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ARTICLE

Enhancing Teachers' Awareness About Relations Between Science and Religion

The Debate Between Steady State and Big Bang Theories

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Abstract Educators advocate that science education can help the development of more responsible worldviews when students learn not only scientific concepts, but also about science, or "nature of science". Cosmology can help the formation of worldviews because this topic is embedded in socio-cultural and religious issues. Indeed, during the Cold War period, the cosmological controversy between Big Bang and Steady State theory was tied up with political and religious arguments. The present paper discusses a didactic sequence developed for and applied in a pre-service science teacher-training course on history of science. After studying the historical case, pre-service science teachers discussed how to deal with possible conflicts between scientific views and students' personal worldviews related to religion. The course focused on the study of primary and secondary sources about cosmology and religion written by cosmologists such as Georges Lemaître, Fred Hoyle and the Pope Pius XII. We used didactic strategies such as short seminars given by groups of pre-service teachers, videos, computer simulations, role-play, debates and preparation of written essays. Along the course, most pre-service teachers emphasized differences between science and religion and pointed out that they do not feel prepared to conduct classroom discussions about this topic. Discussing the relations between science and religion using the history of cosmology turned into an effective way to teach not only science concepts but also to stimulate reflections about nature of science. This topic may contribute to increasing students' critical stance on controversial issues, without the need to explicitly defend certain positions, or disapprove students' cultural traditions. Moreover, pre-service teachers practiced didactic strategies to deal with this kind of unusual content.

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1 Introduction

In several countries, contemporary science education official guidelines and curricula stress the expectation that students should learn about the rich interrelationships between science, culture and worldviews (Brasil 2002, p. 32; Matthews 2009, p. 49). In order to reach this goal, one of the proposed strategies is the discussion of historical episodes and their philosophical implications (Zanetic 1990; Matthews 1994; Salem 2012).

Aiming at a more cultural, beneficial teaching and seeking the formation of more informed, intelligent and responsible worldviews, and thus of a better and more humanistic culture (Matthews 2009), it is important to discuss the historical and contemporary interaction between science and religion (Matthews 1996). In recent years, several authors have argued that science teachers should engage themselves and their students in debates about relations between science and religion. Some of the potential benefits pointed out by these authors are:

- The development of more complex views about nature of science, through the reflection about similarities and differences between science and religion (Loving and Foster 2000; Reiss 2009)
- The need to understand the role of presuppositions in science and religion, as the possibility of knowledge about nature, and the existence of order and causation in nature (Cobern 2000; Cobern and Loving 2001)
- The engagement into constructive dialogues with religious students whose beliefs may be in conflict with scientific theories, like the theory of evolution of species, and of the origin of life and of the universe (Shipman et al. 2002; Hansson and Redfors 2006, 2007; El-Hani and Sepúlveda 2010)

Cosmology is one of the sciences that has more impact on our worldviews, as it is directly related to fundamental questions such as "What sorts of things exist in the universe? Was the universe created by an intelligent Being? If so, what are the Being's properties and if not, what account can be given of creation? (…) Do humans have a nature or essence? How should we live our lives? What is good and bad, right and wrong? What is the best form of government? Is there a purpose in life in general, in the universe as a whole? Is there life after death? How should we go about answering these questions?" (Irzik and Nola 2009, pp. 730–731). Additionally, cosmology is a discipline embedded in philosophical, cultural and religious aspects. Due to the intrinsic interest in these kinds of fundamental questions, cosmology is a quite popular topic in outreach materials, such as books, documentaries and other materials for the general public. While teaching about cosmology, possible conflicts between contemporary scientific theories and students' religious beliefs will be an important challenge to face (Shipman et al. 2002; Hansson and Redfors 2007). For these reasons, we agree with Kragh (2011, p. 343) that "modern cosmology and its philosophical aspects should have a prominent place in science education".

Even though cosmology and its controversial issues are often considered interesting and inspiring, they are rarely addressed in science classes. Irzik and Nola (2011, p. 592) criticized the "consensual view", according to which "we should teach students only those characteristics that are widely accepted either in the science standards documents and/or in the philosophy, history, sociology of science and science education literature and for that reason that are the least controversial aspects of the nature of science". Several educators have argued that science teachers should learn about different positions regarding

controversial issues like the tensions between the realist and the empiricist or instrumentalist interpretations of the theoretical entities, between rationalism and relativism, or about the "social construction of science" (Bagdonas 2011; Matthews 2012; Rozentalski and Porto 2013; Noronha 2014; Bagdonas et al. 2014). Authors interested in contributions of history and philosophy of science in education have been debating how science teachers can introduce controversial issues about science and worldviews in their classes.

The debate opposing universalists and multiculturalists, in which moral, political and philosophical disagreements are evident, has become polarized in recent decades and no consensus has been achieved. Universalists advocate that science is, both as an activity and a body of knowledge, universal in character and cannot be taught in multicultural terms (El-Hani and Mortimer 2007, p. 660). Michael Matthews, as a universalist, argues that respect for cultural diversity cannot have as a consequence the inclusion of other ways of knowing in science. He incites that in liberal and secular societies worldviews like those that support racist, sexist, and casteist values should not be accepted (Matthews 2009, p. 15). Nevertheless, it is important to debate such polemical issues during teachers' education and at schools. If schools neglect such matters, there will be hardly any other opportunity to look for a peaceful coexistence between different worldviews. In this research, we advocate that science teachers should engage in constructive and respectful dialogues with students, inspired by what El-Hani and Mortimer have called "ethics of coexistence":

> We advocate here an ethics of coexistence in social argumentative processes—including those that take place in the context of science education—which demand dialogue and confrontation of arguments in the search of possible (but not inevitable) solutions, and an effort to (co-)live with differences if a negotiated solution is not reached. (El-Hani and Mortimer 2007, p. 658)

However, multicultural science education can be much more complex when dealing with religious students than traditional universalist education (El-Hani and Sepúlveda 2010, p. 104). Since religions usually make statements about natural phenomena, there are some unavoidable conflicts between what must be taught in science classes and some of the students' religious beliefs, chiefly on topics like evolution and cosmology. For instance, Falcão et al. (2008) found that the majority of students in public schools in Rio de Janeiro (Brazil) see Big Bang cosmological universe models as doubtful and in conflict with their religion; and a larger survey from 2010, performed in the whole country, showed that one in four Brazilians can be classified as young earth creationist.[1] Similar results were found in the United States of America and the United Kingdom (Reiss 2008). Young earth creationism supports that, according to biblical accounts, God created Earth, humans and other living organisms about 6000 years ago. This claim is incompatible with several well established scientific pieces of evidence in different fields, like geology, biology, astronomy and cosmology, which forces young earth creationists to seek for awkward strategies to make their faith compatible with such fields of science (Heaton 2009).

El-Hani and Sepúlveda (2010) investigated how Protestant biology pre-service teachers managed the coexistence of scientific and religious knowledge in their classes. Their study found some gaps and limits in the thesis of independence and complementarity between scientific and religious education, as discussed in Sect. 2. They suggested that only teachers "with a religious background who show an open attitude towards science and, thus, are predisposed to know and understand what science is about and what it tells us

[1] Survey published on March 29, 2010, by *Datafolha Institute*. Access in January, 2015, http://datafolha.folha.uol.com.br/opiniaopublica/2010/04/1223573-59-acreditam-na-evolucao-entre-as-especies-sob-o-comando-de-deus.shtml.

about the world" might be able to work with their students towards a scientifically compatible worldview. The authors found that those teachers who held absolutist views of knowledge[2] exhibited extreme attitudes while dealing with conflicts between science and their faith, showing a "systematic and resolute refusal of understanding the scientific discourse" (El-Hani and Sepúlveda 2010, p. 120).

In 1996, philosophers, historians and science educators contributed to a special issue of *Science & Education* entitled "Science, Religion and Education" (Matthews 1996). The debate started with a controversial paper by Mahner and Bunge (1996a) who argued that religious education is an obstacle to scientific education because science and religion are different and incompatible. Their arguments were severely criticized, giving rise to a debate that was continued 13 years later in another *Science & Education* special issue entitled "Science, Worldviews and Education" (Matthews 2009).

Mahner and Bunge's (1996b) interest was not to discuss sophisticated conceptions of religion, but the most common religious views held by people who have not studied theology. Critics of this paper pointed out an unbalanced treatment between sophisticated conceptions of science and naive conceptions of religion. They agreed that there are some incompatibilities between science and religion, but disagreed with Mahner and Bunge's conclusion that religious faith is an obstacle to science teaching, or that science must presuppose a materialist view of the world. We consider the analysis of Mahner and Bunge's argument relevant to a deeper understanding of the challenges that educators face while addressing science and religion issues in science classes, especially with students who hold absolutist views of science believing that scientific knowledge is proved and no matter for negotiation.

Absolutist views of science are an additional obstacle to a respectful coexistence between different worldviews because they nurture scientism, often associated with the promotion of hegemony and superiority of science over other forms of knowledge (El-Hani and Mortimer 2007, p. 663; Hansson and Redfors 2007, p. 463). Whereas religious students will exhibit resistance to scientific ideas that are in conflict with their beliefs if they are presented in an authoritative way, teachers who hold absolutist views of science believe that it is acceptable to tell religious students that their beliefs are incompatible with science and are wrong. Science education should not be confounded with indoctrination.

Despite the fact that the above issues are relevant, science teachers often avoid and hardly discuss them in science classes. The present paper brings results of research conducted during a teacher-training course on the history of cosmology during the late 1940s and the middle 1960s, involving scientists' views about the relations between science and religion. After studying this historical episode, pre-service science teachers reflected on how to deal with conflicts between scientific views and students' worldviews in their teaching. Along the course, pre-service teachers also had the opportunity to learn about and practice didactic strategies suitable for introducing such kinds of controversial themes in classrooms.

[2] El-Hani and Sepúlveda (2010, p. 104) understand epistemological absolutism as the thesis that "humans can have access to ideas about the world that might be proved beyond all doubt, and, thus, become indisputable truths or even pictures of reality-in-itself".

2 Science, Religion and Education

In order to discuss the relations between science and religion with science teachers, we have adopted four theses proposed by Barbour (1990)—*Conflict, Independence, Integration and Dialogue*. The historian of science Helge Kragh has used these categories for analyzing religious beliefs of several scientists who contributed to the creation of the cosmological models in the 20th century (Kragh 2004). Later, Reiss (2008, 2009) adapted the categories for the context of science education.[3]

2.1 The Conflict Thesis

The *Conflict* thesis is common among religiously motivated anti-evolutionists and atheist scientists like Carl Sagan and Richard Dawkins engaged in the defence of science against its "enemies" (Sagan 1985; Dawkins 2006). Shipman et al. (2002, p. 531) called Carl Sagan and Richard Dawkins "dogmatic" because they see the world "through a purely scientific lens" and sustain that "atheism is the only rational position". Although Mahner and Bunge, in their paper of 1996, had not discussed Barbour's categorization, their claims fit in the *Conflict* category.

Loving and Foster (2000) found that radical claims tend to repel teachers, even those with moderate positions regarding religion. They presented Mahner's and Bunge's paper in a teacher-training course; after analyzing teachers' emotionally engaged answers to the paper, they concluded that many religious teachers felt offended by its radical claims. Wherefore these authors defend that *Conflict* views must be carefully addressed in the context of science education since it is important to respect religious views, even if they seem incompatible with scientific theories.

2.2 The Independence Thesis

This thesis considers science and religion as incommensurables; thus the ones who adopt this view have no need to think about any relations between them or to deal with conflicts. According to this view, science and religion are used in different contexts, offering answers to distinct human questions and needs. The supporters of the *Independence thesis* emphasize the differences between science and religion to such an extent that avoids conflicts.

The evolutionary biologist and essayist Stephen Jay Gould argued that religion and science are "non-overlapping magisteria" because science deals with the empirical world, with facts and theories, while religion deals with moral values and meanings (Gould 1999). With such strict borders, there is no need for dialogues or conflicts between science and religion.

The educator Brian Woolnough has also criticized Mahner and Bunge's paper with arguments typical of the *Independence* thesis. For him, there is not a single criterion for establishing truth, since truth has quite different meanings in different contexts. As science and religion are "different forms of knowledge, different descriptions are appropriate in

[3] Due to the multiplicity and complexity of relations between sciences and religions, these categories are neither rigid nor exclusive. One author can sustain a combination of two or more categories, or show positions that change along his life. Science educators have proposed similar categories; for instance, Shipman et al. (2002, p. 532), used Distinct, Convergent, Transitional and Confrontational. El-Hani and Sepúlveda (2010, p. 107) discussed three categories similar to Conflict, Integration and Independence.

different contexts. Each may be true, each may be valid, and each may be compatible with the other. The skill is to know when to use each, when to ask which type of question and which methodology to use in each context" (Woolnough 1996, p. 180).

2.3 The Integration Thesis

Authors who adopt this thesis argue that religion and science are sufficiently similar in their epistemological aspects. Hence they can be related with each other in an ''interdisciplinary'' search for knowledge (El-Hani and Sepúlveda 2010, p. 197). This view is common among religious scientists and theologians with interests in science and the study of scientific knowledge directly connected with religious issues. They advocate that "the existence of God or, at any rate, an appreciation of some of God's attributes, can be deduced from aspects of nature rather than from revelation or religious experience" (Reiss 2009, p. 785).

Regarding teachers, El-Hani and Sepúlveda (2010, p. 121) have found that religious biology teachers "who truly engaged in understanding scientific explanatory models" were not interested only in learning and using scientific and religious concepts in different contexts, as proposed by Woolnough (1996), but also felt "the need to integrate it with their religious convictions".

2.4 The Dialogue Thesis

Authors who share this view admit the integrity and relative independence of science and religion but believe that it is possible to construct rich conversations between them and inspire scientists and theologians. For instance, Reiss (2009, p. 785) has argued that the Anthropic Principle forced us to ask why the initial conditions of the evolution of the universe allowed the development of complex forms of life.[4]

The *Dialogue* thesis, or similar views, is not rare among historians and philosophers related to the science education community. Hugh Lacey (1996) argued that there are "constructive tensions" between science and religion. He disagrees with Mahner's and Bunge's description of religion, and proposes an alternative way of considering religious faith based on liberal arguments for the compatibility between science and religion, mainly inspired by the Liberation Theology in Latin America. For instance, Lacey suggests that "faith involves both beliefs and practices in a dialectical interaction. To believe in a God who is the ground of the hope that there can be fuller embodiments of love, etc., and not to participate in endeavours moving in that direction is a practical contradiction" (Lacey 1996, p. 148). Science, together with politics and economy, might help to identify these endeavours in each historical moment.

Inspired by the concept of *communicative action,* developed by the philosopher Jürgen Habermas, Azevedo (2011) has argued for the importance of dialogues between secular and religious individuals. Although discussions about religion are not mandatory in science curricula, such dialogues will naturally arise when physics teachers present theories about the origin of the universe, or when biology teachers teach evolution.

Santos and El-Hani (2013) have proposed that a "pragmatic naturalism" might lead to fruitful dialogues between science and religion. They argue that religious creationists

[4] The Anthropic Principle states "what we can expect to observe must be restricted by the conditions necessary for our presence as observers" (Carter 1974). However, there is no need to assume the existence of God to explore this concept in cosmological studies. See also Barrow and Tipler (1988).

should not fear or criticize the "naturalism" in scientific theories, because, unlike "materialism", a pragmatic form of naturalism is neutral regarding ontological debates.

Since the goal of the present research is to enhance teachers' awareness of the relations between science and religion, it is important that pre-service teachers become aware of the existence of different views regarding science and religion. Thus, we adopted a philosophically pluralist view along the research.

3 The Historical Case: The Controversy Between Steady State and Big Bang Theories

A controversy took place between the 1940s and the 1960s between two opposing scientific views on the origin of the universe. Briefly, the supporters of the then recently proposed Steady State theory in Britain argued that the universe has always existed; while the supporters of the nowadays called "Big Bang theory" argued that a few billions of years ago the universe was in a hot and dense state that cooled down and evolved to its current state. Also, there was a singular point in the past when all matter was condensed into one single point.

The Big Bang theory does not imply that the universe had a beginning. It can also comply with an oscillating universe that always existed and the beginning of which did not take place at a particular instant in time, but oscillated between expansions and contractions. This kind of model has been considered as both fascinating and controversial by several authors since the beginning of the 20th century and is still investigated by contemporary cosmologists (Kragh 2009).

Ironically, the name "Big Bang" was coined and made popular by the British astronomer Fred Hoyle (1915–2001), one of the supporters of the Steady State theory. In the 1950s he stated his preference for a model of a universe that had always existed in radio broadcasts and popular books that were quite influential in Britain (Hoyle 1950; Kragh 2014). He used this jocular name for criticizing the cosmological models that supposed expansion and a beginning in time. Hoyle had in mind the "primeval atom", proposed by the Belgian priest and scientist Georges Lemaître (1894–1966) in 1931, and the cosmological models based on nuclear physics and general relativity created by George Gamow (1904–1968) and his collaborators Ralph Alpher (1921–2007) and Robert Herman (1914–1997), at George Washington University after the Second World War. The scientific community initially ignored the papers on cosmology published by Gamow, Alpher and Herman from 1948 to 1953. Only after the discovery of the background microwave radiation,[5] in 1965, the majority of the scientific community accepted the core ideas of the "Big Bang" theory (Kragh 1996).

Fred Hoyle was one of the few authors who, after 1965, kept looking for alternative cosmological theories that did not presuppose a beginning for the universe. The name coined by him for the rival theory became one of the most famous names in science. Despite avoiding using the catchy name invented by his rival, Gamow is known as one of the inventors of the Big Bang Theory, together with Lemaître.[6]

[5] Background microwave radiation is a thermal radiation detected in every direction with nearly uniform intensity; according to the Big Bang theory, it is a remnant radiation from the hot and dense primordial universe that cooled slowly while expanding.

[6] Gamow, however, never liked this name. He preferred to call his approach the "evolutionary cosmology", for which the universe started with a "Big Squeeze" (Gamow 1952).

In our course, the religion considered was mainly Roman Catholicism and we focused on how Georges Lemaître, Fred Hoyle and Pope Pius XII saw the relations between cosmology and religion.

3.1 Georges Lemaître: From *Integration* to *Independence*

The Belgian priest and scientist Georges Lemaître (1894–1966) studied astrophysics and general relativity during the 1920s when he collaborated with several scientists in England and the United States. His position regarding the relations between science and religion moved from *Integration* to *Independence* along his life.

In 1921, he wrote the manuscript "God's First Three Declarations", an attempt to interpret scientifically the first verses of Genesis, particularly God's creation of light and the subsequent creation of the material world (Lemaître 1921, quoted in Kragh 2004, p. 141). Supported by the knowledge in physics available at the time, Lemaître discussed how light could exist in a universe that did not exist yet. Since the young Lemaître wanted to understand religious questions using scientific theories, one can say that his position regarding relations between science and religion is closer to the *Integration* thesis.

In 1927, Lemaître proposed a relativistic expanding model to explain the formation of the universe supposing that it evolved gradually from a static universe with no definite age, which implies that the universe is eternal. This model was "re-discovered" and endorsed in 1931 by Arthur Eddington (1882–1944), a very influential British astronomer (Kragh 1996; Lambert 2013). On March 27, 1931, Eddington published an article in *Nature,* with several speculations about the expansion of the universe, space–time, the number of protons of the universe, entropy and the arrow of time. He stated that, by looking into the past, one would find a state with minimum entropy and an abrupt beginning:

> Following time backwards we find more and more organization in the world. […] To go back further is impossible. We have come to an abrupt end of space–time—only we generally call it beginning. I have no 'philosophical axe to grind' in this discussion. Philosophically, the notion of a beginning is repugnant to me. (Eddington 1931, p. 450)

On May 9, Lemaître published a short letter responding to Eddington's article and stating his disagreement with the notion of beginning:

> Sir Arthur Eddington states that, philosophically, the notion of a beginning of the present order of Nature is repugnant to him. I would rather be inclined to think that the present state of quantum theory suggests a beginning of the world very different from the present order of Nature […] In atomic processes, the notions of space and time are no more than statistical notions; they fade out when applied to individual phenomena involving but a small number of quanta. If the world has begun with a single quantum, the notions of space and time would altogether fail to have any meaning at the beginning; they would only begin to have a sensible meaning when the original quantum had been divided into a sufficient number of quanta. If this suggestion is correct, the beginning of the world happened a little before the beginning of space and time. I think that such a beginning of the world is far enough from the present order of Nature to be not at all repugnant. […] If the future development of quantum theory happens to turn in that direction, we could conceive the beginning of the universe in the form of a unique atom, the atomic weight of which is the total mass of the universe. This highly unstable atom would divide in smaller and smaller atoms by a kind of super-radioactive process. (Lemaître 1931, p. 706)

In a manuscript version of this letter, which presents the idea of the "primeval atom" that has been divided to form all atoms of the universe, Lemaître expressed briefly his view about how physics can support the understanding of creation:

> I think that everyone who believes in a supreme being supporting every being and every acting, believes also that God is essentially hidden and may be glad to see how present physics provides a veil hiding the creation. (Lemaître 1931, quoted in Kragh 2004, p. 147)

In the published version of this text, Lemaître excluded this paragraph. Why did he do this? Was it because he did not want to show that religious views inspired his scientific hypothesis? Or did he prefer to avoid inadequate interpretations of his theory by those who could use it as evidence that the universe was created by God? Historians of science have different positions about the possible influences of Lemaître's faith in his cosmological theories. For instance, Edward Harrison (2000, p. 302) and Roberto de Andrade Martins (1994, p. 146) have argued that Lemaître's response to Eddington was influenced by his Catholic faith:

> As an immediate result of Eddington's article [published on March 27], Lemaître changed his ideas. Just six weeks after the publication of Eddington's work, he published in the same journal, the first draft of a new theory […]. Since this beginning of universe is abrupt and different from anything we know, this theory opens the possibility of introducing the need for God to create the primeval atom from which it arose. (Martins 1994, p. 149, authors' translation)

On the other hand, Helge Kragh has argued that religious influences on Lemaître's work were moderate. He quotes Lemaître's letters and interviews about this subject, and advocates that the Belgian priest considered science and religion as different fields and emphatically denied that the Christian view of creation could be scientifically justified, or that God could enter as an argument in scientific theories (Kragh 2004, pp. 141–152).

Even though in the 1920s Lemaître was interested in studying the Bible in light of contemporary physics, a position that aligns with the *Integration* thesis, in the 1930s he changed his approach to this issue. In an interview to *New York Times Magazine,* he argued that the Bible should not be read as a scientific text, moving to a view closer to the *Independence thesis.* According to him, science and religion are "two roads" to the truth, very different from each other; and it is not crucial to know whether cosmology can show that the Bible is correct or not because:

> It will merely encourage more thoughtless people to imagine that the Bible teaches infallible science, whereas the most we can say is that occasionally one of the prophets made a correct scientific guess. (Lemaître 1933, quoted in Aikman 1933, p. 17)

Lemaître advocated that religious and non-religious scientists should have the same attitudes and adopt the same methods in their work, and considered that science would never shake his faith, as religion would never make him question scientific conclusions (Aikman 1933). Therefore, there was no conflict to reconcile. Even though he stressed differences between science and religion, he also admitted that sometimes his faith helped him. He believed that God had given mental faculties to humankind that allowed scientists to discover every aspect of the universe. This approach contributed to Lemaître's optimism during the investigation of challenging scientific problems (Kragh 2004, p. 146). In a talk delivered to the *Scientific Society of Brussels*, he reviewed current theories about the size of the universe, including the static cosmological models proposed by Einstein and De Sitter, and the expanding model proposed by Friedmann and himself. He finished the lecture by stating that:

> We cannot end this rapid review which we have made together of the most magnificent subject that the human mind may be tempted to explore without being proud of these splendid endeavours of Science in the conquest of Earth, and also without expressing gratitude to One Who has said: 'I am the truth', One Who gave us the mind to understand Him and to recognize a glimpse of His glory in our universe which He has so wonderfully adjusted to the mental power with which He has endowed us with. (Lemaître 1929, p. 55)

According to the Canadian astronomer Sidney van den Bergh (2011, p. 1), Lemaître expressed in his last years a preference for a created universe: "in August of 1961 Abbé Georges Lemaître told me (with a twinkle in his eyes) that, being a priest, he felt a slight bias in favour of the idea that the Universe had been created. It must therefore have been a particular pleasure for him to have been the first to find both observational and theoretical evidence for the expansion of the Universe".

3.2 Fred Hoyle: *Conflict* and Anti-religious Arguments

Three British scientists, Fred Hoyle, Thomas Gold and Hermann Bondi, created the most famous theory considering the universe as eternal. The Steady State theory assumes that physical quantities such as temperature and pressure are constant in large scales of time. Hoyle, Gold and Bondi were atheists, hostile to religion, and never mentioned religion in their scientific articles. However it "must surely have added to their satisfaction that it was possible to design a universe in which there allegedly was no room for a Creator" (Kragh 1996, p. 253).

As Lemaître's "primeval atom" was criticized for being influenced by his religious views, there were similar claims that Hoyle created Steady State theory to support his atheism (Kragh & Lambert 2007, p. 467). Kragh argues that there is no historical evidence to support this claim. In a letter in 1995, Hoyle told Kragh that "religious connotations of big-bang theory were opposed by Bondi, Gold and himself, but they are not of primary importance" (Kragh 1996, p. 430). In the last chapter of his book *The Nature of the Universe*, Hoyle expressed his materialist view of religion:

> Now I will consider some contemporary religious beliefs. There is a lot of cosmology in the Bible. My impression of it is that it is a remarkable conception, considering the time when it was written. But I think that one can hardly deny that the cosmology of the ancient Hebrews is but a mere speck of ink compared with the beautiful picture revealed by modern science. This led me to ask the question, is it reasonable to suppose that the Hebrews could understand the deeper mysteries of what we've been able to understand when it is clear that they were completely ignorant about many issues that seem common sense to us? […]. No, it seems to me that religion is but a desperate attempt to find an escape from the truly dreadful situation in which we find ourselves. Here we are in this amazing universe with almost no clue about the existence of any real meaning. No matter that many people feel the need to give them some belief that some form of security and no matter what they get upset with people like me who say that security is illusory. However I do not like this situation more than they do. The difference is that I can see no advantage at deceiving myself. (Hoyle 1950, pp. 137–138)

Hoyle was a poor child who grew up in Britain, in a period of intense religious conflicts between Catholics and Protestants. He included several anticlerical views in popular books about science (Kragh 1996, p. 253; Holder 2013). For instance, according to him religion is "quite characteristic of the outlook of primitive peoples" who "postulate the existence of gods to explain the physical world". For Hoyle, all religious conflicts in Ireland could be solved if every priest and clergyman were arrested, with long jail sentences on the charge of causing a civil war (Hoyle 1955, p. 351). Hoyle's attacks to Christianity caused concern in Britain. Several members of the Modern Churchmen Conference were afraid that Hoyle's famous broadcasts and books affected people's attitude towards Christianity (Kragh 1996, p. 254; McConnel 2000, p. 99). At least in one case, the concern was justified. The British-born American astronomer Wallace Sargent (1935 - 2012) was a Protestant, but Hoyle's talks about astronomy made him "violently anti-religious, and I got into trouble with the school because of it" (Sargent, 1989). In the United States there were also religious responses to Hoyle's anticlerical views, but they were milder than in the UK,

because there the Steady State theory was seen "as more of an oddity than a threat" (McConnel 2000, p. 129).

According to categories set out in Sect. 2, Fred Hoyle's views fit the *Independence* and *Conflict* theses. When Pope Pius XII endorsed the cosmological models with a beginning in time, he contributed to reinforcing a popular view that associates Steady State theory with atheism, and Big Bang theory with religiosity. This association probably led Hoyle to become even more critical of Big Bang cosmology.

3.3 Pope Pius XII: *Integration* and Cosmological Proof in *Genesis*

While Hoyle popularized his anticlerical views, Pope Pius XII (1876–1958) supported the Catholic faith with scientific arguments based on the ideas of Hoyle's rivals Gamow and Lemaître. Pope Pius XII discussed relations between science and Catholicism on several occasions. In 1950, he argued that there is no conflict between the theory of evolution of species and Catholic faith (Kragh 1996, p. 256). In November 22, 1951, he delivered a speech to *The Pontifical Academy of Sciences* advocating that contemporary science agrees with the Bible.

> 32. Let us now turn our attention to the past. The farther back we go, the more matter presents itself as always more enriched with free energy, and as a theatre of vast cosmic disturbances. Thus everything seems to indicate that the material universe had in finite times a mighty beginning, provided as it was with an indescribably vast abundance of energy reserves, in virtue of which, at first rapidly and then with increasing slowness, it evolved into its present state. […] 33. This naturally brings to mind two questions: Is science in a position to state when this mighty beginning of the cosmos took place? And, secondly, what was the initial or primitive state of the universe? […] 36. It follows that, from one to ten billion years ago, the matter of the spiral nebulae was compressed into a relatively restricted space, at the time the cosmic processes had their beginning. 40. Although these figures may seem astounding, nevertheless, even to the simplest of the faithful, they bring no new or different concept from the one they learned in the opening words of Genesis: "In the beginning…," that is to say, at the beginning of things in time […]. (Pius XII 1951)

The papal posture regarding the relation between science and religion fits in the thesis *Integration* because it supports a theological thesis with scientific results. For instance, he was aware of Hubble's measurements of redshifts of galaxies and the interpretation that they are due to the galaxies' relative velocity away from the Earth, which can be explained supposing that the universe is expanding. The Pope was also familiar with results of measurements of the age of the Earth and astronomical bodies that imply that the minimum age of the universe is about 5 billion years.

Pius XII did not mention alternative cosmological theories, such as the Steady State. As conclusion of his speech, he stated that science proves the existence of God:

> 49. What, then, is the importance of modern science for the argument for the existence of God based on the mutability of the cosmos? By means of exact and detailed research into the macrocosm and the microcosm, it has considerably broadened and deepened the empirical foundation on which this argument rests […]. Thus, with that concreteness which is characteristic of physical proofs, it has confirmed the contingency of the universe and also the well-founded deduction as to the epoch when the cosmos came forth from the hands of the Creator. Hence, creation took place in time. Therefore, there is a Creator. Therefore, God exists! (Pius XII 1951)

Even though the Pope had used scientific results to support God's existence, Georges Lemaître, who had proposed cosmological models endorsed by the Pope, did not approve Pius XII's use of scientific arguments. Several theologians, both Catholic and non-catholic, criticized Pope Pius XII attempt to integrate cosmological theories with Catholic principles

(Kragh 1996, p. 251). Until his death in 1958, Pius XII refrained from his strong endorsement of cosmological theories.

In a clear shift of position, Pope John Paul II (1920–2005) argued in the 1980s that Christian faith has a coherent justification of its own. Therefore there is no need for religion to be supported by scientific arguments, despite the availability of new empirical evidence supporting the Big Bang cosmology such as the background microwave radiation discovered in 1965 (Kragh 1996, p. 259; Coyne 2013, p. 72).

In 2014, Pope Francis stated a similar position:

> The Big Bang, which nowadays is posited as the origin of the world, does not contradict the divine act of creating, but rather requires it. The evolution of nature does not contrast with the notion of Creation, as evolution presupposes the creation of beings that evolve.[7]

Therefore, the Catholic Church changed its position regarding the relation between science and religion, from *Conflict* and *Integration* to a stance closer to *Independence* and *Dialogue*.

4 Science and Religion in a Teacher Training Course

Cosmology is a topic that stimulates fruitful dialogues between students and teachers because it might be in conflict with some religious views. Thus, it is important that teachers are prepared to discuss these incompatibilities in science classes while respecting religious and non-religious students' views and their opinions on the topic. In order to prepare a group of pre-service science teachers to deal with this issue, we discussed with them the controversy between Steady State and Big Bang theories. The subjects of the present research were pre-service teachers in the final year of a pre-service science teacher program named "Higher Education in Sciences" at the University of São Paulo, Brazil.

There were 21 pre-service teachers registered for the course, but not all of them attended all the five classes, with 2 h duration each. None of the pre-service teachers had attended formal courses on cosmology before. Some of them had attended the regular seminars for the general public presented at the Astronomical Observatory of the University of São Paulo[8] and learned about cosmology from magazines, TV shows and other forms of science outreach. Pre-service teachers pointed that they did not feel prepared to properly conduct a discussion about this topic in their classrooms. Therefore, besides learning about cosmology and nature of science issues, one of the goals of the course was to provide opportunities for pre-service teachers to practice didactic strategies suitable for dealing with such kinds of controversial themes in classrooms. Among the strategies were short seminars given by groups of pre-service teachers, readings, videos, computer simulations, role-play, debates and preparation of written essays.

A central question guided every class:

Class 1 What is cosmology?
Class 2 Did the universe have a beginning? Or has it always existed?
Class 3 Is the Big Bang a "proven" theory?

[7] http://www.news.va/en/news/francis-in-the-pontifical-academy-of-sciences-emph, address to *The Pontifical Academy of Sciences*, Vatican City, 27 October 2014, Access on November 2014.

[8] http://www.cdcc.usp.br/cda/.

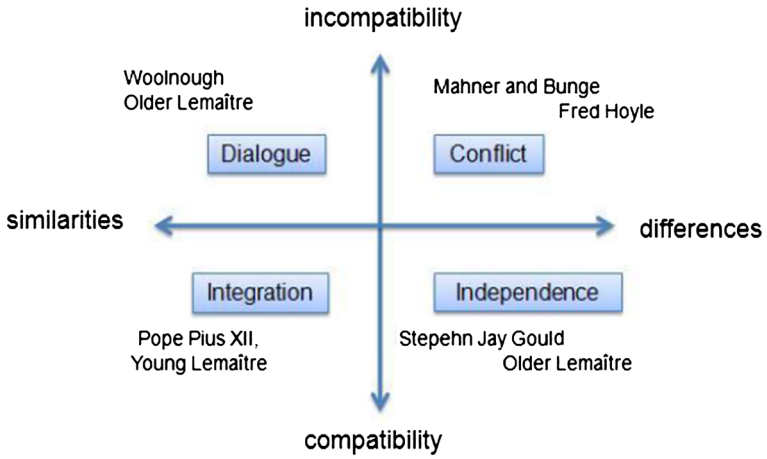

Fig. 1 Diagram to illustrate the categories conflict, dialogue, integration and independence

Class 4 What are the differences and similarities between science and religion?
Class 5 How to deal with conflicts between modern cosmology and students' worldviews?

4.1 The Position About the Relations Between Science and Religion Adopted in the Course

Simplifying such complex historical and philosophical discussions might give rise to several pitfalls, but it is necessary to face this challenge and bring them to a non-specialist public. As discussed in Sect. 2, Barbour (1990) had created a fourfold typology to classify postures regarding relations between science and religion in a range. Therefore, we decided to maintain the names of Barbour's four categories but included axes of similarities/differences and compatibility/incompatibility in quadrants illustrated in Fig. 1. The quadrants on the left emphasize similarities between science and religion (*Dialogue* and *Integration*) while the quadrants on the right accentuate differences (*Independence* and *Conflict*). The quadrants on the top stress conflicts between science and religion either by seeking for constructive tensions between them (*Dialogue*) or by stressing their incompatibilities (*Conflict*). The quadrants on the bottom illustrate views that avoid conflicts because they consider science and religion either as compatible (*Integration*) or incommensurable (*Independence*).

A text summarizing the historical episode including different arguments regarding the relations between cosmology and religion[9] was delivered to the pre-service teachers on the first day of the course and was read throughout the classes. In each class, the pre-service teachers performed activities that were used to analyze the evolution of their views about the relations between science and religion.

[9] The main secondary sources used in this study were the books *Cosmology and Controversy* (Kragh 1996), *Matter and Spirit in the Sky* (Kragh 2004), *Cosmology, the Science of the Universe* (Harrison 2000) and the final chapters of the book *O Universo* (Martins 1994). Some of the primary sources used were books devoted to the general public by the Big Bang supporter George Gamow (1952), and by the Steady State Theory supporters Fred Hoyle (1950) and Hermann Bondi (1952).

Table 1 Pre-service teachers' personal relation to religion

Statements	Agree	Disagree	Neutral
I am religious or have some kind of faith	11	6	3
I go often to churches or religious temples	3	14	3
I go to church because of family influence	2	13	5

4.2 Methods, Results and Discussion

A qualitative methodology of educational research (Bogdan and Biklen 1994) supported the data gathering and analysis. During the course, we have investigated pre-service teachers' views about relations between science and religion, using questionnaires with Likert-type statements and open questions about issues discussed in classes.

In order to stimulate pre-service teachers to consider different relations between science and religion, we proposed activities adopting a position typical of *Dialogue,* with emphasis on similarities between science and religion. We problematized naive views about nature of science often held by teachers and students, such as that scientists follow a simple and straightforward method in their practice, or that scientific theories might be proved beyond all doubt (Lederman 1992; Gil-Pérez et al. 2001; Forato et al.2012; Abd-El-Khalick2012; Hodson 2014).

4.2.1 Questionnaires About Relations Between Science and Religion

In the first class, 20 pre-service teachers responded to a first questionnaire with questions about age, previous experience as teachers, family religion, and Likert-type statements regarding religion, science and cosmology.[10] Table 1 summarizes pre-service teachers' answers about their religiosity.

Table 2 summarizes pre-service teachers' answers to statements about creation and evolution of the universe and life. There were seven Catholic pre-service teachers, four with other religions or forms of spirituality (one protestant, one scientologist and two "spiritual but not religious"), eight agnostics or with no religion and one atheist. Most of the Catholics were neutral regarding the influence of God on the creation and evolution of life, but accepted Big Bang cosmology. The only advocate of young earth creationism was the Protestant pre-service teacher, while most of the non-religious and atheist future teachers accepted the scientific approach for the origin and evolution of the universe and life.

4.2.2 Comic Strips About Science and Religion

In previous studies, Reiss (2008, 2009) invited his students to take four different roles during discussions of the theory of biological evolution and creationism: an atheist with a strong belief in evolutionism, an agnostic, a priest who accepted evolution, and a religious creationist. The goal of this kind of activity was to help students better understand their views and reflect on other views that differ from their own. Inspired by Reiss, we asked our pre-service teachers to analyze three comic strips and to write about them considering three perspectives:

[10] The questionnaire is translated to English in "Appendix A".

Table 2 Pre-service teachers' views about statements concerning explanations to creation and evolution of the universe and life

Position about origin of the universe and life	Catholicism			Other religions			No religion			Atheism		
	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral
God created humankind less than 10 thousand years ago	3	4	–	1	3	–	–	7	1	–	1	–
Humanity is a result of an evolutionary process that has lasted millions of years, but guided by God's interference	2	–	5	3	1	–	–	7	1	–	1	–
Life appeared on oceans some billions of years ago, from chemical reactions that transformed inorganic compounds into organic molecules, without divine interference	3	–	4	1	2	1	7	–	1	–	1	–
The universe appeared billions of years ago, as described scientifically by the Big Bang theory	7	–	–	3	1	–	6	–	2	–	1	–

(a) Conflict-based on their reading of a translation of extracts from a Mahner and Bunge paper;
(b) Their personal view—if different from the previous one;
(c) The position they believed that science teachers should defend—if different from (a) and (b).

The first comic strip stresses the differences in methods between scientists and creationists. Though not all religious people are creationists, usually creationists are religious, thus this strip was used to promote the discussion about different methods to approach nature (http://www.talkorigins.org/indexcc/CA/CA230_1.html).

The second strip highlights similarities between science and religion, showing that both religious people and scientists can use elements of persuasion to convince (or convert) their speakers (http://abstrusegoose.com/31).

Finally, the third comic strip mocks at the traditional view of the scientific method presented in several textbooks (Pagliarini and Silva 2007; Abd-El-Khalick et al. 2008; Irez 2008; Campanile et al. 2015) (http://www.phdcomics.com/comics/archive.php?comicid=761).

Again, the majority of pre-service teachers accepted Mahner and Bunge's views, manifesting a position closer to *Independence*. They stressed differences between science and religion and disagreed that science authority is diminished by the fact that scientists are influenced by personal, cultural and economic factors.

Four pre-service teachers used the third comic strip as an argument against religion, arguing that the "actual scientific method" is typical in religious debates, not in science. Only one pre-service teacher claimed that "the scientific method is trustworthy, but it is limited since it is not possible to explain everything with it. On the other hand, the creationist method is useless for atheists, but to me, being religious, it explains the meaning of everything". Four other pre-service teachers argued that science classes should not mention religion. The majority of pre-service teachers stated that science teachers should be neutral, presenting both the desired and the "actual" scientific methods. Moreover, they should discuss some of the irrational factors that might influence scientific practice such as military and personal interests, cultural and religious influences, but making clear that they are distortions of the standard practice of the scientific community.

4.2.3 Diagrams About Science and Religion

We created a diagram based on the paper of Mahner and Bunge (1996a) in order to instigate pre-service teachers' reflections on the relations between science and religion. The characteristics attributed by Mahner and Bunge to science are on the left side of the diagram, whereas those attributed to religion are on the right, and the characteristics common to both are in the intersection of them (Fig. 2).

Like Loving and Foster (2000), we initially introduced the views of Mahner and Bunge about science and religion, and invited pre-service teachers to think about alternative perspectives on the relation between science and religion, based on authors who criticized it. Then pre-service teachers constructed their own diagrams in order to illustrate their ideas, which were very similar to one another. After reading all diagrams, we drew on the blackboard a composite diagram, represented in Fig. 3.

In order to reach a more complex view about the subject, instead of only stressing basic *differences* between science and religion, we also invited pre-service teachers to think about similarities between science and religion. We asked them if terms like "respect for

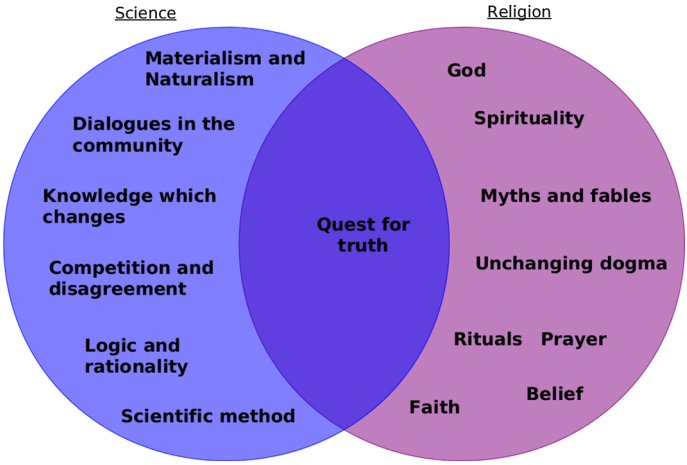

Fig. 2 Diagram summarizing the statements presented in Mahner and Bunge (1996a)

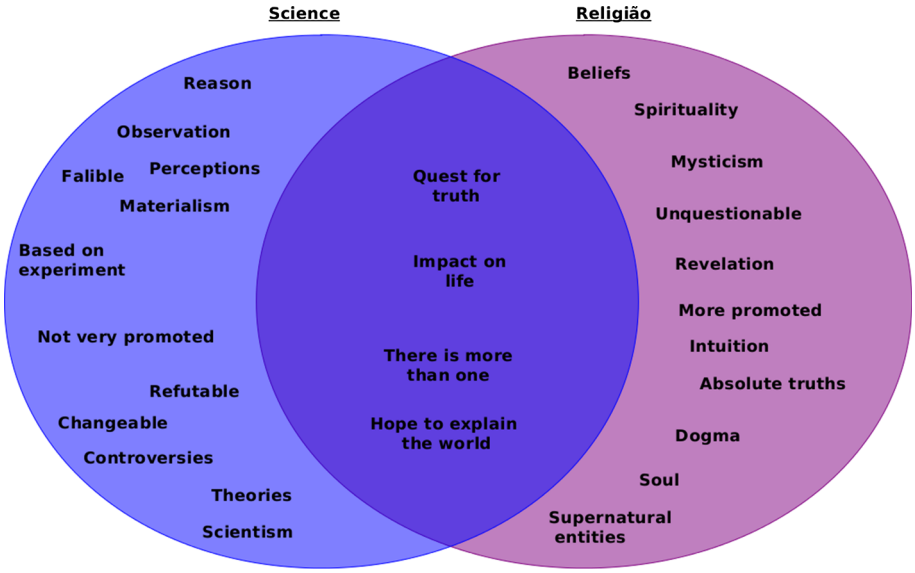

Fig. 3 Synthesis of diagrams built by pre-service teachers

authority", "dogmatism" and "intuition" should be placed as exclusive characteristics of religion, exclusive of science, or common to both. After the discussion, the teacher and pre-service teachers constructed collectively a diagram on the blackboard, showing more elements at the intersection of the diagram, as represented in Fig. 4.

During the discussion, there were no radical ruptures, but a movement from a "classical" and "rationalist" view about science towards a "relativist" view. The pre-service teachers agreed with several statements that emphasized the similarities between science and religion, including those who had low degree of acceptance in the initial questionnaire.

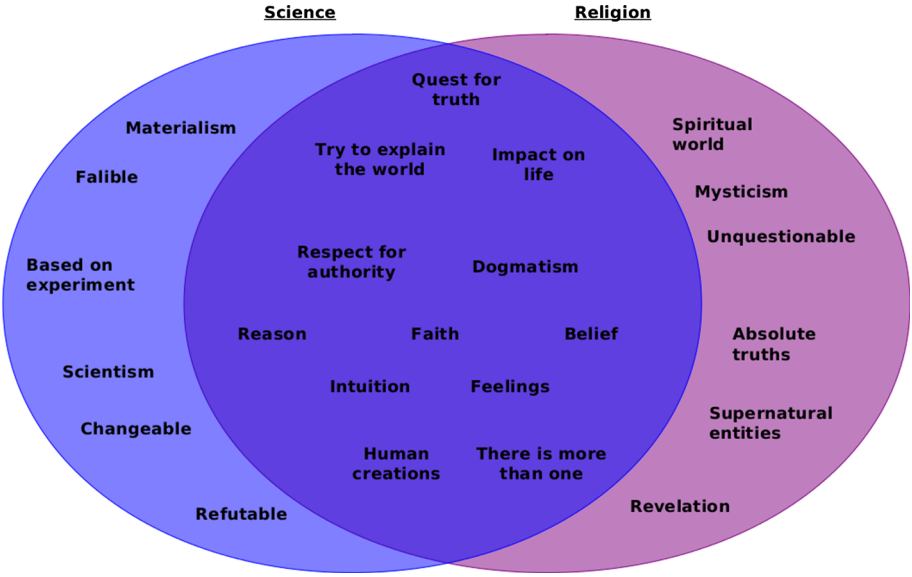

Fig. 4 The diagram built by pre-service teachers emphasizing similarities between science and religion

A pre-service teacher explained this quick shift, saying that the first diagram represents elements of "ideal" science or how we think science should be done (a prescriptive approach); whereas the second version of the diagram represents how science "really" is, or how scientists' practice actually is (a descriptive approach).

4.2.4 Post Test and the Final Essay

In the fourth class of the course, 17 pre-service teachers answered for a second time a Likert-type questionnaire, with 35 statements about relations between science and religion[11] (Bagdonas 2011, pp. 241–242). Table 3 presents a selection of the more representative answers, according to the emphasis on the different theses regarding the science and religion relation (Conflict, Independence, Dialogue and Integration). Most pre-service teachers stressed the differences between science and religion, accepting the proposal by Mahner and Bunge (1996a). Since they emphasized differences and avoided conflicts between science and religion, the *Independence* thesis best describes their position. There was a small acceptance of extreme statements about science and religion, typical of *Conflict* and *Integration.* The pre-service teachers in our study valued scientific knowledge and respected religious beliefs.

The results of the post-test do not indicate shifts in pre-service teachers' views about relations between science and religion. Few of the pre-service teachers changed their initial positions, keeping their posture closer to the *Independence* thesis. However, the ensemble of activities developed along the intervention helped pre-service teachers to expand their views and enrich the arguments supporting their views.

To better understand the influence of our intervention on pre-service teachers' views and to promote the problematization of the posture of *Independence*, we invited pre-service

[11] The questionnaire is translated into English in "Appendix B".

Table 3 A selection of more representative answers to the post-test ($N = 17$)

Statement	Number of agreements Pre test	Number of agreements Post test
Emphasis on differences between science and religion (independence)		
1. Science deals with the objective world using only reason and experiments while religion deals with the spiritual world using faith and rituals	15	16
14. When religious people attempt to verify their ideas scientifically, they often know in advance the conclusion and seek for evidence to support only what they want to defend	13	15
Emphasis on positions closer to conflict		
3. Religion is a form of self-deception, a human invention that used to be dominant in the past but tends to lose power in more advanced societies	3	4
34. The higher one's scientific knowledge is, the lower his/her religiosity is	1	2
Emphasis on position closer to integration		
6. I believe the Bible provides truthful information about the natural world	2	0
27. When teaching subjects like evolution of species and origin of the universe, teachers should also provide religious explanations as equally valid alternatives	4	1

teachers to write a final essay. This task was based on five open questions about the origin of the universe, the existence of proofs in science, believing or understanding as goals for science teaching, conflicts between different worldviews in science classes and the categories for relations between science and religion (*Conflict, Independence, Integration and Dialogue*). It was mandatory that pre-service teachers support their ideas with arguments used by Lemaître, Hoyle, Pope Pius XII and other historical characters presented to them during the course. Table 4 summarizes the pre-service teachers' views about relations between science and religion presented in the final essay according to their religion.

Five out of the seven pre-service teachers who chose *Independence* were Catholics. They considered it positive that this thesis avoids conflicts between science and religion. Lemaître was often cited as a good example of how to manage the peaceful coexistence of religious beliefs and science. By adopting *Independence*, they thought science teachers can focus on teaching scientific concepts by avoiding digressions about complex and controversial aspects in the classroom. The *Independence* thesis does not raise discussions about specific religions being useful in different cultural contexts. In addition, this thesis avoids antagonisms with parents' views on the topic. On the other hand, the pre-service teachers pointed as a disadvantage of this thesis that interesting debates about controversial aspects related to scientific practice are not problematized in a classroom.

The five future teachers who chose *Conflict* accepted some of Mahner and Bunge's arguments about the incompatibility between science and religion. One of them agreed with some of Lemaître's criticisms to a literal interpretation of the Bible as a source to understand natural phenomena and others used arguments that religion has caused damages, and still does, to science and humankind and should be abolished. They recognized as a disadvantage of this view that students' religious beliefs are disparaged.

Table 4 Views about relations between science and religion presented in the final essay

Religion	Conflict	Independence	Dialogue	Integration
Catholicism	1	5	1	
Other religions or forms of spirituality	1		2	1
None/agnosticism	1	2	1	1
Atheism	2			
Total	5	7	3	2

No future teacher chose exclusively *Dialogue* or *Integration* theses but combinations of theses. Two pre-service teachers chose the combination dialogue/integration of theses, mentioning Lemaître and Saint Augustine as examples to be followed by science teachers who look for a peaceful coexistence between science and religion. These future teachers highlighted the moral and religious consequences of scientific research on genetics. One future teacher chose the combination independence/dialogue, highlighting the importance of the existence of constructive tensions between science and religion. One pre-service teacher adopted a combination of conflict/dialogue using a confused argumentation.

5 Final Remarks

In a course on the history of cosmology, in a science teacher-training program, pre-service teachers reflected about different positions regarding relations between science and religion, which helped them to enhance their awareness of the issue. For instance, while discussing with defenders of typical arguments of *Conflict*, the activities stimulated them to think about the compatibility of science and religion. On the other hand, for pre-service teachers whose views were closer to *Independence* and *Integration*, the activities stimulated them to consider the tensions between science and religion, without avoiding conflicts.

Our results differ from the ones obtained by Loving and Foster (2000), who found that, after reading the article of Mahner and Bunge (1996a), teachers had emotional reactions and felt insulted. It is also different in comparison to studies about the science and religion issue that investigated Protestant teachers and students in Brazil (Falcão et al. 2008; Oliveira 2009; El-Hani and Sepúlveda 2010) since in our study there were hardly any critical views about science and its authority. This probably happened because, in our case study, there were few religious pre-service teachers, so the view of Mahner and Bunge was not adequate to promote the debate, and dialogue between science and religion was quickly accepted by the majority of the future teachers. Thus, in order to invite them to consider other alternatives, during several activities of the course we have highlighted similarities between science and religion. The majority of pre-service teachers argued that science teachers should not expect that students believe in science, but that they only understand it. According to them, science teachers should neither avoid nor emphasize conflicts between science and religion; they should only discuss incompatibilities if they emerge from students' discussions. For these pre-service teachers, studying science can change students' scientific concepts, but not religious beliefs.

From the activities conducted during the course, we concluded that most pre-service teachers showed temperate rationalist views about science, avoiding theses that consider science as entirely rational or irrational. They stressed the differences between science and religion, while considering respect to students' religious beliefs as a desideratum. The activities enhanced more complex views about nature of science and might help science teachers to promote the acquaintanceship and respectful coexistence between different worldviews in science classes.

In a multicultural educational context, it is necessary to prepare science teachers to deal with the existence of a plurality of views regarding relations between science and religion rather than merely presenting the "consensual scientific view" that avoids considering students' religious views in science classes. This might allow teachers to make well-informed choices about how to conduct discussions regarding this issue in the future.

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Appendix A: First Questionnaire About Religion, Science and Cosmology

1. Age and gender

20 to 23	24 to 26	Older than 26

Male	Female

2. Work

I work as a teacher.	
I do not work.	
Other.	

3. Experience as a teacher

Up to 1 year	
2 years	
More than 3 years	

4.Your parents' religion

Catholicism	
Evangelism	
Umbandism	
Others (Ahyuasca, Scientology, Spiritualism)	

5. Which is your religion?

Catholicism	
Evangelism	
Umbandism	
Others (Ahyuasca, Scientology, Spiritualism)	

6. What is your view about God?

	-2	-1	0	1	2
I am atheist.					
I am agnostic.					
God is a non personal force.					
God created the universe.					
God intervenes in human existence.					
I am a religious person.					
I often go to churches or religious temples.					
I go to the church to follow my family.					
God created humanity less than 10 thousand years ago.					
Human beings are the result of millions of years of evolution in a process guided by a Supreme being.					
Life appeared in the oceans a few billion years, from chemical reactions that turned inorganic compounds into organic compounds without divine influence.					
The universe began billions of years ago, as described scientifically by the Big Bang theory.					

7. Where did you learn about cosmology?

I did not.	
In courses taken at university.	
At basic school.	
I am a self-taught.	

8. What is the universe for you?

The universe is everything that exists.	
The universe is everything we know.	

9. Is the existence of several universes possible?

No, there is only one universe.	
Yes, it is possible.	
I do not know.	
It does not matter.	

10. Did the universe have a beginning or did it always exist?

It had a beginning.	
It always existed.	
I do not know.	
It does not matter.	

11. If the universe had a beginning, how did it begin?

Big Bang	
God created it.	
I do not know.	

Appendix B: Questionnaire About Relations Between Science and Religion

	Level of agreement				
Part A: Similarities and differences between science and religion	-2	-1	0	1	2
1. Science deals with the objective world using only reason and experiments while religion deals with the spiritual world using faith and rituals.					
2. Science and religion seek to answer the same questions.					
3. Religion is a form of self-deception, a human invention that used to be dominant in the past but tends to lose power in more advanced societies.					
4. "The Bible teaches us how to go to heaven, not how the heavens go."					
5. Science and religion have the search for truth as a common goal.					
6. I believe the Bible provides truthful information about the natural world.					
7. Both science and religion start from ideas that cannot be tested, for instance, the premise that there is an order in nature.					
8. I believe that science provides accurate information about the natural world.					
9. Scientific truths are subject to change while religious truths are absolute and unquestionable.					

10. Neither science nor religion can be sure about anything because knowledge is relative.					
11. Scientific knowledge is reliable because it is objectively proven by experiments, following the scientific method.					
12. Religious theses are not reliable because they are not based on the scientific method.					
13. Both science and religion are, to some degree, based on respect for authority.					
14. When religious people attempt to verify their ideas scientifically, they often know in advance the conclusion and seek for evidence to support only what they want to defend.					
15. Scientists, on the other hand, are objective and are not influenced by their personal ideology and beliefs.					
16. Scientific results are universal and independent of the local culture.					
17. Religions are strongly influenced by local cultures.					
18. One day, science will be able to explain every issue that it does not explain in the present days.					
19. There is a limit to scientific knowledge; beyond this limit, only religion can provide good explanations.					
20. If a scientist is religious, it is not possible to prevent that her/his beliefs influence her/his work.					
Part B: Conflict and compatibility between science and religion					
21. In science classes, one should follow the popular wisdom: religion, football and politics are not a matter of discussion.					
22. The historical conflicts between science and religion should be softened in science classes.					
23. School education must alert students about the dangers of religious fanaticism, remind student the injuries already committed in the name of religion throughout history, such as the persecution of scientists.					
24. There are conflicts between some religious and scientific concepts, for instance about the origin of life and the age of the fossils.					
25. Religious education in public schools can be funded by the State because religion is a form of culture.					
26. Public education should be secular, without preference for any religion.					
27. When teaching subjects like evolution of species and origin of the universe, teachers should also provide religious explanations as equally valid alternatives.					
28. In science classes, it is necessary to demystify the myths such as the belief that the first humans were Adam and Eve.					
29. Connecting science to atheism only brings nothing but harm to science education.					
30. Science teaching should reinforce and convey a scientific world view and critical attitude towards unproven assertions, as the possibility of resurrection.					

31. Science teachers should not express to their students what to think about religions.					
32. Science teachers should avoid conflicts between science and religion and promote the dialogue between them.					
33. Science teachers should not demand that their students fully accept the scientific worldview; understanding scientific concepts is enough even without believing in them.					
34. The higher one's scientific knowledge is, the lower his/her religiosity is.					
35. Science and religion, as well as arts, literature and math, allow different ways of seeing the world, all equally valid.					

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