this was right, but then now they know that this is right'. Science and scientists were also perceived as being dogged with some students believing that this will enable them to find ultimate answers to most things, as Jeff summarised: 'Yeah, science keeps on digging for everything until they've found every last drop…Science will find answers for all miracles eventually'. Amongst survey respondents, however, only 27% were of the opinion that science will eventually be able to explain the whole universe. As Rick explained, 'Religion is helpful if you need something to believe in and science is helpful if we need something to work'. While it was commonly agreed that science changes over time as a result of some understanding being 'proved' wrong, religion (as understood through the Christian faith) has one Bible and 'people aren't making more bibles', so little will change in terms of religious belief.

The children's interview responses indicated that there was an understanding of the importance of evidence in science – 'Oh it can't be true if there's no evidence…. it's more of a guess or opinion if it's not true…..you can't really say someone's opinion is right, you can't go off that opinion unless it's proven or someone finds out it's true' (Arnold). They struggled, however, with there being much evidence supporting religious ideas. Some recognised artefacts such as the Bible as being a sort of evidence, although admitted that it has problems, as Frank described '...you know there is stories that like being told it's true that Jesus was there. It's been passed down through the generations, and yeah, that's evidence'. Jeff talked in terms of proof in science but was not so sure about what it was for religion: 'The proof in religion would be through things such as the Bible, where it's…Jesus spoke of that type of thing, but yeah, that's not as rock hard, because things like that can be altered through time'. Sebastian agreed that the Bible had issues in terms of it being evidence: '…because for all we know some person might have just randomly written all the books in the Bible. They might have just been making all this stuff up like a fiction story'. Of course, science cannot help us with an answer to this dilemma: '…they can't say it is, but they can't say it isn't…they weren't there, and they can't say' (Sebastian). Esty indicated that she had to believe in either science or religion due to her literal interpretation of the Bible: 'It's hard to believe which one is right, but then… 'cause they [science] have evidence but then….this is how the Bible says it is made'.

It was not uncommon for the students to support a person's right to have their own beliefs which should not be challenged (item 34: 64.1%); as Suzie discussed: 'Yeah….because if you believe in one thing and another person believes in something, they're not going to, like criticise you for that, 'cause that's your belief and not theirs'. She felt that these beliefs were not challenged by science, or whether science says God does not exist: 'I think it doesn't really matter what something says, because it's always your own beliefs and your own ideas and whatever you think should be right in your way, not depending on someone else'. Shane also thought they played different roles in your life: 'Because religion helps your spirit, makes you feel good and science is just the hard truth'. He expanded on this, indicating that it is perfectly fine to be both a scientist and religious at the same time: '…you can be interested in science then you can also be religious because like you believe in it even though there's no evidence towards it, you can still believe'.

Science and Religion Are Compartmentalised

The majority of children recognised science and religion as being different, but it was clear that children of this age are still making up their minds about them, and they are not sure about how each contributes to our understanding of the world. Only 15.6% believed that science and religion work together like friends (item 19): *yes they do Science is very open minded so I am sure they work well,* but there were as many students who disagreed (39.1%) with the survey statement as were uncommitted: *I haven't really looked into science and religion put together, only in separate circumstances.* During the interviews, a number of children contradicted themselves as they responded to the different questions, indicating how emergent their ideas were about science and religion. While Paul felt that science and religion were in dispute over the existence of God: 'Well religion obviously tells us that He exists, or existed, or exists I guess…And science tells us that it, He doesn't', he had no problem in thinking that a *religious scientist* would pray to God.

A large proportion of survey respondents (40.6%) disagreed with the statement that 'science makes it hard to believe in God or a Greater Being' (item 15), while 28.1% felt that science *did* make it hard to believe, and a large percentage (29.7%) remained unsure. At the same time, almost as many students (26.6%) believed that you can be a scientist and believe in God (item 21), as did not (23.4%), with the largest percentage not really knowing (46.9%) if that is the case. Children's statements at interview about science and a scientist's beliefs appeared to be coloured by their understanding of the nature of science and the nature of beliefs. The statement of one survey respondent indicates that the term 'belief' might be problematic and warrant exploration: *Science believes that the earth was created by* *the Big Bang, so it's hard for most scientists to believe in God.* When Bob was asked whether he thought about science and religion together, he responded that: 'Ah, not really, it's more those two as being independent'. He later clarified his meaning by saying that: 'there are some similarities which can sometimes join them'. Bob certainly believed that science and religion would have different stories about some aspects of the world: '…so they [the pastor] would say, like, God created the whole universe and then if I asked someone who wasn't like a Christian or didn't believe in God, um, that they would like say it was just made by something else'. The interviews also revealed evidence of quite dogmatic, black and white thinking, for example, Edward felt quite unequivocally that the reverend would say humans exist because God put them on Earth. Equally, he felt that scientists would not believe in miracles and when told that this was not always true, he agreed that it was puzzling:

> 'Because they kind of work to find out that it's not true and they believe it'.

One survey respondent felt that the theory of evolution competes with God: *I agree in the statement,* because nowadays science is being influenced to a high degree by evolution, which is against God. But I chose not to believe in everything that today's [sic] scientists tell us. Edward felt that it was likely that you believe in either science or religion, as 'they're kind of opposites'; he continued by saying that '…some people think science started the Earth and some people think God or, or another person started the Earth'. Sebastian agreed: 'Well, most people have one certain opinion, so you're either science or a different cultural belief'. He believed that science is true because 'science is about knowing, and religion doesn't always know…..and the things that we don't know, a lot of people say God, or ah, religion, um, has made that or done that…um so they're kind of joined because things we don't know, they put God in'. So if one point of view is right, then the other must be wrong.

There was a feeling (28.1%) that science and religion disagreed on so many things that they could not both be right (item 17), and while 23.4% disagreed with this statement, a large percentage (39.1%) remained unsure. Rick was convinced that you have to believe in either science or religion about some things, when they come together into something complex like the beginning of the universe: 'Um, I am pretty religious but I think that science created the beginning of the universe'. Jeff equated the 'clashes' between science and religion as being like politics:

> …nine out of 10 times they do agree there, and I think a lot of things that people don't really hear about as much, that science and religion sort of fit in very well with each other…..they say you go to the afterlife. scientists have nothing really against that, it's sort of 'Okay, maybe, maybe not, it doesn't really matter whether you do or not, that's sort of not our thing', and they're just okay with it.

As one survey respondent put it, there are particular issues around which science and religion clash: I believe that if science was all correct, then science and religion would almost work together like friends. But because of evolution and other theories, this does not happen.

Certainly, within the cohort of survey respondents involved in this study, evolution was a concept that was not well understood, with 39.3% disagreeing with the statement that animals and plants evolved from simpler organisms and 49.2% agreeing that humans did not evolve from simpler organisms. While a large percentage (76.6%) felt sure that the universe was created by God (item 11), a much smaller percentage (15.9%) felt that this view was compatible with the Big Bang (item 13). The scientific theory of evolution of humans was also seen by 35.9% of survey respondents to be incompatible with our having been created by God or a Greater Being (item 12). Patrick had come to the conclusion, however, that science helps religion: 'science says that…religions wouldn't have been able to figure out that God created the world without science…it helps religion work things out'.

A person's background was perceived as being very influential in forming ideas, for example, 'if they're from a religious background, then…' was a common stem from which the children expressed their thoughts. Stories the students had grown up with in their family and or church, and for Christians, their reading of the Bible, were seen to be very influential. In Christian families, if the Bible was taken literally, then gap between science and religion was perceived to be very large, as Frank explained: 'the Bible says that yes God created humans, like full stop. He creates us, with everything else. We didn't like slowly become humans. We just, were there'. Frank went on to share his opinion that science puts religion down, and tries to prove there is not a God: 'It's trying to get evidence that there's not a God. Like while doing that it's sort of getting like evidence that there is a God'. His understanding, he explained, had been informed by conversations he had at his church and through reading the Bible, but very little by his teachers in school. While he was interested in these questions he wouldn't ask questions at school, preferring to ask his pastor with whom he had a good relationship, or with family members at home. As Jeff explained, people surrounding children are very influential: '…unless I started off as a fully formed adult, I sort of get, as a kid I get influenced by people around me…. and [for me] they're more, as I said, scientific in terms of their beliefs, so, yeah, I've probably just sort of listened to that, and went 'mm, yeah…that makes sense'.

Silvester talked about his classmates as coming from a particular religion or having a Christian background due to the fact they were attending a Christian school. He compared their thinking about the issues being raised in the survey and interview, with his own that he said he was still thinking about: '…they probably believe the Bible more than I do. I'm just trying to put…just trying to think, but I'm not quite sure…I reckon a lot of them are sure. Yeah, because their parents and stuff… they're sure of what they know'. Silvester also made assumptions about what his teachers thought about the relationship between science and religion: '…I think a lot of teachers probably don't agree with science at this school. I know there'd definitely be a few, yeah, but they can't exactly tell their students what to believe'. He had gained these ideas by listening to what they said about the Bible: 'a lot of talking about how the Bible is right, whatever's in the Bible is true…', and he had picked up on the nuances of his teachers' language: '…a lot of teachers I have had in the past have said…about people that speak science, that are scientists, and believe in the different things, they often say the word 'they', so like "they believe", yeah…'. Silvester admitted that he did not talk about these ideas at school, '… because a lot of people would disagree with me', but instead talks about his misgivings and emerging ideas at home. Rick agreed that background was important when it came to forming ideas; so a scientist might believe in miracles: 'because it might be the way they're brought up or something'. Students created linkages which seemed to make sense to them, as Rick explained: 'Um I think there might be a relationship but…like people say God created science…so God created science which created the Big Bang'; however, he was also aware that there was a contested space here: '…there's lots of debates between science and religion…whether it's, which one's real or not'.

This level of doubt might have contributed to the students' choice of people to whom they talked about science or religion. Children perceived the people they know to be committed either to science or to religion, and categorised them as being sciency or religious, depending upon their knowledge of the person: 'Oh yeah my dad knows a lot about science so he teaches me' (Bailey); or in regards their job, or how they behave: 'Depends, if my home teacher is very religious, then may be them…you can tell when they're in the chapel if they're quite religious or not…just the way they behave'. Students would talk to sciency people or people with a background in science, about science: 'Dad's quite a sciency person. I talk to him a lot about it' (Michael), but not religion: 'Not really. That sort of stays at home' and vice versa. Patrick talked to his brother about science as he is doing chemistry at university, and speaks about religion at church, but does not talk about any of these things with others at school. Jeff had 'sussed out' his parents: 'my Mum mainly because she's more science, but my Dad, yeah, he knows a fair bit, but it's not his background in terms of his job'. He was choosing people whom he respected and thought could give him an informed answer. Similarly, for Bob, when asked at the end of the interview if he talked about the topics discussed during the interview at home, he said:

> 'Ah, not really, I talk about religion, wait, not together, but I talk about religion and science to my mum and dad'. (Bob)

This rigidity relating to whom you talk to about what extended into the classroom – students indicated that they asked science question in science and religion questions in religion classes: 'Um…Not really. Like, if you were going to ask a science question, you'd seem to ask it – to a science person' (Michael). As Marg pointed out there are rules about how and when you ask particular questions: 'Don't ask questions about science in religion and don't ask questions about religion in science, it's breaking the rules of religion, religion and science have nothing to do with each other'. A large percentage of students (42.2%) indicated that their teachers had not talked about whether science and religion fit together, with another 37.5% not sure if they had or not, and 18.8% indicated that they thought they might have: *They have not specifically talked about this, but the topic has definitely been mentioned.* If the children had questions about how science and religion fit together, they indicated in interview that they were mostly likely to ask their religion teacher rather than their science teacher.

Bob recognised, however, that there was a dichotomy between the ideas portrayed in science/scientists and religion/religious people and felt that he needed someone in the middle between science (e.g. science teacher) and religion (e.g.

Chaplain) to help him come to understand the truth: 'I reckon that would be, ah, you would get, so, Rev [Peter] would say more religion, and then, so, 75% religion and then 25% science, if he would talk about both, because he would be leaning towards religion, because that's his main, um, ah, like, that's his main like study…And then the science teacher would be like 75%, ah, science and then 25% religion, so you would have to find, like, someone in the middle' (Bob).

Shane was lucky enough to have a person close to him, his Pa, who was both religious and interested in science, and he talked to him about the relationship between the two.

Considering the Perspectives of Both Science and Religion

During the interviews, students indicated that they rarely thought of science and religion together, but as a result of participating in the research, recognised it as an interesting thing to do and welcomed the opportunity to do so. A large proportion (47.6%) displayed a thirst to 'find out' about things they did not know, and about how science and religion/cultural beliefs 'fit together' (item 37 and 38): 'Actually, yes, I would [like to know whether science and religion fit together], because I want to know as much as I can. So if they do fit together that's another thing that I know' (Sebastian). When asked if she was interested in whether science and religion fit together, Esty said that as a result of doing the survey, she was now: 'well, I wasn't interested before, but now I think about it more'. Just by participating in the conversation or the survey, some children indicated that they would be thinking further about the questions we touched upon: 'Ah, yea, I reckon I will ask some question the next time I have a chance to just see, ah, if, like reverend [Peter] believes in, ah, religion and science going together well' *(Bob).*

Bailey, who professed not to believe in God or have a religion, stated that he thought about these two ideas together because he wanted to know how science 'proves religion wrong': 'Yeah I just basically want to know which one is actually right…I just believe science basically because it seems more the reality of things'. Bailey felt that many of his classmates did not know much about science and religion and what they each say about being human: 'They would just believe the um priest and go with the things they, he says because like the kids in my class including me don't really know much yet about these two'. He confessed that most of the things he had said in the interview were purely things he had figured out in his head, rather than understanding them through talking about them or learning about them in school.

One student mentioned that it was when he struggled with concepts/ideas that were hard to imagine or explain, for example, the Big Bang, that he might think of science and religion together. It is when such issues are raised, that the two domains might be thought about together, as Michael suggested: 'I find it hard to think that someone's – something's going and created everything. Like, something had to be there first, that the problem…and where, like, if God created everything, where did

God come from?' He struggled to think about what started the Big Bang. Peter felt somewhat similarly: 'Because like things don't magically appear but they did magically appear and it's just kind of going against science rules'; he continued pondering '…because you'll need things in the first place to get the other things and how did those things in the first place get there…if God created everything, who created God?'. So the whole beginning of the universe and development of humans is a puzzle in itself and '…that you'll almost likely never know…there's not people here [to ask] from Adam and Eve's time', only science people and religious people. Similarly, evolution and how it relates to Adam and Eve is a dilemma, as Michael explained: 'Um…I just think it's a little bit of luck that it's happened, and it's…sort of confusing how humans seem to be the only, um, really super intelligent life form'. Jeff thought that ideas like this make it inevitable that we should think about the existence of God: 'Yea, it's something I've thought about, because, yeah, who can't think about something so big?'

Over half of those students surveyed (52.4%) indicated that they have not learnt anything about scientists who believed in God or a Greater Being in school, with a further 15.9% unsure whether they had or had not. Miracles also caused a dilemma for students; unless they were provided with a way to think about miracles, which allowed them to make sense of them, then any progress in thinking is curtailed, as Michael explained: 'I've just found it very hard to believe that a miracle could happen, and sort of, stopped there'. Unsurprisingly, only 18.8% of students agreed that their teachers had talked about whether science and religion fit together, with 42.2% disagreeing with the statement and a further 37.5% remaining unsure. As one survey respondent commented, all students no matter how old pondered about such complex issues: 'I reckon if you're old enough to go to school, you're old enough to have thoughts about things, yeah'.

Whether they have the ability to ask nuanced questions that help them understand how religion and science relate to each other is open to question, however, as Peter explained: 'well they ask science questions and they ask religion questions but they never say it together'. Big questions about this would normally be asked of the pastor, but he would ask science questions of the science teacher. Hence students like Michael, who just let his thoughts fizzle out, and Jeff, who confessed to being undecided: 'So, yeah, just, I'm sort of in a neutral zone, not really atheist, but not really fully against it, so yeah', will remain unsure.

Discussion

The students' survey and interview responses indicated that their ideas about both the nature of science and the nature of religion are still forming. The majority of children recognised science and religion as being different, although they talked about these differences solely in terms of the explanations they provide rather than the questions they ask or purposes they serve. It was not uncommon for students to indicate that science as a discipline had a view on matters such as the existence of

God (item 26 and 30), miracles (item 27) and the influence of prayers (item 28). While not specifically asked, none of the children's responses indicated that they understood the ways in which claims made by science are generated, beginning tentatively (Bickmore et al. 2009) and open to contestation and revision in the light of new or reinterpreted evidence, or that there are well-established ideas in science (e.g. the earth rotates upon its axis and orbits the sun) which are no longer considered tentative. No respondents mentioned anything about there being particular questions asked by scientists, and these questions being those that generate testable claims about the observable, physical world. In Australia, by the end of grade 6, students should be able to develop investigable questions and design scientific investigations looking into simple cause-and-effect relationships. The curriculum, therefore, provides teachers with the incentive and opportunity to interrogate the nature of science, to explore the types of questions that enable the creation of data and to collaboratively determine what their data might mean. The idea that science *proves* things can be unearthed and disputed, through a discussion about the methods the students use and further questions that remain unanswered as a result of their investigations. In Australian schools, while teachers are expected to enable learners to understand the nature of science, they themselves may have never experienced authentic science or developed an understanding of the epistemology of science well enough to teach it effectively.

Scientific investigations also provide the opportunity to use scientific language with clarity and purpose as necessitated by the nature of the discipline. They are the ideal opportunity to explore how we use the term 'belief' and 'believe' in our environment, be it the science environment, the school environment or in our private lives. Price (1965) explained that '….belief-in is an attitude to a person, whether human or divine, while belief-that is just an attitude to a proposition' (p. 5). What is important here is that teachers can provide opportunities for children to unpack the definition of belief and the distinction between the empirical 'belief that' and the non-empirical 'belief in' as a way of developing ways of understanding the discipline of science. When scientists use the word believe (e.g. I believe in the Theory of Evolution), they are really saying that they 'accept the theory' or 'believe that it is correct' (Cooper 2001). These belief statements have degrees of uncertainty and are constructed based upon observable facts, which cohere with rules of logic and have been subject to the process of argumentation. Some thoughts, feelings and beliefs are not empirical; rather they might be philosophical, emotional or religious and not meant to be tested experimentally. Enabling the shared understanding of the meanings of words and phrases helps children to feel comfortable about 'believing in' something while understanding that scientists base their beliefs on the interpretation of empirical evidence within their more holistic understanding of the phenomenon and the discipline, as that is the nature of science.

If there is no way to gather empirical evidence to answer a particular question (does God exist?), then it is not useful for the discipline of science to either pose or answer the question. Equally, if it is not possible for scientists to determine the efficacy of a particular statement (magnets cure cancer), they are unable to support (believe) the claim. While students in this study referred to evidence in science and felt quite comfortable using the word in that context and imagining experiments that would provide such data, they did not have the same confidence when talking about religion or God. Whether they understood the more nuanced definition of empirical evidence or how the analysis and subsequent explanation of the data is a socially constructed endeavour remains unknown. However, many students at interview felt troubled about the extent to which they could argue for evidence in religion. Does a belief in God require evidence in quite the same way as a belief in the efficacy of penicillin in killing some types of bacteria? Is it appropriate to challenge or critique religious beliefs as is the case for beliefs in science? A number of children stated that they felt you should not challenge someone's belief because it is their belief. As described earlier, our understanding of what evidence is differs across disciplines and unpacking these similarities and differences alongside the nature of belief provides children with some tools to understand how they think, feel and can talk about their religious beliefs.

The initial data reported here suggest that there is value in providing opportunities for children to articulate their ideas about science and religion (beliefs and/or world views) both separately and together. Avoiding a discussion of such underlying issues when teaching science and leaving religious beliefs outside the classroom, fearing that heated arguments or offence may follow, is not the solution as students tend to bring their understandings and beliefs with them (Ecklund 2007). As a number of the children mentioned, either they or their friends come from 'religious families' which they felt would most likely have a big impact upon their belief in either science or religion. The children interviewed were all attending either faith-based schools or non-denominational private schools, but not all of them were religious or admitted to believing in God or a Greater Being. All of the students who participated in the interview said that they found it useful to complete the survey and discuss their thoughts about such concepts in more detail in interview. While many indicated that they had access to people with either interest in science or in religion, only one child, Shane, had someone whom he felt he could talk to about both.

These children may benefit from discipline or curriculum 'boundary crossers' who '…understand the connections between diverse, and seemingly separate, disciplines. [who] know how to link apparently unconnected elements to create something new' (Pink 2005, p. 110). Teachers in primary school have the opportunity to think and act in this way as they engage with the priorities, disciplines and capabilities listed in the Australian Curriculum. While the research reported upon here relates to children in year 6, it would be possible to map an appropriate sequence of developmentally appropriate activities that would engage children with such epistemological and philosophical discussions through to their final years of schooling. Just as Ecklund (2007) found from surveying university scientists, it would not be unexpected to find that generalist school teachers of year 6 students in Australia do not have the experience to deal effectively and respectfully with their students' ideas and concerns about science and religion.

This research highlights the challenges present for both religious and science education in Australian state and non-denominational private schools. In Australia, generalist primary school teachers have to engage with science in the curriculum, but they may only have to talk about religion in faith-based schools. Even in such schools, beliefs are often kept private as Sebastian suggests: ‘Um, I don’t really talk about religion, because it’s not one of those things that you kind of talk about’. Where such attitudes exist, perhaps for both students and teachers, it is unlikely that the perceived science-religion ‘conflict’ will be unearthed and addressed in a developmentally appropriate manner. The research undertaken in the *Being Human* project and the ongoing research of LASAR contribute to understandings which will inform the development of curriculum materials for teachers to use in their classrooms. At the very least, teachers are able to address students’ doubts about religion and its relationship with science, by teaching the nature of science and the nature of religion well, which enables the students to come to their own understanding of how the two areas might interact.

References

Alexander, D. R. (2007). Models for relating science and religion. *The Faraday papers, Paper 3.* Cambridge: The Faraday Institute for Science and Religion.

Australian Bureau of Statistics. (2006). *1266.0 – Australian Standard Classification of Religious Groups (ASCRG), 1996*. Retrieved from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Previousproducts/775012EF0058A77DCA25697 E00184BDC?opendocument

Bickmore, B. R., Thompson, K. R., Grandy, D. A., & Tomlin, T. (2009). On teaching the nature of science and the science-religion interface. *Journal of Geoscience Education, 57*, 168–177.

Byrne, C. J. (2014). Religious education, social inclusion and interreligious literacy in England and Australia. *Journal for the academic study of religion, 27*(2), 153–177.

Clark, K. J., & Samuel, A. (2011). Morality and happiness. In K. J. Clark & R. J. Vanarragon (Eds.), *Evidence and religious belief* (pp. 157–174). Oxford: Oxford University Press.

Cooper, R. A. (2001). The goal of evolution instruction: Should we aim for belief or scientific literacy? *Reports of the National Center for Science Education, 21*, 14–18.

Davies, P. (1983). *God and the new physics*. New York: Simon & Schuster.

Dutch, S. (2002). *The single greatest misconception about religion*. Retrieved from: https://www.uwgb.edu/dutchs/PSEUDOSC/BigMiscon.HTM

Ecklund, E. H. (2007). Religion and spirituality among university scientists. In D. Mayri (Ed.), *The religious engagements of American undergraduates*. New York: Social Science Research Council.

Galileo, G. (1615). *Letter to the Grand Duchess Christina of Tuscany*. Retrieved from: http://www4.ncsu.edu/~kimler/hi322/Galileo-Letter.pdf

Jammer, M. (1999). *Einstein and religion: Physics and theology*. Princeton: Princeton University Press.

Kelly, T. (2011). *Consensus gentium:* Reflections on the ‘common consent’ argument for the existence of God. In K. J. Clark & R. J. Vanarragon (Eds.), *Evidence and religious belief* (pp. 157–174). Oxford: Oxford University Press.

Pink, D. (2005). *Whole new mind: Why right-brainers will lead the future*. New York: Riverhead.

Polkinghorne, (2007a). The science and religion debate: An introduction. *The Faraday papers, Paper 1.* Cambridge: The Faraday Institute for Science and Religion.

Polkinghorne, (2007b). The anthropic principle and the science and religion debate. *The Faraday papers, Paper 4.* Cambridge: The Faraday Institute for Science and Religion.

Price, H. H. (1965). Belief ‘in’ and belief ‘that. *Religious Studies, 1*(1), 5–27.

Price, H. H. (1969). *Belief*. London: George Allen and Unwin.

Prideaux, R. A., & Pepper, A. R. (2012). *Science and faith: What is the problem?* Adelaide: Digital Print Australia.
Randolph, J. L. (2005). Epistemology for the masses: The origins of "the scientific method" in American schools. *History of Education Quarterly, 45*(3), 341–376.
Reiss, M. J. (2008). Should science educators deal with the science/religion issue? *Studies in Science Education, 44*, 157–186.
Sandoval, W. A. (2005). Understanding students' practical epistemologies and their influence on learning through inquiry. *Science Education, 89*(4), 634–656.
Smith, M. (2014). The epistemology of religion. *Analysis, 74*, 135–147.
Straine, G. (2014). *Introducing science and religion: A path through polemic*. London: SPCK Publishing.
Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2011). To what extent do pupils perceive science to be inconsistent with religious faith? An exploratory survey of 13–14 year-old English pupils. *Science Education International, 22*(2), 99–118.
Trigg, R. (2007). Does science need religion? *The Faraday papers, Paper 2.* Cambridge: The Faraday Institute for Science and Religion.

Prof. Berry Billingsley specialises in Science Education and leads the LASAR (Learning about Science and Religion) research team at Canterbury Christ Church University. Her interests include students' ideas about the nature of science and, more broadly, developing strategies to support the development of epistemic insight, young people's engagement in science, artificial intelligence, Big Questions bridging science, religion and the wider humanities and the communication of science and technology news in the media. Equipped with a physics degree, Berry's first career was with the BBC where she produced and presented television and radio programmes including BBC World Service's 'Science in Action', BBC TV's 'Tomorrow's World' and BBC Education's 'Search out Science'. She then travelled to Australia, to become a senior project manager with the Department of Education. She regularly publishes in science education.

Sharon Fraser is a Professor of Science Education at the University of Tasmania, Australia. Sharon began her career as a scientist before becoming a teacher of secondary science, mathematics and ICT and proceeding into science and STEM educational research. Her research spans science and mathematics curriculum and pedagogy in both school and higher education, and the professional learning of educators. Sharon is committed to building capacity, enacted through learning enhancement initiatives and STEM research, focussing on the increased engagement in science learning through improved teaching practice, the investigation of what is knowable in science and interdisciplinary learning.

Chapter 17
Introduction to Beyond Chalk and Talk Section

Sharon Fraser and Keith Chappell

Introduction

One of the greatest challenges for pedagogy in the field of science and religion is taking the insights of scholarly activity, whether gained through philosophy, theology or empirical studies, and applying them to the reality of the classroom. In this final section, we bring together a collection of chapters that apply these universal insights to particular situations, whether educational, cultural or national settings. Each author strives to step beyond simple 'chalk and talk' and seeks to bring the issues of science and religion to life whilst recognising that this endeavour is unlikely to receive much space in any curriculum.

In *Science, Ethics, Education and Religion: Connecting and Disconnecting,* John Bryant discusses the authority of science and its moral norms and limits through a consideration of bioethics, with a particular focus on two case studies relating to the 'start of life'. Through his commentary, we are reminded of the ethical issues that face the practice and application of science, particularly in regard to what risks we consider to be acceptable and who has the right to decide. Whilst ethics is concerned with the moral rightness or wrongness of the ways in which humans treat and interact with others, he argues that there is moral significance beyond human beings, citing the intrinsic moral value of the environment. Through his case studies, we are asked to consider the biology of embryonic development and the complexity of the ethical decisions human beings are being asked to make.

S. Fraser (✉)
College of Arts, Law and Education (CALE), University of Tasmania, Hobart, Australia
e-mail: sharon.fraser@utas.edu.au

K. Chappell
LASAR (Learning about Science and Religion), Canterbury Christ Church University, Canterbury, UK
e-mail: k.chappell403@canterbury.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_17

As Bryant emphasises, the bioethical discourse remains fluid, and the debate in this arena is ongoing, underlining the pivotal nature of ethical and bioethical education that draws from a diversity of (world)views: scientific, philosophical, sociocultural and religious.

Richard Cheetham addresses the conflict narrative that prevails in regard the relationship between science and religion in his chapter, *Lies, Damned Lies, Science and Theology*. He acknowledges the influence of science on our epistemology, philosophy and theology whilst drawing from the teachings of Thomas Aquinas in viewing the relationship between science and religion as founded in the pursuit of truth. Cheetham explores myths about science and theology and provides three examples of how social media, film and popular fiction distort both science and theology. He points to issues with school curricula and the lack of explicit teaching of the nature of either science or religion or enabling students to pose and consider questions that could be considered from both scientific and theological perspectives. Cheetham also admonishes Christian churches for not enabling the theological perspective and language to be informed by scientific viewpoints. The chapter concludes with a way forward which challenges the absolutism of both science and religion, enables an understanding of the truth claims of each and results in a meaningful conversation between science and theology.

In Elisabetta Canetta's chapter on *Physics and Faith Synergy*, she echoes the sentiments expressed through Cheetham's writing. Canetta provides us with a detailed summary of a methodology aimed at addressing the perceived schism between science and religion, utilising faith as a medium for understanding. The chapter summarises the outcomes of a series of workshops undertaken by Canetta and colleagues from St Mary's University in London, which focussed on particular concepts in physics, discussed from the perspectives of both physicists and theologians. The presentations and subsequent audience-led discussions enabled the participants to recognise synergies between their faith and physics, which rekindled their interest in physics. Through their evaluation of the series, Canetta found that for a large percentage of the participants, the driving force behind their choice to come to the workshop was their faith. Their involvement in the series enabled participants to recognise similarities between their faith and physics enabling a bridge to be built between the two. Such an outcome challenges the notion that physics and faith cannot coexist.

Siew Fong Yap examines the potential of the cinema in education in her chapter, providing some specific ideas and examples but also guidance regarding the whole approach. The stimulus for the work she reports is the Australian curriculum which includes an element 'Science as Human Endeavour' which asks students to consider science in its broader historical and social context. This is surely something all those developing science curricula should take seriously. As Yap reports, much of the understanding of science amongst young people is gained through popular media such as films and critical understanding and evaluation of such sources helps to equip students to challenge the quality of the science portrayed. This is perhaps true of the relationships between science and religion as much as any other aspect of science, and so any attempts to address many of the issues raised in this book must take popular media seriously.

Paiva, Morais and Moreira provide some insight into the specific challenges faced in a Catholic setting through their study of Portuguese high school students in *If neither from evolution nor from the Bible, where does tension between science and religion come from?* They take the classic flash point of teaching evolution in a Christian setting as their starting point and go on to consider the attitudes of Catholic students and 'non-believers' to the relationship between science and religion. They find a lack of conflict between science and religion in this Catholic educational setting but do encounter a sense of incompatibility in some aspects, coming from both believers and non-believers. Arguing that this is detrimental in terms of both religious and science education, they call for the teaching of more complex notions of science and religion to enable more nuanced relationships to be considered. Drawing on Kant, they believe such an 'enlarged mentality' will overcome narrow notions of both subject areas and facilitate meaningful dialogue.

Also rooted in a particular religious tradition is Mansour's *Science, Religion and Pedagogy: Teachers' Perspectives.* In examining the beliefs and views of science teachers from Egypt, he provides insight into teaching science whilst immersed in a particular religious and cultural context. Mansour ably describes the interaction of the context and the pedagogical approach taken by the teachers, providing some useful and enlightening explanatory models as he does so. The ability to examine the interaction of science and religion in education apart from the secular social setting of most studies provides a deeper understanding not only of the particular Islamic issues at play but also of the role of unchallenged assumptions in education more widely. Mansour closes with some practical, and pragmatic, suggestions for addressing the challenges raised by his study.

Many practical interventions have been proposed for schools attempting to address the issues raised in this book, and Bryant, Daneel and Henderson present a valuable comparative study of interventions used in the United Kingdom in *Engaging young people in positive, interdisciplinary exploration of science and religious faith.* Looking at three diverse interventions, they are able to identify some key aspects that contribute to the success of each, whilst honestly appraising the opportunities for improvements. Whilst insights regarding the need for engaging material may not be surprising, they also find the need for the creation of safe spaces when dealing with these issues which challenge educators regarding these and other sensitive issues. Finally, they develop some synthesis which provides some useful recommendations for those developing their own interventions.

What is clear throughout these chapters is a common belief that science and religion are not necessarily conflicting views of the world, or incompatible ways in which the world might be explored. All authors presume that the failure to address misconceptions about the relationships between science and religion, or to at least offer alternative ways of thinking about them, results in poorer cultural understanding and a less rich or nuanced understanding in many areas of education. Whilst it is perhaps not clear which areas suffer the most, it is not unreasonable to suggest that increasingly compartmentalised teaching and pedagogic or epistemological models which presume conflict reduce the broader understanding of both religion and science in our cultures. The fact that much study in this area is driven by people of faith suggests that perhaps 'science' as a subject and institution feels this gap less directly, but many of the studies in this book suggest that longer-term implications for science exist.

What then might we take away from these diverse studies? Firstly, students are open to dialogue and, indeed, welcome it. They have an agility of mind that allows them to decompartmentalise subjects and, if necessary, recompartmentalise as required. What appears to be lacking in both curricula and school structures is simply the opportunity or impetus for them to do so. Secondly, engaging in teaching about science and religion requires significant effort on the part of teachers. Certainly it requires teachers to be open to the advantages of such pedagogical approaches, but it may also mean that specialist professional learning is required, either postqualification or perhaps within their initial teacher education courses. For the curriculum to develop in schools, it may well have to develop in universities first. Thirdly, and perhaps most excitingly, teaching science and religion in concert provides a particularly good opportunity for creative pedagogy that both enhances subject matter knowledge and nourishes thinking and the broader learning of students at all levels.

Sharon Fraser is a Professor of Science Education at the University of Tasmania, Australia. Sharon began her career as a scientist before becoming a teacher of secondary science, mathematics and ICT and proceeding into science and STEM educational research. Her research spans science and mathematics curriculum and pedagogy in both school and higher education, and the professional learning of educators. Sharon is committed to building capacity, enacted through learning enhancement initiatives and STEM research, focussing on the increased engagement in science learning through improved teaching practice, the investigation of what is knowable in science and interdisciplinary learning.

Dr. Keith Chappell is a Research Fellow in the Learning about Science and Religion team at the University of Canterbury. He has previously taught biological sciences at the University of Reading and the University of Derby. Besides his interests in biology, he writes in the field of theology and religious studies, having been a Las Casas scholar at Blackfriars Hall, Oxford studying Christian social teaching. He is a Visiting Lecturer at the Maryvale Institute, Birmingham and Liverpool Hope University. He is also a theological advisor to the Catholic Bishops' Conference of England and Wales. In addition to science and religion, he is engaged in research in the sociology of religion and the philosophy of biology.

Chapter 18
Lies, Damned Lies, Science, and Theology: Why Everyone Needs to Know the Truth About Science and Religion

Richard Cheetham

Introduction

Both science and religion have a major, albeit variegated, influence across the world on how humankind understands the nature of reality. This in turn has a substantial effect on how we live—so the engagement between science and religion is a crucial conversation for the twenty-first century. It is not just for a few academic specialists but for everyone. This conversation is greatly hampered by the prevailing conflict narrative of the relationship between science and religion. This persists despite a very large body of academic literature which gives a much more nuanced and interesting perspective. My argument is that we need to move beyond this simplistic conflict narrative to a much richer description of truth in all its forms and that the way we teach science and religion needs to embrace a more holistic and interdisciplinary approach.

I begin with some gentle autobiography to explain why this issue is so important for me personally. As a teenager in the early 1970s, I studied physics and mathematics for my A-levels. I became increasingly aware that science and mathematics are hugely powerful ways of understanding the world and the way things really are. At the same time, I was attending a local Anglican church and learning more about the Christian perspective on life. Naturally, as a teenager I was asking all sorts of questions about life, the universe, and everything else. One of the songs which the church youth group used to sing regularly, entitled ‘Can it be true?’, asked about the claims which the Christian faith makes about the understanding of God to be found in the life, death, and resurrection of Jesus Christ. The question of truth is extremely important both in religion and science. As a teenager, I wanted to know how the understandings of the world which I had derived from both science and Christian

R. Cheetham (✉)
Bishop of Kingston, London, UK
e-mail: bishop.richard@southwark.anglican.org

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_18

faith related to one another. That question in part led me to study physics and philosophy at Oxford University and to go on to begin my working life as a physics teacher. After a few years, I entered ordained ministry in the Church of England, where the question of how we understand our lives is central. A proper understanding of the relationship between science and religion is key to that understanding. My doctorate in the 1990s (Cheetham 1999) explored the understanding of the nature and status of religious belief (with particular reference to the concept of 'truth') in contemporary Britain as reflected by acts of collective worship, which are still mandatory in UK schools. It concluded that, in that particular context, religious belief was essentially portrayed as 'an individually chosen, private, practical guide to living'. Any engagement with what might be seen as objective truth claims by any given religion was firmly side-lined in that context.

In the autumn of 2012, I was privileged to have a 3-month sabbatical based at the Church Divinity School of the Pacific in Berkeley, California, and to study at the *Center for Theology and the Natural Sciences.* I had gone with the intention of getting a bit more up to date with the literature and issues relating to my lifelong interest in science and religion as demonstrated by my first degree and my Christian faith. What I ended up with was a deep conviction that there is a major task both of understanding and, crucially, of communication, facing every church leader and educationalist. The attitudes of young people to science and religion are shaped by their families and upbringing, the cultural context in which they live, and by their education. In an age when God-talk has become increasingly irrelevant or nonsensical for many people (e.g. Lawton, New Scientist, 3.5.2014), a failure to communicate a view other than a conflict narrative can leave the field open either to New Atheists or Creationists. Both of these groups take communication very seriously, and the result is that many people are left with a very shallow understanding of the relationship between science and religion.

Modern science has grown exponentially since the seventeenth century, and, as a result, it permeates the whole way we see our lives and our world and what we consider to be ultimate and real. It shapes the way we see our epistemology (how we know things), our philosophy (how we understand reality), and our theology (how we speak of God). Religion, despite the predictions of secularisation theories, remains a widespread and influential part of twenty-first-century life. The conversation between science and religion is both challenging and fruitful and absolutely essential for any thinking person today.

My title echoes a famous nineteenth-century quote, 'There are three kinds of lies: lies, damned lies, and statistics' which is often, but probably erroneously, attributed to the then British Prime Minister, Benjamin Disraeli (University of York, 2014). It points to the widespread practice in politics of supporting weak arguments with dubious statistics which look incontrovertible at first sight but which collapse on closer examination. Today, many widespread caricatures and misleading images of both science and theology look plausible at first sight. A particularly pervasive popular view is that science provides reliable, useful, and objective knowledge, whilst religion and theology offer only speculative and subjective opinion. This is deeply damaging to both science and theology and takes no account of the large and growing body of academic literature which presents a much more nuanced view.

This article will explore popular myths about science and theology, give a brief pointer to the academic literature which gives a more holistic and nuanced approach, and then offer ways of enabling this more informed approach to be more widely heard in the education system, the church, and the wider world. I will also explain why that is crucially important to us all.

What's the Issue?

It is not difficult to find countless examples of distorted media images of both science and theology. Here are just three.

Late in 2012, the actor and writer, Ricky Gervais—who wrote and starred in the TV series, 'The Office'—tweeted a comment which referred to two stories which were then in the news. The first was a sky dive by the Austrian, Felix Baumgartner, who jumped from a helium balloon in the stratosphere and descended safely over 128,000 ft. to land in New Mexico. The second concerned the 14-year-old Pakistani schoolgirl, Malala Yousafzai, who was shot in the head by the Taliban for campaigning for female education rights. The Twittersphere was alive with Gervais's tweet, 'Dear Religion, This week I safely dropped a human being from space while you shot a child in the head for wanting to go to school. Yours, Science'. (Ellis 2012). This is, of course, breathtakingly simplistic.

The second example comes from the blockbuster novels of Dan Brown. In *Angels & Demons* (Brown 2000) the hero, Professor Robert Langdon says, 'Since the beginning of history a deep rift has existed between science and religion'. He continues:

> 'Outspoken scientists like Copernicus—'.
> 'Were murdered', Kohler interjected. 'Murdered by the church for revealing scientific truths.
> Religion has always persecuted science'.

Similarly, in *The Da Vinci Code* (Brown 2003), Langdon says, 'Unbiased science could not possibly be performed by a man who possessed faith in God'. If you are reading this sort of book, the likelihood is that you are not reading critically in a university library, but rather relaxing on holiday by a swimming pool with your critical faculties on sleep mode, and, of course, this kind of stuff can seep into you unawares, especially if you have had little in your education to delve deeply into the nature of science and religion.

The third example comes from a film. My guess is that if you were to name some famous interactions between science and religion, most of them would be along conflict lines: for example, Galileo and the Inquisition in the early seventeenth century over heliocentricity; Darwin, Huxley, and the Bishop of Oxford in the mid-nineteenth century over *On the Origin of Species*; the Scopes Monkey Trial in the early twentieth century over the teaching of evolution in public schools in Tennessee; and currently Richard Dawkins and the New Atheists' opposition to virtually all religion. Conflicts make good stories and film subjects. The film *Inherit the Wind* (1960) gave an influential take on the Scopes Monkey Trial, portraying science as enlightened, open, and forward thinking, whilst religion is bigoted and closed to new ideas. That artistic interpretation typifies many of the popular media accounts of the so-called conflict between science and religion.

Many of the current, excellent science documentaries on UK television are often framed by an introductory or concluding comment which portrays a particular view of the relationship between science and religion, usually that science has superseded religion as the source of reliable knowledge. For example, regarding cosmology, for thousands of years the best we had to explain the heavens were various religious views, whereas now, in the twenty-first century, we could dispense with such myths as we had access to the real truth via science. In addition, there are several prominent UK comedians, such as Dara Ó'Briain (who has a degree in science) whose routines are very funny but damning about the intellectual credibility of any religious belief. All of these examples illustrate the pervasive nature of the conflict narrative between science and religion in popular culture.

In the very useful and comprehensive book, *God, Humanity and the Cosmos*, Paul Murray (Murray 2005) summarizes the caricature of science and theology as follows:

- 'Science is a truly modern form of knowing, while theology represents a pre-modern throwback;
- Science is useful, whereas theology promotes a disengagement from reality;
- Science is value-free, whereas theology is compromised by personal commitment;
- Science is open to falsification and renewal, whereas theology is dogmatically entrenched;
- Science is based upon empirical data, whereas theology is a matter of pure speculation;
- In short, science seeks after objective truth, whereas theology deals only in subjective meaning'.

A second part of the problem with the science and religion debate stems from school curricula and the attitudes of young people. The widespread lack of teaching about the history and philosophy of science leads to a shallow understanding of the nature and scope of the scientific enterprise. In the USA, headlines are often taken by the controversy over whether so-called 'intelligent design' ideas should be taught as an alternative scientific theory to evolution. In the UK, the work of Professor Berry Billingsley and others has highlighted the tendency amongst school students towards attitudes of both scientism (science answers all the important and interesting questions) and a conflict narrative between science and religion (Billingsley et al. 2016). Neither is taught deliberately, but the outcome is an unintended consequence of a rather limited curriculum and simply reinforces the caricature which many people, not least young people, hold about the incompatibility of science and religion. There is more need than ever for good education which teaches not only the content of scientific theories but a deeper understanding of the nature of the scientific enterprise and for religious education which explores the nature of religion in all its guises.

A third area of concern comes from what goes on—or rather, what doesn't go on—in churches. Take, for example, sermons and church study courses. Despite the pervasiveness and importance of science to our way of thinking, there is often little or nothing in sermons about the interface between science and religion. There are several very good study courses available for churches, but this area is still a minority interest which usually comes to the surface when a minister gets enthusiastic about the subject.

There are many obvious occasions when it is vital to inform a theological perspective with scientific ones. For example,

- How might a sermon on prayer really explore our understanding of divine action in the light of modern science? Without this, we can be left with an understanding that God intervenes arbitrarily if we ask persistently enough.
- How is our understanding of humanity as being made 'in the image of God' affected by theories of evolution and our genetic similarities to other species?
- What happens to our view of Resurrection and Eschatology in the light of cosmological theories about the future of the universe?
- How might we see the doctrine of the Fall in the light of evolutionary history?

A failure to address these very real questions can leave people with a deep uncertainty about the credibility of Christian faith in today's world.

There is, therefore, a tremendous need to improve the public understanding of both science and religion. All these examples suggest that the debate is being distorted by pervasive and extensive conflict caricatures of both in the media and in the church. What is taught in schools becomes very important in moving forwards to a better understanding.

Fortunately, there has been an explosion in the amount of academic study of science and religion issues during the last 30–40 years. Many high-quality books and scholarly articles are available. The *Center for Theology and the Natural Sciences* in Berkeley is only one of a number of many similar organisations which have emerged and have achieved a great deal in advancing the scholarly understanding of the issues. However, this academic debate is still largely a minority sport for enthusiasts. There have been some excellent attempts at communicating the material more widely, but they are fairly limited. The academic work is the vital foundation, and without it there would be nothing to communicate. But I consider that we now need a much bigger push on the communication of this material into schools, colleges, churches, the media, and elsewhere.

Why This Matters: The Question of 'Truth Claims'

Given the prevalence and ease of both communication and travel, most people today are aware that we live in a pluriform, interconnected world in which many different and sometimes conflicting world-views co-exist—atheism, humanism, and secularism—as well as religions of various kinds. In all this multiplicity, the questions are to know what to believe, how to live, and what attitudes we should take to the variety. Young people going through an education system need to be equipped with the intellectual tools to engage with this complex situation.

These issues become particularly sharp when we look at them through the lens of 'truth claims'. Most scientists would see themselves as critical realists, describing and explaining something which really is out there and to which our scientific theories point. Most followers of religions also, I suggest, see their religion, not just as a way of living, an emotional support and moral guide, but also as depicting the deepest realities. Both science and religion make truth claims.

However, given the history, it is tempting to downplay the role of truth claims in religion. Too much blood has been spilt over differences in doctrine. We are instinctively suspicious in today's postmodern environment of overarching metanarratives which claim to explain all, particularly if this is at the expense of saying everyone else is wrong. We distrust religious absolutists and prefer to relegate religious belief to the realm of private opinion.

One consequence of this has been the constant attempt to replace the absolutism of religion with the absolutism of science as the only proper way of knowing. The implication is that, if something cannot be put in the language of modern science, it belongs firmly in the domain of opinion or subjective attitude, not of proper knowledge. But this expansion of the domain and reach of science into what is known as 'scientism' can be as damaging and limiting as the religious absolutist approach.

Equally, we can be tempted to go to the other end of the spectrum and become lazy relativists. Finding that there is simply no way of discerning between all the competing world-views which surround us can result in finding one that suits you and helps you along in life and leaving it at that. It becomes nothing more than 'truth for me'. What is needed is a route that takes truth claims seriously without succumbing either to what Pope Benedict has called a 'dictatorship of relativism', (Ratzinger 2005) or to the tyranny of absolutism. Fr Timothy Radcliffe, the former head of the Dominicans, has written (Radcliffe 2005), 'A society which loses confidence in the very possibility of truth ultimately disintegrates. St Augustine called humanity 'the community of truth'. It is the only basis upon which we may belong to each other'. We need an approach to truth claims which is philosophically, theologically, and scientifically sound, a more holistic approach to reality which breaks down some of the more artificial divisions between science and theology.

Many of those undergoing science education may have a religious faith. It is vital for them to be able to engage intelligently with these issues and with the challenges which science brings to their faith. Consider, for example, the question of how we believe God acts in a world governed by natural laws. Does anyone really believe, for example, that devastating hurricanes or earthquakes are a result of direct divine action? Most people are more interested in listening to what the meteorologists and geologists have to say about them. What do we believe about the ultimate end of our lives and the universe? Big Bang cosmology suggests that the universe will either freeze or fry, alarming ends which seem to conflict with Christian understandings of Resurrection, Eschatology, and the new Creation.

There is a real issue about the appropriate context for such reflection to take place. Some may say that it has no place at all in a science lesson, and should be looked at, if at all, in religious education lessons. This could impoverish the engagement due to the lack of science expertise. Others might argue that such engagement is purely a matter for the Churches and religious communities. That could lead to a distorted view of the science. I would suggest that science is so much part of our understanding of reality that we have to work out how it is linked to theological language, and that can be done fruitfully in an educational context which has a more holistic understanding of truth and reality than materialist reductionism allows.

These issues are equally vital for those who are dismissive of religion. The caricature of scientism limits a deeper understanding of reality. In his recent book, *The Master and His Emissary* (McGilchrist 2009), the neuroscientist, Ian McGilchrist, has suggested that western culture over the last few hundred years has become dominated by the 'left brain' with a consequently restricted view of reality which emphasises reason, observation, and empiricism. What is needed, he suggests, is a more balanced conversation between left and right brain which will produce a more holistic understanding of reality.

The modern term 'science' emerged only in the nineteenth century, so the division between science and theology is relatively new, and, arguably, our understanding of these terms and their relationship has become increasingly distorted. The fragmentation of academic disciplines in the last 200–300 years has left a real issue for epistemology and the unity and interrelatedness of human knowledge, which is reflected in our education systems.

The political and social scientist Karl Deutsch described a nation as 'a group of people united by a mistaken view of the past and a hatred of their neighbours'. (Deutsch 1969). That might be taken as a good description of the current widespread understanding of the relationship between science and religion. The unidimensional understanding of knowledge which stems from empiricism and a narrow view of reason is one which leaves much to be desired. The conversation between science and religion is vital to enable a much richer conversation and understanding of the mysterious universe we inhabit—in short, to help us all in our pursuit of truth—and that is why it matters.

An interesting way into this more holistic understanding is via the work of Peter Harrison in his recent book, *The Territories of Science and Religion* (Harrison 2015). He goes back to the understanding of Aquinas that *religio* is not primarily a set of propositions but rather a virtue which is developed through acts of reflection, thinking, devotion, and prayer. As such, *religio* was an interior disposition of virtue which mutated only in the sixteenth century onwards into a set of exterior propositions. Similarly, Aquinas regarded *scientia* primarily as a habit of mind and an intellectual virtue. It involved deriving truths from first principles, and this included reflection on the highest causes of things including God as the first cause.

So What Can We Do to Encourage a Better Conversation Between Science and Religion?

Firstly, we need a better awareness of the science and theology literature which has been produced in academia over the last 30 or more years. A helpful approach is that of Mark Richardson and Wesley Wildman who use three categories for the academic literature when considering this issue: History, Method and Dialogue (Richardson and Wildman 1996).

We need to include far more of the ***history*** of science in the way science is taught. It is absolutely essential to get better and more accurate understandings of the way science has developed and its relationship with religion in general and the Christian church in particular. Several excellent scholars, including John Hedley Brooke, are working in this field. The fact that Ronald Numbers deemed it necessary to write a book with the title, *Galileo goes to jail and other myths about science and religion* (Numbers 2009) demonstrates the scale of the task needed to present a noncaricatured and more accurate account of what has actually happened. Such an approach can bring real life and colour to science education as we engage with the actual stories of how any particular scientific theory developed.

The conflict model between religion and science only really gained much purchase in the nineteenth century, fuelled by the publication of two rather partisan accounts of the relationship between science and religion, John Draper's *History of the Conflict between Science and Religion* which was published in 1875 (Draper 1875) and Andrew White's *A History of the Warfare of Science with Theology in Christendom* published in 1896 (White 1896). Both had particular contexts and agendas. Draper was infuriated by what he saw as an authoritarian Roman Catholic Church, and White was arguing for academic institutions such as Cornell University which were completely free from what he saw as the shackles of religion. Most historians of science now see these hugely influential publications as 'more propaganda than history' (Numbers 2009).

The second category in the literature, under the heading of '***Method***', is about a proper understanding of the nature of both the scientific enterprise and of theology. Science is not simply about wandering about collecting 'objective facts' which are lying around in the world and then using our reason to deduce broader theories and general laws which describe the patterns we see. It is far more complex and provisional. Even the simplest description and measurement is affected by the theoretical framework we bring to it. Even when a theory has been widely accepted, as Karl Popper emphasised, you can never conclusively prove it by induction. The best you can hope for is that a theory is not yet falsified because it only takes one counter instance to force the theory to change, either superficially or sometimes very radically (Popper 1963). Thomas Kuhn spoke of periodic 'scientific revolutions' such as the move from a Ptolemaic view of the solar system to a Copernican one or the transition from a Newtonian mechanistic understanding of the universe to the one described by relativity theory and quantum mechanics. In such revolutions, the whole conceptual structure changes (Kuhn 1962).

There needs to be an understanding of the limits of science. Science, because it deals with repeatable, observable phenomena, has no place for teleological final causes, and can only answer certain types of question. Crudely speaking, it deals with 'how' questions and not 'why' questions. Science also makes great use of models and metaphors to generate theories. These are not necessarily meant to be taken literally, but rather as fruitful ways of picturing and understanding what is going on. For example, we speak of electrons as both waves and as particles.

Theology, too, is far from being the blind unthinking acceptance of certain truths revealed in the scriptures or via the prophets. Rather, it can be seen as the reasoned reflection on the human encounter with the divine in all its variety. As such, it too can be described as a critical realist activity which uses models and metaphors to point to the realities being described and probed. It is a truthseeking activity. The apophatic tradition in theology warns us against taking any particular formulation as final. We should be very cautious before we describe any understanding of God as final or complete. Even those theological traditions with a very strong emphasis on the revelation of God need some methods for interpreting that Revelation.

These more nuanced understandings of the nature of science and theology make us much better placed to understand their relationship. Ian Barbour's famous fourfold classification—conflict, independence, dialogue, and integration—is only one of several typologies which attempt to delineate this (Barbour 1998). Each of Barbour's categories tells us something about the nature of this complex relationship, but for those like me, who regard the critical realist approach to both science and religion as the best position, the '***Dialogue***' model is the most challenging and fruitful.

The third category in the literature deals with particular issues within which there can be, and needs to be, a ***dialogue between science and theology***. Pick up almost any good science and theology book—for example, *The Big Questions in Science and Religion* by Keith Ward (Ward 2008)—and there will be chapters on:

- Theistic and naturalistic understandings of reality.
- Cosmology and creation, including the 'fine-tuning' phenomenon.
- God's relationship with the world including not only beginnings but also accounts of divine action.
- Evolution, so-called 'intelligent design' and the role of chance and purpose in the universe.
- Neuroscience and what it means to be human. Brains, minds, and consciousness.
- The implications of quantum mechanics and chaos theory.

…and so on. There is a vast and growing literature in every one of these areas, and it is the essential foundation for a better understanding of science, theology, God, and reality. This includes, for example, the approach by Stephen Hawking, who comes to the issue as an atheist, in his recent posthumously published book, *Brief Answer to the Big Questions* (Hawking 2018).

As long ago as 1955, the then Rouse Ball Professor of Applied Mathematics at Oxford University, Charles Coulson, argued that, in order to answer fully the question of what it means to be human, we need the multiple languages of science, the arts, and religion to engage with one another (Coulson 1955). Many of the big issues of the twenty-first century, such as artificial intelligence, climate change, genetics, and the growth of the Internet and its effect, will need high-quality dialogue. It will require a multidisciplinary approach which includes science, ethics, politics, and philosophical and religious world-views to engage with one another in a holistic way. Such conversation can be modelled and learned in a good education system which embraces the nuanced academic literature on the complex relationship between religion and science.

The *Center for Theology and the Natural Sciences* in Berkeley has used the Golden Gate Bridge as an image for the need to build the conversation between science and theology. The last 40 or more years of academic study have built a pretty good bridge in my view, but at the moment not many people use it. What is missing is the communication of that literature in a much more popular manner. We have only just begun to build the foundations in that respect. One attempt to get a much better understanding of the relationship between science and theology into the bloodstream of the church can be seen in *Equipping Christian Leadership in an Age of Science*, a Templeton-funded project which I am helping to colead with Professors David Wilkinson at Durham University and Tom McLeish at York University (Equipping Christian Leadership 2017). But this is only part of the story. A deeper understanding is also needed both in education and the media.

I have become more convinced than ever of the importance of this communication task in the area of science and theology, and I applaud the efforts being made so far. But far more needs to be done, and I hope I have given some pointers to how this might be achieved. The way in which both science and religion are taught in the education systems of the world is an essential context for this to happen in an informed way. Ultimately, this matters because both science and theology make important truth claims about the way things really are, and what we believe about this shapes the way we live. At present we have a divided view of reality which fails to integrate the understandings of both science and theology and in the process does justice to neither discipline. A fruitful conversation between these two extraordinarily deep and truth-seeking modes of discourse will give us a deeper understanding of our lives, our universe, and God. That will only happen if more and more people are better informed about the real nature of this conversation, and for that, communication really does matter. Over to you!

References

Barbour, I. G. (1998). *Religion and science –historical and contemporary issues*. London: SCM.

Billingsley, B., Brock, R., Taber, K. S., & Riga, F. (2016). How students view the boundaries between their science and religious education concerning the origins of life and the universe. *Science Education, 100*, 459. https://doi.org/10.1002/sce.21213. http://onlinelibrary.wiley.com/doi/10.1002/sce.21213/pdf. Accessed 28 April 2017.

Brown, D. (2000). *Angels and Demons*. New York: Pocket Books. https://docs.google.com/file/d/0B4-VlDLeqquWY0NNMk94ZGpDbWc/edit. Accessed 27 April 2017.

Brown, D. (2003). *The Da Vinci Code*. New York: Doubleday. https://docs.google.com/file/d/0B5Mu5en8hT40YU05cU1mYjFpMlU/edit. Accessed 27 Apr 2017.

Cheetham, R. (1999). *The nature and status of religious belief if contemporary Britain (with particular reference to the concept of "truth") as reflected by acts of collective worship in a sample of Luton schools since the 1988 Education Reform Act*. London: King's College London. Unpublished thesis.

Coulson, C. (1955). *Science and Christian belief*. London: Oxford University Press.

Deutsch, K. W. (1969). *Nationalism and its alternatives*. New York: Knopf.

Draper, J. (1875). *History of the conflict between science and religion*. London: Henry King & Co.

Ellis, P. (2012, December 22). Dear religion… Yours, science: The joke that needs to go away. *The Huffington Post.* http://www.huffingtonpost.com/philip-ellis/science-vsreligion_b_1975640.html. Accessed 27 Apr 17.

Equipping Christian leadership in an age of science. (2017). http://community.dur.ac.uk/christian-leadership.science/. Accessed 28 Apr 2017.

Harrison, P. (2015). *The territories of science and religion*. Chicago: University of Chicago Press.

Hawking, S. (2018). *Brief answers to the big questions*. London: John Murray.

Inherit the Wind. (Film; 1960). United Artists Corporation.

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Lawton, G. (2014, May). World without God. *New Scientist, 222*(2967), 3.

McGilchrist, I. (2009). *The master and his emissary – The divided brain and the making of the western world*. New Haven/London: Yale University Press.

Murray, P. D. (2005). Truth and reason in science and theology: Points of tension, correlation and compatibility. In C. Southgate (Ed.), *God, humanity and the cosmos: A companion to science and religion* (pp. 82–115). Edinburgh: T & T Clark.

Numbers, R. L. (Ed.). (2009). *Galileo goes to jail and other myths about science and religion*. Cambridge, MA/London: Harvard University Press.

Popper, K. (1963). *Conjectures and refutations: The growth of scientific knowledge*. London: Routledge & Kegan Paul.

Radcliffe, T. (2005). *What is the point of being a Christian?* London: Burns & Oates.

Ratzinger, J. (2005, April 18). *Homily of his eminence Cardinal Joseph Ratzinger, Dean of the College of Cardinals*. http://www.vatican.va/gpII/documents/homily-pro-eligendopontifice_20050418_en.html. Accessed 28 Apr 2017.

Richardson, W. M., & Wildman, W. (Eds.). (1996). *Religion and science: History, method, dialogue*. New York: Taylor & Francis Ltd.

Ward, K. (2008). *The big questions in science and religion*. West Conshohocken: Templeton Foundation Press.

White, A. D. (1896). *History of the warfare of science with theology in Christendom*. New York: D. Appleton and Company.

Richard Cheetham The Rt. Revd. Dr. Richard Cheetham is Bishop of Kingston, Whitelands Professorial Fellow in Christian Theology and Contemporary Issues at the University of Roehampton, Honorary Research Fellow at King's College, London and a former teacher of physics in secondary schools. He read Physics and Philosophy at Oxford University where he developed the lifelong interest in truth-claims which is evident in his work promoting understanding of the relationship between religion and science. He is co-leader of a national project, 'Equipping Christian Leadership in an Age of Science' based at Durham University and funded by Templeton; is working to develop more holistic approaches to the teaching of science and education in schools; and serves on the Church of England's Environment Working Group.

Chapter 19
Interface Between Science and Faith Values in Movies with a Focus on the Use of Socio-scientific Issues (SSI) in an Australian Christian College

Siew Fong Yap

Introduction

The positioning of science as critical to international competitiveness, economic viability, and national science capability in several countries (Millar and Osborne 1998; AAAS 1989; Organisation for Economic Co-operation and Development 2006, 2009) has influenced recent thinking about school science and, in particular, how science is taught in secondary schools and tertiary institutions in Australia (Goodrum et al. 2001; Goodrum and Rennie 2007; Aubusson 2011; Fensham 2016). In addition to this re-emergence, there is a renewed emphasis on science interest and engagement due to the evidence of lack of student interest and lower participation rates in science learning (Batterham 2000; Goodrum et al. 2001; Hattie 2016).

In the development of the Australian school science curriculum, the objective was to create a comprehensive and contemporarily relevant curriculum, emphasizing science inquiry (student investigations, contextualized and relevant science experiences, generating and testing ideas), as well as a raft of changes to pedagogy, school science environments, teacher preparation, and professional learning that were not readily dealt with by the curriculum. Tytler (2007) supported general positions taken by Goodrum et al. (2001) on the main features of the Australian science curriculum and highlighted the need to exploit and create dispositions toward science, to feature creativity and exhilaration in science learning, taking care to avoid rigid prescription. Generating and sustaining interest in science was seen as critical to long-term engagement. So, the intent of the Australian science curriculum to promote student engagement with science was explicit in the national science documents, namely, the *Framing paper* (National Curriculum 2009b) and *Shaping paper* (National Curriculum Board 2009a).

S. F. Yap (✉)
Curtin University, Perth, WA, Australia
e-mail: siewfong.yap@curtin.edu.au

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_19

The Australian Science Curriculum and the Science as a Human Endeavour Strand

A brief summary of the aspects of the new National Science Curriculum follows. It states that: The study of science for Foundation to Year 10 is designed to develop students' interests in science and appreciation of how science provides a means of exploring and understanding the changing world in which they live. It provides an understanding of scientific inquiry methods, a foundation of knowledge across disciplines of science; and develops an ability to communicate scientific understanding and use of evidence to solve problems and make evidence-based decisions. (ACARA 2016)

The new science curriculum is structured into interrelated strands. These are Science Understanding (SU), Science as a Human Endeavour (SHE) and Science Inquiry (SI) Skills. Science Understanding includes content in the areas of biological science, chemical science, Earth and space science, and physical science. Science as a Human Endeavour refers to the nature and development of science and the use and influence of science in society. Science Inquiry Skills focuses on skills that relate how scientists work, so that students question, predict, plan, and conduct investigations, process and analyze data and information, and evaluate and communicate information from investigations.

Of notable interest is the need for informed citizenry that has been perceived as pertinent to significant national and international policy. The strands most frequently described as positively contributing toward a scientifically literate Australia are Science as a Human Endeavour and Science Inquiry, rather than the Science Understanding (Aubusson 2011 p. 235). The focus placed on Science as a Human Endeavour is considered to be a *huge* improvement to previous science curriculum initiatives (Atweh & Singh 2011, p. 191), *italics* emphasis mine).

The Science as a Human Endeavour (SHE) strand incorporates cultures and historical traditions and embraces a thinking of science as a humanistic endeavour that takes into consideration values and ethics of society, and as such, it presents a platform for discussion of values and morals. In this respect, SHE strand links with the nature of socio-scientific issues (SSI) on various fronts. The SHE strand emphasizes an understanding of science concepts and processes which would lead to informed citizenry capable of enacting their knowledge in personal and societal issues. The accessing and integrating of science knowledge in different societal contexts is a complex process that calls for the learning of argumentation that characterized socio-scientific orientations. Such a learning of argumentation takes places through immersion, teaching the structure of argument, and emphasizing the interaction of science and society (Cavagnetto 2010, p. 336). Immersion-oriented interventions used argument as an integrated component to student investigations. Hence, scientific literacy thus developed is supported by the integration of science concepts and processes, metacognitive processes, critical reasoning skills, and cultural aspects of science. Collectively, these understandings and abilities reflect the practice of science.

Socio-scientific Issues and Science Literacy from a Science Educator's Perspective

Socio-scientific issues (SSI) are open-ended, ill-structured, debatable problems that involve multiple perspectives and interpretations in the discipline of science in daily life, technology, and society (Sadler 2009). The use of SSI under the SHE strand of the Australian science curriculum coheres well with the visions of scientific literacy proposed by Roberts (2007) and Callahan and Dopico (2016). Science education must provide students with all four dimensions of the cognitive process: *factual* knowledge, *conceptual* knowledge, *procedural* knowledge and *metacognitive* knowledge (Callahan and Dopico 2016, p. 411). We can observe in classrooms at all levels of education that students understand the concepts better when they have the opportunity to apply the scientific knowledge in a *personally relevant* way. Scientific concepts are the products of human development and systematization of knowledge and reach educational institutions through the subjects of disciplines. Such concepts usually restructure the informal knowledge, allowing learners to reinterpret their experiences.

Douglas Roberts (2007) relates this sentiment with his two visions of scientific literacy.

Vision I relates to science itself, particularly the products and processes of scientific enterprise. Vision I subsumes three concepts: basic scientific concepts, the nature of science, and scientific ethics. Vision I primarily affects those students who aspire to become scientists and are geared to the practical aspects of working scientifically.

Vision II is the essence of scientific literacy, or the body of knowledge that all educated citizens should possess. This vision relates directly to Vygotsky's spontaneous dimension. Zeidler and Sadler (2011) argue that, for any conception or significant meaning of scientific literacy to be realized, moral reasoning, *ethical* considerations and the *formation of character* must be included. Take, for example, in exploring the moral effects of science from a World Values Survey of 52 nations, Chan (2018) notes that "moral values are often important to one's acceptance of different scientific advancements, such as embryonic stem cell research (Ho et al. 2008)." Socio-scientific issues cultivate such a scientific literacy by empowering students to bring in moral reasoning and ethical considerations to make well-informed decisions.

When students find value in their learning activities that provide the opportunity to reinterpret their experiences, greater learning gains are achieved. In this sense, a key aspect of educational innovation is the change in teaching methodology. To that end, *Vision II* requires teaching that involves argumentation and evidence-based reasoning skills. This innovation requires that science teachers are convinced that argumentation is an essential component of learning science and that this also necessitates a range of pedagogical strategies that will both initiate and support argumentation if they are to adopt this in the science classroom (Osborne et al. 2004; Osborne et al. 2019).

Science Literacy and Responsible, Informed Citizenry from a Christian Educator's Perspective

What does the Australian science curriculum mean for the Christian Science educator? This may also apply to other religions or values. However, as the context of the present study is carried out within a Christian school setting, reference is made here specifically to the Christian Science educator. This calls for reflection on the kind of knowledge structures that Australian science curriculum mandates and the need to make explicit assumptions about the pedagogical practices within the science field of study. How, then, does a Christian teacher apply biblical principles within such pedagogies to fulfill the objectives of the Australian curriculum? Rooney (2013, p. 38) draws our attention by stating that "being a teacher" encompasses one's passionate commitment to Christ by recognising the importance of distinguishing between secure and controversial issues (Cooling 2007). The students respond by "being a learner" to such transformative professional practice.

Rooney suggested that as a way forward, the challenge (among two others) within the type of pedagogical enlightenment lies with guiding teachers toward identifying the *complementary* and *distinctive pedagogical practices* existing between biblical and secular worldviews as the final step. To achieve this goal, there is a need to develop a collaborative approach to pedagogy *within* and *across* Christian educational institutions. It requires a comprehensive understanding of the application to pedagogy from the biblical-informed signature pedagogies for the twenty-first century and signature pedagogies within the various courses of studies in the Australian Curriculum as well as a strong desire to integrate faith and learning (p. 43).

Rethinking the Australian Curriculum

The Shape of the Australian Curriculum (AC) v.2.0 (ACARA 2010) stated that the first intended outcome of AC requires a solid foundation in *values* achieved through supporting "students to relate well to others and foster an understanding of Australian society, citizenship and national values including the study of civic and citizenship" (p. 16). The second requires students to "understand the spiritual, moral and aesthetic dimensions of life" (p. 16) as part of the process to achieve deep understanding. Habermas refers to "political integration via citizenship" (1993, p. 8) as one mechanism affecting social integration. This exemplifies Groome's (1998) theory into action (praxis), a *shared praxis* within the national cultural community that we are a part of (Carson 2008).

While teaching moral development and ethics to senior school students, and supporting the importance of values, Thomas Smith (2008) notes that Christian educators can assist students to articulate their faith position within the framework of secure and controversial public truths. His work sharpens one edge of a two-edged sword by placing God's Word as central to understanding knowledge and its values. The other edge intensified current secular national values that often marginalize the centrality of Christ. The edges involve individual development as citizens and reflect the essence of the human endeavour: one edge with Christ, the other without Christ.

Teaching both edges of the sword is the teacher's challenge in dealing with alternative views of the human endeavour within the Australian curriculum: Science.

Science as a Human Endeavour (SHE)

Within the Australian science curriculum (ACARA 2010), science is viewed as a natural part of the human endeavour – the fourth content strand. Science is "influencing society through the posing and responding to social and ethical issues and science research is influenced by societal challenges or social priorities" (p. 6). In addition, the interdependent union of science, mathematics and technology informs "the scientific endeavour" (p. 11). For these reasons, the shifting sands of societal change allow science to maintain the momentum of its position as a problem solver within the post-secular reality that it cannot solve all social ills.

The human endeavour content is a reconceptualization of science for students that "in making decisions about science and its practices, moral, ethical and social implications must be taken into account" (p. 6). This position resonates with past debates and issues concerning the knowledge content of science and Christianity. Articulating the process of science research as part of the human endeavour poses the question of the extent to which teachers are prepared to debate the ontological issues of theological and scientific construction within their pedagogical practices.

Reconceptualizing science supports the claim of Rooney's observation (Rooney 2013) that a national curriculum can open up opportunities to participate in the debates and issues of the public sphere. Christian Science educators can help their students to consider both secular and biblical ideas to solve social pathologies, acknowledging that biblical knowledge anchors are *one* possible key for unlocking deep knowledge and deep understanding concerning secular and biblically informed curriculum content. Christian educators who understand the complementarity/distinctiveness framework for the relationship between science and religion can make more explicit the epistemic controversies that currently exist.

The Rationale and Objective of the Present Study

The present study offers the rationale of a pedagogical practice that reinforces the high priority for integration of faith and learning. Thus, Science as a Human Endeavour (SHE) becomes an understanding of what it means to be in the world (*knowledge complementarity*) but not being of the world (*knowledge distinctiveness*) while offering one of the greatest challenges in entering the debates and issues of the twenty-first century. And in so doing, this fulfills the Christian's human endeavor to reflect Christ in *all* aspects of life. Christian educators have the mandatory task and the scope to explain the alternate conceptions of what it means to be human through transcendent and non-transcendent worldview explanations.

The present study proposes a pedagogical approach that uses the popular medium of films/movies to engage students with SSI and develop argumentation and evidence-based reasoning skills with due consideration to the values (including faith values) and ethics of modern science technology.

Movies as a Medium

The medium of movies and films is utilized for science education in this millennium because of its wide appeal and captivating relevance to the individual and contemporary society (Yap 2016, xiii; Yap 2018, p. 115). It is recognized that much of the cultural weight of films, in particular science fiction, comes from the science they contain (Reid and Norris 2016). Whether depicting humans battling extraterrestrial beings or a brave geologist saving lives as the volcano erupts, science-themed films are an exciting visual and sensuous introduction to the workings of science and technology. The current plethora of films explore a range of complex topics in vivid and accessible ways from space travel such as *Interstellar* and *The Martian* to genetic engineering, global warming, and the consequences of nuclear weaponry. The popular medium of movies provides an engaging yet powerful medium where students can explore science concepts (Goble 2010, p. 30), address any misconceptions, weigh the pressing issues and ideas of our time as well as discuss the ethics of controversial science and technology (Orthnia 2015, p. 901), and consider the future implications.

Ethics and Values in Science Education

The term “ethics” refers to the branch of philosophy dealing with questions related to rights and normative judgments. Traditionally, “morals” are more often used in the personal contexts, while “ethics” is more frequently referred to in professional settings (Zeidler and Sadler 2008). In most modern contexts, including the area of science education, ethics and morality are used interchangeably, and such an understanding is taken in the present study.

The term “values” used in this study refers to “the principles, fundamental convictions, ideals, standards, or life stances which act as general guides or as points of reference in decision-making or the evaluation of beliefs (including religious/faith values) or actions and which are closely connected to personal integrity and personal identity” (Halstead 1996, p. 5) The present study is based on the understanding that values can emerge from science, both as a product and a process, and this can be redistributed and articulated more broadly in the culture of society (Allchin 1998, p. 1083).

The Research Questions

The present study investigates the following research questions.

1. How effective is the use of movies as an integrative aspect of science learning in enhancing students' ethical reasoning and argumentation skills?
2. In what way does the use of movies as an integrative aspect of science learning help students incorporate values (including faith values) in their socio-scientific reasoning?

Research Method

The present study is based on a case study research methodology which investigated a contemporary phenomenon in depth and within its real-life context (Yin 2009, p. 18). Such a method relies on multiple sources of evidence with data converging in a form of triangulation. This research method was used to assess the effectiveness of using the movies as an integrative aspect of science learning to enhance ethical reasoning and argumentation skills and to determine the ways in which values are incorporated in students' socio-scientific reasoning.

The quasi-experimental design involved a comparison group of 30 students taught by a biological science teacher and an experimental group of 30 students taught by another biological science teacher. These two classes typified a sample of Year 10 class in a suburban school in Australia. All students were 14–15 years of age with rather similar socioeconomic (middle class) and religious backgrounds. These students participated in an 8-week biological science program which was focussed on the study of the DNA structure, cell divisions, Mendelian genetics, biotechnology, and natural selection. In this program, each student attended six periods of lesson/practical per week. Each period lasted 50 min. Each lesson may take the form of a lecture (with multimedia presentations) over a period or a laboratory session that covered two periods usually once a week. Students also completed activities involving case studies as well as a formative and summative assessment.

The experimental group completed their case studies with scaffolded inquiry formatted in the form of viewing snippets of the movie followed by small group and class discussions. The comparison group completed their case studies with scaffolded inquiry structured in the form of the written narratives based on similar SSI themes followed by collaborative activities such as small group and class discussions.

Data were collected from a pre-program and post-program questionnaire. A triangulated mixed methods design was used in which different but complementary data were collected during the 8-week program. The comparison group and the experimental groups were both taught the use of five ethical frameworks (Yap 2013, pp.33–34) and Toulmin's pattern of argumentation. The ethical frameworks and argumentation patterns were taught and practiced over a similar period of time of 3 weeks for both groups by the researcher. Both comparison and experimental teachers worked together to ensure that all teaching resources and strategies were similar and utilized to the same extent.

Quantitative data from the pre- and post-program questionnaires were used to determine the effectiveness of the use of movies in enhancing the quality of argumentation and ethical reasoning using the evaluation tools developed by the researcher. The pre- and post-program questionnaires assessed the students' understanding, ethical thinking, and quality of arguments developed.

Concurrently, qualitative data such as students' written responses to case studies, observation of participants by the researcher, and reflections from students' journals were used to explore the ethical reasoning and argumentation skills development. These data were collated to identify emergent patterns or themes characterizing development of ethical thinking and use of ethical frameworks.

Classroom observations were made with reference to the type of teaching strategy of socioscientific issues that engaged the students, for example, small group discussions, the use of the ethical frameworks in facilitating the individual student's and small group's argumentation, reasoning, and decision-making. The reason for collecting both quantitative and qualitative data was to bring together the strengths of both forms of research to compare, validate, and corroborate results.

Both qualitative and quantitative methods were designed to ensure that both internal and external validity were addressed. The internal validity criterion was met by representative sampling, prolonged engagement and persistent observations in the field, triangulation of methods, triangulation of sources, members checking, peer examination and measures to minimize researcher's bias. To ensure external validity and reliability, a detailed and thorough description of data was collected and analyzed, and the position of the researcher and the participants were given much consideration when using multiple methods of data collection and analysis and providing a detailed and comprehensive audit trail.

The Choice of Five Ethical Frameworks and the Rationale

In most of the current models of teaching socio-scientific issues, teachers present resource materials (real-life situations, scenarios, moral dilemmas, etc.) with a range of different viewpoints and invite students to articulate their opinions based on their evaluation of the evidence (Dawson 2003). In this regard, the choice for the use of the five ethical frameworks was to provide all students participating in this research with the same tool to work out some kind of justification based on the range of viewpoints.

The five ethical frameworks adopted for both the comparison and the experimental groups were based on the work of Reiss (2008) which provided a selection of ethical perspectives drawn from well-established approaches to ethics and ethics education (Table 19.1). These four established approaches are rights and responsibilities, consequentialism (specifically in the form of utilitarianism concerned with both the beneficial and harmful consequences of action), autonomy (recognition of

Table 19.1 Reiss (2008): Four ethical frameworks – a summary

EF1	Rights and duties (deontological)
Rights define what people can expect as their due, so far as it is under the control of people or human society. There is always a duty associated with a right, though in many cases, the duty on other people is simply that they do not interfere with or prevent others claiming their rights. Any right an individual has relies on other people carrying out their duties or other people's rights may be neglected	
EF2	Maximizing the benefits (utilitarian)
This framework balances the benefits of an action against the costs. It promotes the common good to help everyone have a fair share of the benefits in society, a community, or a family. This framework is often described as "the greatest happiness for the greatest number." It could be seen as a "right" to override the rights of the individuals in order to bring about happiness in the wider community	
EF3	Making decisions for yourself (autonomy)
Autonomy is concerned with the respect due to individuals. People act autonomously if they are able to make their own informed decisions and then put them into effect. The principle of autonomy is the reason why people should be provided with access to relevant information, for example, before consenting to a medical procedure or taking part in a clinical trial	
EF4	Leading a virtuous life (virtues/character)
Justice is about equality, fair treatment, and the fair distribution of resources of opportunities. For example, private medical care could be seen as making superior resources available to those who can pay; alternatively, it could be seen as providing a "choice." This framework supports the moral "rightness" or "wrongness" of actions. An action can be described as right or wrong independently from any consequences of the action. It is not the consequences that make an action right or wrong but the principle or motivation on which the action is based. Traditionally, the seven virtues were said to be justice, prudence (i.e., wisdom), temperance (i.e., acting in moderation), fortitude (i.e., courage), faith, hope, and charity	

Reiss (2008, pp. 900–901)

Table 19.2 The fifth ethical framework

EF5	Christian (moral) ethics
This framework is based on principles and standard stipulated in the Scripture (Holy Bible). The Scripture provides the basis and motivation for which a decision is based. This framework promotes the values undergirding the belief which centers on the person, the work and the teachings of Jesus Christ, whom, through his life, death and resurrection points to the existence of a Triune God and to the nature and character of God, the Father, and whose work continues on earth is instrumental by the empowered community of faith – the Christians	

Yap (2013, pp. 33–34)

the individual's right to free choice), and virtues (emphasizing motives and good characters rather than actions). In addition to these four, the *fifth* one added by the researcher incorporates a Christian perspective, not only as a means of studying a particular religious moral outlook (if expressed, and how, in a predominantly religious institution) but also to explore the possible link between faith and ethical/moral reasoning development (Table 19.2).

Tables 19.1 and 19.2 provide a list of the five ethical frameworks that was used by both the comparison and the experimental groups.

Table 19.3 List of codes on the features of sound decision-making

Code	Features of sound decision-making
(A)	Understanding why decision is to be made
(B)	Integrating two or more ethical frameworks
(C)	Identifying benefits and risks in the consequences
(D)	Establishing sound evidence (scientific knowledge, intuition, values)
(E)	Thinking through the thinking process (metacognition)
(F)	Attitude (openness, engagement, motivation, etc.)

In this study, the researcher chooses to complement the evaluation of decision-making competence by identifying and evaluating the number of ethical frameworks used in resolving dilemmas of socio-scientific issues as well as using a decision-making code as a measuring instrument – a tool the researcher has used in her earlier research work with some measure of success (Yap 2013).

Use of a Decision-Making Code

In assessing decision-making skills of the student work, the researcher developed a code (Table 19.3) incorporating the essential components of sound decision-making skills. Sound decision-making skills demonstrate a reasonable understanding why a decision has to be made and an understanding of the source of the problem (Ratcliffe and Grace 2003). This was accompanied by a consideration of a plausible number of options (Eggert and Bolgeholz 2009). The options could refer to, for example, the number and type of ethical frameworks used; this would be indicative of an integrated approach in shaping the argumentation process toward decision-making. Attention was also given to the consequences of weighing the benefits and risks of a technology or practice employed (Siegel 2006). The ability to monitor and guide one's own thinking process or metacognition (Kolsto 2006) was determined by the kind of question posed or type and sequence of reasoning used to build toward a well-informed decision. In another socio-scientific study in a Christian college, the use of rational, emotive, and intuitive modes of informal reasoning was employed to determine the degree of high and low religious beliefs shaping students' attitude toward controversial issues in biotechnology (Pope et al. 2017).

Table 19.3 provides a nonhierarchical array of features that constitute sound decision-making in dealing with socio-scientific issues in the classroom activities. This list of codes was developed by the researcher as a means of identifying the progress (if any) of the comparison group and the experimental group in their use of the five ethical frameworks.

Examples of the Use of the Five Ethical Frameworks

The following students' responses (Table 19.4) are selected as they demonstrate the use of each of the five ethical frameworks from the comparison and experimental group in response to the stated case studies. In most cases, students stated them explicitly (as headings), while others reasoned implicitly within a particular framework without mentioning it at all. Ethical framework templates were provided for the case study.

In keeping this article to a reasonable length, only samples of some assessments are provided here, so there may be some limitations in viewing the overall scope of assessment conducted.

Case Study: *Jurassic World*
Jurassic World featured a new hybrid dinosaur in the Isla Nublar Theme Park that combines the deadliest traits of several others to create a perfect predator, *Indominus Rex*, using genetic engineering and mass amplification of dinosaur DNA from fossils. Can science be used to serve human curiosity at the expense of risking dangers to humans?

Table 19.4 provides a sample of students' response in the utilization of the five ethical frameworks.

The following is an example of an experimental group student's response demonstrating the use of argumentation.

Case Study: *Gattaca*
Is it right to use your own DNA as evidence of "imperfections" against you?
A student response:

It is wrong for one's DNA to be used as evidence (e.g. imperfections) against a person if that evidence creates prejudice and limits opportunities for that person. [Claim/Qualifier] Physical 'imperfections' often do not limit a person who has a good character. We see many examples of such people who have overcome their limitations. [Data] DNA testing is not always accurate and physical limitations do not limit a person's mind or potential so DNA testing should not be the "be-all and end-all" as evidence against a person. [Warrant] If the DNA evidence is used as a reason why a person is not capable in something or should be provided with an opportunity to try, this is wrong. A person amounts to more than their physical imperfections and their true workings. [Claim] This is often revealed in their character. People may argue that DNA testing is never wrong but due to human error and interpretation, an error is always possible. [Backing] My summative response: DNA should not be used as decisive evidence of imperfections against a person as these imperfections are used to deny the person of his/her opportunities or discriminate. DNA testing has the potential to be wrong through technological flaws or human errors and should not be used as a reason why someone is incapable of trying something. In life, there are many cases where someone has defied physical odds that bring great benefit to the world. Just take a look at Stephen Hawking. Overall, people should not be limited by potentially wrong DNA interpretations, as humanity is defined by more than just tangible fitness but is shown by one's character.

Case 1A – Scientists may soon be able to revive long extinct species. Given the advancement of technology now, scientists should de-extinct the long lost species. Do you agree or disagree? Explain.
Case 1B – *Jurassic World* featured a new hybrid dinosaur in the Isla Nublar Theme Park that combines the deadliest traits of several others to create a perfect predator *Indominus Rex* using genetic engineering and mass amplification of dinosaur DNA from fossils. Can science be used to serve human curiosity at the expense of risking dangers to humans?
Case 2A – "Public funding for pre-natal testing should only be made available to high risk pregnant women." Do you agree or disagree?
Case 2B – In the film GATTACA, every baby at birth had their genome sequenced and their life's trajectory could be read like a weather forecast. Vincent Freeman's forecast was not good but he aspired to have a career in space but his mother remarked: "The only way you'll see the inside of a space shuttle is if you are cleaning it." Vincent says, "It is illegal to discriminate – this is called 'genoism'."
Do you agree that one should be discriminated based on one's genome? Is it possible that we have discrimination down to a science?

Table 19.4 Sample of students' responses demonstrating the use of the five ethical frameworks

Rights and duties (deontological)
"Although genetic engineering can be extremely interesting, it should not risk the lives of humans. The rights of the humans (and their safety) should be maintained. Animals and nature are beautifully created and they should not be modified and/or revived to the point that it becomes dangerous to mankind."
Maximizing the benefits (utilitarian)
"I don't agree that we should de-extinct long lost species without weighing the consequences and the benefits. It is important to consider whether this is done with extreme caution and in a humane way. The people making this decision need to take into account any consequences that come out of this technology and find out if the consequences are so severe that it actually outweighs the benefits. Rare animals can be important for a country's economy and tourism. Take for examples, the quokkas are important for Western Australians, and the pandas for China, etc."
Making decisions for yourself (autonomy)
"I think every decision should be left to one's own morals. Each decision made has to be carefully considered in terms of its ability to harm people or not. It is also important to decide in terms of the animal well-being."
Leading a virtuous life (virtues)
"I think science should be spending time and resources on worthy causes such as finding a cure to diseases than just serving human curiosity in bringing to life extinct animal species. A human life is more valuable than an exciting science experiment. Weapons of mass destruction has been built in the name of satisfying human curiosity but in the end destroyed many lives. Just because it can be done does not mean it should."
Christian values
"It depends on the characteristics of the animals that were brought back and whether they would be able to handle society or whether society could deal with them. Scientists should bring back extinct species that would benefit society instead of flesh-eating giant creatures that would harm people. God has a plan for the extinction of the dinosaurs – it is for a purpose and I think bringing back past animals with such ferocious carnivorous nature will have a massive impact on man, upset the ecosystem and destroy the environment. Man has been charged to be responsible, to manage and take care of the earth."

Examples of the Use of Faith Value-Based Lines of Reasoning

The following are students' responses and their lines of reasoning based on their faith values from both comparison and experimental groups. The case studies are stated as follows:

Table 19.5 provides a list of students' responses and their lines of reasoning based on faith values from both comparison and experimental groups.

Research Findings

How effective is the use of movies as an integrative aspect of science learning in enhancing students' ethical reasoning and argumentation skills?

Case study analyses for both comparison and experimental groups demonstrated comparable understanding of the argumentation patterns and use of the five ethical frameworks. On an average, both groups used at least two ethical frameworks to substantiate their views and were conversant in outlining the claim and data for each argument, with occasional use of the backing and rebuttal to support their summative response.

The pre-and post-surveys for both groups also showed a logical and coherent pattern of argumentation and set out definitive lines of ethical reasoning. Students' responses from both groups highlighted features of **A, B,** and **C** features of the sound decision-making indicated in Table 19.3. Here, **A** refers to understanding why decision is to be made; **B** refers to integrating two or more ethical frameworks; and **C** refers to identifying the benefits and risks in the consequences.

In this respect, the use of case studies in the comparison group and the use of movies on socioscientific issues in the experimental group are both relatively effective in enhancing students' ethical reasoning and argumentation skills. The writing of the arguments and the lines of ethical reasoning was also observed to be a potentially useful strategy to engage students in the social and cognitive practices of gathering and evaluating evidence, allowing for reflection and further refinement.

With the experimental group, it is noted that students were given opportunities to apply their ability to use evidence-based argumentation strategies regarding broader topics (by including imaginative ones with the use of science-themed movies). This has led to a notably increased degree of multiple perspective-taking. Students demonstrated a distinct capacity to think beyond their stated positions to consider perspectives counter to their own ideas.

In what way does the use of movies as an integrative aspect of science learning help students incorporate values (including faith values) in their socio-scientific reasoning?

With reference to the features of decision-making code, the experimental group was noted to score higher on **D, E** and **F**. These features include **D** as establishing sound evidence – scientific knowledge – **E** as displaying intuition and values as well

Table 19.5 Students' written responses and lines of reasoning based on faith values

	Case 1A – De-extinct long-lost species
Against God's created order Not natural Alter God's creation	"I disagree scientists should de-extinct long lost species, as bringing back these species may bring unforeseen consequences. The extinct species, food and habitats were different from what they now are. So their roles may change the eco-systems too. We do not know how much they would be eating. Also, the health and safety for humans is a concern. They could carry diseases which are now brought back to life. Overall, I think by doing this, we are tampering with God's creation as he would not allow them to become extinct if he didn't think they would fit into modern society today."
God's role in creation	"I disagree. Firstly, I believe we should let nature takes its course, and interfering with it is not wise because of our overall lack of understanding regarding this. If the species had died out long ago, contemporary knowledge of the characteristics and behavior exhibited would be limited, especially with regards to how it would react to today's environment. The question must also be asked: how would human society benefit from this de-extinction? From a biblical perspective, though God had created the world, he has called us to look after it and with our limited knowledge, it is irresponsible to interfere with his creation."
Responsible use of God's gift of technology for mankind	"Yes, I agree as long as these de-extinct creatures do not present a danger to us or the eco-system. With any sort of herbivore or species that has died within the last 1000 years, there is no reason why they can't be brought back. Improvement in technology is God's gift to mankind. They will teach us about the past, they can help people make money, and they won't hurt us. I can see no reason how this contradicts God's plan. We can and should learn to be responsible with the technology gifted to us."
	Case 1B – IVF *Jurassic World*
Playing God Displacing God	"I strongly disagree that science should be used to serve human curiosity. Animals should not be genetically modified. This is like playing God or saying to God that what he has created is not good enough for us. To use it for entertainment is very selfish, especially when it risks the lives of so many people."
God's plan and God's will	"I disagree. If there is any potential risk or danger towards humans, it shouldn't be done. Gene modification and humans creating living things is against God's will. There are many other ways to entertain humans."
	"We shouldn't use science to bring back extinct animals. They are dead for a reason and that is what God wanted. If we bring them back, it could help with science and economics but we are going against God's plan and will."

	Case 2A – Prenatal testing
Sanctity of life	"Prenatal testing should only be made available to high risk pregnant mothers. Ethics experts worry that the test results could make it easier for parents to terminate their pregnancy if the child is not their preferred sex. I agree that prenatal testing is helpful for testing serious health defects such as Down Syndrome but this could also lead to doing what is morally wrong – that is, having a fetus aborted due to gender."
God's plan and will	"I believe such tests should not be encouraged. Ethics experts has noticed that an increase in popularity of prenatal testing can prompt an increase in abortion rate killing humans on the basis of some abnormalities. These babies are fearfully and wonderfully made in the likeness of God, and with these precious lives, they can be utilized to fulfil His great plan and purpose."
	Case 2B – *Gattaca*
Uniqueness of God's Creation	"Everyone is unique and made by God just the way they are supposed to be. You shouldn't be judged on your weaknesses but have your strong points highlighted."
Made in God's image	"We are all created in the image of God and we are all equal as sinners in his eyes. So creating two groups of people by discriminating them as 'valids' and 'invalids' over physical factors would not be right."
God as source of help	"I disagree. If you really believe in something and with the help of God, your genetics don't add it all up. People should be treated equally no matter what their DNA says about them. Many people with genetic disorders have some many amazing things – you earthly body is not just a shell genetically predetermined – what really determines who you are, is your spirit in you."

as developing metacognitive thinking skills, and **F** as displaying an attitude of openness, engagement, and motivation.

The experimental group displayed a greater level of engagement and participation in giving *voice* to various roles noted in the movies. A more sophisticated level of perspective-taking was observed, with the use of movies, as an increased openness toward other viewpoints was expressed, or in small group discussions and in writing in students' reflection journals. Discussions took on a significant degree of interaction with the scientific and artistic content of the media as students deliberated over values and challenges to one's beliefs presented in the narrative/story/plot structure of the movies and *debated* before arriving at a consensus view. The art of dialogue, listening and questioning – all vital features of collaborative efforts – were also enhanced.

Case studies and journal reflections in the experimental group underlined a prevalent theme on the use of movies in cultivating an awareness of the relevance of science to everyday life and a greater appreciation of science as one of the various ways to know the world and that science has something to say about certain matters of significance to life, nature and the environment. The incorporation of personal beliefs and societal values were significant in small group discussions and student's individual written responses in the experimental group.

Conclusion

This study shows that the use of socio-scientific issues employed in both case analyses and science-themed movies are comparatively effective in enhancing students' argumentation skills and ethical reasoning. Due to the emotionally engaging and intellectual intriguing nature of movies, their integration in science learning helped students incorporate values, including faith values and personal beliefs, and ethical thinking in their socio-scientific reasoning, hence fulfilling the objective of the Science as a Human Endeavour (SHE) strand of the Australian Curriculum.

The medium of science-themed movies (science fiction) proved to be an excellent tool to tap students' creativity and active imagination and provided a viable avenue for students to develop argumentation skills and ethical reasoning in dealing with controversial socio-scientific issues. Although the quality of argumentation is not always easy to assess, even with the provision of a criterion in the form of a decision-making code, the present study indicates that the use of this teaching strategy has an impact on enhancing students' argumentation and reasoning skills. This is due to the nature of socio-scientific issues where argumentation can be justified using scientific content knowledge in a more or less sophisticated way (multiple or simple justifications, plural or single ethical frameworks, intuitive and moral lines of reasoning) but also, and often mainly, on values (religious and cultural) clarification, articulation, and demonstration in real-life settings and possible future scenarios.

The innovative approach recommended here also brings to the fore the *processes* and *practices* of a scientific community that are at the heart of the forms of science learned by students, moving beyond many traditional science curricula which only value *products* of science. Science is very much integrated with culture and society, and their shared meanings influence and shape how science is used in daily life and its impacts in the future. Experiencing how science is used in daily life and society as a whole encourages students to recognize the multidisciplinary and value-laden nature of real-world science. They can learn to think critically and reason ethically how science-related problems and issues relate to them personally (as with *GATTACA*) and to the community (as with *Jurassic World* and *The Day After Tomorrow*). Such an innovative approach creates an avenue where students experience how scientific meaning, societal applications, and ethical considerations are created and shared through debate, argumentation, and values-based lines of reasoning. These learning experiences also authenticate the process of acquiring and applying scientific knowledge as a collaborative effort through settings of small group discussions and well-structured debates.

It must also be acknowledged that the implementation of this innovative approach has its limitations as due consideration needs to be given to time constraints amid an overcrowded national science curriculum, while the teaching staff would need provision of time, resources, and professional development support to facilitate this approach effectively and with confidence. It would be worthwhile to increase the sample size across schools of different religious affiliations, including government schools, and over a longer period of time, to determine its sustained effects. While the use of movies as a medium in this approach may appear to be primarily responsible for enhanced learning, other extraneous variables that may be operating and need to be accounted for such as media literacy could be viable potential areas for research.

In summary, the present study highlights that social, cultural and religious values influence students' argumentation and ethical thinking on socio-scientific issues. Moral and sometimes religious issues (e.g., Christian beliefs and values) are taken into account by the students although distinctions between knowledge complementarity and knowledge distinctiveness may not always be clearly drawn. The use of socio-scientific issues in the science curriculum through the medium of movies enthuses and engages students in the quest for scientific knowledge and conceptual understanding. It also enables students to appreciate that science as a human endeavor involves epistemic, social, and religious values and that students can be taught to develop open-mindedness and perspective-taking as well as develop a keenness to identify bias, reflect critically, argue cogently, and reason ethically.

References

ACARA. (2010). *The shape of the Australian curriculum*. Version2.0. Sydney: ACARA. http://www.acara.edu.au/verve/_resources/Shape_of_the_Australian_Curriculum.pdf. Accessed 12 Jan 2019.

ACARA. (2016). *The Australian curriculum: Learning areas: Science*. Retrieved from http://acara.edu.au/curriculum_1/learning_areas/science.html. Accessed 12 Jan 2019.

Allchin, D. (1998). Values in sciences and science education. In B. Fraser & K. Tobin (Eds.), *International handbook of science education*. Dordrecht: Kluwer Academic Publishers.

American Association for the Advancement of Science. (1989). *Science for all Americans*. Washington, DC: Author.

Atweh, B., & Singh, P. (2011). The Australian curriculum: Continuing the national conversation. *Australian Journal of Education, 55*(3), 189–195.

Aubusson, P. (2011). An Australian science curriculum: Competition, advances and retreats. *Australian Journal of Education, 55*(3), 229–244.

Batterham, R. (2000). *The chance to change: Final report by the Chief Scientist*. Canberra: Commonwealth Department of Industry, Science and Resources.

Callahan, B. E., & Dopico, E. (2016). Science teaching in science education. *Cultural Studies of Science Education, 11*, 411–418.

Carson, D. A. (2008). *Christ and culture revisited*. Nottingham: Apollos.

Cavagnetto, A. R. (2010). Argument to foster scientific literacy: A review of argument interventions in K – 12 science contexts. *Research in Science Education, 80*(3), 336–371.

Chan, E. (2018). Are the religious suspicious of science? Investigating religiosity, religious contexts, and orientations towards science. *Public Understanding of Science, 27*(8), 967–984. https://doi.org/10.1177/096366251/8781231.

Cooling, T. (2007). The challenge of passionate religious commitment for school education in a world of religious diversity: Reflections on evangelical Christianity and Humanism. *Journal of Education and Christian Belief, 11*(1), 23–34.

Dawson, V. (2003). Effect of a forensic DNA testing module on adolescents' ethical decision making abilities. *Aust Sci Teach J, 49*(4), 12–17.

Eggert, S., & Bogeholz, S. (2009). Students' use of decision making strategies with regard to socio-scientific issues: An application of the Rasch partial credit model. *Science Education, 94*, 230–258.

Fensham, P. J. (2016). The future curriculum for school science: What can be learnt from the past? *Research in Science Education, 46*, 165–185.

Goble, R. (2010). Developing a mindful practice around moving images in the K – 12 Classroom. *Knowledge Quest, 38*(4), 28–33.

Goodrum, D., & Rennie, L. J. (2007). *Australian school science education national action plan 2008–2012*. Canberra: Commonwealth Department of Education, Science and Technology.

Goodrum, D., Hackling, M. W., & Rennie, L. J. (2001). *The status and quality of teaching and learning of science in Australian schools*. Canberra: Commonwealth Department of Education, Training and Youth Affairs.

Groome, T. H. (1998). *Sharing faith the way of shared praxis: A comprehensive approach to religious education and pastoral ministry*. Eugene: Wipf and Stock Publishers.

Habermas, J. (1993). Citizenship and national identity. *Praxis International, 12*(1), 1–19.

Halstead, J. H. (1996). Values and values education in schools. In J. M. Halstead & M. J. Taylor (Eds.), *Values in education and education in values*. London: The Falmer Press.

Hattie, J. (2016, October). Shifting away from distractions to improve Australia's schools: Time for a Reboot. *Australian Council for Educational Leaders Monograph, 54*, 1–22.

Ho, S., Brossard, D., & Scheufele, D. A. (2008). Effects of value predispositions, mass media use, and knowledge on public attitudes toward embryonic stem cell research. *International Journal of Public Opinion Research, 20*(2), 171–192.

Kolsto, S. D. (2006). Patterns in students' argumentation confronted with a risk-focussed socio-scientific issue. *International Journal of Science Education, 28*(14), 1689–1716.

Millar, R., & Osborne, J. (1998). *Beyond 2000: Research in education: Science education for the future*. London: King's College.

National Curriculum Board. (2009a). *Shape of the Australian Curriculum: Science*. Melbourne: Author.

National Curriculum Board. (2009b). *National science curriculum: Framing paper*. Melbourne: Author.

Organisation for Economic Co-operation and Development. (2006). *Assessing scientific reading and mathematical literacy. A framework for PISA 2006*. http://www.occd.org/dataoecd/65/35/37464175.pdf. Accessed 6 July 2016.

Organisation for Economic Co-operation and Development. (2009). *PISA 2009: Assessment framework – Key competencies in reading, mathematics and science*. Paris: OECD.

Orthnia, L. A. (2015). Science fiction. In R. Gunstone (Ed.), *Encyclopaedia of science education 2* (pp. 899–902).

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*, 994–1020. https://doi.org/10.1002/tea.20035.4.

Osborne, J., Borko, H., Fishman, E., Zaccarelli, F. G., Berson, E., Busch, K. C., Reigh, E., & Tseng, A. (2019). Impacts of a practice-based professional development program on elementary teacher's facilitation of and student engagement with scientific argumentation. *American Education Research Journal*. https://doi.org/10.3102/0002831218812059.

Pope, T., Dawson, V., & Koul, R. (2017). Effect of religious belief on informal reasoning about biotechnology issues. *Teaching Science – The Journal of the Australian Science Teachers Association, 63*(2), 27–34.

Ratcliffe, M., & Grace, M. (2003). *Science education for citizenship: Teaching socio-scientific issues*. Philadelphia: Open University Press.

Reid, G., & Norris, S. P. (2016). Scientific media education in the classroom and beyond: A research agenda for the next decade. *Cultural Studies of Science Education, 11*(1), 147–166.

Reiss, M. (2008). The use of ethical frameworks by students following a new science course for 16 – 18 year-olds. *Sci Educ, 17*, 889–902.

Roberts, D. A. (2007). Scientific literacy/science literacy. In S. K. Abell & G. Lederman (Eds.), *Handbook of research on science education* (pp. 729–780). Mahwah: Lawrence Erlbaum Association.

Rooney, P. (2013). National curriculum, post secularism and pedagogy: Opportunities for Christian education. *Journal of Christian Education, 55*(2), 29–45.

Sadler, T. D. (2009). Situated learning in science education: socio-scientific issues as contexts for practice. *Studies in Science Education, 45*(1), 1–42.

Siegel, M. A. (2006). High school students' decision making about sustainability. *Environmental Education, 19*(2), 166–189.

Smith, T. (2008). Teaching ethics and mature Christian thinking in Christian schools. *Journal of Christian Education, 51*(1), 31–40.

Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future*. Victoria: Australian Council for Educational Research.

Yap, S.F. (2013). *Developing, Implementing and evaluating the use of ethical frameworks in teaching bioethics in a Year 10 biotechnology program*. An unpublished thesis.

Yap, S. F. (2016). *Science at the movies – Remediating the misconceptions*. Perth: SF Publications.

Yap, S. F. (2018). Science at the movies – Remediating the misconceptions and developing ethical reasoning. In *A teacher's guide to science and religion in the classroom*. London/New York: Routledge.

Yin, R. K. (2009). *Case study research: Design and methods*. Thousand Oaks: Sage.

Zeidler, D. L., & Sadler, T. D. (2008). The role of moral reasoning in argumentation: Conscience, character and care. In S. Erduran & M. P. Jimenez-Alexandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 201–216). Dordrecht: Springer.
Zeidler, D. L., & Sadler, T. D. (2011). An inclusive view of scientific literacy: Core issues and future directions. In C. Linder, L. Ostam, & P. Wickman (Eds.), *Promoting scientific literacy: Science education research in transaction* (pp. 176–192). New York: Routledge.

Siew Fong Yap is the Head of Science at Perth's Kingsway Christian College and a sessional teaching academic at Curtin University, Western Australia. She is the co-author of Oxford Science Western Australian Curriculum Year 7–10 textbooks. Her research focus is on bioethics and values in science education. Her most recent book publications include *A Teacher's Guide to Teaching Science and Religion in the Classroom* (2018) and *The Art of Teaching Science* (2019).

Chapter 20
Physics and Faith Synergy: How to Engage Audiences of Different Ages, Backgrounds and Beliefs

Elisabetta Canetta

Introduction

Our modern society is heavily based on technology (Greenfield 2009). We constantly hear about the daily life of astronauts on the International Space Station (ISS), the future colonisation of the planet Mars, the slimmest and more powerful mobile phone or computer, the latest advance in robotics, etc. Our minds swing from the infinitely large, such as the Universe, to the infinitely small, such as the nanotechnology used in modern gadgets, appliances, mobile phones, etc. Nanotechnology is thought to be the Third Industrial Revolution (Keiper 2003), and it started about 30 years ago. It permeates our lives and allows us to enjoy most of our daily comforts (e.g. ultrafast broadband, touch screens, virtual reality, etc.) (Currall 2009). The spirit of nanotechnology is to "shape the world atom-by-atom" and to make things very small in order to benefit from the unique physical, mechanical and chemical properties of nanomaterials, which are essential to make many of the objects and tools that we use in our daily work and life (Logothetidis 2012). However, if we stop thinking about the purely materialistic aspect of our society, a few Big Questions come to mind: Where is God in all this? Is there any space left for God in our lives? Is gaining more scientific knowledge of the Universe and what is made of bringing us closer to God? Is our ability to manipulate matter at the atomic and subatomic level giving us some more insight into God's thoughts? The answers to these questions can range from "there is no reliable and concrete evidence for the existence of a supernatural being (God)" (atheistic view) to "the Universe and its contents are a visible and tangible proof of the existence of God" (believer view). According to some recent psychological research by B. Mercier and collaborators (2018), belief in God could be caused by evolutionary causes, whereas

E. Canetta (✉)
School of Sport, Health and Applied Science, Mary's University – Twickenham, London, UK
e-mail: elisabetta.canetta@stmarys.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_20

N. Barber in his book "*Why atheism will replace religion: The triumph of earthly pleasures over pie in the sky*" (2012) presented a systematic study on the possible relationship between anxiety/insecurity and belief in God – the more anxious and insecure people feel, the more compelled they are to believe in the existence of a supernatural being.

Another possible source of the polarity between "believing in" and "denying" the existence of God could be the "divorce" between science, religion and philosophy that recurred during the twentieth century (Hooykaas 2000). Interestingly, people who deny the presence of God do so because they consider God as an unnecessary presence, since science can explain everything. Notably, the world-famous cosmologist Prof Stephen Hawking argued that there is no need of God because the laws of physics are capable of explaining the Universe, its behaviour, what it is made of, how it began, etc. (Hawking and Mlodinow 2010).

The relationship between science, theology and philosophy has been and still is quite eclectic. In ancient times, these three areas of knowledge were not considered separated silos, and scientists of the calibre of Galileo (1564–1642), Kepler (1571–1630) and Newton (1643–1727) not only cultivated a strong interest in theology and philosophy but also combined the latter with mathematics and physics to unravel the inner mysteries of the Universe. More recently, world-famous scientists such as Einstein (1879–1955) (he developed the so-called Cosmic Religion), de Chardin (1881–1955) (Jesuit, palaeontologist and geologist, who studied the Bible using scientific concepts) and Lemaître (1894–1966) (Catholic priest, cosmologist, and the father of the "Big Bang Theory") were also theologians and philosophers. However, the schism between science and religion (or knowledge and faith) that our current society is witnessing did not happen instantaneously but was the final product of a process that started in the medieval period with the development of alchemy.[1] The famous psychiatrist and psychotherapist C.G. Jung (1875–1961) explained very clearly this point when he said it was the alchemists that:

> made the world conscious that the revelation was neither complete not final. […] Revelation conveys general truths which often do not illuminate the individual's actual situation in the slightest, nor was it traditional revelation that gave us the microscope and the machine. And since human life is not enacted exclusively, or even to a noticeable degree, on the plane of the higher verities, the source of knowledge unlocked by the old alchemists and physicians has done humanity a great and welcome service – so great that for many people the light of revelation has been extinguished altogether. Within the confines of civilization man's wilful rationality apparently suffices (Jung 1977).

Historically, the science-religion debate (Dampier 2008) has played a pivotal role in defining and tuning a constructive relationship between science and theology that would allow these two apparently distant disciplines to shape each other (Hedley Brooke 2000). The past thirty years have been quite prolific and seen a rekindled interest in nurturing the science-religion dialogue. Two physicists have been particularly active in this quest: John Polkinghorne (Anglican priest and theoretical particle physicist who used physics and theology to seek God)

[1] Alchemy is the medieval science concerned with the transformation of matter from where modern chemistry stemmed.

(Polkinghorne 2008) and Paul Davies (quantum physicist, cosmologist and advocate of the idea that "science cannot be free of faith") (Davies 1993), who use science, theology and philosophy to bridge physics and theology and to contribute to answer some of the fundamental questions about the ultimate meaning of Life and the "role" played by God in the "grand scheme of things". There is a renewed desire to rediscover Natural Theology (Paley 2006) and to explore further the ideas of Plato (Plato 2008) and Thomas Aquinas (Aquinas 2015) on the interrelation between reason (science) and faith (religion) and on how they are not in conflict but use different tools to answer the Big Questions about God's existence and our place in the Universe. In our scientific investigation of life and the natural world, it is important to recognise that the beauty and fascination of any scientific discovery does not lie in its application to our current and modern technology but in the deep insights into the Universal Truth that it can lead to, as the German physicist Werner Heisenberg (1901–1976) explained in the book "*Physics and Beyond: Encounters and Conversations"* (1971):

> […] one is almost scared by the simplicity and harmony of those connections which nature suddenly spreads out in front of you and for which you were not really prepared. […] when one stumbles these very simple, great connections which are finally fixed into an axiomatic system the whole thing appears in a different light. Then our inner eye is suddenly opened to a connection which has always been there – also without us – and which is quite obviously not created by man (Heisenberg 1971).

To further develop the science-religion dialogue, it is essential to develop adequate educational tools that can empower new generations and allow them to unravel knowledge (through scientific research) and to understand its deepest meaning (through faith and revelation) (Long 2013).

The "Connecting Physics with Faith" project

To contribute to rediscovering and further strengthening the synergy between science and theology, and to engage the Christian general public with the science-religion debate, physicists, theologians, philosophers and bioethicists at St Mary's University joined efforts and organised a series of events consisting of talks in physics and theology followed by an informal audience-led discussion. The events were run within the "Connecting Physics with Faith" project, a St Mary's University, SEPnet (South East Physics Network) collaboration funded by the Institute of Physics aimed to enable Christian general audiences to engage with physics by introducing them to the aspects of cosmology and quantum physics that are more related to creation and human consciousness: The Big Bang Theory and Quantum Superposition.

The project was part of a larger cross-disciplinary collaboration whose final goal is to create the right environment to nurture a new generation of scientists, theologians and philosophers who can appreciate the inner beauty and deep meaning of Life, Nature, the Divine and Man through the laws of nature and science, the deep view of philosophy and the insight into the Divine that only faith can offer.

Aims and Objectives of the Project

The main aim of the "Connecting Physics with Faith" project was to engage Christian communities with physics, using faith as a hook and a safe medium. The general misconception that physics and faith do not have anything in common has forged in some

Christians' minds the stereotype of physicists being atheists and dismissive as far as faith is concerned. This has contributed to building a thick and high wall between physics communities and faith communities. A way to inspire and enthuse Christian general audiences was to raise awareness in Christian communities of some similarities between Christian faith and physics: Both require

1. A strong belief in fundamental concepts
2. Undeniable experimental evidence
3. Openness of mind to correct and/or change opinions about certain topics and concepts based on new experimental evidences and/or life experiences.

The assumption underpinning the project was that engaging a general audience with the exploration of the connection between faith and physics could help break that barrier of "fear of physics" and create a safe space in which Christian general audiences could be willing to either develop an interest in or further deepen their knowledge of some of the most fascinating topics in cosmology and quantum physics, such as the Big Bang Theory (and its relation to creation) and quantum entanglement (and its relation to human consciousness). The project had three main objectives:

1. To encourage Christian communities to engage with physics and to explore the role that it plays in understanding the world around us
2. To help consolidate the view that physics and faith can coexist and shape each other
3. To contribute to the development of an approach in which the driving force is the richness of ideas and views of the general audience, rather than specialists in the fields of physics and theology, that could bridge physics and theology

Audience Attending the Workshops

The audience was a mixture of:

– GCSE and A-level students from local faith (Christian) and non-faith schools taking Physics (2%), Philosophy (3%) and RE (5%) subjects

– University Physics (4%), Theology (6%) and Bioethics students (2%)

– Members of local Christian communities (52%)

– Members of the local community including faith other than Christian and non-faith background (26%)

The age of the audience ranged from 15 to 65+ of which 26% was aged 15–35, 33% was aged 36–55 and 41% was aged 51−65+.

The audience was quite general not only because of their cultural and social background but also for the reasons why they attended the workshops. As far as the background of the attendees is concerned, 19% had a background in science (e.g. science teachers, science graduates, retired scientists, science students); 24% were not scientists but had a strong interest in science and kept themselves up to date with the latest discoveries, ideas, technological developments, etc.; 12% had either a background in philosophy and/or theology (e.g. RE and philosophy teachers, parish priests, bioethicists); and the remaining 45% of the participants did not have a particular interest in either science or theology. Concerning the reasons for attending the workshops, the GCSE and A-level students were encouraged by their philosophy and RE teachers to participate because the science-religion relationship was one of the topics covered in the syllabus. The University students attended because of their own religious beliefs and how these could coexist with scientific and ethics issues. The rest of the attendees were keen in exploring further the physics-faith debate because of their personal religious or non-religious (about 4% of the audience was from a non-faith background, such as Humanism) views.

Methods Used to Engage the Audience

Three interactive workshops were held at local parishes and at St Mary's University. Twickenham, London, and covered the following topics:

1. "Fr Dr G. Lemaître and Rev D. J. Polkinghorne: Their lives at the intersection between physics and theology". Talks on the lives and scientific achievements of Fr Dr G. Lemaître and Rev Dr J. Polkinghorne were delivered. The workshop took place at St Mary's University.
2. "The Big Bang Theory and the creation of the Universe: The cosmological and biblical viewpoints". Two talks were delivered, one on the basic concepts of cosmology and the other on the basic theological views on creation. The physics talk focused on key cosmological ideas of the Copernican principle, the very early universe and its evolution as well as final demise, and some of the different ways in which observations today can be used to reconstruct the universe of billions of years ago. The theology talk focused on the first chapter of the Book of Genesis and how the author used ancient cosmology as a blueprint for the restoration of Judah and how this cosmology was not necessarily at odds with the scientific view. The workshop took place at St Mary's University.
3. "Quantum superposition and human consciousness: Anything in common?". Only one talk was delivered which introduced the basic principles of quantum mechanics (e.g. probabilistic aspects of quantum physics, meaning of wave function and its collapse) in a simple and lay-person accessible way (no prior knowledge of the basic principles of quantum physics was required). The last

part of the talk introduced the concept of human consciousness using quantum mechanics concepts. The workshop took place in a local Catholic Parish.

The workshops were two hours long and followed a set pattern: 30-min talk on the physics of the chosen topic, followed by a 30-min talk on the theological aspects of the same topic. The talks were delivered by physicists and theologians and were pitched at a lay level to enable an engaging exploration of physical and theological concepts regardless of the audience's cultural background (i.e. no prior knowledge of physics or theology was required). After the talks, a 1-h audience-led discussion took place in which a panel formed by physicists, theologians, philosophers and bioethicists answered the questions asked by the audience and discussed:

– The lives of priests-physicists Fr Dr G. Lemaître and Rev Dr J. Polkinghorne (Workshop 1)
– Differences/commonalities between the physical and theological approaches to creation (Workshop 2)
– Human consciousness (Workshop 3)

It is important to notice that all St Mary's staff members involved in the project were believers (90% Christian and 10% Muslim) and practising their faith.

Because of the delicate and potentially controversial topics, the discussion session was facilitated by an atheist physicist who was a SEPnet member of staff. To make the event as inclusive as possible and allow everybody to feel comfortable with actively contributing to the discussions, the audience was able to ask questions and make comments via Twitter @PhysicsStMarys. The hashtag #physicswithfaith was also used to further promote participation during and beyond the workshops. The audience was also provided with self-adhesive notes where they could write down their questions anonymously and place them on a "questions wall". The questions asked via social media and the self-adhesive notes were read out to the panel by the facilitator.

Workshops' Contents and Delivery

At each workshop, the audience was asked to sit at round tables (a maximum of six people per table) to facilitate interaction between the attendees. At each table, pen, paper and post-it were made available to encourage the participants to actively engage with the debate by writing down and then sharing their thoughts, views, questions, etc.

Workshop 1 – "Fr. Dr. G. Lemaître and Rev. Dr. J. Polkinghorne: Their lives at the intersection between physics and theology"

The workshop took place at St Mary's University. The talk on Fr Dr G. Lemaître was delivered by a cosmologist and focused on the close relationship between mathematics, theoretical physics and the Catholic priesthood that formed the very back-bone of Fr Lemaître's life. The talk lasted for 30 min and brought the audience in a "time-machine" tour of the main milestones in Lemaître's career as a theoretical physicist and a world-leading cosmologist who formulated the "Big Bang Theory". In particular, emphasis was given to:

– The publication in 1927 in the *Annales de la Société Scientifique de Bruxelles* of Lemaître's ground-breaking article "Un univers homogène de masse constante et de rayon croissant rendant compte de la vitesse radiale des nébuleuses extragalactiques" (A homogeneous Universe of constant mass and growing radius accounting for the radial velocity of extragalactic nebulae), in which Lemaître derived Hubble's Law, which relates the speed with which a galaxy is moving away to its distance.

– Lemaître's paper translation in English and publication in the *Monthly Notices of the Royal Astronomical Society* (Lemaître 1931) thanks to the intervention of the famous theoretical physicist Arthur Eddington.

– Conjectures that Lemaître's deep Catholic belief made him come to the conclusion that the universe had to begin at a finite time in the past as asserted by the book of Genesis: "In the beginning God created the heavens and the earth" (Genesis 1: 1) (*Catholic Bible: Revised Standard Version* 2006).

– The fundamental role played by faith in Lemaître's scientific work as clearly expressed by a journalist of the New York Times: "*There is no conflict between religion and science, Lemaitre has been telling audiences over and over again in this country … His view is interesting and important not because he is a Catholic priest, not because he is one of the leading mathematical physicists of our time, but because he is both*" (Midbon 2000).

The talk on Rev Dr J. Polkinghorne was delivered by a theoretical nuclear physicist and focused on the Polkinghorne's life and career before and after 1977, when he made the life-changing decision to enter the ordained ministry of the Church of England. The talk lasted for 30 min and emphasised the following milestones in Polkinghorne's career:

– 1974: Polkinghorne became a Fellow of the Royal Society (FRS) for his outstanding contributions to mathematical physics.

– 1977: Polkinghorne decided to become an Anglican priest. As he explained in an interview in 1997: "I didn't leave science because I was disillusioned, but felt I'd done my bit for it after about twenty-five years. I was very much on the mathematical side, where you probably do your best work before you're forty-five. Having passed that significant date, I thought I would do something else. Since Christianity had always been central to my life, the idea of testing my vocation and seeking ordination seemed a suitable second career" (O'Connor and Robertson 2008).

– 1997: Polkinghorne was knighted for distinguished service to science, religion, learning and medical ethics.

– 2002: Polkinghorne was the recipient of the prestigious Templeton Prize: "John C. Polkinghorne is a mathematical physicist and Anglican priest whose treatment of theology as a natural science invigorated the search for an interface between science and religion. He resigned his position as Professor of Mathematical Physics at the University of Cambridge in 1979 and became a priest in 1982. His writings apply scientific habits to the fundamentals of Christian orthodoxy – including the Trinity, Christ's resurrection, and God's creation of the universe – and have brought him recognition as a unique voice for understanding the Bible and evolving doctrine. Among his many books are The Way the World Is (1983), The Faith of a Physicist (1984), Belief in God in an Age of Science (1998), and Exploring Reality: The Intertwining of Science and Religion (2006)" (A chronicle: Templeton Prize 2002).

After these two talks were delivered, the audience was given 20 min to comment on the talks, to share views and ideas, and to formulate questions via discussion with the other attendees (either at the same table or at other tables). After that, the floor was opened for audience-led discussions, in which the participants could share their thoughts with and ask questions to a panel formed by St Mary's physicists and theologians. The audience engaged extremely well with this activity as shown by the range of questions asked about Lemaître's idea of a "primordial atom" or "cosmic egg" and how this related to the concept of "singularity" (i.e. at the beginning, all the energy of the Universe was concentrated in an infinitesimally small single point) and to Genesis 1:1, "In the beginning God created the heavens and the earth". Some attendees also commented on the prolificacy of Polkinghorne as a renowned author of many highly successful books (over 30 books) regarding the physics-theology relationship of which he is a very strong advocate. Interestingly, some participants felt that this was a sign of Polkinghorne's insecurity on the validity and importance of the science-religion interface, i.e. Polkinghorne wrote so many books on the topic because he had to convince himself, as well as others, of the importance of such an interface in seeking Truth.

A very interesting discussion also occurred on Polkinghorne's:

1. Belief that his move from science to religion had given him "binocular vision" of reality
2. Belief that science and religion address aspects of the same reality because both seek the Truth about reality using different but complementary tools
3. Acceptance of the existence of God as a "tool" which can enable the scientist to fully and truly understand reality.

This debate allowed the participants who were less familiar with Polkinghorne as a world famous theoretical physicist to actively participate to the discussion through their religious and faith-based understanding of "reality" and "Truth". This made the audience-led discussion inclusive.

Workshop 2 – "The Big Bang theory and the creation of the Universe: The cosmological and biblical viewpoints"

The workshop took place at St Mary's University. The 30-min talk on the cosmological viewpoint and interpretation of the creation of the Universe was delivered by a cosmologist and focused on different cosmological theories (Kragh 2013), such as:

- Aristotle's Universe: The Earth is surrounded by concentric celestial spheres containing the planets and the fixed stars.
- Ptolemy's Universe: The Earth is a static planet at the centre of the Universe and the planets orbit the Earth, following circular epicycles.
- Copernicus's Universe: The Sun is at the centre of the solar system with the planets (including the Earth) orbiting it.
- The Big Bang theory of the Universe: The Universe stemmed from an extremely small and dense point (called a singularity) about 13.8 billion years ago. Since its "birth" the Universe has been expanding.

The 30-min talk on the biblical viewpoint and interpretation of the creation of the Universe was delivered by a biblical scholar and was centred on Genesis 1 and 2. In the talk, the agreement between Genesis 1.1–2.3 and modern scientific cosmology was emphasised and the following points presented:

- Text was a carefully crafted biblical cosmology based on the plan of the Jerusalem Temple.
- Genesis account began not with God creating *ex nihilo*, as commonly assumed, but with the deity working with undifferentiated matter, a cosmic mishmash. Primordial light, the first act of creation, was distinguished temporally from the light transmitted by the Sun and other stars.
- Genesis account charted the progressive differentiation of the cosmos from cosmic mishmash to an intricate structure that supports biodiversity in which *Homo habilis* and *Homo sapiens* were the latest arrivals on our evolutionary calendar.

As in Workshop 1, after these two talks, the participants were given 20 min to share their thoughts, doubts, questions, etc. At the audience-led discussion that followed, the attendees had the opportunity to share their views and ask questions to a panel composed of physicists and theologians. The audience appeared to have a keen interest on exploring further the extent to which the biblical and scientific understanding and interpretation of creation were not in contradiction but seemed to corroborate each other. In particular, the synergy between physics and faith was discussed not only from the point of view of the Big Bang theory and how it could connect to the creation described in Genesis 1 but also from that of the relationship between biblical cosmology and the Jerusalem temple, and how Genesis 1.1–2.3 was a corrective against polytheistic concepts encountered by the Israelites in Egypt and Babylon as well as in Canaan. A debate on how physics and the scriptures overcome the geocentric theory (i.e. the Earth at the centre of the system with the Sun and the other planets orbiting around it) followed. As in Workshop 1, the participants who were less familiar with the physics of the creation of the Universe appeared to feel comfortable with exploring it, using as a starting point the biblical cosmology they were familiar with. This workshop was well attended by GCSE and A-level students in physics, religious studies and philosophy who participated actively in the discussions and showed a genuine interest in the interrelationship between physics and theology.

Workshop 3 – "Quantum superposition and human consciousness: Anything in common?"

This workshop was different from the two previous for two reasons: the venue was the hall of a local Catholic parish and the talk was one hour long and was delivered by a physicist only. The focus was on:

– How the elegant mathematical framework of quantum mechanics explains how all the Universe and every living and non-living entity in it (from galaxies to the atoms composing a rock on Earth) are connected in a harmonious pattern (McTaggart 2008).
– Quantum entanglement: Actions of subatomic particles can influence each other no matter how distant they are from each other (Clegg 2009).
– The thought experiment of "Schrödinger's cat" and how it shows the influence that the observer has on the object and/or phenomenon under study (Schrödinger 1935).
– Human and cosmic consciousness and their interrelationship (Lipton 2011; Tegmark 2015).
– How some of the "mysteries" of reality can be explained by quantum physics (Gribbin 1985).

Similar to the previous two workshops, after the talk the audience had 20 min to discuss their views and questions with other attendees, and this was followed by an audience-led session where the participants were invited to ask question to the panel formed by physicists, philosophers and bioethicists. The level of engagement of the audience was quite high and the questions ranged from the relationship between how we define human consciousness from the point of view of psychology and quantum physics, to the effects of quantum entanglement in the Universe. Particular attention was given to exploring further the concept of cosmic consciousness and the fact that consciousness is inextricably linked to reality as we know it: nothing can happen on the physical plane if it is not observed by a conscious mind. The participants seemed to be keen in understanding better the concept of the "observer effect" in quantum mechanics[2] and how the observer-matter interrelationship makes reality "real" for us.

[2] The "observer effect" tells us that before we observe it a wave is free to spread and move in time and space; however, when we observe the wave it becomes a specific event localised in time and space.

Evaluation of the Audience Feedback

At the end of each workshop we asked the audience to fill in a short feedback form. The form comprised a series of questions on the event to understand:

– Who the participants to the event were
– How often the participants attended a science event
– How often the participants attended events based on their faith
– How the participants found out about the Physics and Theology event
– Whether the event changed the participants' perspectives on the compatibility of Physics and Faith
– Whether the event changed the participants' views on Physics
– Whether the event encouraged the participants to explore more science and its impact on nature, society, humanity, etc.

There was also a space for general comment so participants could leave feedback and opinions on the event. We also asked the participants to leave their contact details to create a database for future events.

Results of the Audience Feedback and Discussion

The number of attendees to each event is the following: 20 participants at the first workshop, 41 at the second workshop and 52 at the last workshop. The numbers of completed feedback forms received are: 17 (85%) for Workshop 1, 25 (61%) for Workshop 2, and 31 (60%) for Workshop 3.

Type of Audience Attending the Workshops

The first three questions on the feedback form helped us identify what type of audience was participating at the events.

Figure 20.1 shows the results to the feedback question: "Do you attend weekly mass/service/congregation?" This question aimed to quantify the percentage of participants who were believers and practiced their faith, as this type of audience was the primary target of the project. Figure 20.1a shows that 67% of the attendees to the three workshops attended a weekly service, 7% attended the services but not weekly, and 27% never attended their weekly service. Interestingly, if only the replies from the third workshop (which was held in a local Catholic parish) were considered (Fig. 20.1b), the analysis of the feedback answers showed that 93% of the audience attended a weekly service regularly. This finding seemed to indicate that the best

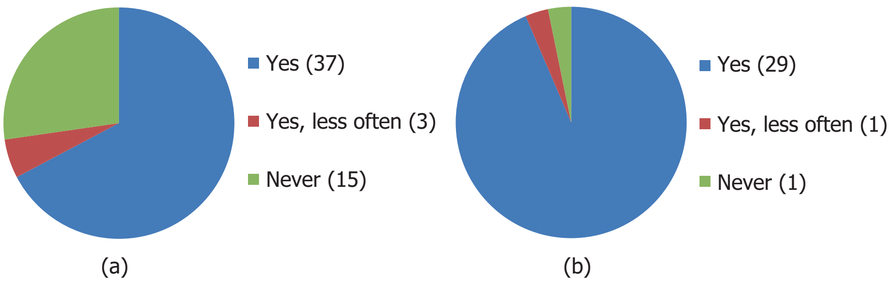


Fig. 20.1 Summary of the answers to the feedback question: "Do you attend weekly mass/service/congregation?" given by the participants to (**a**) all three workshops and (**b**) the third workshop only

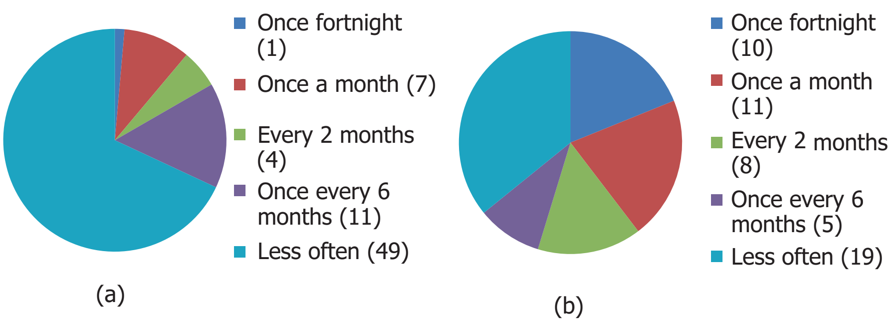


Fig. 20.2 Summary of the answers given by the participants to the feedback questions: (**a**) How often do you attend science events?, and (**b**) How often do you attend faith-based events beyond your weekly congregation?

way of engaging Christian audiences with science would be to hold events at a local parish, probably because the more informal and familiar environment offered by a parish hall would make people, who would not normally attend a science event but who attend regularly their weekly services, feel more comfortable in attending one.

The second and third questions were: "How often do you attend science events?" and "How often do you attend faith-based events beyond your weekly congregation?", respectively. These questions aimed to compare the participants' cultural capital based on religious events versus cultural capital based on science events. The results are shown in Fig. 20.2 and indicate that 68% of respondents attended a science event less than once every six months (Fig. 20.2a), whereas 36% of the participants attended a faith event less than once every six months. These findings seem to infer that the attendees normally did not engage with science and that they were more likely to attend an event based on faith than science. Therefore, faith as a "hook" appears to have some potential to engage with science audiences who normally would not attend a science event.

It is interesting to notice that at the second event (held at St Mary's University), there were about 20 people who attended the first event (also held at St Mary's University). This was due to a general feeling among the audience of a community being built based on these events, which provided a safe space for discussion. However, at the third event (held at a local Catholic parish located at about 11 miles from St Mary's University), there were only two people who had attended the previous two events. This could be due to the location being perceived as too far away from where the participants live. These findings appeared to indicate that a suitable approach would be to hold the physics-faith workshops alternately at St Mary's University and a local parish. In fact, St Mary's University seems to provide the safe community space where more challenging topics can be covered, while events held at local parishes appear to enable the reaching out to new audiences.

Audience's Perception of the Compatibility or Lack Thereof Between Science and Religion

The following three questions in the feedback form aimed to better understand the attitude of the audience towards science (and more specifically physics) and faith.

Figure 20.3 shows the summary of the audience's answers to the questions: "In your opinion, are faith and science compatible?" and "Is this different from the opinion you had before tonight's event?" Most (68%) of those attending the events thought that both faith and science are compatible (Fig. 20.3a). Interestingly, four of the five participants who answered "Yes" to the question "Is this different from the opinion you had before tonight's event?", were A-Level students. The results seem to show that even though 86% of the respondents did not change their opinion about the compatibility of science and religion as a result of the events, the workshops not only did encourage some of the participants to rethink their views on the science-religion synergy but also did provide an opportunity to question and challenge the science and faith compatibility as shown by the following comments:

> A very worthwhile evening which for me highlighted the value in not considering knowledge in a compartmental subject-based way but taking a wider view e.g. allowing theological thinking into physics and vice versa. This evening didn't change my views radically but it was very entertaining (Event 2 participant)

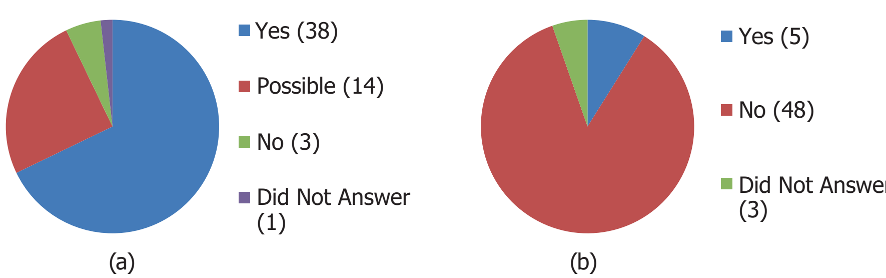
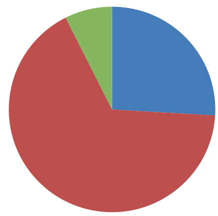


Fig. 20.3 Summary of the answers given by the participants to the feedback questions: (**a**) "In your opinion, are faith and science compatible?" and (**b**) "Is this different from the opinion you had before tonight's event?"

Fig. 20.4 Summary of the answers given by the participants to the feedback question: Did tonight's event change how you view physics?



Very refreshing discussion and interesting perspective on the meaning of creation in Genesis, confirmed my belief that science & theology are compatible! (Event 2 participant)

My opinion is different as I have now seen and realised that they can work together than constantly being in competition with one another (Event 2 participant)

The fact that the workshops did not change their opinion on the compatibility of science and religion is probably due to the fact that the majority of the attendees already agreed on their coexistence. Nonetheless, the events seemed to encourage further exploration of the science-theology relationship.

The last question on the feedback form was: "Did tonight's event change how you view physics?" As shown in Fig. 20.4, 67% of the attendees did not think that the workshops changed their ideas and views on physics.

However, the events did help change some (26%) participants' views on physics. In particular, it was interesting to see how these perceptions had changed as indicated by some of the comments:

Even more exciting than I thought! (Event 2 participant)

It's now clearer and I found it more interesting. (Event 2 participant)

Far more interesting and engaging (Event 2 participant)

There's so much still unknown (Event 2 participant)

Always have been interested but now more enthused to read more. (Event 3 participant)

Of the 14 participants whose opinions on physics were changed at the events, seven (50%) did attend weekly services, one (7%) attended the weekly services but not regularly, and six (43%) did not attend weekly service. The fact that over 50% of these attendees attended weekly services could indicate that faith can potentially act as a medium to engage Christian communities with science.

General Comments

A blank space was provided at the end of the feedback form for participants to leave general comments from the events. Some of the comments are below:

Workshop 1

A very interesting and thought-provoking discussion.

Very useful and informative.

Workshop 2

Excellent. The presenters complemented each other well and defined the arena of knowledge of each of their disciplines. Very competent handling of questions. I came away more curious now as much about the psychology of believers and scientists as in the relationship between faith and science.

Wonderful event with such levels of knowledge from speakers, and a total lack of fear of integration. It was so refreshing to have a room of people confident and total in their beliefs and feelings be so willing to embrace challenge and discussion. Thank you!

A very worthwhile evening which for me highlighted the value in not considering knowledge in a compartmental subject-based way but taking a wider view e.g. allowing theological thinking into physics and vice versa. This evening didn't change my views radically but it was very entertaining.

After tonight's event I have definitely seen physics and religion mixed together from a new and more enlightened point of view.

Workshop 3

Interesting discussion. Better than I thought it would be. Quantum Mechanics experimentation a little difficult and some be characterised. It would have been good to have had a non-believer in addition to the faith.

The evening was very thought provoking and incredibly interesting. It was a privilege to hear the views of such learned and experienced people. Thank you!

Would have liked a theologian's input. Excellent have a much clearer understanding of Quantum Mechanics

I love the concept of science living side by side with theology because science is trying to define existence hence nature. So science should live side by side with theology.

Very interesting – Would like to have heard more about the relationship between science & theology!

This is the first Physics event I have ever understood anything! Very clear, excellent slides, dynamics and very interesting. Could have done with a bit more theology. I am an RE teacher and would have loved to have seen more like this.

These comments gave us an insight into how the slightly different formats worked. The format for the second event appeared to be more successful in engaging and providing a more balanced debate between physics and theology. This was probably due to the fact that there were two distinct talks for physics and theology and that they were delivered by a physicist and a theologian. Conversely, at the third event, there was only one talk with no clear distinction between the physics and the theology aspects of the topic covered. As a result, the audience asked primarily questions on the physics part of the talk. Hence, the format where two speakers (one for physics and the other for theology) are present seems to work better perhaps because it helps the participants gain a deeper understanding of the different aspects (scientific and theological) of the topic.

Conclusions

The audience attending these events was diverse and ranged from professional scientists, school teachers and GCSE- and A-level students studying philosophy, theology and/or physics, to clergy, active members of local parishes and members of the local community. Some members of the audience had never attended a science event before and from the results of the feedback forms and the audience comments it would appear that they found faith a safe medium to explore complex concepts, such as the Big Bang theory and quantum physics, through more familiar concepts, such as creation and human consciousness.

The analysis of the feedback forms showed that ~67% of the participants attended a science event less than once every six months. For some of the participants, this was the first time they attended a physics event as they usually did not feel comfortable with going to science events. This result could indicate that some of the participants did not normally engage with science and that the driving force behind their choice to come to the workshop could be the faith component. In addition, some of the comments from the participants indicated that these workshops provided an opportunity to question and challenge the relationship and compatibility between science and religion.

Overall, the outcome of the project was satisfactory and the events contributed to engaging Christian communities with physics and its relationship with theology. Additionally, the workshops helped school students and science, philosophy and/or religious studies teachers to explore further the synergy between physics, philosophy and theology.

Acknowledgements The "Connecting Physics with Faith Project" was supported by the Institute of Physics (IOP) and the author wishes to thank the IOP for the award of an IOP Public Engagement Grant. The author also wishes to thank Dr Dominic Galliano (Director of Outreach – SEPnet), Dr Ali Mozaffari (Lecturer in Physics at St Mary's University), Dr Tarcisius Mukuka (Lecturer in Theology at St Mary's University), Prof Geoff Hunt (Prof of Philosophy and Society at St Mary's University) and Dr Trevor Stammers (Programme Director for Bioethics and Medical Law at St Mary's University) for their contributions to the "Connecting Physics with Faith" project.

References

A chronicle: Templeton Prize. (2002). Templeton Prize Laureate, Rev. Dr. John C. Polkinghorne. The Templeton Foundation.

Aquinas, T. (2015). *Summa theologica*. Los Angeles: Leopold Classic Library.

Barber, N. (2012). *Why atheism will replace religion: The triumph of earthly pleasures over pie in the sky*. Amazon Digital Services LLC.
Catholic Bible: Revised Standard Version (2006), Ignatius Press; 2nd new edition.
Clegg, B. (2009). *The God effect: Quantum entanglement. Science's strangest phenomenon*. New York: St. Martin's Griffin.
Currall, S. C. (2009). Nanotechnology and society: New insights into public perceptions. *Nature Nanotechnology, 4*, 79–80.
Dampier, W. (2008). *A history of science and its relations with philosophy and religion* (4th ed.). Cambridge: Cambridge University Press. London, England (UK).
Davies, P. (1993). *The mind of God: The scientific basis of a rational world*. London: Simon & Schuster UK.
Greenfield, S. (2009). *ID: The quest for meaning in the 21st century*. London: Sceptre.
Gribbin, J. (1985). *In search of Schrödinger's cat*. Updated edition. Black Swan.
Hawking, S., & Mlodinow, L. (2010). *The grand design*. New York: Bantam Books.
Hedley Brooke, J. (2000). *Reconstructing nature: The engagement of science and religion* (1st ed.). Edinburgh: Oxford University Press.
Heisenberg, W. (1971). *Physics and beyond: Encounters and conversations* (World perspectives). New York: Harper & Row.
Hooykaas, R. (2000). *Religion and the rise of modern science*. Vancouver: Regent College Publishing.
Jung, C. G. (1977). *The collective works* (Mysterium coniunctionis) (Vol. 14, 2nd ed.). Princeton: Princeton University Press.
Keiper, A. (2003). The nanotechnology revolution. *The New Atlantis*, Summer, pp. 17–34.
Kragh, S. H. (2013). *Conceptions of cosmos: From myths to the accelerating universe: A history of cosmology*. Oxford: Oxford University Press. (Reprint edition).
Lemaître, G. (1931). A homogeneous Universe of constant mass and growing radius accounting for the radial velocity of extragalactic nebulae. *Monthly Notices of the Royal Astronomical Society, 91*, 483–490.
Lipton, B. H. (2011). *The biology of belief: Unleashing the power of consciousness, matter and miracles*. London: Hay House UK.
Logothetidis, S. (Ed.). (2012). *Nanostructured materials and their applications*. Berlin/Heidelberg: Springer.
Long, D. E. (2013). Finding Jesus' magic pineapple: or, improving science education by improving religious education. *Cultural Studies of Science Education, 8*, 389–398.
McTaggart, L. (2008). *The intention experiment: Use your thoughts to change the world*. London: Harper Element.
Mercier, B., Kramer, S. R., & Shariff, A. Z. (2018). *Belief in god: Why people believe, and why they don't*. *Current Directions in Psychological Science, 27*(4), 263–268.
Midbon, M. (2000). A day without yesterday': Georges Lemaître and the Big Bang. *Commonweal Magazine, 127*, 18–19.
O'Connor, J. J., & Robertson, E. F. (2008). John Charlton Polkinghorne. *MacTutor History of Mathematic.* Available at http://www-history.mcs.standrews.ac.uk/Biographies/Polkinghorne.html
Paley, W. (2006). *Natural Theology.* Oxford: Oxford University Press. (New edition).
Plato. (2008) *Timeus and Critias*. Penguin Classics. (Revised edition). Scotts Valley: CA, USA.
Polkinghorne, J. (2008). *From physicist to priest: An autobiography*. Eugene: Cascade Books.
Schrödinger, E. (1935). Die gegenwärtige situation in der quantenmechanik (The present situation in quantum mechanics). *Naturwissenschaften, 23*, 807–812.
Tegmark, M. (2015). Consciousness as a state of matter. *arXiv*:*1401.1219* [quant-ph].

Elisabetta Canetta Elisabetta graduated from the Department of Physics of the Universita' di Bologna, Bologna (Italy) with an MPhys in Theoretical Nuclear Physics. In 2000, she moved to the Universite' Joseph Fourier, Grenoble (France) and obtained a PhD in Experimental Biophysics in 2004 with a thesis entitled '*Micromanipulation of living cells by using an AFM spectrometer: Application to cancer*'.

In 2004, Elisabetta joined the University of Abertay Dundee as a Postdoctoral Research Assistant (PDRA), where she focused her research on the investigation of the microrheological, biomechanical and structural properties of yeasts, proteins, viruses and living mammalian cells by atomic force microscopy (AFM), small angle neutron scattering (SANS) and neutron reflectivity (NR). In 2007, Elisabetta joined the Department of Physics of the University of Surrey as a Postdoctoral Research Fellow (PDRF) where she worked within the framework of two FP6 Projects on the investigation of the physical, mechanical and structural properties of nanocomposite polymers by AFM, nuclear magnetic resonance (NMR) profiling, differential scanning calorimetry (DSC), macro-mechanical analysis (MMA), and X-ray photoelectron spectroscopy (XPS).

In 2009, Elisabetta joined the Optical Trapping Group at the School of Physics and Astronomy of the University of St Andrews as a PDRF where she worked on the further development of modulated Raman spectroscopy (MRS) techniques for fast and reliable discrimination of normal and cancer cells.

In 2011, Elisabetta moved to the School of Biosciences of Cardiff University as a Lecturer in Biophotonics, and in 2013, she joined the School of Sport, Health, and Applied Science of St Mary's University as Lecturer in Physics on the BSc Applied Physics undergraduate course.

Chapter 21
If Neither from Evolution nor from the Bible, Where Does Tension Between Science and Religion Come from? Insights from a Survey with High School Students in a Roman Catholic Society

João C. Paiva, Carla Morais, and Luciano Moreira

Introduction

Where modernity was endogenous—to use an expression borrowed from Touraine (1992)—that is, essentially in occidental society, science and technology served as a beacon to guide politics or, at least, to justify them, while religion, on the other hand, was expected to be limited to the private sphere of citizens' life. Nonetheless, modernity is an heir of the Judaeo-Christian worldview, according to which the world exists, it is good and it is knowable (Artigas 2000). While heirs of modernity, can *occidental citizens* pretend that their lives are split into separate boxes that do not communicate and that even contradict each other?

In this chapter, we will try to learn what High School students think about science and religion endeavours and to determine if they think of them as conflictual fields. If conflict between science and religion exists and, if so, in what do these conflicts consist for young men and women in the context of a Catholic country is our specific purpose. In the following pages, we will (1) briefly examine literature on the relationship between science and religion, paying special attention to the Barbour's models and to the Portuguese case; (2) describe the quantitative survey used in this research; (3) present the statistical results; and (4) discuss them in the light of what is already known and try to devise new avenues for research and interventions.

J. C. Paiva (✉) · C. Morais
Faculdade de Ciências da Universidade do Porto, CIQUP, Unidade de Ensino das Ciências, Porto, Portugal
e-mail: jcpaiva@fc.up.pt; cmorais@fc.up.pt

L. Moreira
Faculdade de Engenharia da Universidade do Porto, CIQUP, Porto, Portugal
e-mail: lucianomoreira@fe.up.pt

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_21

Literature Review

Barbour's Approach

In his Gifford's lectures, Barbour (1990, 1997) looked into the relations between science and religion from an analytical perspective. He unveiled the epistemological and metaphysical assumptions behind publicly known declarations on science and/or religion. As Longest and Smith (2011) underline, the analysis drove the author to suggest an orthogonal model about the relationship between science and religion: independence, conflict, dialogue, and integration (Fig. 21.1).

We must stress, with Reiss (2008), that the order of presentation of the models does not intend to signify a logical hierarchy:

– Independence model: science and religion are thought as separate realms, without shared interests.
– Conflict model, on the contrary, says that science and religion are concerned with and diverge about specific themes, such as the origins of the universe. In this model, strong and polemical beliefs emerge from theological, metaphysical, or epistemological systems, such as creationism (in religion) and materialism (in science).
– Dialogue model: according to this model, science and religion do have shared interests about specific issues, but these shared fields are considered as an opportunity to dialogue. Scientists and religious people are open to share their own perspectives with others.

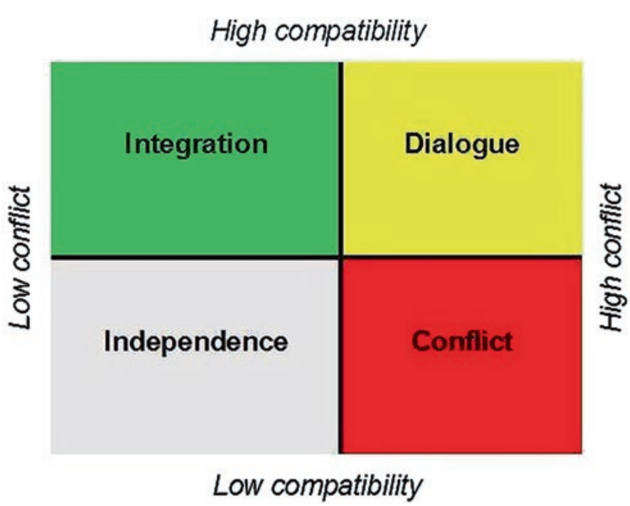


Fig. 21.1 Barbour's (1990, 1997) orthogonal approach (our own adaptation)

– Integration model: Barbour asserts that in what concerns creation and human nature it is possible (and desirable) to formulate a comprehensive metaphysics that encompasses a coherent word view.

This approach is indeed useful to analyse formal scientific and religious discourses and perhaps to understand ordinary people's views. We agree with Longest and Smith (2011) when they reject "the conceptualization of the relationship between religion and science as operating along a continuum from conflicting to compatibility" (p. 849) and consider Barbour's orthogonal model more suitable. Nonetheless, is it correct to reduce complex systems of beliefs, attitudes, and representations to one of four compartments?

The Portuguese Case

The first part of the current research was published elsewhere (Paiva et al. 2016a). Using a questionnaire developed by Taber et al. (2011) and a set of questions developed by Longest and Smith (2011), we investigated the views of Portuguese High School students about the relation between science and religion.

The majority of the students reported to be Catholics. They also indicated a trust in science and an acceptance of the theory of the evolution of species and scientific explanations of the origins of the world. They do not think that their teachers avoid answering questions about religion or ignore their religious faith. Let us stress that the factorial analysis of the results of the questionnaire on the epistemic insight did not corroborate the concepts targeted by the authors and, consequently, further research is necessary to understand its heuristic power in assessing pupils' perceptions on science and religion.

Interestingly, although students accept the theory of evolution of species and the scientific explanation for the origins of the world, they still think that science and religion conflict with each other and are not compatible (Longest and Smith 2011).

One possible explanation for these findings is that individuals may emphasize external controversies and minimize internal conflict in order to keep psychological balance, a hypothesis that finds some support in a recent enquiry in the USA. According to the PEW Research Center (2015), 30% of the respondents said that their own religious beliefs did not conflict with science, but, nevertheless, 59% of them acknowledged that science and religion are often in conflict.

Ethics may be an important avenue to link science and religion. In accordance with Aflalo (2013), freedom of enquiry is more challenged by those who reported more religious practices, but our data has also shown that freedom of enquiry in science is challenged by those with more science-related practices.

The findings suggest that polemic issues, for example, in America or England, creationism or Bible literalism, are not perceived as such among our subjects. In this matter, they seem to adopt the scientific perspective. If this is or is not a consequence of *an epistemic insight,* it is not possible to say for sure. Given that they still perceive science and religion as conflictual, it is more likely that *cultural* reasons explain their answers.

Our study also shows that attitudes towards science and religion are still associated with gender roles. Boys seem more likely to get involved in science and comparatively girls seem more likely to get involved in religion. This is in line with recent international results (Voas et al. 2013).

In synthesis, literature shows that science and religion relations are still greatly associated with conflict (e.g. Taber et al. 2011; Billingsley et al. 2013). Although our previous research confirms this picture, among Portuguese students, conflict does not seem to come from creationism or literal readings of the Bible (Paiva et al. 2016a). Consequently, we have turned our attention to contexts and issues that could acquire special relevance in a predominantly Catholic country, such as Portugal.

Portuguese students, through K5 up to K12, are free to enrol in religious courses when available at their schools (Paiva et al. 2016b). The more frequently available course is Catholic education and often the choice is between a Catholic course and no course at all (because alternatives are often not available). However, religious teachings—properly speaking—are taught outside school in catechesis, which means roughly the same as Sunday school. Many children attend at least the first stages of catechesis (when they receive communion for the first time, usually where they are 7 years old) either because their relatives are active Catholics or because they value this Catholic tradition. Despite the fact that there is not – to our knowledge – any public report about the global number of children enrolled in catechesis nor about the catechist profile, we might ask how Portuguese students perceive catechesis and catechists in relation to science and religion.

On the other hand, an important issue in Catholic tradition is the role ascribed to saints and miracles. In order to recognize someone as saint, the Holly See goes through a deep analysis of the candidate's life and writings as well as testimonies from acquaintances and friends (for details, see the Apostolic Constitution Divinus Perfectionis Magister by John Paul II 1983). The process of canonization, however, is not complete until a miracle can be attributed to the candidate's intercession. At this moment, religion meets science, because a committee of experts (e.g. doctors) is asked to determine if the presumable *miracle* can be explained by natural causes. In the absence of a natural explanation, the miracle is accepted and most likely the saint recognized. Regarding this subject, it is convenient to ask: what value do Portuguese students attribute to saints and miracles? What do they think about the process of canonization?

Finally, Catholic religion includes a long and diversified range of practices and rituals. Often, people use and recycle these *devices* for their own purposes, moved by magical rather than religious drivers. So, to what extent is religion perceived as magical in its essence?

Behind these questions, another and fundamental question lays: "Where does the tension between science and religion come from?" We will address this question in this study.

Method

Subjects

The study sample consisted of 308 high school students (110 males and 198 females), including 200 Catholics and 49 nonbelievers, from two Portuguese schools (one private and one public). Both schools are located in villages in the centre of Portugal and have between 1000 and 1500 students each. Subjects' mean age was nearly 17 years ($SD = 0.898$), distributed as follows: 32% were in year 10, 45% in year 11, and 24% in year 12.

The majority attended the Sciences and Technology program (68%), 12% Arts, 15% Economics, and 5% Fine Arts. Most parents are educated at least to the ninth grade. Approximately two thirds were Catholics, while 49 subjects did not express a religious belief (see Table 21.1). Further information on this sample can be found elsewhere (Paiva et al. 2016a).

Instruments

The questionnaire included two scales retrieved and adapted from the literature on science and religion (scale 1 and scale 2); an original scale to cover questions such as science culture or catechesis (scale 3); and a set of sociodemographic items. The Portuguese version of scale 1—translated from Taber et al. (2011)—consisting of 39 five-point Likert scale items (plus an "I don't understand" option) was found to include eight components, but results were not entirely satisfactory (Paiva et al. 2016a). Scale 2, translated from Longest and Smith (2011), included four five-point Likert scale items (plus an "I don't understand" option) about science and religion conflict, science and religious views, science and teachings of religion compatibility, and freedom of enquiry.

Scale 3 originally consisted of 26 five-point Likert scale items (plus an "I don't understand" option). Seven items were found to be problematic and were deleted, because 20 respondents or more did not understand. Despite this, however, internal consistency for the 19 scale items was still found to be low ($\alpha = 0.60$). A principal component analysis (with varimax rotation) suggested the existence of six components, but given that they were statistically weak and theoretically inconsistent, they were dropped and each item was considered separately.

Table 21.1 Religious belief by sex

	Catholics	Other religion	Believers without religion	Nonbelievers	None of the previous	Total
Male	67	0	9	26	8	110
Female	133	9	16	23	15	196
Total	200	9	25	49	23	306

Procedure

Questionnaires were sent to teachers of each school and administered during students' regular classes. Data was analysed with the version 22 of SPSS (*Statistical Package for Social Sciences*).

Results

Complementary Data on Epistemic Insight

As we have mentioned in the literature review, in a previous study, we have presented the factorial analysis of the *epistemic insight questionnaire*, but we did not compare our results directly with those of the original study. For this reason, it is relevant to start this section by indicating the major differences between our most recent study and the original study.

As one can observe in Table 21.2, in our sample 34% of the respondents totally disagree or disagree that miracles can happen as religion describes. On this issue,

Table 21.2 Absolute frequencies and percentages of relevant items of scale 1

Items	1	2	3	4	5
I believe miracles can happen as religion describes	40 (13%)	64 (21%)	109 (35%)	72 (23%)	20 (7%)
A good scientist can NOT believe that the universe was created about 6000 years ago	44 (14%)	54 (18%)	90 (29%)	49 (16%)	62 (20%)
I believe that the universe was created in the way the Bible describes	100 (33%)	93 (30%)	87 (28%)	15 (5%)	12 (4%)
I accept the scientific theory that the whole universe was created in a big bang	7 (2%)	12 (4%)	73 (24%)	158 (51%)	55 (18%)
I think a lot about whether science and religion fit together	27 (9%)	71 (23%)	66 (21%)	104 (34%)	35 (11%)
I am confused about what to believe—we are told different things about how the universe and life began	52 (17%)	49 (16%)	39 (13%)	114 (37%)	49 (16%)
Religious ideas about how the universe began have been PROVED WRONG by science	10 (3%)	46 (15%)	110 (36%)	112 (36%)	23 (8%)
The scientific and the religious versions of how the universe began CANNOT both be true	26 (8%)	71 (23%)	101 (33%)	68 (22%)	37 (12%)

1, I totally disagree; 2, I disagree; 3, I do not know; 4, I agree; 5, I totally agree

Portuguese pupils are more critical than English pupils are. Also more than one third (34%) of the respondents think that a good scientist cannot believe that the universe was created 6000 years ago against a quarter in the original study. On the other hand, nearly the same proportion (32%) as in the original study (a third) rejects the idea that a good scientist cannot believe that the universe was created 6000 years ago.

Almost two thirds of the respondents do not believe that the Universe has been created as the Bible says (a large majority of 63% versus a minority in the original study). Congruently, Portuguese students largely accept the Big Bang theory (69%) and only a 6% reject it (as opposed to one quarter in the original study). Almost half of the Portuguese pupils admit that they think a lot about the compatibility of science and religion (45%) as opposed to only over a quarter in the original study. Accordingly, more than half declare to be confused about what to believe in (53%) against two fifths in the original study. More than two fifths (44%) were of the opinion that religious ideas about the beginning of the universe were contradicted by science (against only over a quarter in the original study). Nevertheless, they were less confident to conclude that the scientific version and the religious version cannot be both held as true (34% against almost half in the original study).

A New Scale on Science and Religion

Scale 3 was specifically proposed for a Catholic context. Notably, many of the items omitted in the analysis, because pupils did not understand them, related to the process of canonization.

Table 21.3 presents the means for each item that was included in scale 3. The items with the highest level of agreement were about acceptance for the theory of the evolution of species ($M = 3.80$, $SD = 0.902$), the impossibility of a literal reading of the Bible ($M = 3.74$, $SD = 1.108$), the lack of scientific explanations for some events ($M = 3.67$, $SD = 1.057$), and the extraordinary features of miracles ($M = 3.54$, $SD = 0.977$).

Items which affirmed that magic and superstition are part of religion ($M = 2.74$, $SD = 1.062$), 'God is an invention of religion' ($M = 2.77$, $SD = 1.157$), 'catechism is all about religion, therefore it has no need for scientific culture' ($M = 2.89$, $SD = 1.019$), and 'scientists tend not to have faith' ($M = 2.85$, $SD = 1.032$) were rejected by the respondents.

Table 21.4 compares Catholic ($n = 200$) respondents with nonbelievers ($n = 49$). While nonbelievers expressed stronger support for the view that the Bible cannot be read literally (Catholics Mean Rank = 117,56; Nonbelievers Mean Rank = 141,56; $U = 3575$, $p < 0.05$), Catholics expressed higher support for the acceptance of the theory of the evolution of species, despite that in this last case the difference was not statistically significant (Catholics Mean Rank = 123.13; Nonbelievers Mean Rank = 122.46; $U = 4627.5$, ns).

Table 21.3 Means (*M*) and standard deviations (*SD*) on scale 3

Items	*M*	*SD*
6. The theory of evolution can be accepted by believers	3.80	0.902
3. The Bible can NOT be read literally	3.74	1.108
18. Science has no explanation for some events—and it never will	3.67	1.057
17. The essential about miracles is their lack of scientific explanation	3.54	0.977
14. Both religion and science have a dynamic character	3.43	0.839
21. Saints are important because they are an example of life	3.43	1.039
7. Many believers still have a vision of the world as if Galileo and Darwin had never existed	3.38	0.995
12. Catechism teachers should have scientific training to sustain their logic	3.36	0.967
2. Many issues in typical catechesis disagree with the current scientific culture	3.35	0.935
5. Believers should know more about science so as to sustain reasons to have faith	3.31	1.015
4. A greater scientific culture might lead to a more mature religious practice	3.31	0.909
24. Scientific culture contributes to a mature faith	3.26	0.886
10. As science develops, religion loses importance	3.10	1.083
8. Religion has been adapting to science	3.03	1.026
22. Saints are important for the miracles they've done or do	2.97	1.032
13. Catechism is all about religion, therefore it has no need for scientific culture	2.89	1.019
11. Scientists tend not to have faith	2.85	1.032
9. God was invented by religion	2.77	1.157
26. Magic and superstition are part of religion	2.74	1.062

Nonbelievers were more prone to think that religion was losing importance as science develops (Catholics Mean Rank = 114.52; Nonbelievers Mean Rank = 155.96; $U = 3057$, $p = < 0.001$); 'scientists were not likely to have faith' (Catholics Mean Rank = 117.71; Nonbelievers Mean Rank = 144.71; $U = 3686$, $p < 0.05$); 'catechists should learn more about science to support their faith' (Catholics Mean Rank = 113.10; Nonbelievers Mean Rank = 162.96; $U = 2693$, $p = < 0.001$); yet paradoxically, catechesis does not need scientific culture (Catholics Mean Rank = 116.29; Nonbelievers Mean Rank = 152.01; $U = 3242.5$, $p = < 0.001$). Nonbelievers also considered to a higher degree that magic and superstition were religious realms (Catholics Mean Rank = 118.44; Nonbelievers Mean Rank = 141.73; $U = 3829$, $p < 0.05$) and that God is an invention of religion (Catholics Mean Rank = 105.88; Nonbelievers Mean Rank = 184.64; $U = 1625.5$, $p = < 0.001$).

On the other hand, Catholic believers were more prone to think that science does not have explanation for some events—and it never will (Catholics Mean Rank = 129.84; Nonbelievers Mean Rank = 99.78; $U = 3613.5$, $p < 0.01$). Catholic believers recognize the merits of saints' lives (Catholics Mean Rank = 131.94; Nonbelievers Mean Rank = 83.94; $U = 2853$, $p = < 0.001$) and miracles (Catholics Mean Rank = 135.36; Nonbelievers Mean Rank = 74.59; $U = 2404.5$, $p = < 0.001$).

Table 21.4 Percentiles, Mean ranks, and Mann-Whitney test between Catholics and nonbelievers on scale 3

	Catholics				Nonbelievers					
	Percentiles				Percentiles					
	25th	50th (Mdn)	75th	Mean rank	25th	50th (Mdn)	75th	Mean rank	U	p
6. The theory of evolution can be accepted by believers	4	4	4	123.13	4	4	5	122.46	4627.500	.949
18. Science has no explanation for some events—and it never will	3	4	4	129.84	2	4	4	99.78	3613.500	.006
3. The Bible can NOT be read literally	3	4	4	117.56	3	4	5	141.56	3575.000	.031
21. Saints are important because they are an example of life	3	4	4	131.94	2	3	4	83.94	2853.000	.000
14. Both religion and science have a dynamic character	3	4	4	120.78	3	3	4	100.30	3367.000	.051
17. The essential about miracles is their lack of scientific explanation	3	4	4	117.41	3	4	4	128.00	4089.000	.321
2. Many issues in typical catechesis disagree with the current scientific culture	3	3	4	120.91	3	3	4	110.83	3952.500	.346
7. Many believers still have a vision of the world as if Galileo and Darwin had never existed	3	3	4	117.88	3	4	4	130.97	4105.500	.217
4. A greater scientific culture might lead to a more mature religious practice	3	3	4	120.03	3	4	4	127.61	4295.500	.477
5. Believers should know more about science so as to sustain reasons to have faith	3	3	4	119.56	3	4	4	139.74	3972.500	.066
22. Saints are important for the miracles they've done or do	2.75	3	4	135.36	1	2	3	74.59	2404.500	.000
12. Catechism teachers should have scientific training to sustain their logic	2	3	4	113.10	3	4	4.50	162.96	2693.000	.000
8. Religion has been adapting to science	2.75	3	4	123.27	2	3	3.50	124.47	4705.500	.913
10. As science develops, religion loses importance	2	3	4	114.52	3	4	4	155.96	3057.000	.000
11. Scientists tend not to have faith	2	3	3	117.71	2	3	4	144.71	3686.000	.014
13. Catechism is all about religion, therefore it has no need for scientific culture	2	2	4	116.29	2	3	4	152.01	3242.500	.001
26. Magic and superstition are part of religion	2	3	4	118.44	3	3	4	141.73	3829.000	.034
9. God was invented by religion	2	2	3	105.88	3	4	5	184.64	1625.500	.000

Interestingly, saints were given more importance for their example of life than for their miracles.

No systematic differences were found between male and female respondents nor between schools.

Discussion

In this chapter, we presented the results of an enquiry about the perceptions and attitudes on science and religion among Portuguese High School students. Our previous research suggested that the source of the tension between science and religion did not seem to come from controversies such as the origins of the universe or Bible literalism. The present research aimed at looking into this further in the context of a society with a Catholic tradition.

It is a reasonable hypothesis to argue that sociocultural context and life experiences influence peoples' views of science and religion (Longest and Smith 2011), but one should not forget that the respondents in our survey were somewhat older than the English respondents (Taber et al. 2011) and that most of them were studying sciences.

This said, it is true that in some key points Portuguese pupils answer differently. In our study, such as in Billingsley et al. (2013, p. 1728), "science and religion were perceived to present contradictory claims", but whereas only a minority of the English pupils refused to believe in the Genesis version of the creation, a large majority of the Portuguese pupils not only refuse this perspective but also accept the Big Bang theory. A quarter of the English study refused to accept the Big Bang theory compared with 6% of the Portuguese pupils.

In addition, Portuguese students clearly accept that the Bible is not meant to be read literally (see item 3 results in the previous section). They do admit to thinking a lot about whether or not science and religion are compatible. The question is thus: what opportunities do they afford to reflect upon this?

The complex net of relations that underlies students' perceptions has paradoxical intersections. Prejudice can come not only from religious radical perspectives, but also from misconceptions about the nature of science, eventually associated with a deified or idealist vision of science (Barbour 1990, 1997). Let us keep in mind that a lot of respondents think that, in science, theories become facts when proved. This urges us not only to provide students with adequate views on the nature of science, but also on the nature of scientific enquiry (Lederman et al. 2014). Although perceptions on science do not seem to be correlated with academic background (Fleener 1996; Aflalo 2013), they seem to be correlated with religious beliefs (Afalo 2013), which requires us to get more reliable assessments about the nature of science and the nature of religion.

In a Catholic country such as Portugal, Bible literalism and the theory of the evolution of species do not seem to be the reasons why science and religion are still perceived as conflictual among young believers. Catholics and nonbelievers however have different perceptions on a variety of issues.

Saints, miracles, catechesis as well as public and private religious expressions of faith play an important role in believers' life. The results of our survey showed that the perceptions of the Catholic pupils are different from those of nonbelievers. On the one hand, nonbelievers expressed great criticism. For them, religion is somewhat static, believers and catechists need more training, and saints are not to be taken as models of life. They perceive religion as essentially magical.

On the other hand, Catholic pupils did not think unanimously about these issues. If their answers are more moderate, they also range considerably. It may be that some of them think that the relation between the content and ways of expressing one's faith needs to be subjected to reflection. Perhaps, then, the discussion can move from the classically controversies on world creation and Bible literalism to contemporary moral dilemmas, role models, and expressions of faith.

It may also be as if conflict was pushed (projected) onto other people or other groups (PEW 2015). At the same time, nonbelievers seem to be more prone to think that scientific culture is important to support the principals of faith, yet they admit that science does not need to play a strong role in catechesis.

Our intention is not to say that conflict did not happen or even that it is now solved. Instead, we acknowledge that conflict existed and exists. *Evolutionism* and *Bible literalism* are surely among its possible causes. At the same time, we suggest that conflict assumes particular sociohistoric expressions, which varied and changed. As such, an enquiry to understand what troubles or feeds the conversation between science and religion is necessary. To go in the direction of such an enquiry, it is necessary to unmask and destroy one fallacy (a) and be open to admit that the net of relationships between science and religion may be more complex than it appears (b).

The conflict between science and religion does not consist exclusively in an opposition between two or more persons or groups that have different perspectives; it is, first of all, an internal conflict that can be more or less profound. The conflict—or whatever the form the relationship takes—thus can be analysed in four different levels of analysis in social psychology, as proposed by Doise (1986), intrapersonal, interpersonal, positional, and ideological.

The relation between science and religion is dynamic. The heart of the matter is not whether they are compatible, since compatibility is often possible even if with immense damages for one's own sense of coherence. In our perspective, it is necessary to conceive two sets of representations that progressively adjust and change one another in a horizontal plan and that do not conflict in a vertical plan. By horizontal plan, we refer to the relationships that may occur within a given level of analysis. For example, if we report to the intrapersonal, psychological level, we can ask whether one's attitudes towards *miracles* are coherent with one's metaphysical position on materialism. By vertical plan, we refer to the relationships that occur between levels of analysis. For example, are one's attitudes towards religious services (intrapersonal level) with one's participation in a coral group (positional level)?

This multidimensional approach allows us to determine the position and extent of each eventual conflictual area (Reiss 2008), giving Barbour's (1990, 1997) models of relating science and religion a renewed interest.

Further research is necessary to understand the stability or patterns of fluctuation of the models across levels of analysis (intrapersonal, interpersonal, positional, and ideological), since tension between science and religion may not only vary across levels of analysis, but also be caused by paradoxes or inconsistencies across these levels where human beings move. We would like to stress the need to approach this area through the lens of social representations. We believe that they will allow us to comprehend how both science and religion are appropriated by social groups and, ultimately, by individuals. This implies a critical examination of the arguments used by ordinary people. In fact, if social representations can be seen as *distortions* of scientific theories/models or religious teachings, they would allow people to build an internally coherent and balanced discourse.

Educators need to convey a coherent, yet complex, vision of both science and religion and help students to develop an "enlarged mentality", in Kant's words (1785, 2014), according to which one can understand and represent the other in one's own mind. We can say with Billingsley et al. (2013, p. 1729) that, "what students seemed to lack were the intellectual tools needed to explore the dilemmas in any depth". Thus, students should be given more chances to think deeply about the nature of science and religion in order to compare their assumptions on various subjects.

Because nonbelievers in our sample are a minority and the three last components turn out problematic, results must be considered carefully. New items must be added to address relevant dimensions (e.g. perceptions on religious practices and contemporary expressions of faith). In brief, more studies are required to understand the potential of the instrument as a means to capture pupils' perceptions and attitudes towards science and religion.

Acknowledgements The authors are grateful to João Moreira for reviewing the manuscript. Luciano Moreira is supported by the Fundação para a Ciência e Tecnologia grant: PD/BD/114152/2015.

References

Artigas, M. (2000). *The mind of the universe. Understanding science and religion*. Philadelphia/London: Templeton Press.

Aflalo, E. (2013). Religious belief: The main impact on the perception of the nature of science on student teachers. *Cultural Studies of Science Education, 8*, 623–641.

Barbour, I. G. (1990). *Religion in an age of science: The gifford lectures 1989–1991* (Vol. I). London: SCM.

Barbour, I. G. (1997). *Religion and science: Historical and contemporary issues*. London: HarperCollins.

Billingsley, B., Taber, K., Riga, F., & Newdick, H. (2013). Secondary school students' epistemic insight into the relationships between science and religion—A preliminary enquiry. *Research in Science Education, 43*(4), 1715–1732.

Doise, W. (1986). *Levels of explanation in social psychology* (E. Mapstone, Trans.). New York: Cambridge University Press.

Fleener, M. J. (1996). Scientific world building on the edge of chaos: High school students' beliefs about mathematics and science. *School Science and Mathematics, 96*(6), 312–320.

John Paul II. (1983). *Apostolic constitution divinus perfectionis magister*. Retrieved March 28, 2017, from http://www.vatican.va/roman_curia/congregations/csaints/documents/rc_con_csaints_doc_07021983_norme_po.html

Kant, I. (2014). *Fundamentação da metafísica dos costumes* [Groundwork of the metaphysic of morals, P. Quintela, Trans.]. Lisboa: Edições 70.

Lederman, J. S., Lederman, N. G., Bartos, S. A., Bartels, S. L., Meyer, A. A., & Schwartz, R. S. (2014). Meaningful assessment of learners' understandings about scientific enquiry—The views about scientific enquiry (VASI) questionnaire. *Journal of Research in Science Teaching, 51*, 65–83. https://doi.org/10.1002/tea.21125.

Longest, K. C., & Smith, C. (2011). Conflicting or compatible: Beliefs about religion and science among emerging adults in the United States. *Sociological Forum, 26*(4), 846–869.

Paiva, J. C., Morais, C., & Moreira, L. (2016a). Attitudes towards science and religion: Insights from a questionnaire validation with secondary education students. In Pixel (Ed.), *International conference new perspectives in science education – conference proceedings* (pp. 430–434). Padova: libreriauniversitaria.it.

Paiva, J. C., Moreira, J., Morais, C., & Moreira, L. (2016b). *Windows for science-religion dialogue in Portuguese school education*. Available at http://www.srsp.net/global/Portugal.docx/

PEW Research Center. (2015). *Science and religion*. Retrieved October 10, 2016, from http://www.pewinternet.org/2015/10/22/science-and-religion/

Reiss, M. J. (2008). Should science educators deal with the science/religion issue? *Studies in Science Education, 44*(2), 157–186.

Taber, K. S., Billingsley, B., Riga, F., & Newdick, H. (2011). To what extent do pupils perceive science to be inconsistent with religious faith? An exploratory survey of 13–14 year-old English pupils. *Science Education International, 22*(2), 99118.

Voas, D., McAndrew, S., & Storm, I. (2013). Modernization and the gender gap in religiosity: Evidence from cross-national European surveys. *Kölner Zeitschrift für Soziologie und Sozialpsychologie, 65*, 259–283.

Touraine, A. (1992). *La critique de la modernité*. Paris: Librairie Arthème Fayard.

João C. Paiva was born in 1966 in Coimbra. He got his PhD in Chemistry from the Universidade de Aveiro and is an Associate Professor at the Faculdade de Ciências da Universidade do Porto. He has published both in national and international journals and has written many textbooks and popular science books. With Alfredo Diniz, he wrote in 2010 a popular book about science and religion. Since then, he has delivered hundreds of conferences, especially at schools, about science and religion. Recently, he created the interdisciplinary group Science, Religion and Knowledge at the Universidade do Porto.

Carla Morais was born in Valpaços in 1980. She has a PhD in Teaching and Communication of Sciences from the Faculdade de Ciências da Universidade do Porto. She is an Assistant Professor at FCUP, Director of the Master in Science, Education and Communication. She has published articles in national and international chemistry, education and educational technology journals. She has presented lectures in schools, conferences and scientific meetings, in the field of chemistry teaching and the use of computers in teaching. She is co-author of textbooks, popular science books and educational software for chemistry and physics teaching.

Luciano Moreira was born in Porto in 1982. He got a degree in Psychology from the Universidade de Coimbra and an MSc in Psychology from the Universidade do Porto. Currently, he is a PhD candidate in Digital Media at the Universidade do Porto (UT Austin Portugal). He teaches at the Faculdade de Engenharia da Universidade do Porto in the Master in Multimedia. He has published in peer-reviewed, international journals and delivered communications in several conferences. His areas of interest include social representations and practices on digital media, technological and digital ecologies and scientific research methods.

Chapter 22
Engaging Young People in Positive, Interdisciplinary Exploration of Science and Religious Faith

Stephanie Bryant, Cara Daneel, and Lizzie Henderson

Introduction

Many of the concepts and mental structures around which we form our worldviews are built on foundations laid during our early, formative years. During this stage strong curiosity naturally combines with constant learning and re-evaluation of the world around us. As we grow older and construct a more complicated worldview, individual concepts become less flexible, and our ability to re-evaluate diminishes. Even our advanced, intellectual endeavours, therefore, are strongly influenced by our basic understanding of, and approach to, the world as developed in our very earliest years.

It is apparent from extensive research that many young children are exposed to influences which inspire misleading impressions of science, religion and their interactions. These misconceptions shape the thinking of these children and the society they form as they grow up. Research carried out by Dr Berry Billingsley, then Associate Professor in the Education Department of Reading University, UK, as part of the "Learning About Science and Religion" [*LASAR*] project, has demonstrated very clearly that by the time school pupils reach their teenage years, the great majority already see science and religion as belonging to two quite distinct domains of thought, if not directly opposed.

Indeed, research carried out as part of the Church of England's *God and the Big Bang* project (GatBB), in collaboration with Dr Berry Billingsley and the *LASAR* team, indicated that many 14- to 18-year-old students have deeply rooted misconceptions and a general lack of understanding regarding the interaction of science and faith, with over half of the 1,000 students surveyed in agreement that "science makes it hard to believe in God".

S. Bryant (✉) · C. Daneel · L. Henderson
The Faraday Institute for Science and Religion, Cambridge, UK
e-mail: sb804@cam.ac.uk; cld56@cam.ac.uk; eec34@cam.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_22

One of the suggested contributing factors to students' struggles with concepts regarding the compatibility of science and religion is the communication gap created by dividing learning into distinct subjects in different classrooms, each with different teachers and each increasingly specialised and pressured to meet the demands of their respective curricula. This structure is understandable from a logistical perspective but encourages very little space for students to think about bigger interdisciplinary topics or consider the underlying philosophies of these various subject areas and how they might interrelate. This educational structure also contributes to a general feeling amongst teachers of being underprepared and ill-equipped to tackle interdisciplinary questions or those beyond their own subject area. The interactions between scientific and religious thinking currently fall into this communication gap.

The impact of the increasingly divided education system can be observed in the research and experience of the projects described in this chapter. They demonstrate that younger children, whose learning is less-segregated, appear to more quickly and freely ask questions and engage with the interdisciplinary topic of science-faith interactions than their older colleagues. This is thought to indicate that as children grow older and move through the school system, they not only learn to categorise their thinking according to "subject" but also learn to avoid asking questions which appear to lie across or outside of those boundaries. This, in turn, reflects the projected uncertainty or unwillingness of teachers to engage with topics outside of their own "subject areas" and does little to counter formation of misconceptions regarding science and faith.

If we are to enable a generation of young people to develop robust, intellectually rigorous and enriched views regarding the interactions of science and religion, it is clear that they must be encouraged to explore and access these interdisciplinary topics from a young age.

In recent years, a number of projects have begun working with young people and teachers to encourage discussion in this area and dispel the widespread "conflict myth" before it becomes established in the thinking of new generations of students, researchers, teachers and members of society.

This chapter will introduce three, related intervention-based projects and also present available data regarding the effectiveness of this work for engaging young people in positive exploration of science and religious faith.

The Faraday Institute for Science and Religion: Schools Outreach

The Faraday Institute for Science and Religion was established in Cambridge in 2006 as an academic research enterprise with a strong focus also on providing accurate and accessible information on science and religion for the international media and wider public. The Faraday Institute's connection with the University of

Cambridge, along with an impressive list of well-respected staff and associates, has afforded it a strong reputation and allowed the Institute to become a leading voice in the study and communication of the science-faith discussion.

A Brief History of the Faraday Institute in Schools

Since its inception, the Faraday Institute's work has included outreach to schools, recognising the vital importance of reaching those younger members of our society during the years in which so much of one's worldview is formed. Within the first months of the Institute's work, many hundreds of school students were reached through lectures on science-faith topics given by senior Faraday Institute academics. Each of these lectures was arranged at the request of teachers and school event organisers, demonstrating a desire amongst those in education and school leadership for this discussion to be made available and accessible to the students in their care with expert intervention and contribution.

The early days of the Faraday Institute also saw the beginnings of the now extensive work carried out by Dr Berry Billingsley. In 2008, funding was secured from the John Templeton Foundation for school-based outreach, research and the production of online resources. In 2012, this project became a collaboration with Reading University, forming the "LASAR" (Learning About Science and Religion) project which now exists distinctly from the Faraday Institute as a collaboration with Canterbury Christ Church University, though strong collaborative links remain between the work of the *LASAR* project and the Faraday Institute. The *LASAR* project team have carried out an impressive body of research and outreach work and have produced a wide range of resources for use in schools, many of which are available online at www.neverofftopic.com.

A number of the Faraday Institute's other projects have also included outreach to schools and those of school-age. A notable example is *Test of FAITH*, a resource-based project run by Dr Ruth M. Bancewicz exploring science-faith questions at an introductory level. The project included production of a wide range of resources all based around three 30-minute films exploring central questions of the science-faith discussion such as creationism, evolution, origins of the universe and the problems of evil and suffering. A variety of accompanying resources were produced including resources for use in the UK GCSE or A-level religious education classroom, with each session including background information to help the teacher in exploring the relevant topics and their curriculum links, discussion ideas to use in the classroom, photocopiable worksheets and activities at a range of levels. These school resources are now available for free download from www.testoffaith.com/schools. The *Test of FAITH* project also included and inspired the continuation of a series of school events under the banner "*Test of FAITH: LIVE!*" which are led by Chip Kendall, former lead singer of thebandwithnoname, and include music, video, live science experiments, a short talk from a scientist and Q & A.

Both the *LASAR* and *Test of FAITH* projects have made significant contributions to the resources available to support teachers in the vital work of exploring interdisciplinary science-faith questions. The resources produced are widely used and very effective. A particularly important attribute of their success is the way in which they clearly relate to and support the curriculum points which busy teachers must already include in their teaching, rather than adding to their work, making these resources welcome additions to the classroom for teachers and students alike. In addition, the direct intervention methods for reaching school student offered by these projects have been very well received, and demand has quickly outstripped the ability of these projects to supply it.

Current Projects: The Faraday Institute Youth and Schools Programme – 2013–present

Since 2013, with the employment of Lizzie Henderson (née Coyle), the Faraday Institute has been increasing its communication to children and young people through the development of a dedicated outreach programme. A strong focus of this programme has always been to provide accessible communication of Faraday Institute expertise to children and young people through school visits and events. In addition, the programme has expanded to support the production of resources and training of speakers, teachers and others in positions of influence.

The Faraday Institute is uniquely and ideally placed to provide students with opportunities to meet and learn from world-class academics from a wide range of disciplines and with particular expertise in various aspects of the science-faith discussion. In addition to Faraday Institute staff, school visits and events are frequently arranged with scholars who are associated with the Faraday Institute or visiting for a period.

As such, through both large- and small-scale events, across the UK, the Faraday Institute provides opportunity for children and young people of all ages to interact directly with those with extensive expertise in the science-faith discussion and training in communication of those topics to young people. The impact of these events has been significant, prompting overwhelmingly positive feedback and ever-increasing demand.

The Faraday Institute's schools communication is based around a combination of accessible, honest, dynamic and thought-provoking discussion and lively demonstration or hands-on practical science experience. The aim is to celebrate and consider the scope of scientific exploration whilst also recognising its limits and the importance of the interaction of various types of questioning in forming a worldview. Within this, the Faraday Institute's school sessions are tailored to support both science and religious education curricula and provide additional benefits to teachers in relating to particular targets and their aims to provide far-reaching, engaging and well-rounded education. For example, occasions such as the Cambridge Science

Festival or the Faraday Institute's public lectures can be used to invite schools to large-scale events allowing exploration of science-faith questions outside of the classroom. For older students, in particular, these events provide a valuable opportunity to experience a university-type approach to a subject.

A strong aspect of the Faraday Institute's schools outreach is its flexibility. The Faraday Institute's experienced communicators bring an engaging combination of expertise, clarity and enthusiasm to the sessions they deliver, for students of all ages (3–18), on a wide range of science-faith topics, including the interactions and compatibility of science and religion; the role of religion in the history of science; the philosophy, reach and limits of science; compatibilities and differences in thinking about creation, evolution and intelligent design; and what science and religion have to say about ethics, conservation and sustainability, evil and suffering. In this context it goes without saying that the Faraday Institute is committed to the teaching of mainstream science. Sessions are specifically tailored to fit factors including timetable constraints, subjects of interest or relevance and audience size. This flexibility allows school sessions to range from sessions as diverse as structured, full-day, interactive workshops for hundreds of 10-year-olds to informal discussions on scientific ethics with a handful of A-level students.

In over 300 lessons, workshops and other sessions over the first 3 years of this programme, the Faraday Institute team saw more than 10,000 students respond enthusiastically to exploration of science, faith and their interactions. This work is fulfilling a vital need to disseminate the research of those in the Faraday Institute and elsewhere to new generations, enabling them to form worldviews which recognise the positive and important interactions of science and religious faith.

Practicalities of School Outreach: Getting into Schools, Growing a Reputation, Engaging Young People and Lessons Learned

As previously mentioned, since its beginning, the Faraday Institute has frequently been approached with requests for speakers for school events. The strong reputation for academic expertise and rational discussion already held by the Faraday Institute has proved a useful accolade in seeking to expand its school outreach. In addition, the schools outreach team has been developing an excellent reputation in its own right. The most powerful tool in building a reputation and engaging new schools is often formation of connections with specific teachers or school leaders. Work to establish and maintain contacts in various UK school networks, such as the network of Church of England Diocesan Education Directors and Advisors, who carry a degree of authority amongst CofE schools, has seen growth in reach and influence of the team. Spreading promotional material through such networks has often yielded productive contacts.

Another important way to build connections has been through recommendation from one teacher to another in a different school. Teachers, school leaders and others in education are extremely busy and rarely have time to consider new proposals, especially where they appear to represent some departure from a teacher's particular subject area. However, uptake of the events on offer increases dramatically when individual teachers and school leaders encounter the offer of the Faraday Institute's work through trusted colleagues or presented in accessible promotional material highlighting feedback from teachers and students. In addition to positive feedback from other students and teachers, new school contacts respond positively to indications that the sessions on offer support curriculum points and extracurricular aims such as interdisciplinary discussion, debate experience, promotion of STEM subjects, interaction with experts in various academic fields and, in the case of schools with religious foundation, discussion and exploration of applied religious faith. Overall, however, recommendation leading to development of personal communication with individual teachers and school has been the most successful method of reaching students and schools by far.

Once contact with schools has been established, feedback response to the sessions themselves and the flexibility and calibre of the Faraday Institute team's work is extremely positive, often leading to repeat bookings and recommendation to other colleagues and school contacts, yet further developing the Faraday Institute's contacts and reputation. Some examples of teacher feedback are given below:

The speaker was highly inspiring. She encouraged the children to think laterally and openly. All the children were highly engaged with how this potentially difficult topic was addressed. They really enjoyed it and continued asking questions after the session.

This session was absolutely fantastic. It really got them thinking and questioning their own perspectives.

A fun, interactive, engaging and energetic session showing how religion and science can go hand in hand. It was a good experience for the students, giving them and the staff something to think about.

The session was well planned. The children were a captive audience, very enthusiastic and engaged, posing some good questions. The speaker was a natural presenter and the children (and adults) gained a lot from her thought-provoking session. Many of them asked if we could have her visit again.

Key to the positive reception of the Faraday Institute's schools outreach has been the way in which speakers enthuse and engage the young people attending each session. The Faraday Institute schools team have significant experience in communicating potentially complicated concepts clearly to children and young people of all ages and also offer guidance and training to visiting speakers. The fundamental aspects of the Faraday Institute team's presentation method include establishing an open, welcoming, respectful rapport with each group of students; demonstrating willingness to share about experiences on a personal level; translating the complicated into a form that is readily accessible and interesting to students; using interactive and hands-on activities to engage and cater for a variety of learning styles; and "on the spot" flexibility in delivery of take-home messages to suit the interests and ability of students[1].

Feedback Themes and Informal Assessment of Impact

The work of the Faraday Institute, along with the other groups mentioned in this chapter, demonstrates the positive impact of this kind of intervention method, going some way towards meeting the great need for good communication about positive science-faith interactions amongst children in school. As this work continues, feedback from teachers and students alike remains overwhelmingly positive, word continues to spread, and demand for events only increases.

Informal analysis of the feedback received from teachers and students has allowed the Faraday team to recognise several common themes. Some of these are outlined below:

1. Teachers and students enjoy the sessions

Both teachers and students value the interactive, interdisciplinary and personal approach of the sessions run by the Faraday Institute. Experienced teachers frequently praise the success of speakers in engaging and supporting students of all ages, learning styles and interest levels in subjects which have the potential to be divisive or controversial.

I wish we had that every day. – Student

This was my best day so far. Most of my questions were answered and the speaker inspired me so much, I thought my head was going to explode! – Student

The session was positive and thought-provoking, a masterful juxtaposition of science and religion. The speaker was able to engage everyone at a personal level and then build up to eloquent, intellectual ponderings, speaking intelligently on controversial subjects without a hint of confrontation. – Teacher

The speaker was exceptional and communicated a difficult subject in a clear way. She met the needs of all our children, quite a challenge given we range from 3-11yrs old! – Teacher

The session was extremely valuable for the students and members of staff. The speaker was very engaging; dialogue, interspersed with experiments was perfectly timed to hold the audience attention. – Teacher

2. Teachers are often surprised by the way their students engage with previously unexamined interdisciplinary topics

This is particularly true for secondary schools, where teachers usually only see their students engaging in one particular subject area (such as science) and are

[1] These will be further discussed as part of this chapter's section on common themes in effective intervention-based projects.

surprised by their ability to explore, question and expound on interdisciplinary areas. Some teachers even comment, "it was like watching an entirely different group of students!" In both primary and secondary schools, teachers are often impressed by the sophistication of the questions asked by students about a subject area assumed to be beyond their academic level. Following these experiences, many teachers profess an intention to provide more opportunity for students to think and question more widely.

We were really impressed with the session. The speaker was engaging and approachable and the children felt very comfortable talking and listening to her. They had lots to talk about and lots of questions to ask! – Teacher

We all really enjoyed the visit. It obviously tied in with things the children have been thinking about and they asked relevant questions and talked about it afterwards, at school and at home! The speaker was clear, had fun with them and answered their questions respectfully I'm just sorry we didn't have longer! – Teacher

3. Conversations continue amongst students and staff after the sessions

One obvious difficulty with the one-off intervention method of communication is that the interaction of the project team with students is very time-limited. In order to facilitate longer-term consideration of these topics, the Faraday Institute team are working to develop teaching resources and training to support teachers and students. However, feedback does demonstrate that the sessions provided already inspire and generate continued discussion which is, in many cases, supported by existing resources recommended by the Faraday team, such as those produced by the *LASAR* and *God and the Big Bang* projects.

The speaker was highly inspiring. She encouraged the children to think laterally and openly. All children were highly engaged with how this potentially difficult topic was addressed. They really enjoyed it and continued asking questions after the session. – Teacher

The subject matter was stimulating at a number of levels and resulted in further debate, discussion and reflection once back in the classroom. – Teacher

4. Students and teachers are keen to book follow-up or repeat sessions

In addition to the continuation of discussion directly after events, the long-term impact of the Faraday Institute's work is indicated by multiple repeat bookings.

The session was well planned. The children were a captive audience, very enthusiastic and engaged, posing some good questions. The speaker was a natural presenter and the children (and adults) gained a lot from her thought-provoking session. Many of them asked for us to have her visit again. – Teacher

The whole afternoon was inspirational. The depth of discussion and level of questioning was astonishing. There was not one question that the speaker shied away from. All schools need this debate – there was lots of hard-thinking and questioning which made every single child feel enriched and informed. We are very much looking forward to welcoming them next year. Thank you so much. – Teacher

5. Students and teachers profess a change in their thinking

Perhaps the clearest measure of success for these sessions is feedback from students and teachers along the lines of that below.

I used to think that scientists couldn't be religious but now I know that's not true. – Student

I now understand how science and religion are compatible. – Student

Following the visit, one of my pupils (age 8) explained very clearly to an assembly of students, teachers and parents that at first she hadn't understood how faith and science go together but through [the speaker]'s explanation and the work with fossils she now believed the two were compatible. – Teacher

The pupils got a lot from the experience and many of them commented the following day how much they enjoyed all aspects of the day. The speakers really engaged all the children. I received excellent feedback from staff members who were delighted at the seminars. They loved the experiments and chance to ask lots of questions. Some of them even considered the religious viewpoint more deeply. – Teacher

Feedback demonstrates that even a short session often has significant impact through exposing students and teachers to a personally relatable example and discussion of the theoretical and practical interactions of science and religious faith. For many, this presents them with a new means of considering these two ways of thinking which they had previously assumed (often without a great deal of consideration) to be unrelated or conflicting. Additionally, sessions may have a broader impact through encouraging students and teachers to expand their thinking beyond traditional subject areas in considering the breadth of information and evidence relevant to worldview foundation.

Expanding the Reach of the Faraday Institute Schools Programme

The intervention methods described above are positively impacting the thinking and education of students of all ages and their teachers, directly influencing generations of young people, enabling and encouraging them to form worldviews which consider personal experience of positive science-faith interaction.

As demand continues to grow, the Faraday team are further developing and expanding their work to support continued and further-reaching science-faith dialogue amongst children and young people. In addition to providing direct intervention sessions, the Faraday team are developing training for teachers and speakers and a variety of resources for children of all ages. The production of such resources will begin to fill the significant gap in the market for materials of all kinds presenting positive science-faith interactions to children and young people.

These resources will significantly widen the impact of the Faraday team's expertise and experience, making their knowledge available to teachers, parents, church children's workers and children through a variety of contexts and media outputs. Planned outputs range from interactive digital presentation of creation and the natural world, through exploration of biblical interpretation, to science fiction adventure stories and expert discussion of "big questions" as asked by children in school sessions.

The Faraday team are working closely with a number of world-class publishers, authors, illustrators and other children's content creators. Therefore, in addition to presenting positive science-faith interactions to each resource's audience, this project will engage those who create and produce children's resources in the conversation. Many of those already involved in this project have stated significant impact on their own perspectives and demonstrated their intention and inspiration to produce content presenting positive science-faith interactions through a wide variety of materials.

For me, [working with The Faraday Institute has] opened up an area in the market which I hadn't thought was there. I feel the project warrants as much help as we can give it I think I'll be looking closer at Creation and miracle stories and our 'future publishing list' with the view that we shouldn't be afraid to cover science. With your help, I think we could do that. – Representative of leading publisher

The expansion and extension of the Faraday Institute's youth and schools outreach reflects both the ongoing need for good communication regarding science-faith relationships to this key demographic and also the impressive success of those measures and projects already in place. Many of the ongoing research and communication projects of the Faraday Institute will continue to feed into the schools outreach through provision of willing speakers, cutting-edge content for school sessions and development of resources directed to schools or younger age groups. One such current project, *Wonders of the Living World*, is described below.

For more information about the work of the Faraday Institute's youth and schools programme, please visit www.faradaykids.com.

Wonders of the Living World: A Resource to Engage Students in Positive Discussions About Biology and Religion

Wonders of the Living World is a project managed by Dr Ruth M. Bancewicz, run by the Faraday Institute for Science and Religion and funded by the Templeton World Charity Foundation from 2015 to 2018. It is a communication and dissemination project aimed at engaging people in positive discussions about biology and religion. The project uses interviews and literature research to explore the respective scientific and theological work of seven scientists, a theologian and a biblical scholar and communicate this at an accessible level alongside their personal faith stories.

Planned outputs include online video resources, short blog posts, church group study guides, an illustrated coffee table book and religious education lesson resources for schools[2]. The aim of the project as a whole is to produce resources that explore the wonders of the living world as revealed by science and promote positive discussions about biology, faith and questions of meaning and purpose raised by science.

At the school level, it is hoped that this will communicate the following take-home messages: people of faith are involved in the full range of biological sciences; the biological world is wonderful; wonder at biology leads people of faith to awe and worship; and science is compatible with the existence of a God who has a purpose for the world. To communicate these concepts, the project uses video clips of interviews with each of the project's scientists and theologians. In response to a question sent by a school student, "Can you be a Christian and a biologist?", theologian Alister McGrath responded "There are sociological studies that show that when people are asking questions like this very often they don't think about the intellectual issues, they think 'I know someone who's both a Christian and a biologist and they hold them together and that shows it can be done.' In other words, it's not so much the arguments, it's the personal example of someone who's done this which is really important. And so I think the point I'd want to make here is that anybody who's a Christian and a biologist that's listening to this, you're one of the best arguments that this can be done and you need to talk about how you do this".

This question and response illustrate not only *why* the project is important but also *how* the project hopes to achieve positive engagement in the classroom setting through, as Alister highlights, the significance of relational connection as well as intellectual content. The project plans to address this by "bringing the scientist into the classroom" using illustrated, purpose-made videos through which the interviewee can explain scientific concepts and personal points for themselves. By opening this channel between the students and the scientist, it is thought that the students will better identify with the scientists as people. This method also supports the RE teacher by transferring the presentation of scientific thinking to those with scientific expertise.

Interview Content

The interview questions encouraged the scientist to reflect upon:

1. Their research and the scientific questions it raises. (At this level students are directly seeing Christians as scientists and are invited to share in the awe inspired by the scientific findings.)

[2] At the time of writing, the schools resources are not yet finished products; hence this section focuses on project aims and progress rather than feedback and results.

2. How they connect their scientific work and their faith. (At this level, answers reflect general science-faith compatibility ideas.)
3. How their field raises questions beyond science about meaning. (At this level each interviewee emphasises a different thought-provoking theological/biblical point which resonates with them on a personal level.)

This approach will therefore satisfy the vital intellectual and relational aspects of the science-faith discussion, so neatly alluded to by Alister McGrath.

The Interviewees

Professor Stephen Freeland (University of Maryland, Baltimore County) is an astrobiologist who introduces the remarkable nature of the genetic code and stimulates discussion about humanity's relationship to the cosmos.

Dr Rhoda J Hawkins (University of Sheffield) is a theoretical physicist who explains how cells move and interact, facilitating discussion on randomness and order in biology.

Professor Jeff Hardin (University of Wisconsin-Madison) is a developmental biologist introducing how embryos develop – from a single fertilised egg to 15 trillion cells in essential symmetries and asymmetries by the time we are born. His comments open discussion on beauty, humble beginnings and Jesus as both human and the son of God.

Professor Simon Conway Morris (University of Cambridge) is a palaeobiologist. His focus is on evolutionary history and patterns in the map of life, driving discussions of a purposeful universe, rather than purpose in biology.

Professor Jeff Schloss (Westmont College) is a behavioural biologist introducing cooperation and explaining its extent and creative power. He is able to broaden discussions on evolutionary biology to include cooperative drivers and overturn the traditional competition-centred focus.

Dr Margaret Miller (US National Oceanic and Atmospheric Administration) is a marine conservationist specialising in coral reef systems. Her ecosystem-level focus expands the conversation to include conservation action, discussions of the intrinsic value of natural systems, sources of hope when problems are daunting and "playing God" in ecosystems.

To draw together and expand upon the themes raised by the scientists, an interview with theologian **Dr Alister McGrath** (University of Oxford) is available, in which he discusses natural theology, suffering and intrinsic value.

Dr Hilary Marlow (the Faraday Institute for Science and Religion), a biblical scholar, is also interviewed and discusses ideas regarding creation,[3] praising God, our call to care for creation and interpreting Genesis.

[3] "Creation" in this context is not intended to refer to the 6-day "creationist" concept but rather to the natural world as created by God through processes described by mainstream scientific enquiry.

Using the Interview Material to Enable Interdisciplinary Exploration in the Religious Education Classroom

In aligning the overall topic and interview content with the multiple GCSE, AS and A-level (14- to 18-year-olds) religious education syllabi in use in the UK, four major themes of overlap appear: those of natural theology, creation care, interpretation of the Genesis creation accounts and general science-faith interactions. Each syllabus treats these topics differently, but each could benefit from the nuance brought by Christians who are scientists, theologians and biblical scholars with expertise in these areas. The *Wonders of the Living World* schools resource will provide this nuanced view, helping both students and teachers. To maximise the relevance and utility of the planned resource for religious education teachers, the project has been working in collaboration with a religious education teacher whose professional experience of classroom dynamics and curriculum pressures has enabled her to shape this rich, raw material into suitable and helpful lesson plans and reference information.

These lesson plans will be freely available for teachers to use or adapt as needed[4]. Alongside these plans and their corresponding interview clips, additional video clips will be available for teachers to feed into any current lesson plans both within the four key areas and beyond: into module topics such as suffering, awe and wonder, challenges of secularisation or wherever a video may contribute to the discussion at hand.

Effectiveness of Similar Interventions

Test of FAITH, as mentioned previously, is a video-style resource-based project which explores how believing scientists respond to contemporary questions and issues from the world around us, unpacking these issues from a faith perspective. Specific material was developed for this project for GCSE and A-level classes, alongside material for home schoolers to help teachers in exploring these difficult but exciting parts of the syllabus with their students. This award-winning project has been well received, is widely used and has been translated into nine languages.

This style of teaching has demonstrated itself to be an accessible and attractive one, and therefore *Wonders of the Living World: Biology and Belief* is likewise expected to be a fascinating and informative resource for school use.

For more information about the *Wonders of the Living World*, *Test of FAITH* and other related projects from the Faraday Institute, please visit www.scienceandbelief.org or www.faraday.cam.ac.uk.

[4] For details see the Faraday Institute for Science and Religion website (www.faraday.cam.ac.uk) or contact schools@faraday.ac.uk

God and the Big Bang: Encouraging Secondary School Students to Discuss, Discover and Debate the Compatibility of Science and Faith

The teaching materials of the *Wonders of the Living World* project represent an exciting new contribution to a growing collection of secondary school resources promoting exploration of positive science-faith interactions. The position of new materials such as these is strengthened by the established reputation of those existing projects which have proven themselves to be effective. *God and the Big Bang* is one such established project that has, to date, collected and analysed feedback and impact assessment data from more than 2,500 secondary school students since 2013. *God and the Big Bang* is a collaborative project initiated in 2013 by the Church of England Diocese of Manchester, funded by the Templeton World Charity Foundation and supported by the *LASAR* (Learning About Science and Religion) team. This project also included significant collaboration with the work of the Faraday Institute for Science and Religion.

Findings of the *LASAR* project indicate that opportunities for young people with interests in science or religious studies to explore and learn about matters of science and faith are rare, despite this being an area of deep interest for many.

The aim of the *God and the Big Bang* project has been to tackle this issue by providing secondary school students, with an opportunity to discover, discuss and debate the compatibility of science and faith with inspirational role models in the area of science and faith, including globally renowned scientists. The project has equipped young people with the all-important tools they need in order to form their own opinions and engage in rational, exciting, well-reasoned and thought-provoking discussion.

By March 2017 the first 3 years of the project had been completed, including collection and analysis of data and feedback regarding the effectiveness of this approach. During this 36-month stage of the project, Michael Harvey, Executive Director of *God and the Big Bang*, and Stephanie Bryant, Project Coordinator, initiated, sustained and developed a high-quality project that has allowed thousands of 14- to 18-year-olds to access the viewpoint that mainstream science and wholehearted faith are not only compatible but also complementary and enriching concepts to hold alongside one another as humanity seeks to explore the big questions about the universe, life, meaning and purpose. The next phase of the project is beginning to also offer these opportunities to those aged 9 to 11, at the top end of primary school.

Research was conducted at school events, including intervention impact assessments, both in the short-term and 2–3 months post-intervention, as well as analysis of the baselines views held by students.

Based on the questions that young people asked during *God and the Big Bang* question and answer panel sessions, a curriculum resource for secondary school RE teachers was produced in collaboration with RE Today. The resource consists of a handbook of lesson plans and activities for exploring the compatibility of science and faith in the classroom, as well as a DVD of *God and the Big Bang* session leaders sharing their thoughtful insights on particular science-faith topics, designed to provoke thought and discussion.

The project has received widespread and primarily positive feedback from schools and early-career scientists alike, and research has indicated that the impact of the project has been substantial.

School Events

Approach

Initially it had been suggested that *God and the Big Bang* full-day school events would involve four sessions:

1. A keynote lecture
2. A science demonstration presentation
3. An interactive science session
4. A question and answer panel

However, early in the lifetime of the national project, it was decided that, in order to maintain an intimate, engaging and interactive style with large numbers of students, the number of speakers would be increased to allow for multiple interactive or demonstration sessions to be held simultaneously alongside one another with a maximum of 35 students in each session. This move to incorporate more sessions into the day allowed students to spend time with excellent science-faith communicators in small groups and fully benefit from the opportunity, inspiring them to voice their big questions in front of their peers during the question and answer session, maximising the impact of the day.

By the end of March 2017 in excess of 6,000 students had been reached by the project's full-day school events.

Feedback

Feedback from both teachers and students was predominantly positive, with teachers keen to highlight the quality, passion and engaging nature of the speakers involved and students emphasising a newfound realisation that science and faith are not necessarily in conflict.

Teachers

A huge thank you to all for making this event a great success today and for giving our students a unique opportunity. Speakers engaged students throughout, encouraging them to voice deep, deep questions.

The speakers were absolutely brilliant at answering very tough questions very clearly, and challenging students to open their minds to all sorts of possibilities.

We were delighted to host such a worthwhile event. The day stimulated discussion and the Q+A session with knowledgeable and articulate experts allowed everyone to ask questions and make their own decisions.

It has really inspired our students to think more positively about science and faith – and also to consider science as a vocation in its own right, which came across very strongly from you and your colleagues through your passion and enthusiasm.

An enormous success and an occasion that will stay in the mind for many years to come.

A thought-provoking and exhilarating day.

I thought the researchers/presenters were excellent and engaged with students on their level.

This was an excellent opportunity for my students engage in this debate and critically consider the validity of some of the assumptions made by their generation.

Students

I liked the chance for independent thinking, the sessions were interactive and exciting!

All the sessions were exciting and engaging and the day really made me think.

The Q+A session was mind-blowing, answering questions I really wanted the answers to.

Helped me see that science and religion can go hand in hand, conflict of the two is not necessary.

It gave me some of the most logical explanations to faith I have come across, particularly the honesty in which they spoke of doubt/questioning faith.

Made me realise scientists can be and are people of faith.

Made me realise how my own faith can interact with science and see it from a separate religious perspective.

The question and answer session was a highlight, very honest and well organised.

Very informative and shows science from a different perspective.

Having grown up as a Christian I've been asked these kinds of questions so many times and until today I've never heard helpful answers to them. Thank you so much!

Curriculum Resource

All questions from *God and the Big Bang* school events prior to June 2016 were compiled and grouped by Stephanie Bryant into key categories and topics about which students regularly asked questions. It was decided that *God and the Big Bang* would work with RE Today to produce a teaching resource for secondary school RE teachers, enabling them to explore these topics with their students in an exciting and engaging way. As such the project produced a high-quality and innovative new resource, including a handbook of lesson plans and ideas, and a DVD featuring material filmed with many of the project's regular speakers, for use with students in KS3, KS4 and KS5 (11- to 18-year-olds).

The resource was expected to be a lasting legacy of the project, allowing RE teachers to explore science and faith in a knowledgeable and interesting way with their students even if they and their students are unable to attend a *God and the Big Bang* full-day school event.

Feedback

Initial feedback from teachers and other interested parties for the resource, which first went on sale in January 2017, was affirmative:

This resource is first and foremost excellent RE. Considering aspects of science thinking as well as philosophy and ethics enlarges the scope of conversations possible in RE. Even if this resource is not utilised in a specific lesson on religion and science, it allows the teacher to explore questions surrounding truth, belief, knowledge and reality with constant reference to both Christian theology and the twenty-first century world.

This book really hits every level. It supports me to lead the class into thinking at a deeper level, but offers a lot to stretch and challenge the most able. The scientists are earthed and coherent, not nerds at all! The students can relate to them easily and they bring the book to life. Fabulous quality, rich and complex. Worth every penny.

This rich, well-designed and fascinating resource-pack will help teachers of religious studies as well as science to help pupils work through the vital questions of science and faith that arise, in some measure, for nearly everyone.

Research Findings

Extensive research was undertaken at *God and the Big Bang* school events between March 2014 and December 2016. More than 2,500 upper secondary school students in Church of England schools, in attendance at events, were asked to complete a pre- and post-intervention survey rating their level of agreement with a set of statements about science and religion. The data were analysed by Dr Berry Billingsley and the *LASAR* research team. Three papers were developed from the collected data focusing upon students' pre-intervention perception of the relationship between science and religion and their perception of how their teachers approach this topic at school; the impact of *God and the Big Bang* events assessed by comparing pre-intervention data with post-intervention data from immediately subsequent surveys and 2–3-month subsequent interviews; and Church of England students' relative interests regarding specific science-faith topics.

The analysis of the first 1,132 secondary school students asked to complete a pre- and post-intervention survey indicated that many students have deep-rooted misconceptions and a general lack of understanding regarding the interaction of science and faith. Encouragingly, initial data analysis also indicated *God and the Big Bang* events to be a successful intervention strategy, challenging misconceptions, encouraging exploration and ultimately leading to an increased understanding of the relationship between science and faith.

Below are some of the pre-intervention survey findings alongside the corresponding post-intervention survey findings (in **bold font**), highlighting the students' change in understanding.

- 464 (41%), **215 (19%)** students agreed with the statement that the "scientific view is that God does not exist"; 408 (36 %), **385 (34%)** were unsure about the statement; and 260 (23%), **532 (47%)** students disagreed.
- 623 (55%), **351 (31%)** of students agreed that "science makes it hard to believe in God"; 283 (25%), **374 (33%)** were unsure, whilst 226 (20%), **407 (36%)** disagreed.
- 350 (31%), **623 (55%)** of students agreed with the statement "I believe that science and religion fit together", whilst 476 (42%), **351 (31%)** were unsure, and 306 (27%), **158 (14%)** disagreed.
- 373 (33%), **611 (54%)** of students agreed that "Evolution is compatible with creation by God"; 453 (40%), **363 (32%)** were unsure; and 306 (27%), **158 (14%)** disagreed.
- 566 (50%), **725 (64%)** of students agreed with the statement "I am interested in whether science and religion fit together"; 351 (31%), **272 (24%)** were unsure; and 215 (19%), **135 (12%)** disagreed.

Conclusions

It was made evident by previous research of the *LASAR* project that many students struggle to access the view that science and faith are not necessarily incompatible and that, therefore, the *God and the Big Bang* project would be an important way of reaching students with this message. Baseline data collected upon the students' arrival at *God and the Big Bang* school events supported these findings, emphasising that many students have a number of misconceptions about the relationship of science and faith and that the struggle to access views of compatibility is widespread and, for the most part, independent of school-type.

At the same time the research indicated that large numbers of students were interested in the compatibility of science and faith: they had questions they wished to find answers to but had yet to find a place where they were supported in asking these big, interdisciplinary questions. *God and the Big Bang* has been able to provide students with a safe environment in which to question and explore with knowledgeable speakers, and the quality of the questions asked has often far exceeded the expectations of the project staff and teachers. Post-intervention data suggested that the result of finding a place to ask these questions and hear them discussed was powerful and effective in challenging misconceptions and offering alternative, academically rigorous viewpoints.

For more information about the *God and the Big Bang* project, please visit www.gatbb.co.uk or email contact@gatbb.co.uk.

Common Themes in Effective Intervention-Based Projects for Engaging Young People in Positive Exploration of Science and Religious Faith

In considering the particular characteristics which have made each of these intervention projects effective, a number of common themes have emerged.

Communication and Complexity

Much discussion about the interactions of science and religion is held on an academic level. As a result, many of those with deep knowledge regarding this complex and subtle topic have greater experience in communicating their thoughts and positions in language suited to the academic platform than in a manner that is accessible to young people. Additionally, the academic nature of much of the science-faith discussion has resulted in many assuming that the topic is immensely complicated. Whilst there are certainly complex discussions to be had, the majority of the related ideas can be easily discussed at a level accessible to even the youngest school children. In addition, many of the same questions and conclusions heard amongst adults discussing these topics also emerge from children and young people when given the same opportunity.

Students instinctively tend towards respecting the authority of those who appear knowledgeable about a subject. However, a large factor in them benefiting from an intervention and respecting the opinions and authority of speakers is the ability of that speaker to communicate their views in a simple, accessible and engaging manner, as opposed to what can be perceived by young people as hiding behind academic jargon. The key to this form of communication lies in framing the discussion with appropriate language and illustrations. For instance, one of the most commonly used examples in the science-faith discussion concerns the idea that the question "why is the kettle boiling" can be answered in complementary, rather than conflicting ways by both science and the desire for a cup of tea. This example of complementary but different explanations is easy to describe to children and young people of all ages and provides the basis for widely ranging discussion about the categorisation and interaction of any number of questions about life, the universe and everything. In essence, this example can be equally well-understood by a 6-year-old child and a 60-year-old professor. The additional depth of scientific or theological application likely in the professor's understanding comes from the prior knowledge he or she brings to it, but the lack of this knowledge in no way prevents the 6-year-old from understanding the concept.

The success of these various intervention projects in allowing young people to access the same questions as those so often raised by adults is demonstrated by the questions below, which comprise a selection of those voiced by children of a variety of ages during intervention sessions:

Do we need anything other than science?
Were Adam and Eve real people?
Can miracles happen?
What came before the Big Bang?
Does science mean God does not exist?
If fossils are so old why does the Bible talk about the world being made in 6 days?

This and additional qualitative and quantitative feedback from the three projects demonstrate that young people are able to access often complex topics and can leave sessions with an enhanced grasp of a range of relevant science-faith concepts that may previously have been thought too complicated.

Interaction

Some of the most effective ways of enabling young people to access and engage with science-faith topics include creating opportunities for interaction, such as hands-on activities, simple quizzes, question and answer sessions, keeping straight lecture-style presenting to no more than 5 minutes at time, using a combination of spoken and visual presentation, and carefully considering what the key points and "take-home message" being offered are.

Many science-faith topics easily lend themselves to demonstration and hands-on interactivity through their science content and also to discussion through the related theology, philosophy and/or ethics. Including a variety of interactive elements is an approach that both engages multiple learning styles and renders a session memorable and engaging for all involved. Successful methods vary to some extent with their age and experience, but guidance on these matters can easily be gathered by exploring suggested teaching material for the relevant cohort. For example, younger students generally require shorter, more guided activities or periods of discussion, whereas older students accustomed to philosophy classes will happily discuss suggested topics extensively but may require more guidance for interactive experiments than those studying science subjects.

It is important to note that hands-on interactives needn't be especially costly or complicated. Use of materials such as fossil collections or various laboratory apparatus certainly makes an impact. However, far simpler and less expensive materials can also be used to great effect. Frequently used examples include felt-tip pen chromatography (using only felt-tips, filter paper and plastic cups), "earthquake-proof marshmallow towers" (using marshmallows and spaghetti to attempt to build towers that will withstand shockwaves) and "food chain tag" (using only small coloured plastic or paper counters).

In addition to hands-on science activities, interactive engagement can be achieved in a number of ways. Perhaps the greatest difference in student response is seen between presentations with long spoken sections and presentations in which these sections are broken up. This can be achieved through including quizzes or dedicated discussion questions or can be as simple as allowing the students opportunity to offer answers to otherwise rhetorical questions. One particularly successful method of engaging students involves presenting students with a series of statements about science and religion, such as "now that we have science we don't need religion anymore", and asking them to stand along an imaginary line between "agree" and "disagree". This takes only a few minutes and requires no particular student to expose their reasoning but gets everybody moving and relaxed whilst also successfully engaging every student in considering the relevant topics and beginning to think through their own reasoning.

It is also important to ensure sessions are clearly structured so as to effectively communicate the relevant points. One way to work on this is for the speaker to consider what simple take-home messages they wish to impart and develop their session from this point.

Embracing such a range of presentation styles can be daunting for some, particularly those accustomed to academic paper presentation. However, the Faraday and *God and the Big Bang* teams have seen many speakers develop truly excellent sessions through a small amount of training, feedback and preparation.

Personal Engagement

The work of the Faraday Institute, *God and the Big Bang* and *Wonders of the Living World* emphasise and demonstrate the importance of enabling young people to connect with experts on a personal, human level, not simply on an academic level, in order to maximise the effectiveness of opportunities to explore science and religious faith. Once students have connected with speakers on a personal level, they often engage more willingly with the larger concepts too. For example, establishing a good rapport with students appears to encourage them to voice their big questions to the speaker or panel, something that can make students feel vulnerable in front of their peers.

Simple ways to do this tend to include encouraging experts to share their personal stories, thoughts, experiences and questions alongside their academic views. Equally, demonstrating genuine interest in the thoughts and lives of the students brings a sense of mutual respect to the speaker-student relationship. This can easily be achieved through the speaker making clear their willingness to listen to the students' questions and honour them with a thoughtful response (no matter how seemingly trite, ridiculous or insignificant the question!).

This factor recognises one of the main advantages of being a "one-time guest" to the students. In many schools (especially amongst older students in larger schools), students may not relate personally to their teachers. In addition, many teachers are particularly wary of communicating personal views, especially those regarding topics such as religious faith. There is great advantage and privilege in the freedom to share more personally with the students, including regarding religious faith. In addition, as something of an "unknown quantity", there is generally a great deal of interest from students in learning about the scientific work and personal experience of someone who has all the potential to be completely fascinating! Recognition of this unusual status carries the opportunity to engage with students on a more personal level, vital in encouraging them to ask questions which they might feel uncomfortable asking a teacher or adult in another context.

Integrity and Handling Uncertainty

Intrinsically linked with building rapport with young people is the concept of integrity and honesty when handling uncertainty. Current intervention-based projects have highlighted the perceptive nature of young people. This, when paired with their general dislike and mistrust of manners that could be deemed as patronising or bluffing, means that speakers can easily alienate young people if they appear to be concealing uncertainty on a specific topic. Students appreciate and respect transparency and honesty in discussion, responding far more positively to the humility required to say "I don't know", than to cover-ups and intellectual smoke screens.

As such, a willingness to admit uncertainty, and in particular conveying a sense of being comfortable and excited in the face of mystery and uncertainty, can be far more powerful than aiming to display academic prowess.

Flexibility

Working with children and young people is often unpredictable and requires flexibility. However, this represents another key advantage of the "one-time-guest" status of a speaker and marks a significant departure from the academic "university" style of teaching to which some speakers are accustomed. In general, teachers are bound, to some extent, to their syllabus requirements. This often means that they lack opportunity to encourage and extend discussion on particular topics which capture the imagination of their classes. Whilst external intervention sessions are still subject to time limits, there is rarely pressure to cover a particular set of teaching points. The purpose of the intervention session in question is not primarily to convey particular scientific or theological information but to encourage the students to question, discuss and explore. This frequently requires some departure from the planned material, and the timing and manner of this departure vary with each different group. If only 10 minutes of an hour's worth of planned content about stem cell ethics is delivered before the group develops a lively and engaged discussion about scientific ethics and the place of religion therein, then there may be more to be gained from supporting that discussion with relevant information and guidance than by shutting it down to deliver the remaining material.

The importance of this flexibility is well exemplified by a quote from one particularly eminent visiting lecturer who commented, following a session with a school group, "I began the session in discussion with them and realised that whenever I started lecturing them, they lost interest, so I just stopped lecturing and helped them to discuss!". This session, his first with a group under the age of 18, received glowing feedback from teachers and students alike.

Further Directions for Engaging Young People in Positive Exploration of Science and Religious Faith

Based on the work of these three projects there are a number of key areas to be considered in engaging young people in positive exploration of science and religious faith. The focus of these projects moving forward is to both continue and expand work with school students and church youth groups, reaching a greater number and wider age range of young people; provision of training for individuals in key areas of influence including early-career scientists and science-faith communicators, teachers and church youth group leaders; development of further training and teaching resources; and generation of new media materials on science and faith to support young people, particularly children aged 2–12 in their exploration of science and religion topics.

Changes which allow greater interdisciplinary learning at secondary school level would also be welcomed as an important way to allow young people the opportunity to consider the relevance and interaction of wide range of different disciplines beyond primary school. One way to facilitate this is to provide teacher training events and resources that can equip and enable teachers across the UK to better support their students. Interventions such as those described above have had a large impact on students; however, directly equipping teachers has the potential to be effective in reaching an even greater proportion of students with a positive message of compatibility and exploration.

The ongoing work of the Faraday Institute's schools outreach team, the *Wonders of the Living World* project and the Diocese of Manchester's *God and the Big Bang* project have demonstrated that whilst misconceptions regarding the interaction of science and faith develop at a young age, appearing common and often entrenched, these views are neither inevitable, academically rigorous nor satisfying for many young people. The opportunity for exploration of alternative viewpoints is well received by young people and teachers alike. It is hoped that through enabling interdisciplinary discovery for the young people of today, the opinion formers of tomorrow will be open-minded, confident thinkers well-placed for considering the important questions of ultimate reality and their place and purpose in the universe.

Stephanie Bryant previously coordinated the God and the Big Bang project and is now the Youth and Schools Programme Co-Director for the Faraday Institute for Science and Religion alongside Lizzie Henderson. The Faraday Institute Youth and Schools Programme provides lessons, workshops and talks on the interactions of science and faith for children, young people and students of all ages in a variety of classroom, school society and other contexts. Steph holds a degree from the University of Cambridge, specialising in conservation science, ecology, physiology and evolutionary and behavioural biology. She has been involved in a number of conservation and communication projects since graduating, from studying wolves in Bulgaria, to frogs and salmon in Canada, and working with local communities and landowners to reduce human-wildlife conflict.

Cara Daneel is a marine biologist and science communicator. After receiving her degree in Marine Biology and Oceanography from the University of Cape Town, South Africa, Cara worked in conservation and education in multiple countries across Northern and Southern Hemispheres. At the time of writing, Cara was a Research Assistant supporting the work of Dr. Ruth Bancewicz and her project 'Purpose in Biology' at the Faraday Institute for Science and Religion. She has worked in various departments and academic centres across the University of Cambridge, currently working as a communications manager within a centre in the Engineering Department.

Lizzie Henderson is the Youth and Schools Programme Co-Director for the Faraday Institute for Science and Religion, where she has been instrumental in expanding and developing the Youth and Schools Programme. The Faraday Institute Youth and Schools Programme provides lessons, workshops and talks on the interactions of science and faith for children, young people and students of all ages in a variety of classroom, school society and other contexts. Lizzie holds a degree in Natural Sciences from the University of Cambridge, specialising in Evolutionary and Behavioural Biology, Geology and the History and Philosophy of Science. She has a strong interest in the communication and public understanding of the interactions of science and faith and has participated in formal and informal discussion of the science-faith dialogue for many years.

Chapter 24
Science, Ethics, Education and Religion: Connecting and Disconnecting

John Bryant

Introduction

I was recently a member of a panel considering the question 'Are scientists playing God?' (On Common Ground 2017). Playing God is a term quite frequently used in relation to modern medical science, to the applications of science in medicine and rather less often in other areas of science, such as plant breeding. What exactly it means is often not clear, even to those who use it (many of whom do not actually believe in God!). However in general we may take it as a term of disapproval. There is a sense of boundaries or limits: scientists or doctors are going further than they should, taking actions or making decisions that exceed their authority and that this is morally wrong. Thus we see that there is a moral or ethical dimension in the ways in which scientific knowledge is used.

However, it does not stop there. In respect of ethical issues, these also arise in two areas within the actual practice of scientific research. Firstly there is the question of whether there are any areas of research or types of experiment that are beyond acceptable moral limits. Secondly, there are the moral norms of scientific research itself. This then leads to a general consideration of ethics and science.

Ethics and the Practice of Science

It is not surprising that ethical issues arise in respect of doing science. Scientific research is just one of a wide range of activities that characterise modern society (Resnik 1998). Indeed, in all industrialised countries and in increasing numbers of

J. Bryant (✉)
Biosciences, University of Exeter, Exeter, UK
e-mail: J.A.Bryant@exeter.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_24

less developed countries, a significant proportion of GDP is devoted to it. Associated with this, societies (or at least their governments) place different values on different types of research. This in itself carries the notion that some areas of research are regarded as more worthwhile than others. Despite this, some authors have insisted that the actual performance of science is neutral, free from social or ethical construction (e.g. Wolpert 1992). In my view the latter view is not sustainable (see also Resnik 1998).

Like all human activities, there are actions associated with science that are regarded as morally wrong. Thus, experiments carried out by the notorious SS doctor, Josef Mengele, elicit universal condemnation and feelings of disgust, as any of our students of twentieth century history will tell us. Involvement of human subjects in research is now subject to the Declaration of Helsinki (7th revision, 2013).[1] In many cases it is very clear that particular research activities are wrong and should not be carried out. However, there are also grey areas in which moral decision-making is more fluid or where it involves deciding which course of action is less bad or more good. Many of these relate to, for example, use of experimental treatments where all else has failed: the person being treated is both a patient and a subject of research (e.g. Reardon 2015).

There are also wider aspects of this topic. For example, is it morally acceptable to use animals in research and, if so, what species of animal and what types of research? Further, some people are concerned about the trialling in the field of crop varieties bred by GM techniques, thus making the general environment a subject of our ethical concern. (See Bryant and la Velle (2018) for a much fuller discussion of the two latter issues.)

When we consider the ethical norms of science, again, what is right and wrong may sometimes seem obvious. Just as there is condemnation amongst sports fans (and within the organisations that govern sport) of cheating and of 'throwing' matches, there is equal condemnation of those scientists who present fraudulent data, fraudulent either because they are actually made up or because they have been 'optimised' to give the best possible impression. In both sport and science, unethical practices deceive the relevant communities and the wider public. Other examples in science include failure to publish negative results (especially in drug trials: Goldacre 2013) and plagiarism – copying someone else's work or, even more blatant, claiming someone else's work as one's own. However, several recent high-profile cases of scientific fraud show that the moral norms of science are not always observed; in this respect science may be no different from any other human activity. However, we may also note that although, in the words of Mark Twain, 'right is right and wrong is wrong', there are contexts in which transgressing moral codes has greater effects than in other contexts. In science, we 'stand on the shoulders of giants' – we are dependent on the work of those who have gone before – but if those giants turn out to have fabricated data, then our perch on their shoulders may be very unsteady. So at what point are school students introduced to the ethics of science? Up to Key

[1] It is not actually legally binding under international law but has been very widely adopted into national laws across the world.

Stage 4, ages 14–16, (UK Department of Education 2014), there is a gradual development of an understanding of scientific method and scientific thinking, but, apart from discussing objectivity and the need to avoid bias, there is no *specific* mention of the ethical norms of science itself. However, the *teaching objectives* at KS 4 include helping students in 'appreciating the power and limitations of science and considering ethical issues which may arise'. The greater flexibility at Key Stage 5 (ages 16–18) may allow this topic to be discussed in more depth, but in the main, detailed teaching about ethics and morals lies outside science.

Ethics and the Applications of Science

We now move on to consider how the results of scientific research may or may not be used. In the science fiction film *Jurassic Park*, scientists had discovered that they could re-create creatures using ancient DNA and decided to use it to clone dinosaurs and to set up a 'Jurassic' wild-life park. This prompted one of the characters in the film, Dr. Ian Malcolm,[2] to say *'Yeah, yeah, but your scientists were so preoccupied with whether or not they could that they didn't stop to think if they should'*. The word 'should' here is interesting firstly because it actually implies that the scientists *should not* have done what they did and secondly because there is a sense of imperative, similar to that in a sentence such as 'I know that I should have visited my grandmother but I went to the cinema instead'. Going back to the film, the implication is that cloning the dinosaurs was wrong, and as the plot unfolds, we learn that Dr. Malcolm thinks it is wrong because it is risky and that there is danger of harm both to the environment and to human visitors to Jurassic Park. Imposing unquantifiable and unknown risks is wrong.

The film thus presents one of the ethical issues that arise in the applications of science, the imposition of risk on those who have not chosen it or who are unaware of it (see also Bruce 2002). It featured strongly in early discussions about GM crops (see, e.g. Mayer 2002) and more recently in the debate about mitochondrial donation in IVF (often called, very misleadingly, three-parent IVF).

However, there are many more issues than risk in the applications of science. In considering this we need to think of the remit of ethics or morals. At its most basic, ethics is concerned with the moral rightness or wrongness of the ways in which humans treat and interact with each other. In the distant past, that consideration was confined to those within one's own group, society or tribe. Those outside the in-group were often treated very differently; sadly some elements of that attitude have persisted to the present day. However, in Christian teaching, everyone else is our neighbour and thus, in theory at least, we regard all humans as being morally significant. But it does not stop there. The discussion of Jurassic Park raised the possibility that the environment is a morally significant entity, not just because of its value to humankind but also because it has intrinsic moral value (see also Southgate 2002,

[2] Played by the American actor, Jeff Goldblum.

and Bryant and la Velle 2018). We also noted earlier that there are ethical issues concerning the use of animals in research and that again is related to extending moral significance beyond the human species (see Frey 2002 and Bryant and la Velle 2018, for further discussion of this).

The final general point that needs to be made is this: we need to understand that, in discussing ethical issues arising from the applications of science, in common with other areas of human activity, different people come to different conclusions as to what is right and what is wrong. Indeed, in some issues, deciding what is right or wrong may be difficult. As we noted earlier, it may be a case of deciding which action is better (from a particular ethical standpoint) rather than which one is clearly right or clearly wrong, thus leading to fluidity or even ambiguity in decision-making. This becomes very apparent when dealing with bioethics as is shown in the next section.

Bioethics

Introduction

Bioethics is the term used to cover those ethical issues that arise from or within biological, biomedical and medical science; it may also be extended to include environmental issues. In respect of the school curriculum, Key Stage 4 Science (UK Department of Education 2014) includes, as mentioned above, '*appreciating the power and limitations of science and considering ethical issues which may arise'* and '*evaluating risks both in practical science and the wider societal context, including perception of risk'*. Further, the specific elements of the biology syllabus include *the uses of modern biotechnology including gene technology and some of the practical and ethical considerations of modern biotechnology*. Ethical/bioethical issues are certainly there but are worded in a very general way.

By contrast, syllabuses[3] for religious education at this stage usually have a much more detailed statement about a range of bioethical topics, including abortion, 'beginning of life', *in vitro* fertilisation, genetic modification and stem cells (see for example AQA 2017). It is here that problems begin to arise. While one probably does not need to know much (or indeed anything) about nuclear fission to have an ethical discussion about atomic bombs, we cannot make a similar statement about ethical discussion of, for example, genetic engineering or of genetic selection of embryos. Some understanding of the actual biology is necessary in order to inform our ethical decision-making; teachers of religious education, appropriately qualified in their own area, may lack the required biological knowledge to guide their pupils through the discussion. Now we might argue that the pupils themselves have

[3] Detailed syllabuses in religious education are set by local education authorities usually with reference to the requirements of the relevant examination board(s).

obtained the relevant knowledge in their biology classes.[4] However, that makes two assumptions. Firstly, it is assumed that the relevant material in biology is taught before the bioethical discussion comes up in religious education, but in fact, unless there is close cooperation between the relevant teachers, this is often not so. Secondly, it is assumed that pupils will readily use knowledge gained in one area and apply it in another. It is the experience of teachers at all levels (including university) that this often does not happen (see, e.g. Haws 2001; Leggett and Robertson 1996; Stacey-Chapman 2015 and, for a theological perspective, Park 2013). So, although the better pupils may be able to transfer and apply knowledge across subject boundaries, for the most part it does not happen. There is the basis of an argument here in favour of lessons jointly run by teachers of science and of religious education. However, space does not permit further discussion of this, so instead we move on to consider particular issues in bioethics in more depth.

Bioethics and the Beginning of Life

Many of the issues mentioned in the list of ethical topics relate to the early stages of human development; indeed, several of them deal with human embryos in the first few days after fertilisation. The question is raised 'when does human life begin?', but actually the real question is 'when do we start to ascribe to a developing human the same moral significance as a born person?'. It is thus the same question as was addressed earlier – viz. who or what is a morally significant entity – but given greater poignancy because it involves human development. In relation to 'human rights', a foetus is not regarded as having such rights until it is actually born. However, the complexity of this issue is illustrated by the fact that in the law of the UK and in other countries where abortion is legal, there is a time limit within gestation after which abortion may not be carried out (except in very exceptional circumstances). Thus it is decided that after a foetus has reached a particular stage of development, it has the moral right to be protected even if it does not 'possess' human rights. Nevertheless, even with this level of protection, those who espouse a strict 'pro-life' position hold the view that abortion is always (or, for some, nearly always) wrong, however early in pregnancy it occurs.

But let us go back to those first few days after fertilisation. It is during this period that, in IVF, embryos exist outside of the human body, prior to being inserted into the uterus of the prospective mother. It is because of the development of IVF in the 1970s, with the first IVF baby being born in 1978, that so many other procedures can now be performed on the early embryo. In order to set the scene for understanding and evaluating both IVF and other procedures dependent on it, a brief description of developmental processes is necessary (see also Bryant and la Velle 2018).

[4] However, detailed discussion in biology may not occur until Key Stage 5.

- Firstly, fertilisation results in the entrance of one sperm cell into the egg. Normally it takes an ‘assault’ on the egg of about 100,000 sperm to achieve the entry of one, although in IVF this can be bypassed if necessary by the injection of a single sperm into the egg (a process known as ICSI).
- Fertilisation takes about 10 h, so, if ‘conception’ is being used to describe fertilisation, it is difficult to define ‘the moment of conception’.
- After about 24 h, the two sets of genetic material merge to form one diploid nucleus and cell division starts (embryologists call this ‘cleavage’ because of the appearance of one big cell being ‘cleaved’ into smaller cells). The embryo is moving down the fallopian tube towards the uterus.
- After about seven days, the blastocyst stage is reached. The embryo consists of a hollow ball with an outer skin of cells to which it is attached, protruding into the interior of the ball, the inner cell mass (Fig. 24.1). It is at this stage that some differentiation of the embryo becomes apparent with the outer layer of cells and the inner cell mass having different functions.
- If the blastocyst attaches to the wall of the uterus, a process known as implantation, a pregnancy is established. In humans this occurs only with 20–30% of blastocysts. The outer layer of cells forms the placenta and the inner cell mass will form the embryo proper. The embryo may split within the first few days after implantation to form identical twins. Note that the term ‘foetus’ is used from about eight to ten weeks after fertilisation.

In respect of this chapter, the main question that arises is ‘What is the moral status of the early embryo?’ We can also ask whether the biological facts outlined above help to answer the main question. The answer provided by the Warnock Committee, set up by the government of the day to consider the ethics and regulation of working with gametes and embryos outside the body, was somewhat ambiguous: ‘… the early embryo is not yet a person but nevertheless should not be regarded

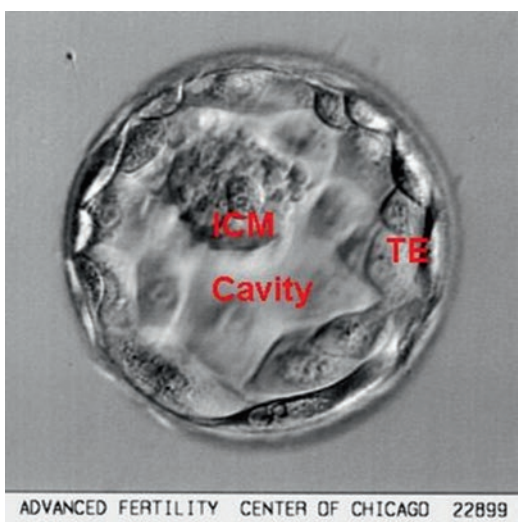


Fig. 24.1 Human blastocyst. *ICM* inner cell mass, *TE* trophoectoderm. Diameter of blastocyst is ca 150 μm

as just a ball of cells. Thus the embryo of the human species [should] be afforded some protection in law' (Warnock Committee 1984). The first part of the statement is clear enough – the early embryo is not a person, so our ethical frameworks for interacting with persons do not apply. It is therefore acceptable that in routine IVF procedures, several embryos are created and so some are 'spare'. But wait a minute – what does the second half of the statement mean? In practice it limits the type of research that can be done with human embryos and the uses to which spare embryos may be put.

The recommendations of the Warnock Committee became embedded in law with the passing of the Human Embryology and Fertilisation Act (1990). Nevertheless, significant numbers of MPs opposed the Bill that led to the establishment of the Act. Their view was that, despite the undifferentiated state of the early embryo, despite the high 'failure' rate at the implantation stage and despite the possibility of twinning, some people hold the view that from fertilisation onwards, the early embryo should be viewed as a person with all the moral significance that the term implies. For example, there can be no such thing as a spare embryo because it would imply that there can be such a thing as a spare person. This view is held by some evangelical Christians and by many Roman Catholic Christians. Indeed, the Roman Catholic Church totally opposes IVF in general, while those evangelical Christians who hold a very high view of the early embryo may accept IVF if no 'spare' embryos are created. However, many Christians find IVF, including the practice of creating several embryos, entirely acceptable. Muslims also find IVF acceptable but oppose gamete donation and surrogacy.

In addition to IVF itself, there is now a range of powerful genetic techniques that can be applied to the early embryo, ranging from genetic selection of embryos to genetic modification (GM). Under the terms of the HFE Acts (1990, 2008), GM techniques may be used in specific types of research on embryos, but GM embryos may never be used to start a pregnancy.[5] However, genetic *selection* of embryos is permitted and this forms the basis of the two case studies that now follow.

Case Studies in Embryo Selection

Before setting out the two case studies, it is emphasised that the procedures described are possible because of developments in genetics and molecular biology, in particular, the detection of specific mutations that lead to genetic disease and the ability to amplify specific DNA sequences. When we add our knowledge about early embryonic development and our very extensive experience of looking after embryos in vitro, we can see that we have a powerful set of techniques available to us. Thus it is relatively straightforward to remove one cell from an eight-cell embryo and to

[5] Exceptions are now allowed in respect of genome editing and mitochondrial donation. Details of these lie outside the scope of this chapter but may be found in Bryant and la Velle (2018).

test it for a particular mutation while it is being kept in a healthy state. This is known as pre-implantation genetic diagnosis (PGD). The first case study illustrates this.

Case Study One: Selecting Against Cystic Fibrosis[6].

- Peter and Helen[7], a British couple in their late 20s, wished to start a family
- Because of their family histories, they requested to be tested for the cystic fibrosis mutation.
- They were both heterozygous carriers of the mutation (CF is a recessive mutation, which means that people with just one mutated copy of the gene, i.e. who are heterozygous, do not have the disease).
- However, each child that the couple produced between them would have a one-in-four chance of being homozygous for the mutation, i.e. of having cystic fibrosis
- In order to avoid having a child with CF, the couple elected to use IVF and PGD
- Several embryos were created and were tested for the CF mutation
- An embryo free from the mutation was used to start a pregnancy; Helen eventually gave birth to a healthy child.

We should note two points in particular. First, as already noted, the usual procedure in IVF is to harvest several eggs and to create several embryos (a practice that, as noted above, some object to). In that respect, this procedure does not present us with anything new. Secondly, however, it is new that a further criterion has been added in deciding which embryo to place in Helen's uterus. Not only must the embryo be developing normally and look healthy, but it must also have the right genotype in respect of the CF mutation. Now, for many, that seems entirely reasonable, but others have suggested that it opens the way to selection for non-medical purposes. In the UK, the strict guidelines laid down by the Human Fertilisation and Embryology Authority do not permit selection for non-medical reasons, but that does not mean to say that such selection could not happen in other parts of the world.

The second case study illustrates how the technique may be used for other purposes, but still within the 'medical arena'.

Case Study Two: Selecting for a 'Saviour Sibling'

- Jack and Lisa Nash[8], an American couple living in Denver, Colorado, did not know that they were heterozygous carriers of the Fanconi anaemia[9] mutation until their first child Molly was born with the condition.
- In Fanconi anaemia, the bone marrow slowly fails and thus not enough blood cells are produced to keep up with the child's growth. Death usually occurs

[6] Details about cystic fibrosis may be found at https://www.cysticfibrosis.org.uk/what-is-cystic-fibrosis.

[7] The names are fictitious; this is a real case but the couple's real names are not known

[8] These names are real.

[9] Details about Fanconi anaemia may be found here http://www.fanconi.org.uk/wp-content/uploads/2008/08/fa-fact-sheet-11-0713.pdf

between the ages of five and fifteen, depending on the severity of the condition (although in some patients, symptoms do not appear until adulthood).

- Because it is a bone marrow condition, it may be cured by a stem cell transplant from an immunologically compatible donor who does not have Fanconi anaemia.
- No compatible donor could be found for Molly, so eventually the couple elected to opt for IVF and PGD, in order to select embryos that were free from the Fanconi mutation and which would also, when born, be immune-compatible donors for Molly.
- After several failures (which must have been heartbreaking), Adam was born. Molly was 6 years old and very ill.
- She received stem cells from Adam's umbilical cord which effectively cured her.

In addition to the points raised in connection with the first case study, more need to be made.

Firstly, because of the necessity to find a compatible donor, embryos that were free from the Fanconi mutation were nevertheless rejected because of incompatibility with Molly.[10] Secondly, there were concerns that Adam was regarded as a commodity. For these reasons, added to the points made in connection with the first case study, there was an outcry of opposition to the procedure.[11] Some 'pro-lifers' claimed that the science was becoming 'more and more monstrous', while in the UK it was suggested that the procedure transgressed the HFEA guidelines on genetic selection of embryos (but actually it did not). The term 'designer baby' was widely used in much of the discussion.

We may make two further points. First, we may wonder how Adam feels about his role in saving Molly (or even about his being born in order to save Molly). Secondly, there is the theoretical question of how he might have felt, had Molly not lived (presuming that the facts would come out at some point in his childhood). These points add a little more complexity to the ethical debate (see also Bryant 2012).

Wider Applications

The two case studies illustrate that, within the medical arena, pre-implantation genetic diagnosis is a versatile technique. Within that arena, it is used more and more widely as we discover more about the genetics of human disease, for example, through the 100,000 Genomes Project. However, the technique can also be used to select for those non-medically relevant traits for which we have clear genetic information (see Bryant 2013 and Bryant and la Velle 2018 for more detailed

[10] In the successful attempt, 14 embryos were created, of which several were healthy but could be used because of incompatibility with Molly

[11] See http://news.bbc.co.uk/1/hi/health/954408.stm

discussion). In the UK, such use of PGD is not permitted under HFEA Guidelines. However, in countries with less rigorous guidelines, it is possible that the use of PGD may be extended for non-medical use, and even in the UK, some have argued for a loosening of the guidelines, in some instances, to allow prospective parents to select for any trait that they wish. Thus, the Manchester philosopher John Harris states that *I cannot see a downside to research that increases the range of human possibility and choice* (Harris 2009). Meanwhile, in Oxford, Julian Savulescu has developed the idea of *procreative beneficence* that wherever possible we should 'select the best children'[12] (Savulescu 2001; Clarke et al. 2016). Similar ideas were expressed by the American commentator, Gregory Stock (Stock 2003), who went as far as saying '…neither governments, nor religious groups will be able to stop the coming trend of choosing an embryo's genes, and that there is little point in even trying'. The journalist Madeleine Bunting also wrote of the inevitability of such developments, although with very much less enthusiasm (Bunting 2006). Others are even more concerned about the liberalisation of genetic choices and the attitudes that lie behind it. For example, Celia Deane-Drummond (Deane-Drummond 2005) writes … *we should be more concerned with broader cultural trends that elevate liberalism to such an extent that children become rights which can be purchased according to parental desires and wishes.*

So, while for the present, the UK guidelines on genetic selection are maintained, there is amongst some secular ethicists and other commentators a wish for liberalisation. The issue will not go away and the debate will continue, emphasising the need for good ethical/bioethical education.

Bioethics and Religion: A Brief Comment

The attitudes of different Christians and of Muslims to aspects of IVF have already been mentioned. Here I will focus briefly on Christian attitudes. Reading some texts written by and for Christians on these topics, an impression is gained that there is a specific Christian view (and it is often very negative; see for example, Sutton 2008). Such ideas are often justified by use of the Bible, but it is here that we run into difficulties. The Bible is a collection of pre-scientific texts, written for several different purposes, but those purposes do not and cannot provide specific guidance on biotechnology, genetic modification, genetic selection and so on. However, some commentators have attempted to make biblical texts speak about science or, putting it another way, forcing science upon a text where it does not belong (see Bryant and Searle 2004, for a discussion of this). Two examples will suffice. First, in biblical times, nothing at all was known about the pre-implantation phase of human development that we have discussed here. Mammalian, including human, eggs were not discovered until the late seventeenth century (and rediscovered in the early nineteenth century). In the Bible, conception meant becoming pregnant, and it thus is

[12] Interestingly though, he also writes of the need for moral enhancement.

confusing that the word is now usually used to describe fertilisation. However, my point is clear: when the Bible talks about pre-birth life, it is talking about pregnancy and never about the pre-implantation phase because that phase was unknown. This leads on to the second example, namely, 'finding' in the Bible things that are not there. Thus, the conservative theologian and Christian ethicist Richard Hays points out that the Bible is totally silent on the subject of abortion (Hays 1996) and to say otherwise shows a misunderstanding of the text. In this example and in many others, we should therefore be wary of the statement that 'the Bible says' or the 'holy Qur'an says'.

However, along with Richard Hays (Hays 1996), we acknowledge that much of religious opinion on start-of-life issues (and on other issues in bioethics) is much more nuanced. For example, opposition to abortion may arise from application of general Christian principles and virtues, along with the idea found throughout the Bible, that a child is a gift from God. And so, going back to the pre-implantation phase of development, it might be said that it does not matter that this phase was unknown in biblical times; we do know about it now, and thus our care must extend back that far. This is of course the position taken by those who state that 'human life begins at conception' (where conception means fertilisation). And what all this leads to is that, as religious people think about these issues, there is likely to be a diversity of views. In recognising that, we will be better able to contribute to the ongoing ethical debates.

References

AQA. (2017). *GCSE specification: Religious studies B*. http://filestore.aqa.org.uk/subjects/AQA-4055W-SP-14.PDF

Bruce, D. (2002). Finding a balance over precaution. *Journal of Agricultural and Environmental Ethics, 15*, 7–16.

Bryant, J. (2012, January) Learning to play God. *Third Way*. Archived at https://thirdway.hymnsam.co.uk/editions/janfeb-2012/features/learning-to-play-god.aspx

Bryant, J. (2013). *Beyond human?* Oxford: Lion-Hudson.

Bryant, J. A., & la Velle, L. B. (2018). *Introduction to bioethics* (2nd ed.). Chichester: Wiley-Blackwell.

Bryant, J., & Searle, J. (2004). *Life in our hands*. Leicester: IVP.

Bunting, M. (2006, January 30). There is no stop button in the race for human re-engineering. *The Guardian*. https://www.theguardian.com/comment/story/0,,1697702,00.html

Clarke, S., Savulescu, J., Coady, C. A. J., Giubilini, A., & Sanyal, S. (Eds.). (2016). *The ethics of human enhancement: Understanding the debate*. Oxford: Oxford University Press.

Deane-Drummond, C. (2005). *Genetics and Christian ethics*. Cambridge: Cambridge University Press.

Frey, R. (2002). Human use of non-human animals: A philosopher's perspective. In J. Bryant, L. B. la Velle, & J. Searle (Eds.), *Bioethics for scientists* (pp. 101–112). Chichester: Wiley.

Goldacre, B. (2013). *Bad pharma: How medicine is broken and how we can fix it*. London: Fourth Estate/HarperCollins.

Harris, J. (2009, July 7). A world without men – that's not the real issue here. *The Independent*. http://www.independent.co.uk/voices/commentators/john-harris-a-world-without-men-thats-notthe-real-ethical-issue-here-1736211.html

Haws, D. R. (2001). Ethics instruction in engineering education: A (mini) meta-analysis. *Journal of Engineering Education, 90*, 223–229.

Hays, R. B. (1996). *The moral vision of the new testament*. London: T & T Clark.

Leggett, M., & Robertson, S. (1996). Curriculum fragmentation impedes students' understanding of technology and the environment. *Journal of Education Policy, 11*, 681–691.

Mayer, S. (2002). Questioning GM foods. In J. Bryant, L. B. la Velle, & J. Searle (Eds.), *Bioethics for scientists* (pp. 141–152). Chichester: Wiley.

On Common Ground. (2017). *Are scientists playing God?* http://oncommonground.net/events/week2/

Park, R. S. (2013). Fragmented knowledge structures: Secularization as Scientization. *Heythrop Journal, 54*, 563–573.

Reardon, S. (2015). Leukaemia success heralds wave of gene-editing therapies. *Nature, 527*, 146–147.

Resnik, D. (1998). *The ethics of science: An introduction*. New York: Routledge.

Savulescu, J. (2001). Procreative beneficence: Why we should select the best children. *Bioethics, 15*, 413–426.

Southgate, C. (2002). Introduction to environmental ethics. In J. Bryant, L. B. la Velle, & J. Searle (Eds.), *Bioethics for scientists* (pp. 39–56). Chichester: Wiley.

Stacey-Chapman, A. (2015). From compartmentalised to a complicated past: Developing transferable knowledge at A-level. *Teaching History, 158*, 8–15.

Stock, G. (2003). *Redesigning humans: Choosing our children's genes*. London: Profile Books.

Sutton, A. (2008). *Christian bioethics: A guide for the perplexed*. London: T & T Clark.

UK Department of Education. (2014). *National curriculum in England: Science programmes of study*. https://www.gov.uk/government/publications/national-curriculum-in-england-scienceprogrammes-of-study/national-curriculum-in-england-science-programmes-of-study

Warnock Committee. (1984). *Report of the committee of inquiry into human fertilisation and embryology*. London: UK Department of Health.

Wolpert, L. (1992). *The unnatural nature of science*. London: Faber and Faber.

John Bryant was formerly a Professor of Cell and Molecular Biology and Head of Biosciences at the University of Exeter and is now a Professor Emeritus of Biosciences. His research has mainly focussed on DNA biochemistry and the workings of genes. He has an active interest in the ethical aspects of biological and biomedical research, and since 2002, he has been together with Dr. Chris Willmott (Leicester University), Bioethics advisor to the Higher Education Academy and to Heads of University Biosciences (HUBS). John is a past-President of the Society for Experimental Biology and a former Chair of Christians in Science.

Chapter 23
Science, Religion, and Pedagogy: Teachers' Perspectives

Nasser Mansour

This chapter is based on the findings of a series of research studies that I carried out in the area "religious beliefs and science education" with Egyptian science teachers. I begin with a brief representation of Islamic perspective of the nature of science (part one). Then I present Science teachers' views of science and religion in Islamic context (part two). In part three, I will discuss science teachers' cultural beliefs and serotypes of science, religion, and scientists. This is followed by discussing the impact of these religious beliefs on teachers' pedagogical practices and views of teaching science (part four). The last part explains how professional learning programme might respond to teachers' cultural beliefs and serotypes of science, religion, and scientists (part five).

Part One: Islamic Perspective of the Nature of Science

In approaching the relation of science to Islam, we need to clarify what is meant by the terms 'Islam' and 'science'. Islam is not only a religion with theological and ethical beliefs, but it is also as much a way of life which organises the social, economic, and political relations among the individuals of the society. Science is often referred to as organised knowledge which is capable of querying other knowledge and may be used in prediction, discovery, and practical applications of technology. In the Qur'anic view, the study of nature is not for its own sake; rather, it is supposed to serve as a means of bringing one closer to God. The Muslim scientists of the past believed that God's wisdom is reflected in His creation. Similarly, the founders of modern science did not pursue the study of natural phenomena to understand nature

N. Mansour (✉)
University of Exeter, Exeter, UK
e-mail: N.Mansour@exeter.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_23

per se or for the sake of their own gratification, but as a means of proximity to God. The Islamic view and the scientific view share the same methodology, i.e. they both involve experimentation, observation, and theoretical work. Their difference is in the underlying worldview which affects their outlook towards God, the cosmos, and humanity, which in turn affect their decisions concerning the practical consequences of their scientific work.

Scientific knowledge comprising the natural sciences was vigorously pursued and developed by Muslim scientists and mathematicians commencing from the last decades of the first century of Hijra.[1] The Qur'an and Hadith[2] encourage Muslims, and even make it obligatory for them, to pursue the truth (*hakikah*) freely from all possible sources; they also contain certain guiding principles that could provide a secure foundation for the development of religious and secular sciences. Some Prophetic traditions even give priority to learning over performing supererogatory rites of worship. There are several Islamic traditions that indicate that a scholar's sleep is more valuable than an ignorant believer's journey for pilgrimage (hajj) or participation in holy war, and that the drops of a scholar's ink are more sacred than the blood of a martyr (Akhtar 1984). Religion needs science for its worldview if its interpretations are to be credible and process vivid actuality, and science needs religion to incorporate its knowledge into a meaningful world (Hefner 2002).

The Islamic conception of science does not confine knowledge of reality to that obtained through experimentation and theoretical reasoning alone, and does not consider the scientific study of the world exhaustive. Rather, by accommodating revelation and intuition, it encompasses spiritual as well as physical aspects of humanity and the cosmos, and it claims that there is more to reality than meets human eyes. In addition, the application of the modern natural sciences to everyday life experiences has a deep impact on how people in the Islamic world relate to the question of science on the one hand, and their culture's intellectual and scientific tradition on the other. Regardless of what particular position one takes, this debate about Islam and science in Islamic societies has two important components. The first is associated with the practical needs and concerns of Muslim countries. Keeping pace with modern science and technology is the supreme priority for governments in the Muslim world. The second concerns the intellectual domain in which the Islamic scientific tradition is seen as an alternative to modern science and its philosophical foundations in the study of nature (Kalin 2006).

According to the Qur'anic view, God is the Creator and the Sustainer of the universe. He has created everything in measure and has decreed for it a telos. The creation is in truth, not for sport or vanity, and everything has a definite term (Golshani 2003). In the holy Qur'an, God said 'Not without purpose did We create heaven and earth and all between! That were the thought of unbelievers!' (Qur'an, 38:27). The Qur'an has made a distinction between the Creator, the design, and the internal

[1] Hadith refers to narrations originating from the words and deeds of the Islamic prophet Muhammad.

[2] The English translations of the Qur'anic verses are based on Ali,Yusuf (2004). *The meaning of The Holy Qur'an: English translation*. Birmingham: Islamic Dawah Centre International.

order of the created things on the one hand and their guidance on the other hand. God said 'Our Lord is He Who gave to each (created) thing its form and nature, and further gave (it) guidance' (Qur'an, 20:50). The direction that everything follows is not a result of its internal order. Rather, it is something beyond its orderly structure. The Qur'an mentions a universal notion of purpose and direction for the created universe. God said, 'Who has ordained laws. And granted guidance (2). And Who brings out the (green and luscious) pasture (3)' (Qur'an, 87: 2–3).

The Qur'an calls for the study of nature not for its own sake but rather as a means to bring one closer to God. Islam advocates scientific enquiry and encourages the investigation of the universe and its nature as a method to explore the creation of God. Early Muslim scientists believed that God's wisdom is reflected in His creation. The following verse of the Quran addresses this issue:

> Do they not look at the sky above them? How We have built it and adorned it, and there are no rifts therein? And the earth - We have spread it out, and set thereon mountains standing firm, and caused it to bring forth plants of beauteous kinds (in pairs). An insight and a Reminder for every slave who turns to God. And We send down from the sky blessed water whereby We give growth unto gardens and the grain of crops. And tall palm-trees, with shoots of fruit-stalks, piled one over another. (Quran 50:6–10)

Muslim scholars thought that the study of natural phenomena can disclose the interrelation between various parts of the universe and the unity behind the world of multiplicity, and this may lead one to the unique Creator. Golshani (2003) argues the Islamic perspectives of the nature of science on the following grounds:

(a) Science can at most inform us of some attributes of God, such as knowledge, power, etc. The jump from finite to infinite requires an intellectual exercise. Even in science, we encounter the same situation. The laws of physics and chemistry are not direct results of experimental facts. Rather, they are abstracted from the latter through an intellectual effort. Thus, for instance, matter itself is recognised through inference processes, because experiments in physics or chemistry inform us only about the properties of matter.

(b) The argument from design is neither a purely philosophical argument, nor it is a merely empirical one. It has an empirical component and a philosophical one. It is the neglect of this fact that has caused confusion about this argument or has resulted in its refutation. The real value of the argument from design is that it takes us to the frontier of science and metaphysics. It gives a hint that there is a supra-natural reality. But whether that reality is one or more, is finite or infinite, or has finite power or infinite power is beyond this argument. These aspects need separate arguments.

(c) The opposition between theistic and atheistic interpretations of physical processes, especially those related to the origin and formation of the universe, is due to their different metaphysical presuppositions. Metaphysical assumptions are often deeply embedded in our interpretation of physical processes.

It is because of metaphysical presuppositions of this argument that many scientists don't deduce God's existence from their study of natural phenomena and insist on their atheistic positions, no matter what they observe from the wonders of nature.

The Qur'an, too, reminds us that the knowledge of natural phenomena, that is, science in our modern terminology, can bring one closer to God, if one already has some faith in God. The study of nature and its secrets and beauties then fortifies one's faith: Say:

> Behold what is in the heavens and the earth; but neither signs nor warnings avail a people who do not believe. (Qur'an, 10: 101)

In short, the Islamic epistemology can be summarised as the study of nature through the methods of empirical science which can lead to God, if science is interpreted within a proper metaphysical framework in which the limits of science and the existence of higher levels of knowledge are recognised. The findings of Mansour's (2011) study concur with those of Cobern and Loving (2002), concluding that some science teachers value science, but they do not place science at the top of an/the epistemological pyramid, nor do they consider science more important than religion. In Mansour's study most of the science teachers emphasised that science is an endeavour on the part of humans to understand nature. However, God created nature and knows everything about it and its laws. Our role is that of *ijtihad*, i.e. to think, and thereby to discover these laws. We may get these natural laws right, or we may get them wrong. Scientists are human beings and they can make mistakes. One teacher said:

> I can't see any conflict between science and religion in terms of the ways of gaining knowledge. The Islamic religion, as is clear in the Qur'an, encourages us to use our minds and to use what is called in science education, 'scientific processes'. For example, the Qur'an mentions the use of *tabassur* (understanding and reflection).

Ayman supported his argument with the following verse from the Holy Qur'an:

> Behold! in the creation of the heavens and the earth, and the alternation of night and day – there are indeed Signs for men of understanding. (Qur'an 3:190)

The findings of Mansour's (2011) study showed that some teachers held negative attitudes about certain aspects of science just because non-Muslim scientists had discovered this knowledge. For example, teachers felt that the conflict between science and religion arose from the scientists who failed to consider religious viewpoints in their work, especially in Western societies. These teachers view that the conflict between science and religion is always due to the scientific discoveries, experiments, and practices that are carried out in Western societies, e.g. transplantation and cloning. These discoveries cause a conflict on the cultural level between Western and Islamic cultures. For example, one teacher commented that:

These scientists do not believe in the existence of God. That is why there are a lot of contradictions between these discoveries and religion; for example, issues or theories involving cloning and evolution. (T/Ahmed questionnaire)

This attitude about Western scientists does not correspond exactly with the Islamic epistemology of knowledge, which encourages the gaining of knowledge from everywhere at any time. To support this view, one need only refer to the *Hadith* (saying of the Prophet) that advises the individual 'to seek knowledge even in

China', a direct invitation to learn and gain knowledge from a non-Muslim country. What knowledge was available in China at the time of the Prophet? Certainly there could not have been more knowledge about Islam than there was in Mecca and Medina, in Arabia where Islam had its origins. The knowledge that could be acquired in China would have been non-religious knowledge, since China at that time was already advanced in papermaking, ceramics, explosives, and the practice of administration and of war. Clearly, Islam also wants Muslims to learn about subjects that are not specifically linked with religion, even if the source of knowledge is not Muslim (Mohamad 2002). In this regard, Kamali (2003) argues that the Prophet Muhammed could not have considered knowledge as an extension, or even a concomitant, of the beliefs, *aqida*, of Islam; he also maintains that the Prophet's sayings take a pragmatic and utilitarian view of knowledge, which can be sought outside Islam if necessity demands it. Here, the great and underlying message from the *Hadith* is that a Muslim's loyalty and commitment to Islam is unaffected by his or her attempt to seek knowledge from a non-Islamic source, though knowledge obtained from non-Islamic sources may not be 'rooted in God' or necessarily lead to Him.

Part Two: Science Teachers' Views of Science and Religion in Islamic Context

The above discussion shows not only a debate between Islam and science but also a debate between religion and science education. But the question is how do Egyptian science teachers view this debate? And which side (science or religion) do they support? How they interpret the nature of Islam and science?

This section focuses on how Muslim science teachers in Egypt have responded to this debate. It presents evidence based on interviews with ten Egyptian science teachers about their views about the relationship between science and religion. Also, it discusses Egyptian teachers' epistemological and ontological positions of science and religion and to what extent their views are on line with the Islamic epistemological and ontological positions of science. The argument in this section will be supported with the findings of research I have carried out recently with Egyptian science teachers (for more details, see Mansour 2008a).

The Relationship Between Science and Religion

(a) Conflict from the 'science' side

Science teachers, like other Muslims in the Islamic world at large, base their beliefs (*aqida*) on the claim that God is the Creator of everything. Elements of the creation story are found throughout the Qur'an; some are expressed more than once and in different ways. In the Qur'an God says:

> Who made good everything that He has created, and He began the creation of man from dust (7). Then He made his progeny of an extract, of water held in light estimation (8). Then He made him complete and breathed into him of His spirit, and made for you the ears and the eyes and the hearts; little is it that you give thanks (9). (Qur'an 32:7–9)

Some Egyptian science teachers viewed any conflict between science and religion not as 'religion conflicting with science', but as 'science conflicting with religion'. For example, teacher A said: 'For me, Islam encourages science and research in science. But science itself conflicts with Islam. That might be because science is concerned solely with material things, while a religion such as Islam concerns itself with everything in the material world and how we use it' (T/A).

Teachers' views of the conflict are based not on a separation between scientific materialism and Qur'anic literalism but on understanding and respect towards science from the Islamic-religious side and on perceived conflict and ignorance over religious values and morals from the science side. In this respect, Al-Hayani (2005: 566) argues that 'the base of the disagreement between science and religion is the notion that science is a secular pursuit driven and guided by worldly needs and gratifications, without an ethical or religious base to guide these pursuits'. However, from the teachers' point of view, the key conflict between Islam and science was about the reality of the origin of the universe.

For example, teacher C said: 'My main problem with science is the issue of Creation. I do believe as a Muslim that God creates everything. That is why I don't believe so much in science'. In this respect, Strassberg (2001) argues that some people might see conflict between religion and science on the level of knowledge (creation and big bang), but appreciate the contact between them at the level of norms (religion reinforcing the legal system).

(b) Independence with religious dominance

A few teachers viewed science and religion as having an independent relationship, seeing them as two independent disciplines. Each was asking a distinctive type of question, employing distinctive methods, and serving distinctive functions in human life. For example, Teacher D said in the interview

> I do believe in God as a Muslim; however, I view science and religion as two different disciplines that look at the issues from two different perspectives. I do like science because it is ultimately based on observation which I can do by myself; however, as a Muslim, I do believe that we have our own morals that organise our life. (T/D)

This view agrees with Barbour's statement (2000) 'Science and religion can be distinguished according to the questions they ask, the domains to which they refer, and the methods they employ' (Barbour 2000, p. 17). However, this view is not quite in line with the Islamic epistemology of knowledge, which encourages the gaining of knowledge in different fields of science and with different research methods. In the history of Islamic sciences, there are three sources for the acquisition of knowledge: they include reason, experience, and the evidence of transmission from a reliable source.

Ahmed (1999) argues that when we become skilled at testing these sources of knowledge against one another, then we know that we are coming closer to the truth. The Qur'an offers high praise of all three of these sources of knowledge. It praises reason and repeatedly condemns the polytheists for their adherence to ideas that contradict their intellectual sense. The Qur'an insists: 'Do they not look at the sky above them? How We have made it and adorned it, and there are no flaws in it?' (Qur'an, 50:6). 'He Who created the seven heavens one above another: no want of proportion wilt thou see in the creation of (God) Most Gracious. So turn thy vision again: Seest thou any flaw?' (Qur'an, 67:3).

These Qur'an verses reflected the Islamic view of science and research in science.

(c) Dialogue under the authority of religion

Some other teachers advocated a dialogue relationship between science and religion, believed that science by itself was limited and could not answer all the questions, and that religion could suggest possible answers to such questions. Science teachers' understanding of the dialogue between science and religion was based on their understanding that science needs religion to guide it, control it, and alert people to its dangers. For example, teacher G stated that religion should have authority over science:

> The relationship between science and religion is a strong and firm one; because without religion there is no science. Qur'anic verses stimulate and encourage us to learn, and noble Hadiths show us how to pay attention to science and relate it to religion because there are issues that cannot be applied except after coming back to religion. (T/G)

They also expressed views on the dominant role of religion in scientific research. This understanding of the dialogue relationship between science and religion arose from teachers' understanding that religion should have authority in science. This viewpoint on the part of science teachers can be explained by comprehending their understanding of the ontological position of Islam regarding science, as I will discuss later.

(d) Integration with science as a part of Islamic body

In contrast to the conflict and independence views, there were a large number of teachers who expressed the integration view of the relationship between science and religion. These teachers viewed science and religion as a unity and considered that they complemented each other. They were two sides of one coin and there was no discrepancy between them. The Arabic word *ilm* and its derivatives are frequently used in the Qur'an. It means 'knowledge' in its general sense, including the sciences of nature and the humanities. With this perspective there are, epistemologically, no separation of religious sciences and secular sciences and no dichotomy or dualism; the only thing that exists is categories (Yahya 2005). For example:

Religion calls for science and scientific research and this is clear in a lot of the Holy Qur'anic verses. So religion and science are not dichotomous. So, science must always be related to religion. (T/L)

It's a relationship of integration because both science and religion complement each other. The scientist experiments, searches and invents. However, he takes religion and what it calls for into account. Thus both science and religion complement each other. (T/K)

The discoveries of science consistently verify the scientific miracle in the Qur'an. When scientific theories (premises) turn into facts in the light of scientific discoveries, we find that there is an agreement between them and what has been cited in Qur'anic verses. (T/I)

Barbour's contention (2000, p. 57) that 'proponents of an integration thesis seek a closer correlation of particular religious beliefs with particular scientific theories than is advocated by exponents of dialogue' supported the finding that 34% of the teachers interviewed in this study believed there was an integration relationship between science and religion. They viewed God as the Creator of everything but also viewed science as a part of God's creation. So, there was no conflict at all. In contrast with dialogue ideas about the dominance of religion in communications between scientists and religious scholars, teachers considered that such communication should be based on respect and equality.

Roth and Alexander's analytical framework was used to interpret how teachers accommodate the relationship between science and religion within their belief system. Roth and Alexander's analytical framework includes two repertoires: a rational, which was used to classify statements that referred to the rationality of scientific and religious pursuits, and subjective, which was used to classify statements that referred to social and personal attitudes which make scientific and religious knowledge claims less than reliable.

As shown in Fig. 23.1, the analytical framework consists of four quadrants. In each of these, knowledge claims are absolute or socially constructed. Quadrant I refers to rationality in the scientific enterprise, quadrant II refers to the rational in religious discourse, and quadrants III and IV represent the personal and social beliefs that influence people's claims about scientific and religious knowledge; these last two quadrants represent claims that cannot be publicly accounted for in rational terms. Truth-Will-Out-Device 'TWOD', 'incompatibility', and 'complementarity' are devices that mediate the relationship between cells in order to avoid the conflict apparent between two contradictory knowledge claims. To mediate conflicting statements that arise from two statements—such as 'scientific knowledge is true' (Quadrant I) and 'society influences scientists' knowledge claims' (Quadrant III)—some individuals use discursive mediation devices. These discursive devices allow scientists to claim the objectivity of their knowledge claims while maintaining influences of a contingent (subjective) nature. When two reper-

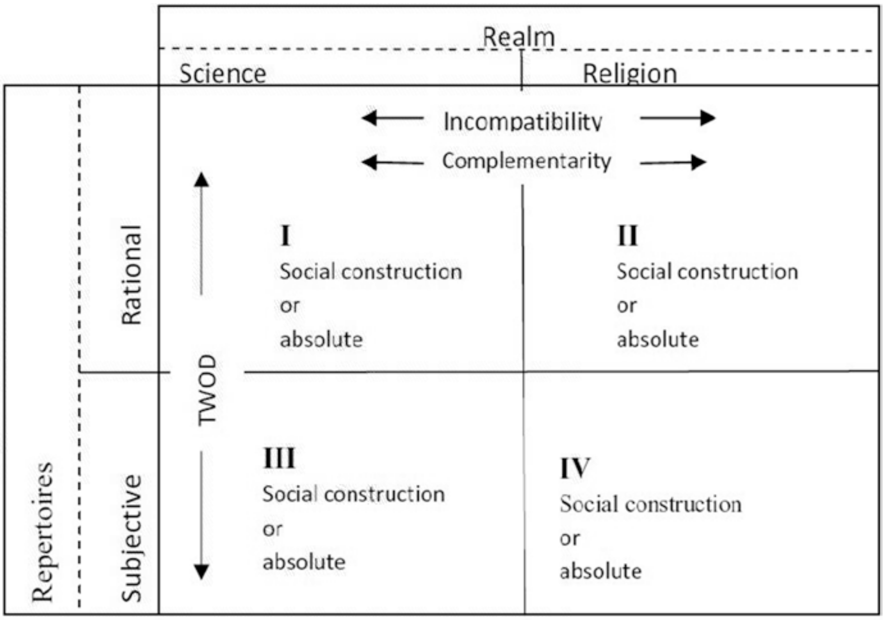


Fig. 23.1 The analytical framework of interpretive repertoires used by Roth and Alexander (1997, p. 133)

toires lead to conflict, discursive mediating devices are invoked. These devices included the TWOD and incompatibility devices and, in the case of some scientists, the complementarity device (Roth and Alexander 1997).

As shown in Fig. 23.2, teachers holding conflict, independent, dialogue, or integrative views about science and religion combined two interpretive repertoires in which they viewed science as a social construction (Quadrant I and III, Fig. 23.2) and looked at religion as if it is absolute (Quadrant II and IV, Fig. 23.2).

Teachers described scientific knowledge as socially constructed (Quadrant I and Quadrant II, Fig. 23.2). While scientific knowledge is socially constructed (an epistemological claim), teachers make absolute statements about the creation of the world, including science, by God (an ontological claim) (Quadrant III and Quadrant IV, Fig. 23.2). Because the notion of social construction allows multiple viewpoints of the same 'object', teachers did not experience conflict bringing the two realms of 'science and religion' together in the process of rational discourse. In some instances, teachers expressed conflict between science and religion, when they talked about controversial issues (e.g. cloning, evolution, creationism, etc.) in which both realms 'science and religion' might be concerned, and they usually decided to privilege the religious realm over the scientific one (Roth and Alexander 1997). Therefore, teachers in the current study did not need a mediating device such as TWOD, incompatibility, or complementarity (see Fig. 23.2). Teachers' religious orientation together with their social construction view of science provided them

		Realm	
		Science	Religion
Repertoires	Rational	**Social construction I** • Not all scientific knowledge can be reliable • Science changes every second. • Science is concerned just with material things • Science is a means of understanding what religion advises us to do • Methods of science are not reliable sources of discovering the truth • Theories and premises are still an object of study and are not yet facts	**Absolute II** • Allah is able to know and do everything • Everything around us in this universe shows the superlative work of Allah • Religious methods are more valid than science • The Holy Qur'an is not a science textbook; it is a guide for all humankind • Religious descriptions must be taken into consideration because they are more reliable source[s] of truth
	Subjective	**Social construction III** • Scientists do not believe in the existence of God. That is why there are a lot of contradictions between these discoveries and religion • Most of the discoveries in science come from Western scientists who assume that things happen just because of natural causes • Non-Muslim scientists do experiments without any consideration for religious principles or social morals • The of applications of genetic engineering alter the creation of God in plants or animals • Scientists should get guidance and ethics from the Holy Qur'an. • Religion demands that scientists search for and think of every phenomenon • Science continuously comes to show clearly what we don't understand about religion • There is no discrepancy (conflict) with the Islamic religion	**Absolute IV** • Believing in the absolute power of Allah is very important and is the basis for studying any scientific phenomenon • The Islamic religion, as is clear in the Qur'an, encourages us to use our minds • The Holy Qur'an has included all kinds of sciences on the earth

Fig. 23.2 Examples of the interpretive repertoires of the participants in this study

with an important device to keep a balance between their religious beliefs and their views about science (Roth and Alexander 1997). The teachers' use of both the social construction of science and the absolute truth of Islam illustrates why some science teachers in the study hold negative attitudes towards non-Muslim scientists, which will be discussed in the following section.

Part Three: Science Teachers' Cultural Beliefs and Serotypes of Science, Religion, and Scientists

Brooke (1990) argues that historians of science who have made a special study of relations between science and religion have observed that many of the debates that used to report a conflict between the two are in reality more about the cultural meaning of the new scientific ideas. He also argues that the Copernican system as a new system had to be resisted not because it proved 'the centralisation of the Sun' but because it implied 'the decentralisation of humanity'. Pearlstein (1990) argues that the key conflict between religion and science is not in particular scientific ideas such as evolution, but in how the scientist arrives at conclusions. Therefore, debating the relationship between religion and science should consider carefully their epistemological and ontological orientations. Religious evidence is based on religious authority which relies on a book or a set of traditions. In this sense, religion claims 'Eternal Truth' (Vroom 1990; Wiebe 1981). However, science does not recognise absolute authority. It considers 'truth' to be relative and tentative (Abd-El-Khalick et al. 1998). In this respect, Ball-Rokeach et al. (1984) suggested that a person's value-related attitudes towards objects and situations and the organisation of values and beliefs about the self form a comprehensive belief system that provides an individual with a cognitive framework. However, the story is more complex than simply to claim that religion is contradictory to science, and hence religious individuals do not go into science (Ecklund and Park 2009). In the history of science, there are a number of examples about the conflict between scientists and the Catholic Church. Roger Bacon, a thirteenth-century English priest, spent the final 14 years of his life in jail for writing that in the quest for truth, experimentation and observation are challenges to the uncritical acceptance of spiritual and secular authorities. In the nineteenth century, Charles Darwin was mocked and declared harmful for claiming that all living things evolved from lower life forms (Weerakkody 2010).

The perceptions teachers have of scientists may be formed through the mass media or by learning about scientists they encountered in their own studies (Gouthier 2007) and those teachers' perceptions shed light on the links between the social and the epistemic dimensions of science (Gouthier et al. 2006; Mansour 2013). In this respect, this chapter argues that teachers' perceptions about science and scientists are developed throughout their lifetimes and are influenced by a variety of factors, including events, experiences, and other people in their lives (Knowles 1992). Some perceptions are directly adopted from their culture. For example, each individual shares similar experiences as a child, as a member of a family, and as a parent or teacher. These experiences shape their beliefs about students, curriculum development, and the overall schooling process (McGillicuddyDe Lisi and Subramanian 1996). In addition, Reiss (2000) argues that within a particular society, there are some characteristics of the individuals such as gender, religious beliefs, ethnicity, age, and disability which make these individuals differ in their scientific understanding and conception of the world. Also, he argues that a teacher can play a positive role to react to the interaction between the inter-individual and inter-cultural differences in scientific understanding and practices. In this sense, Mansour (2013) argues that science teachers' interactions with their sociocultural contexts form their experiences, supporting the view that teachers not just simply form or socialise by the sociocultural contexts in which they operate, but they are, in fact, active participants in the interactions with these sociocultural contexts, which created the conditions for how they teach in schools. Teachers' interactions with, and internalisations of, their sociocultural experiences were transformed in many cases into teaching practices. McGinnis (2006) has noted similar cultural considerations influencing teachers' professional lives. Akerson et al. (2012) identified interesting relationships between cultural values personally held and pre-service teachers' conceptions of Nature of Science NoS aspects. A study I carried out (See Mansour 2015) discussed that some science teachers believed that scientists' religious beliefs influence their scientific research and discoveries (see Tables 23.1 and 23.2).

These views about scientists coincided with Ecklund and Park's results (2009) which concluded that scientists raised in religious homes often remain relatively religious. In the same respect and as shown in Table 23.3 about the influence of their cultural beliefs on the scientists' decisions, most of the teachers thought that scientists should be guided and influenced by their internal or external cultural beliefs.

They believe that scientists should interact with their society's needs, traditions, and morals. Therefore, scientists can create a dialogue with people in society. This will help scientists understand the beliefs of this society, which can inform the scientists' views and guide their discoveries. But also and most importantly, this might minimise the society's resistance to these discoveries. In this sense, Katz (2002, p. 46) argues, 'To begin a more effective dialogue, some scientists have suggested that religions of the world [should] become more informed about science. They believe that misunderstandings in the religious community prevent research that would be based on good, practical, instrumental grounds. In essence, these scientists believe that misinformation and insufficient understanding of what the issues

Table 23.1 Teachers' views of the relationship between scientific research and the scientists' cultural beliefs

Some cultures have a particular viewpoint on nature and people. Scientists and scientific research are affected by the religious or ethical views of the culture where the work is done. Your position, basically: (Please read from A to J, and then choose one.)	
Item	%
Religious or ethical views *do* influence scientific research:	
A. Because some cultures want specific research done for the benefit of that culture	13.6
B. Because scientists may unconsciously choose research that would support their culture's views	2.5
C. Because most scientists will not do research which goes against their upbringing or their beliefs	6.2
D. Because everyone is different in the way they react to their culture. It is these individual differences in scientists that influence the type of research done	32
E. Because powerful groups representing certain religious, political, or cultural beliefs will support certain research projects or will give money to prevent certain research from occurring	18.5
Religious or ethical views do *not* influence scientific research:	
F. Because research continues in spite of clashes between scientists and certain religious or cultural groups (e.g. clashes over evolution and creation)	19.8
G. Because scientists will research topics which are of importance to science and scientists, regardless of cultural or ethical views	3.7
Neutral views:	
H. I don't understand	2.5
I. I don't know enough about this subject to make a choice	1.2
J. None of these choices fit my basic viewpoint	0

Table 23.2 Teachers' views of the relationship between scientists and their religious views

A scientist's religious views will *not* make a difference to the scientific discoveries he or she makes. Your position, basically: Please read from A to G, and then choose one	
Item	%
Religious views do not make a difference:	
A. Scientists make discoveries based on scientific theories and experimental methods, not on religious beliefs. Religious beliefs are outside the domain of science	28.4
B. It depends on the particular religion itself and on the strength or importance of an individual's religious views	27.2
Religious views do make a difference:	
C. Because religious views will determine how you judge science ideas	4.9
D. Because sometimes religious views may affect what scientists do or what problems they choose to work on	24.7
Neutral responses:	
E. I don't understand	3.7
F. I don't know enough about this subject to make a choice	3.7
G. None of these choices fit my basic viewpoint	7.4

Table 23.3 Teachers' views of the scientists' decisions about techniques that will be used with unborn babies in Egypt

Scientists should be the ones to decide what techniques will be used with unborn babies in Egypt (e.g. amniocentesis for analysing chromosomes of the foetus, altering embryo development, test-tube babies, etc.) because scientists are the people who know the facts best. Your position, basically: Please read from A to G, and then choose one	
Item	%
A. Scientists and engineers should decide because they have the training and facts which give them a better understanding of the issue	3.7
B. Scientists and engineers should decide because they have the knowledge and can make better decisions than government bureaucrats or private companies, both of whom have vested interests	–
C. Scientists and engineers should decide because they have the training and facts which give them a better understanding; *but* the public should be involved—Either informed or consulted	4.9
D. The decision should be made equally; viewpoints of scientists and engineers, other specialists, and the informed public should all be considered in decisions which affect our society	12.4
E. The government should decide because the issue is basically a political one; *but* scientists and engineers should give advice	4.9
F. The public should decide because the decision affects everyone; *but* scientists and engineers should give advice	1.2
G. The public should decide because the public serves as a check on the scientists and engineers. Scientists and engineers have idealistic and narrow views on the issue and thus pay little attention to consequences	3.7
H. I don't understand	3.7
I. I don't know enough about this subject to make a choice	63
J. None of these choices fit my basic viewpoint	2.5

really are have led to some of the resistance and impasses'. On the other hand, teachers expressed concerns about the process by which questions are or are not selected for investigation, by suggesting that religious views may affect what scientists do or what problems they choose to work on. In this case, scientists will be limited by the religious influence and not by their religious beliefs (see Table 23.3).

Part Four: Religious Beliefs on Teachers' Pedagogical Practices and Views of Teaching Science

Based on empirical study I carried out, multi-grounded theory and 'theory diagrams' were used to generate the personal religious beliefs (PRBs) model as shown in Fig. 23.3 (also see: Mansour 2008a). This model explains the relationships among cultural contexts, religious beliefs, pedagogical practices, and professional identity. The term 'personal religious belief' (PRB) is used in this chapter to refer to the views, opinions, attitudes, and knowledge constructed by a person through

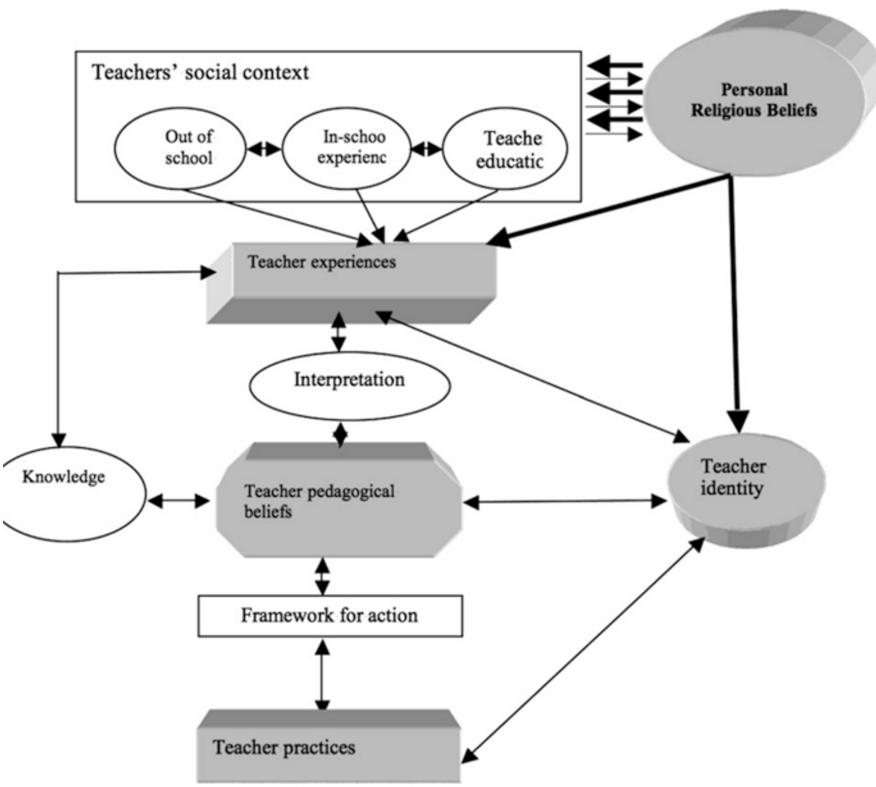


Fig. 23.3 Personal religious beliefs (PRBs) model

interaction with his/her sociocultural context through his/her life history and interpreted as having their origins in religion. The PRB is a social construct based broadly on the various experiences (and more particularly on the religious experiences) that a person lives through. PRBs are products of the interactions among all the experiences that the person accumulates and depend on the sociocultural context in which the individual has been brought up.

Knowledge and Teachers' Personal Religious Beliefs

The settled or developed teachers' beliefs 'schema' act as an information organiser and priority categoriser and in turn controlled the way it could be used. In the interactions between knowledge and beliefs, beliefs controlled the gaining of knowledge and knowledge influence beliefs. This suggests that teachers need to create their own knowledge through a process of interaction between their existing beliefs and knowledge base and the new ideas with which they came into contact. A number of researchers suggested that increased content knowledge went hand in hand with increased confidence, while having knowledge about teaching carried its own kind of authority that had the potential to empower teachers (e.g. Dadds 1995). As shown in Fig. 23.3, there is a reciprocal interaction between teachers' beliefs and knowledge on one hand, and between teachers' experience and knowledge on the other.

The classroom observations I carried out revealed that teachers' beliefs regarding their roles, students' roles, the aims of science, and their teaching methods were strongly shaped by personal religious beliefs derived from the values and instructions inherent in the religion. Teachers' personal religious beliefs worked as a 'schema', defined as 'a cognitive structure or mental representation containing organized, prior knowledge about a particular domain' (McIntosh 1995, p. 2). He also noted that schemas were built via encounters with the environment 'social context' and could be modified by experience.

The religious schemas of these teachers influence the way they perceive new experiences. Teachers arrange the elements of their social context to reflect the organisation of their own personal religious beliefs or religious schemas. A teacher with personal religious beliefs or religious schemas is more likely to force a religious interpretation on experience than a teacher without such personal religious beliefs or religious schemas. Moreover, teachers with particular personal religious beliefs may understand the situation or the experience very differently from those without these personal religious beliefs. However, teachers also hold beliefs about themselves, the nature of science, the individual students, teaching and learning science and religion issues, the social context in which they live, the school environment in which they work, and the constraints they have to deal with. These beliefs, in turn, work through the lens of past experiences, since they are translated into teacher practices within the complex context of the classroom. Teachers' personal religious beliefs controlled the gaining of new knowledge and experiences. A person's value-related attitudes towards objects and situations and the organisation of values and beliefs about self can be thought of as forming a comprehensive belief system that provided an individual with a cognitive framework, map, or theory (Ball-Rokeach et al. 1984).

In addition, teachers' personal Islamic religious beliefs can embrace their beliefs about what science is and what science should be for. Mansour's (2008b) study showed that personal religious beliefs acted as a filter for new experiences; i.e. teachers' understanding or interpretations of Islamic religious beliefs worked as the criteria or bases for interpretations of the new experiences. In this case, teachers' understanding of religion determined their understanding of what early experiences meant to an individual at the time of an event. The findings indicated that other family, daily life, and school experiences were viewed through the lens of teachers' personal religious beliefs. So, through such beliefs, each teacher had some values that she/he used to evaluate knowledge that had to be accepted and actions that had to be taken.

The influence of personal religious beliefs on other kinds of experience is represented in Fig. 23.3 by bold arrows that point from 'personal religious beliefs' to 'teachers' experiences' as well as to shaping teachers' beliefs and practices. The developed PRB model also shows that personal experiences can affect teachers' personal beliefs. However, the interactive influence between teachers' experiences and their personal religious beliefs is not equal. Personal religious beliefs are the stronger influence.

Teachers' Experiences and Pedagogical Beliefs

From a cultural perspective, the teachers' pedagogical beliefs are not just simply formed or socialised by their lifetime experiences; they are, in fact, active participants in interpreting these experiences. The particular interpretation assigned to an experience was transformed to a schema, which I take to be 'a way of understanding or a cognitive filter and a basis for teacher-centred classroom practices' (Knowles 1992, p. 138). The term instructional schema meant a settled system of pedagogical beliefs following the process of filtering by teachers' previous religious beliefs and experiences. Teachers' prior experiences had molded their educational thinking, and through the interpretations of these experiences, they formed the beliefs that they used directly to evaluate their own teaching practices.

The interpretation and subsequent schema developed by an individual with regard to classroom practices and other relevant experiences was highly idiosyncratic. Individuals experiencing a singular event would have multiple perspectives on that event. The schema or settled beliefs determine the manner in which teachers might take certain steps, so that the schema becomes an evaluative tool for examining teacher practices and is transformed into a framework for action. For example, teachers who view science as a body of knowledge rely on textbooks to assist them in transmitting science knowledge. Also, a teacher who believes that science is merely a body of knowledge to be acquired will have a very different approach to teaching science from one who believes science is a way of making sense of the world, of asking questions and seeking answers, of observing and exploring (see Fig. 23.3). The figure shows that teachers' beliefs were among the major constructs driving teachers' ways of thinking and classroom practices. So far, the developed personal religious beliefs (PRBs).

Model (Fig. 23.3) has highlighted the idea that teachers' interpretation is the link or the transmitter between teachers' experiences and their formed teachers' beliefs.

Sociocultural Contexts and Personal Religious Beliefs as a Framework of Teaching Science and Religion Issues

Here at the end of this chapter I endeavour to point out that the concept of science in a religion as shown on the PRB model will depend on the interpretations of the religious principles as understood by its followers at a certain period and may differ from time to time. Religion influences science only to the extent that its interpreters could persuade other people to adapt their conceptions. In fact it would be misleading for our purpose of teaching/learning science to consider the religious conceptions alone without taking into account the other sociocultural contexts in the situation that may collectively influence science.

By dealing and interacting with the sociocultural contexts, teachers create their own zone of understanding and interpretation of Islam related to science. This zone, as shown in Fig. 23.4, is the personal religious beliefs or 'PRB zone'. Teachers sometimes created a false contradiction between Islam and science due to their individual interpretations of the nature of Islam and science. That is why, as shown in the top left of Fig. 23.4, there is a big gap between teachers' understanding, interpretations, epistemology, and ontology of the socio-scientific issue related to religion on one side and the religion's epistemology and religion of the same issue, on the other side. This gap might be created due to the lack of the awareness by the right understanding of religious beliefs (RB zone) of science or a controversial issue.

Most of the teachers' religious experiences related to teaching controversial issues were from informal sources (including family, previous teachers, and the media). Educational decision makers and science educators around the world should be made aware that teachers' personal religious beliefs within sociocultural context are a highly effective variable that can have a positive or negative influence on the entire educational process. It was also shown that teachers' personal religious beliefs could be considered a positive factor in developing positive attitudes among teachers towards science and teaching science. It is therefore suggested that decision makers, curriculum developers, and science educators should engage in thoughtful reflection and discussion about developing various study programs. These would act as formal knowledge sources about the relationship between science and religion and would also train teachers how to debate issues related to

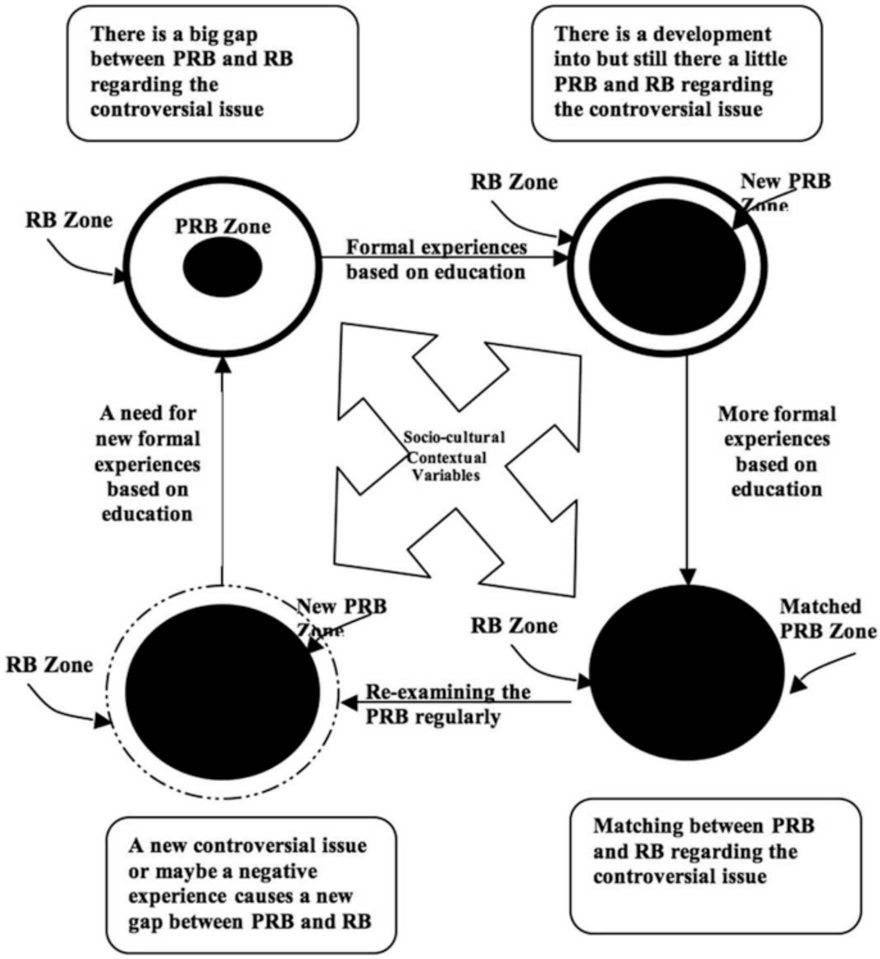


Fig. 23.4 Sociocultural contexts and PRB

science and religion. To minimise the gap between the RB zone and the PRB zone, a formal experience about the relationship between science and religion should be based on the coordination among the scientific institutions, and the religious one is much needed with considering the other sociocultural contexts. I agree with the position that compatibility is needed between religious education and science education. In cultures where religion has a major influence on people's lives, the development of science curricula should be made in a partnership between science educators and religion scholars, especially with regard to socio-scientific issues associated with religion. This process would provide opportunities to challenge teachers' personal religious beliefs, to introduce appropriate perceptions of religious attitudes, and to leave the door open for different views and different understandings. By this educational process, PRB zone will get to the stage to match the

RB zone. However, by developing advanced technology and developing the scientific research, a new controversial issue may emerge which in turn will cause a new gap between PRB and RB. This will require a regular examination of the PRB and a regular training. Also, in cultures where religion has a major influence on people's lives, the development of science curricula should be made in a partnership between science educators and religion scholars, especially with regard to socio-scientific issues associated with religion.

Part Five: How Professional Learning Programme Might Respond to Teachers' Cultural Beliefs and Serotypes of Science, Religion, and Scientists

The chapter advocates that a dialogue between scientists, religious scholars, science educators, and science teachers is very important and very much needed in order to improve the teachers' professional development and develop models to teach controversial issues. This experience allows learners to gain insights into the communal nature of science and may facilitate the learners' adoption of ways of perceiving and interacting with the world that are consistent with those of real scientists (Barab and Hay 2001). Universities should create opportunities for academics and company researchers and executives with shared interests to come together and develop a dialogue (Gaskill et al. 2003).

The chapter argues for a scientist-religious scholars-teacher partnership model to support teaching science and socio-religious issues and to challenge both teachers and students' cultural models and stereotypes of scientific research and scientists' practices. It was theorised that these partnerships situated in classrooms where participation in pedagogical decision making and action was possible, and where dialogue could be grounded in this participation, had the potential to transform participants' understanding and practices relevant to science education (Lave and Wenger 1991). Therefore, the study strongly calls for a partnership programme between scientists, religious scholars, and teachers as professional development for science teachers to help them deal with socio-religious scientific issues. This programme should involve teachers, religious scholars, and scientists in authentic, formal and informal settings. This partnership will help teachers' understanding of the NoS but also explore the scientists and religious scholars' views of science. In addition, this partnership will help teachers explore the scientists and religious scholars' cultural views and how scientists negotiate their cultural beliefs when they are studying natural phenomena. A study by Willcuts (2009) showed that scientist-teacher partnerships are a unique contribution to the professional development of teachers of science, something that is not replicated in other forms of teacher training.

References

Abd-El-Khalick, F., Bell, R., & Lederman, N. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education, 82*(4), 417–436.

Ahmed, I. (1999, March 20). *Islamic contributions to modern scientific method*s. Lecture delivered on the occasion of the Tenth Anniversary of the Centre for Faith and Science Exchange, the Islamic Society of Boston, Wayland, MA.

Akerson, V., Buzzelli, C., & Eastwood, J. (2012). Bridging the gap between preservice early childhood teachers' cultural values, perceptions of values held by scientists, and the relationships of these values to conceptions of nature of science. *Journal of Science Teacher Education, 23*, 133–157.

Akhtar, S. W. (1984). The Islamic concept of knowledge. *Al-Tawhid*, *XII* (3), 1–9.

Al-Hayani, F. (2005). Islam and science: Contradiction or concordance. *Zygon, 40*(3), 565576.

Ball-Rokeach, S., Rokeach, M., & Grube, J. (1984). *The great American values test*. New York: Free Press.

Barab, S., & Hay, K. (2001). Doing science at the elbows of experts: Issues related to the science apprenticeship camp. *Journal of Research in Science Teaching, 38*(1), 70–102.

Barbour, I. (2000). *When science meets religion: Enemies, strangers or partners?* San Francisco: Harper.

Brooke, J. H. (1990). The Galileo affair: Teaching at 17. *Physics Education, 25*, 197–201.

Cobern, W., & Loving, C. (2002). Investigation of preservice elementary teachers' thinking about science. *Journal of Research in Science Teaching, 39*(10), 1016–1031.

Dadds, M. (1995). *Passionate enquiry and school development: A story about teacher action research*. London: Falmer Press.

Ecklund, L., & Park, J. (2009). Conflict between religion and science among academic scientists? *Journal for the Scientific Study of Religion, 48*(2), 276–292.

Gaskill, D., Morrison, P., Sanders, F., Forster, E., Edwards, H., McClure, S., & Fleming, R. (2003). University and industry partnerships: Lessons from collaborative research. *International Journal of Nursing Practice, 9*(6), 347–355.

Golshani, M. (2003). Does science offer evidence of a transcendent reality and purpose? *Islam and Science, 1*, 45–65.

Gouthier, D. (2007). Teachers' perception of European scientists. *Journal of Science Communication, 6*(3), 1–10.

Gouthier, D., Cannata, I., Castelfranchi, Y., & Manzoli, F. (2006). The perception of science and scientists in the young public. In *The 9th international conference on public communication of science and technology*, Seul.

Hefner, P. (2002). How science is a resource and a challenge for religion: Perspective of a theologian. *Zygon, 37*(1), 55–62.

Kalin, I. (2006). Islam and science: Notes on an ongoing debate. In A. Eisen & G. Laderman (Eds.), *Science, religion, and society: An encyclopaedia of history, culture, controversy*. Armonk: M.E. Sharpe. Inc.

Kamali, M. (2003). Islam, rationality and science. *Islam and Science, 1*, 90–120.

Katz, S. (2002). Questions for a millennium: Religion and science from the perspective of a scientist. *Zygon, 37*(1), 45–54.

Knowles, J. G. (1992). Models for understanding pre-service and beginning teachers' biographies: Illustration from case studies. In I. F. Goodson (Ed.), *Studying teachers' lives* (pp. 99–152). London: Routledge.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Mansour, N. (2008a). The experiences and personal religious beliefs of Egyptian science teachers as a framework for understanding the shaping and reshaping of their beliefs and practices about Science-Technology-Society (STS). *International Journal of Science Education, 30*(12), 1605–1634.

Mansour, N. (2008b). Religious beliefs: A hidden variable in the performance of science teachers in the classroom. *European Educational Research Journal, 7*(4), 557–576.

Mansour, N. (2011). Egyptian science teachers' views of science and religion vs. Islamic perspective: Conflicting or complementing? *Science Education, 95*(2), 281–309.

Mansour, N. (2013). Modelling the sociocultural contexts of science education: The teachers' perspective. *Research in Science Education, 43*, 347–369. https://doi.org/10.1007/s11165-011-9269-7.

Mansour, N. (2015). Science teachers' views and stereotypes of religion, scientists and scientific research: A call for scientist-science teacher partnerships to promote inquiry based learning. *International Journal of Science Education, 37*(11), 1767–1794. https://doi.org/10.1080/09500693.2015.1049575.

McGillicuddy-De Lisi, A. V., & Subramanian, S. (1996). How do children develop knowledge? Beliefs of Tanzanian and American mother. In S. Harkness & C. M. Super (Eds.), *Parents' cultural belief systems: Their origins, expressions, and consequences* (pp. 143–168). New York: the Guiford Press.

McGinnis, J. R. (2006). Cultural considerations. In K. Appelton (Ed.), *Elementary science teacher education: International perspectives on contemporary issues and practice* (pp. 275–298). Mahwah: Erlbaum.

McIntosh, N. (1995). Religion-as-Schema, with implication for the relation between religion and coping. *The International Journal for the Psychology of Religion, 5*(1), 1–16.

Mohamad, M. (2002, April 21). *The power of knowledge in the new area*. Paper at the Thirty-first international conference of the International Federation of Training and Development Organization (IFTDO), Manama, Bahrain.

Pearlstein, E. (1990). Science and religion: Conflicting or complementary? *Physics Education, 25*, 239–240.

Reiss, M. J. (2000). Teaching science in a multicultural, multi-faith society. In J. Sears & P. Sorenson (Eds.), *Issues in science teaching* (pp. 16–22). London: Routledge Falmer.

Roth, W.-M., & Alexander, T. (1997). The interaction of students' scientific and religious discourses: Two case studies. *International Journal of Science Education, 19*(2), 125–146.

Strassberg, B. A. (2001). Religion and science: The embodiment of the conversation: A postmodern sociological perspective. *Zygon, 30*(3), 521–539.

Vroom, H. M. (1990). *Religions and the truth: Philosophical reflections and perspectives*. Amsterdam: Rodopi B.V.Editions.

Weerakkody, W. (2010). *God, science, and the Buddha: Understanding the theory of everything*. Lulu.com.

Wiebe, D. (1981). *Religion and truth: Towards and alternative paradigm for the study of religions*. The Hague: Paris/New York.

Willcuts, M. (2009). *Scientist-teacher partnerships as professional development: An action research study*. Washington, DC: Pacific Northwest national laboratory.

Yahya, I. (2005, June 4–8). *Integration of religion and science in the Indonesian State Islamic Universities*. Paper at the science and religion: Global perspectives program, Metanexus Institute, Philadelphia, PA.

Dr. Nasser Mansour is a Senior Lecturer in Science Education at the Graduate School of Education at Exeter University. He is Fellow of the Higher Education Academy (HEA). Dr. Mansour graduated from the University of Exeter, UK, in 2008. His PhD looked at teachers' beliefs and practices about STS with emphasis on the interaction between cultural issues, e.g. religious beliefs and the teaching of science. Dr. Mansour published in prestigious education journals such as *Science Education*, *International Journal of Science Education*, *Journal of Science Teacher Education*, *Cultural Studies of Science Education*, *Research in Science Education*,

Computer and Education and *European Educational Research*. Dr. Mansour has been awarded the best paper Award at the European Educational Research Association conference in 2007 and The University of Exeter Merit Award in 2011. Dr. Mansour has been involved in international educational projects in Egypt, Saudi Arabia and UK. Dr. Mansour is a member of national organizations including ESERA, NARST, ASTE, BAAS and BERA. For further information, see http://education.exeter.ac.uk/staff_details.php?user=nm259

Chapter 25
Closing Remarks

Berry Billingsley, Keith Chappell, and Michael J. Reiss

This book has its origins in the output from a conference that took place in Oxford in the Autumn of 2016. The conference represented a ground-breaking attempt to bring together interdisciplinary researchers and practitioners in order to have a meaningful dialogue about the many issues that surround science and religion in an educational setting. Initially, the organisers hoped that the conference would provide a forum for discussion of underlying scholarly thought of the insights brought by the social sciences and to share good practice, hence the structure of this book. Yet, as is sometimes the case with such gatherings, it soon became apparent that the conference had achieved much beyond this – fittingly as the title of the first section was 'Beyond Barbour'.

Topics that have been at the forefront of the study of science and religion, such as evolution and the origins of the Universe, were considered from new perspectives. In particular, the notion of conflict as a necessary model for the relationship between science and religion was challenged and new approaches considered. Conflict itself was considered in new ways, recognising that it too can be creative and constructive if dealt with appropriately. The broad range of expertise and experience reflected amongst the participants allowed that most exciting of things to occur – creative friction, something that often only comes about at the margins of existing disciplines. In the chapters of this book, we find physicists and social scientists considering matters of religious education, theologians and biologists thinking about social patterns and all recognising that strict adherence to the boundaries

B. Billingsley · K. Chappell
LASAR (Learning about Science and Religion), Canterbury Christ Church University, Canterbury, UK
e-mail: berry.billingsley@canterbury.ac.uk; k.chappell403@canterbury.ac.uk

M. J. Reiss (✉)
Institute of Education, University College London, London, UK
e-mail: m.reiss@ucl.ac.uk

B. Billingsley et al. (eds.), *Science and Religion in Education*, Contemporary Trends and Issues in Science Education 48,
https://doi.org/10.1007/978-3-030-17234-3_25

we place on knowledge (often for eminently sensible reasons) restricts our ability to grasp the full nature of many problems, not only the challenges of science and religion in education.

Thus, the debates and questions relating to science and religion continue and will continue for quite some time, of this we have little doubt. The work reported in this book, we believe, represents a step forward at all levels, not least the thorny problem of how we present these debates and questions to young people. Clearly, this isn't simple or easy, but it is important for the future of science and religion in our societies. We do not wish to make claims that are too grandiose for this work, but we do wish to suggest that it presents an important starting point for many intellectual journeys from the academy to the early years' classroom. Whether the challenges recognised are specifically relating to science and religion, or to other questions that transcend the boundaries of traditional classrooms and university departments, the research and pedagogies found in this book provide an important model of how these questions can help all disciplines to move forward and help students to learn.

It is our belief that this offering provides an important contribution to the wider academic and social discussions relating to science and religion and that it will help educationalist to devise valuable approaches to teaching in this area. It is also our hope that the chapters in this book may stimulate a host of other debates at the local and other levels relating to science and religion and to how we approach teaching interdisciplinary issues. In a world where borders (whether between subjects or countries) can easily become fixed and forbidding, the conference and the chapters which grew from it have shown to us that making them a little more porous can be truly exhilarating.

In the early chapters of this book, we saw challenges to what have become orthodoxy in the study of science and religion, the models proposed by Ian Barbour for the potential interaction of the disciplines, or ways of thinking – conflict, independence, dialogue and integration. As Bethany Sollereder highlights in her introduction to the first section, thought since Barbour's valuable contribution has recognised that things are a little more complex and nuanced than simple typologies. This, of course, is the problem with trying to create any system of classification or typology. Such schemes are, of their nature, an attempt to simplify and make sense of a complex world – just as both science and religion are. The relationships that can be observed between science and religion are both complex and flexible, subject to fluctuation not only for a group or discipline but for an individual. In light of this, a conflict-based model such as Barbour identified as his first type makes eminent sense in terms of simplicity and elegance, reducing dissonance for the individual and the need for complex and conflicting notions. Instinctively, however, we often tend to shy away from conflict and feel it is something to be reduced or avoided. This then presents a thinking person with a moral challenge: the comfort and rationality that can be achieved in exclusive notions of science and religion versus the social message that conflict is bad and that we must all try to 'get along' in whatever sphere of life.

But this is to simplify conflict itself too much and to fail to understand the important social and intellectual role of this sociological phenomenon. As Lewis Coser proposed back in the 1950s, drawing on the work of George Simmel, conflict has important social functions both when it occurs within a group and between groups (Coser 1956). Within a group it clarifies roles and functions, in some cases establishing power structures and helping to maintain them. Conflict can act as an important 'safety-valve', enabling issues to be handled at a point before differences become catastrophic. For social groups, but also for belief or thought systems, it is often conflict that defines boundaries and enables members to define their membership. Thus, our instincts to avoid conflict as a way of understanding the relationship between science and religion may at times have been counterproductive, resulting in the often destructive and polarised polemic witnessed in the writing of some authors in recent years. So, acknowledging that conflict does exist is a vital first step in enabling those in the classroom to consider the nature of that conflict and whether it requires total rejection of the 'other'. To draw on Alfred North Whitehead: 'The clash of doctrines is not a disaster, it is and opportunity' (Whitehead, *Science and the Modern World,* 186).

Taking the opportunity inherent in the 'clash' between science and religion is what is apparent in many of the chapters in this book. In the first section of the book, we are presented with opportunities for thinking differently about how science and religion relate.

McCleish (Chap. 5) presents us with a theology of science which shifts thought beyond any of Barbour's models towards an intimate interaction of the fields in which we are challenged to consider whether we can ever truly understand one without the other. This takes us past notions of dialogue or integration towards a layered epistemology that applies to any two, or more, disciplines and how they are taught in schools. Compartmentalised thought and teaching are valuable in that they make subjects manageable, but if they become the sole mode of teaching, then much can be, and is, lost. Trubody (Chap. 10) draws on Kierkegaard to take this approach into the realms of the language we use to talk about and frame subject areas and how this can lead us to believe that particular ways of investigation can have exclusive access to the 'truth'. Any person or belief system claiming possession of the truth to the exclusion of all others takes conflict to a level that cannot be constructive and isolates itself, preventing the mutual enhancement of self-understanding that comes through applying different modes of understanding to one's own field. Sally Riordan touches on the possibilities of broadening insight by taking the discussion beyond the academic to look empirically at the moral implications of allowing dialogue between science and religion. In finding implications for the way young people live their lives, she not only opens up a point at which educational efforts could focus through enhanced engagement of attention but brings to light the very real lifelong implications for students who may never engage in the science-religion debate but will gain new insights into the nature of science, of religion and of ethics. This, then, highlights the moral imperative for the many efforts reported in this book to provide serious pedagogical responses to debates that are no longer limited to the academy but are frequently encountered in religious communities, online fora and general discussion for old and young alike.

Through the process of mutual regard that McCleish presents, common and constructive language considered by Trubody and moral dimension introduced by Riordan, we can see Barbour's notion of dialogue emerging, but something much more. In her introduction to the first section, Sollereder introduces the value of biography in understanding the complex relationships between science and religion and in doing so points to an important direction for development in the field of science and religion. Biography of key figures is valuable but only goes so far. We are creatures who make sense of life through stories, and in the elements outlined above, we have the components to build stories about science and religion – perspective, language and moral. In a story we can easily come to address many of the limitations discussed throughout this book that relate to the models we have. A narrative can easily contain within it notions of conflict, independence, dialogue, integration or any number of other models of relationship. The reader, or hearer, can place each in context and recognise their dynamic relationship and, as with any biography, gain a sense of growth and value in each element of the life of a relationship.

Stories, of course, are not a mystery to teachers. Indeed, they are the very basis of much pedagogy and come through in many of the empirical studies and interventions presented in this book. This, we suggest, could be an extremely valuable way in which the many insights reported here could be developed for both theoretical but, more importantly, educational purposes. What is clear from so many of the studies in the second and third parts of this book is that young people are interested in and seeking to make sense of the questions being considered by scholars. These are seen in some fundamental questions, such as the nature of truth considered by Easton in Chap. 12 and Cheetham in Chap. 19. Not only the epistemological implications concern young people but also the moral and social implications. In Billingsley and Nessajji in Chap. 13, for example, we encounter young people considering the nature of knowing and the nature of personhood and personal responsibility through concepts of the soul in advanced artificially intelligent robots. Again and again, students rise to these questions and come to a fuller understanding of scientific and religious concepts by doing so. As witnessed by several studies, such as Nevarro et al. (Chap. 20) and Cameron (Chap. 16), diverse cultures and religious backgrounds yield similar desires to engage with fundamental questions of science and religion. If students are given access to interdisciplinary approaches, this will give them the opportunity to consider the questions at hand; narrative approaches may well give them the grammar and structure to enable them to do the work.

References

Coser, L. (1956). *The functions of social conflict*. New York: Free Press.
Whitehead, A. N. (1967). *Science and the modern world*. New York: Free Press (1925).

Prof. Berry Billingsley specialises in Science Education and leads the LASAR (Learning about Science and Religion) research team at Canterbury Christ Church University. Her interests include students' ideas about the nature of science and, more broadly, developing strategies to support the development of epistemic insight, young people's engagement in science, artificial intelligence, Big Questions bridging science, religion and the wider humanities and the communication of science and technology news in the media. Equipped with a physics degree, Berry's first career was with the BBC where she produced and presented television and radio programmes including BBC World Service's 'Science in Action', BBC TV's 'Tomorrow's World' and BBC Education's 'Search out Science'. She then travelled to Australia to become a senior project manager with the Department of Education. She regularly publishes in science education.

Dr. Keith Chappell is a Research Fellow in the Learning about Science and Religion team at the University of Canterbury. He has previously taught biological sciences at the University of Reading and the University of Derby. Besides his interests in biology, he writes in the field of theology and religious studies, having been a Las Casas scholar at Blackfriars Hall, Oxford studying Christian social teaching. He is a Visiting Lecturer at the Maryvale Institute, Birmingham and Liverpool Hope University. He is also a theological advisor to the Catholic Bishops' Conference of England and Wales. In addition to science and religion, he is engaged in research in the sociology of religion and the philosophy of biology.

Michael J. Reiss is a Professor of Science Education at UCL Institute of Education, Visiting Professor at the Universities of Kiel, York and the Royal Veterinary College, Honorary Fellow of the British Science Association and of the College of Teachers, Docent at the University of Helsinki, a Fellow of the Academy of Social Sciences and a Priest in the Church of England. He is the President of the International Society for Science and Religion and of the International Association for Science and Religion in Schools and has research and consultancy interests in science education, bioethics and sex education.