Physics Teachers' Discourses on the Origin of the Universe and the Impact of Personal Beliefs in the Classroom

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Abstract

Conflicts in regular education classrooms due to differing personal views on scientific knowledge are recurrent. This article is motivated by enquiries into the significance of the topic of "the origin of the universe" in the context of elementary school curriculum, as well as concerns regarding how educators handle this topic, their academic preparation to take this tack, and the impact of students' and teachers' own personal beliefs on the classroom setting. Focusing on this topic, we investigated the discourses of teachers with a degree in physics, educated at the same public institution, under the same curricular framework, considering their training, teaching methods, and personal convictions. The study was conducted with open-ended interviews designed to be used in a video-communication setup. Through our analysis, it was possible to verify that teachers feel unprepared to handle the issue in the classroom due to the cultural diversity of their students and the need for greater scientific knowledge. In addition, it was determined that everyone has an independence stance about the connection between faith and science, which reduces the likelihood of conflict.

Introduction

The topic of *the origin of universe* is frequently infused with arguments from multiple epistemological sources, backed by insufficient and frequently erroneous materials, so that teachers and students often keep this topic at arm's length at school (Medeiros & Monteiro, 2001). The variety of personal perspectives and knowledge sources on the issue frequently results in contentious classroom settings.

Such disputes call for thoughts on educators' and students' perceptions of nature of science, its effects on humanity, and the boundaries in terms of influence and scope of human understanding of the cosmos. How should science be approached in regular education, considering the cultural, religious, social, political, and curricular context of the learning scenario at hand? (Leal & Forato, 2017).

These kinds of questions add to the debate that takes place in educational settings and offer perspectives that avoid the epistemological disputes that are often seen during classes on the topic.

To investigate and analyse the discourse of licensed teachers of physics regarding their perspectives on the topic of *the origin of universe* in relation to their training, teaching practices, and personal convictions, we seek to answer the following question: what are the impacts of the teacher's training and personal convictions on an approach concerning the beginning of the universe in the classroom?

Science and the scientific knowledge

Scientific knowledge is not unanimous in the conception of science with respect to the historical study of its nature. Thomas Kuhn (2012) argues that scientific knowledge can be understood as a current paradigm that determines the perspective of a given scientific community until this paradigm is confronted experimentally and reformulated theoretically, thereby giving rise to a new paradigm. This concept of knowledge and the scientific community is akin to Ludwick Fleck's (2010) theories on thought collectives or styles, which affect how well people understand scientific knowledge.

In contrast with the above-mentioned writers, Karl Popper takes a positivist stance, arguing that purely theoretical approaches cannot be regarded as scientific. Popper challenged Kuhn's dogmatic paradigm theory, supporting Science as the result of refutations, whether they be experimental or theoretical (Chalmers, 1993). Popper considered that science must have a falsifiable character—as soon as a theory can no longer be refuted or falsified, it ceases to be scientific.

In addition to the conceptual view of the nature of science, we also demonstrate how scientific knowledge is handled in the classroom. With students' comprehension as the central objective of the teaching practise, two models of this kind were investigated; both of which were suitable for the research context.

The first paradigm, according to Mortimer (1996), is teaching through conceptual shifts, in which students' alternative notions are replaced with scientific concepts. The second method is that of conceptual profiles, in which concepts are not necessarily changed, but other conceptions and interpretations of the same concept are conceivable. The learner would then be able to discriminate and analyse the application of an idea to its most appropriate environment, and the concept would have more than one cognitively preserved conceptual profile (Mortimer, 1996).

It is also worth highlighting that, from the perspective of self-regulated learning, students are expected to build and modify their conceptual structures. Thus, part of learning success is related to the reconstruction of learners' mental models (Higgins, Frankland & Rathner, 2021).

Faith and Science

As described by Barbour (2004), responses to approaches to the relation between faith and science can be categorised into four types: conflict, in which both groups deny the possibility of validity of the other group's theory; independence, in which science and faith do not clash since they address distinct questions of their academics and they deal with different subject

areas; dialogue, in which science and religion are not only renouncing confrontation, but are also approaching each other in some respects and; integration, in which faith and science strive to understand each other, seeking to integrate the perspectives into a single whole (Barbour, 2004).

Mahner & Bunge (1996) argue that Science and Religion not only offer an epistemological distinction of Nature, but are also incompatible and inconceivable within the same framework of knowledge.

Woolnough (1996) and El-Hani and Bizzo (1999) present a constructivist perspective of religious and scientific knowledge, from which the individual can strive to balance the aspects of each epistemological field and apply them in diverse settings of their own, therefore considering them as explanations from different points of view, with distinct languages and different aims, rather than as opposing explanations of the universe.

El-Hani & Bizzo (1999) define associative assimilation as the process by which new perspectives or concepts are adjusted and fit in a consistent manner with those already present in the students' cognitive sphere. Such cognitive assimilation possibilities would aid in classroom dynamics, avoiding epistemological conflicts that are detrimental to the learning environment and are frequently observed in schools.

Science and Religion: Views on the Origin of Universe

We based our analysis on the scientific position regarding the origin of the universe based on the Big Bang theory. According to CERN (Conseil Européen pour la Recherche Nucléaire), the theory contributes to the physical study of the expansion of the universe in its earliest moments, despite its inability to explain the state of the universe prior to the Big Bang (CERN, 2018).

In 1929, Edwin Hubble noticed that galaxies were receding from Earth, with the more distant ones receding at faster rates. From this, he calculated expansion rate of the Universe and reasoned that, if galaxies are moving apart, they should have been joined in the distant past. Based on research, scientists have calculated that the expansion started around 13.7 bn years ago. Furthermore, in 1998, scientists were able to confirm that the expansion of the universe is accelerating (CERN, 2018).

The gradual cooling of the universe following the explosion allowed for the formation of matter, beginning with quarks and electrons, and progressing to the formation of protons and neutrons, which eventually clustered into nuclei. Only 380,000 years after the explosion, electrons began to orbit the nuclei, accounting for most of the pioneering hydrogen and helium atoms. As the universe continued to expand, only about 1.6 million years after the expansion began, gravitational forces eventually pulled together enough matter to form the first stars (CERN, 2018).

Conversely, the creationist perspective holds that an intelligent and creative creator actively participated in the formation of the universe and all its living and nonliving components; in this view, the complexity and specificity of matter and phenomena as we know them (and of those we do not yet know) are not the result of a natural process of cosmic evolution, but rather of an intention, a purposeful movement on the part of an origin entity.

To address the creationist viewpoint, this study does not limit itself to specific monotheistic or polytheistic faiths (Christianity, Islam, ancient mythologies, etc.) but instead considers all possible accounts of the deliberate formation of the universe. Yet, it should be noted that the Brazilian Institute of Geography and Statistics (IBGE, 2021) reports that more than three-quarters (79%) of the Brazilian population identify with religions with Christian roots and values.

Pêcheux's Discourse Analysis

The research was conducted through interviews with licensed Physics teachers who graduated from the same public university and followed the same curricular structure. Questions posed in an open-ended fashion were used to guide the interviews' direction. To better understand the meanings established in the discourse of physics teachers, this study used Pêcheux's Discourse Analysis (DA) as a qualitative framework for data analysis (Silva & Almeida, 2017).

Because an investigation rests on the analysis of a discourse whose meaning is shaped by its context of creation and the subjects engaged, it is crucial to describe the context and circumstances under which the research was produced.

Language is not transparent; it is defined by its relationship to what is outside of it. And what is more, every discourse is produced in the context of a pre-existing interdiscursive or discursive memory. "The discursive memory is constituted by the set of formulations that have been made and are already forgotten, that is, by all the discourses that have already been produced" (Silva & Almeida, 2017:886). Therefore, it is understood that no individual speaks for themselves, and that their language is not defined solely by them and their immediate context. Absolutely no discourse can be regarded as individual (Silva, Baena and Baena, 2006).

Circumstances of discourse formation give rise to mechanisms of anticipation and relations of power in the interaction between subjects. As the discourse is produced, the subject employs these discursive tactics to anticipate how their utterances will affect the other.

Besides, the discourse is formed by what is assumed and by what is imagined, consciously or unconsciously, about the interlocutor's interpretation (Silva & Almeida, 2017:887). These assumptions are mediated by representations the images that the subjects have of themselves, the other interlocutors, and the context in question demonstrating the influence of the power relations established during the production of discourse (Orlandi, 2005).

In this way, the theoretical work by Frenchman Michel Pêcheux, a method for Discourse Analysis (DA), was deemed adequate. With the help of DA, we might comprehend the discourse by analysing how the subjects' linguistic choices interact with the set circumstances for its formation. This underscores the necessity to seek answers to "[...] questions on the relationship between the speaker and the listener and the context in which each party talks [...]" (Almeida, Silva and Machado, 2001:4).

Methodology for our research

We interviewed eight teachers working in public schools (n = 7) and private schools (n = 1) who achieved their Licentiate Diploma of Physics in 2019-2020, accredited by a public university in the state of São Paulo. This group was selected because they all completed the same programme or set of classes; in other words, their education and experience used the same curriculum. Three women and five men participated in the interviews. For a graduating class that had 17 students who were granted licences, this is a substantial number of replies. This research is supported by the Research Ethics Committee of the Faculty of Sciences of UNESP, registered on the Plataforma Brasil[1], under number CAAE: 19500919.0.0000.5398.

All respondents had basic teaching experience, which was a vital prerequisite for selecting interview participants. All interviews were conducted online, using video and audio, and on the same platform (Google Meet). The open-ended questions that guided the interviews are exposed below. They are centred on teacher training and experience regarding "the origin of the universe", as well as cultural and religious diversity in the classroom from the students' and educators' perspectives. All interviewees were given aliases to protect their anonymity.

1) Was your teaching experience during your undergraduate course or afterwards?

2) Do you have any knowledge about the topic "the origin of the Universe"?

3) How relevant do you consider this theme for your training?

4) How relevant do you consider this theme for regular education?

5) Do you think that students' religious options may conflict with scientific theories about the origin of the Universe?

6) Can the teachers' religious choice influence the way they approach this subject in the classroom?

7) In your case, how would you approach this subject? Could your religious convictions influence the way you approach this topic? How would you handle a room with students from different religions?

8) Would you like to add any other comments on the topic?

The interviews lasted about 40 minutes on average and had a casual, friendly tone, given that the interviewer was also a graduate of the programme. Silva & Almeida (2017:889) write, "one of the possibilities to try to limit the impact of power relations on the anticipation mechanism with research participants is to engage in the connection of trust between them and the researcher."

[1] Access in: http://plataformabrasil.xn--sade-rra.gov.br/.

Data analysis and discussion

Without any form of specialisation or ongoing education, half of the teachers interviewed reported having obtained knowledge about the origin of universe on their own. The other half has gained this knowledge via academic instruction. One educator expressed that they had taken specific electives outside of their major that complemented their academic preparation, which they credited for showing diverse approaches to regular education and for their understanding of the universe's origin, while another credited the training programme itself.

By analysing the speech of the interviewees, it was determined that seven of the eight teachers mentioned that the topic had been touched on only a few times, superficially, at selected times in one or more courses during their academic training. The second instructor stated that the topic had never been addressed during their academic training.

Seven of the eight teachers cited the need for a more in-depth approach to the topic in some specific course during the graduating programme. Because of the potential for disputes surrounding this theme to surface in the classroom, another interviewee brought up the importance of addressing it within the scope of the education courses. A second respondent stressed the importance of including this topic more broadly in the curriculum by integrating it into several classes.

Also notable in the teachers' speech are their remarks on their teaching practices. Five of those interviewed stated that they had never discussed the topic of "the origin of the universe" in the classroom; two had discussed it a few times (one respondent pointed out how absent the theme is in the teaching materials), and another mentions bringing it up once.

Table 1 shows that out of the 8 respondents, 6 underline the need for this issue to be addressed in elementary school, with 2 expressing deep worry (one of the interviewees brought up the sensation of being afraid to confront this topic). All individuals polled highlight the need for more preparation in terms of didactics and specialised knowledge when dealing with the topic.

Table 1: Teachers' feelings on approaching "the origin of universe" in the classroom

Interviewed teachers	Worry/fear	Caution
Ana		X
Bárbara		X
Gustavo	X	X
Otávio		X
Sandra		X
Leonardo		
Henrique	X	X
Ricardo		

The feelings highlighted in Table 1 were evidenced by keywords identified in the teachers' speech, such as "fear", "caution", "afraid", among others. Next, we quote a teacher who

emphasised the worry that comes through in the words of several of those who were interviewed.

> *Gustavo: "If I put myself in the teacher's shoes, I think it's a subject I'm maybe a little afraid to handle because, I don't know, people can be a little sentimental about it."*[2]

Despite the absence of dread, we have selected the following extract from Otávio's interview to illustrate how worry and care are important parts of addressing the issue in the classroom.

> *Otávio: "At this time, I can state the following: it is contentious; caution is advised; I would discuss it, try to look into it, and do not hesitate to approach the subject in the classroom. "However, I am aware of the fact that I must proceed with caution on the topic at hand, on how I set out to start this dialogue concerning the issue of the origin of the universe."*

As illustrated in Figure 1, based on the interviewees' discourses regarding their own faith, four of them mentioned adhering to a religious belief; two mentioned not belonging to any religion, and two did not indicate either way. In their discourses about cultural diversity in the classroom, three of the eight teachers only mentioned the Christian views of creation of the universe. The remaining five also mentioned other creationist theories.

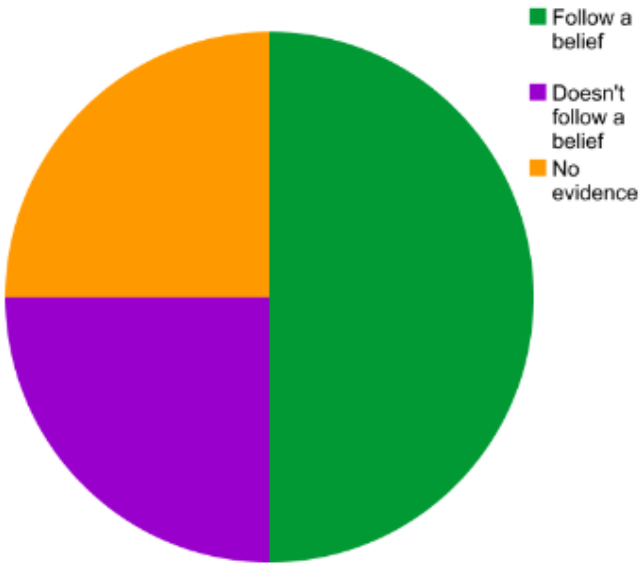

Figure 1 – The religious convictions of the interviewed teachers.

We have selected the following extract from Sandra's interview to illustrate a position without adherence to any faith or religion.

> *Sandra: "[…] They consider the teacher's opinion very relevant. Even if we don't talk about it, they ask. So, I think we have to try to "circumvent" this. I never responded. I don't have a religion. In fact, I don't have any religion. I neither believe nor disbelieve in anything, like that."*

[2] Gustavo: "Since I try to put myself in the shoes of the teacher, I imagine that this is a subject that I'm a little bit reluctant to tackle, perhaps, due to the fact that it evokes some strong feelings in people."

Below is an excerpt from Bárbara's interview, highlighting her position of belief in a specific religion.

> *Bárbara: "[...] I am Catholic, and I am also a scientist. So, I'm a physicist. And, in my opinion, I can work and develop both options without any problems."*

Regarding the potential postures and trends of the relation between sciences and religion that might be analysed in the interviewees' discourse, following Barbour (2004), all teachers exhibited the posture of an autonomous relation between faith and science for a classroom approach.

To demonstrate the relation of independence that runs through the interviewees' discourses, one teacher's speech is featured below.

> *Otávio: "[...] If the teacher knows how to pass it on, it's... there's no problem, no problem at all, it's... for example, they can be, whatever, Christian, Muslim, Jewish, it's... as long as, like, they can separate religious knowledge from scientific knowledge, so, ok. As long as they can pass scientific knowledge on without mixing both... there's no problem.*[3]

Additionally, the graph in Figure 2 highlights the words of a teacher who emphasized the concept of dialogue between religion and science, as seen in the extract below:

> *Sandra: "So, maybe treating it in a more general manner, such as saying, "Look, we have these scientific assumptions; we have these religious beliefs. One does not outweigh the other." We're not certain, but it could be a combination of them."*

Furthermore, it is noteworthy to mention the passage from the teacher's interview that exemplifies a personalized approach to the integration between these two domains of knowledge:

> *Henrique: "I, for instance, used to be really devout as I grew up. However, my understanding of science played a significant role in my decision to no longer believe in religion. So I attempted to 'reinterpret religion' using science."*

None of the teachers demonstrated a conflict between faith and Science, which highlights a non-naturalistic scientific discourse, as previously discussed. The possibility of simultaneous cognitive support between religious theories and scientific theories already contradicts the premise of scientific naturalism that "the final authority to establish any debate around metaphysical or ontological questions in contemporary philosophy should come from scientific investigation" (Santos & El-Hani, 2013:232).

[3] Otávio: "(...) if the teacher knows how to teach it, then there's no problem at all. It doesn't matter what their religious beliefs are, whether they're Christian, Muslim, Jewish, or anything else. As long as they can separate religion from scientific knowledge, it's all good. As long as he can effectively convey scientific knowledge without blending the subjects, it's really not a big deal."

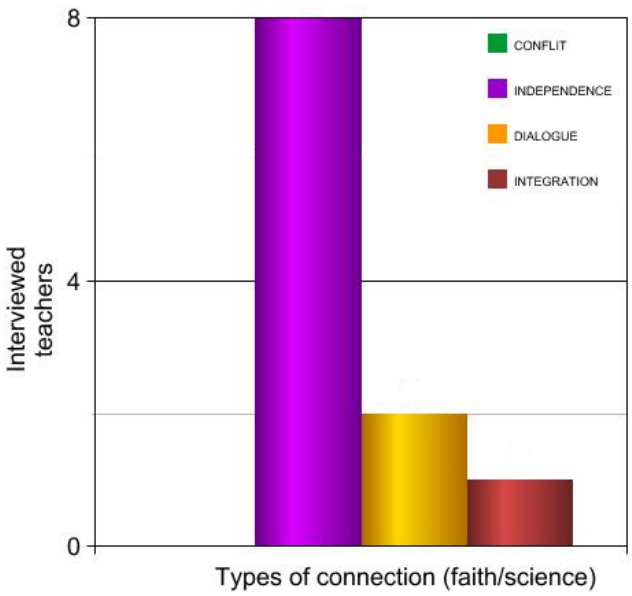

Figure 2 - Kinds of relations between religion and science recognised in the speech of the interviewed teachers. Names of the relations as in Barbour (2004).

The importance of properly preparing teachers to tackle the topic of the "origin of universe" appears often as a theme in the analysis's findings. Teachers' discourses expressed the desire for further in-depth training in several areas, including: the scientific knowledge behind the universe's origin, in relation to its processes of formation and associated physical phenomena; the diversity of explanatory theories for the theme; the didactics in approaching the issue in the classroom; and the teachers' autonomy in the continuing pursuit of knowledge to stay up-to-date on the topic (Libâneo, 2003).

The interviewee Otávio emphasises the importance of reviewing and acquiring complementary knowledge for an approach that meets the expectations of the students. He underlines the complexity of the topic, which is still under investigation by the scientific community, and how this complicates the approach:

> *Otávio: "Even in the scientific world, there are many doubts, you know. For example, if a youngster comes up and asks me, 'Hey, what is dark matter?' They've asked me that in the school. 'Look, teacher can't give you an answer with certainty right now; anything I say here is without certainty'."*[4]

Despite these considerations for teacher education, it is important to note that numerous factors of school reality are equally crucial to the classroom approach to the topic, such as: criteria that private institutions use to decide what content to teach; the absence of the topic of "the origin of the universe" in textbooks, despite the national curriculum's emphasis on this subject (MEC, 2018); preparation for college admission tests as a major priority during high school years, hiring teachers without specific training in physics.

[4] Otávio: "Within the scientific community, there are many doubts that arise, you know. So, like, picture this: a kid comes up to me and goes, "Hey, what's the deal with dark matter?" I've been asked that before at school. 'Look, I'm afraid I can't give you a proper answer to this question right now... Anything I say here will be without certainty, ok?'."

Besides, the statistics on their sentiments of worry, fear, and caution towards the topic interacts with the reality that the vast majority of those questioned had never discussed the issue in the classroom. This analysis of interviews reveals the potential for continuity in the research in terms of safety, preparation, and comfort for the teacher in their practice. As the interviewee Otávio pointed out, there are other problems in society that education should address and that may cause conflict or discomfort in the classroom. These include recent political actions, health care, public safety, information science, etc.

In addition to the feelings of fear and concern that teachers have in relation to approaching the theme, the short time for approaching content outside the curriculum and textbooks was also an aspect highlighted by the interviewees. Sen & Sari (2018) discuss in their article the fact that many teachers feel obliged to follow the contents of the curriculum strictly, which restricts the time for activities practiced for the in-depth debate of subjects such as the nature of Science and theories about the origin of the Universe.

Notable also is the fact that, regardless of their personal beliefs, the respondents indicated to use a relation of independency between faith and science (Barbour, 2004) in their teaching approaches, which makes for less conflicts between the subjects. In addition, some also used non-Christian creationist theories as an example of an approach, which is consistent with national curriculum guidelines (MEC, 2018) about respecting cultural differences when addressing “the origin of the universe".

Final remarks

The contributions of this research to science learning include not just thoughts on the current object of the investigation, but also projections of future research possibilities. Research on teacher training and teaching practices about “the origin of the universe" can widen the meanings of the data analysed in this investigation, following the questions that were partially answered and the questions that emerged through this investigation.

It is hoped that the findings of this study will inspire additional research and that, as the topic becomes more prevalent in academia, teachers will be increasingly encouraged to teach the topic in a meaningful and critical manner. As a result, students will have more opportunity to understand the issue, which is relevant for the student's approach to Science from a critical, autonomous, and contextualised perspective.

It is worth noting that the results are the output of a study whose data source is a sample of physics graduates from a public university, who studied within the same curricular structure, and in a short period of time. In this sense, a sample in different settings would likely lead to different results, which illustrates the need for caution when generalising the brief yet fruitful findings of this research.

Suggested future studies

This research provides the possibility of continuity, both for future researches by the authors and also for other researchers in the area, incorporating validated instruments to analyze

teachers' beliefs about the origin of the universe and considering similar studies with different samples and, thus, allowing more general and valid conclusions or trends to be obtained.

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