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Scientists' and teachers' attitudes toward relating to religion when teaching evolution

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Abstract

Background: The presumed conflict between religion and evolution is considered one of the main causes for rejection of evolution worldwide. It has been shown that when students' perceived conflict is not answered, they may not accept evolution. However, there is a debate in the literature whether teachers should relate to students' religious faith in evolution class, although teachers tend to agree that it should be related. The aim of this study was to explore the attitudes of scientists and teachers, toward relating to religion when teaching evolution.

Results: When scientists ($n = 124$) were asked in an online survey whether teachers should relate to religion when teaching evolution, most scientists said teachers should not relate to religion, in contrary to teachers who were asked the same question and said that teachers should relate to religion. When religious teachers ($n = 10$) and scientists ($n = 10$) were asked the same question—all the religious teachers agreed that teachers should relate to religion, emphasizing mainly the importance of connecting to the students' inner world, preparing students for the future, etc. Most religious scientists also agreed, although they were more hesitant and emphasized the challenges and limitations of relating to religion in a science class. When asked how to relate to the issue, the teachers emphasized the importance of relating to the students' culture and self-choice. Moreover, they took responsibility and emphasized it is their role to provide a proper response to their students. Most interviewed scientists emphasized that the boundaries between science and religion should be emphasized clearly by the teacher, and some suggested that biology teachers themselves should not discuss the issue, but that an external figure such as a rabbi or the religion/bible teacher should do it.

Conclusions: When discussing the issue of relating to religion in a science class, the differences between scientists and teachers that were identified here emphasize the need to relate to teachers' experiences in this academic discussion, as they are aware of their students' difficulties. In addition, it is important to consider the attitudes of religious scientists and teachers, as they demonstrate the possible co-existence between religion and science in their own life, thus they understand the conflict and may have practical solutions to it. Teachers' professional development programs in this issue, may help teachers face with the limitations and challenges that the presumed conflict between religion and evolution may create.

Keywords: Evolution education, Teachers' attitudes, Scientists' attitudes, Teaching practices, Science and religion

Background

The presumed conflict between religion and evolution is considered one of the main causes of rejection of evolution around the world, in a wide range of cultural and geographical contexts (Deniz and Borgerding

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2018; Miller 2006; Sbeglia and Nehm 2020). The notion that to accept evolution one must become an atheist is the most threatening aspect to the learning of evolution (Lyons 2010). Religiosity has been found to be the main factor influencing acceptance of evolution: as religiosity increases, acceptance of evolution decreases (Alters and Nelson 2002; Barnes and Brownell 2017; Winslow et al. 2011), although recently it was shown that students' perceived conflict between evolution and religion is a stronger predictor of evolution acceptance than religiosity (Barnes et al. 2021). When religious students are required to learn evolution, they may get the impression that the teacher wants to change their whole belief system, which may dampen their motivation to engage in studying evolution (Barnes and Brownell 2016). Many instructors hold the personal belief that evolution and religion must be in conflict; some of them teach evolution as fundamentally atheistic and even make disparaging remarks about religion during class (Barnes and Brownell 2016). Studies have suggested that students' rejection of evolution and their feelings of exclusion in the biology classroom are, in part, the result of cultural differences between mostly secular instructors and mostly religious students (Barnes and Brownell 2016; Hermann 2012; Southerland and Scharmann 2013). Barnes et al. (2022) found that when the instructor was negative about religion while teaching evolution, students less agreed with evolution at the end of the semester.

Relating to religion in a science class

Whether or not it is an educator's job to help students accept evolution has long been debated in the literature (Nadelson and Southerland 2010; Sinatra et al. 2003; Smith 2010). Smith and Siegel (2016) argued in support of acceptance of, and belief in evolution, being important and legitimate instructional goals in evolution instruction. However, biology educators may believe that persuading their students to accept evolution is a form of indoctrination, and that their duty lies only in helping students understand evolution scientifically (Smith and Siegel 2019). The debate was also addressed in 2005 when an editorial in the journal *Nature* suggested that scientists should relate to 'intelligent design' or creationism in their science classes, and claimed that scientists should learn how religious people accommodate science with religion and challenge this in their classes with scientific evidence. In that way, students would be able to accept the scientific explanations much more easily and might pass this acceptance on to their communities (Nature editors 2005). Rejecting this suggestion, Dawkins and Coyne (2005) stated that the science classroom is not the place to teach students how to settle the conflict between science and religion; rather, it is a place to teach science.

The official stance of the National Association of Biology Teachers agrees that teachers should not deal with non-scientific matters regarding evolution in class (National Association of Biology Teachers 2019).

However, researchers have emphasised the importance of relating to students' religious faith, and have shown that acknowledging it helps increase students' acceptance of evolution (Lindsay et al. 2019; Truong et al. 2018). In addition, teachers are willing to relate to religion in a science class, if it will promote their students understanding (Stahi-Hitin and Yarden 2022a; Siani et al. 2022). Reiss (2013) distinguished the question of whether religion has a place in science education, to the question of whether it has a place in science: "It is perfectly possible to conclude that religion has no place in science but that it does in science education. The reason for this is simply that science education is a broader field of study than is science. Just as we might conclude that ethics has a role to play in science education (Jones et al. 2010), even if it doesn't in science, we need to examine whether religion has a role to play in science education" (Reiss 2013). In addition, Eve et al. (2010) showed that since the acceptance of evolution is affected by social and psychology factors, teaching good science alone is not enough to increase students' acceptance of evolution.

What solutions that address the conflict are offered in the literature?

Different approaches were offered in the literature for increasing students' acceptance of evolution. For example, Tolman et al. (2020) found that utilizing a reconciliation module effectively increased evolution acceptance while allowing students to maintain their religious views. Barnes and Brownell (2017) summarized different teaching practices in a framework, entitled Religious Cultural Competence in Evolution Education (ReCCEE). These teaching practices are: (1) Acknowledge that some students may see a conflict between evolution and their religious beliefs; (2) Discuss and encourage the exploration of students' personal views on evolution and religion; (3) Explain to students the bounded nature of science and different ways of knowing; (4) Explain that there are diverse viewpoints on evolution and religion and that viewpoints are not restricted to atheistic evolution and special creationism. Discuss the possibility of theistic evolution; (5) Highlight religious leaders and biologists who accept evolution; (6) Explicitly discuss the potential compatibility between evolution and religion. These practices were shown to reduce students' perceived conflict between evolution and religion, increase students' acceptance of evolution, and help create more inclusive undergraduate biology classrooms. A recent study that was conducted among in-service teachers in Israel,

indicated that using the ReCCEE framework increased some formerly “resistant” learners’ willingness to learn about evolution and include it in their own teaching. In addition, using the ReCCEE practices created a liberal and relaxing atmosphere that enabled the teaching of evolution—even human evolution—within a group of culturally diverse and antagonistic participants (Alkather et al. 2020).

Rationale and research questions

It was shown in the literature that different teaching practices of relating to religion when discussing evolution in class are necessary for increasing students’ acceptance of evolution and reducing their presumed conflict toward evolution (Lindsay et al. 2019; Truong et al. 2018). However, the National Association of Biology Teachers (NABT 2019) and some scientists (Dawkins and Coyne 2005) reject the idea of relating to religion in a science class. Thus, in order to understand the gap between the opposers in the academia and the teachers in the field (Stahi-Hitin and Yarden 2022a), we conducted the first part of this study, in which we surveyed scientists in Israel and asked them whether religion should be related to in a science class. The second and main part of this study focused on trying to understand the attitudes of religious scientists and religious teachers toward relating to religion in a science class. The attitudes of religious scientists and teachers are relevant to the discussion since they demonstrate the possible co-existence between religion and science in their own life. They are aware of the presumed conflict and its possible solutions, and their experience in the field—as scientists or as teachers—may help in shaping a better teaching materials and practices that attempt to consider the concerns of the opposers to relating to religion in a science class, together with practical ideas of how to relate to religion in a science class.

In this study, we attempt to answer the following research questions:

1. What are the attitudes of scientists toward relating to religion in a science class, and do they differ from teachers’ attitudes?
2. What are the attitudes of religious teachers and scientists toward relating to religion in a science class?
3. What practices do religious teachers and scientists think should be used when relating to religion in a science class?

Methods

Population

The participants of the first part of the study were 124 scientists who answered the scientists survey, which was

published in a closed Facebook group of biologists from different universities in Israel. The scientists are active researchers or hold at least an MSc degree and they originate from different sectors in Israel.

The participants of the second and the main part of this study were religious biology teachers ($n=10$) and scientists ($n=10$). All the participants defined themselves as modern Orthodox, except S7, who defined himself as ultra-Orthodox. The average age of the participants was 45, ranging from 27 to 80 years old. Among the teachers, 2 hold a BSc, 4 MSc and 4 PhD, most are qualified in Biology or in science teaching. Among the scientists, 3 hold an MSc, 5 hold a PhD, and 2 are professors. Most of the scientists are biologists, and 8 of them teach or taught evolution in the academy (as instructors or practitioners). Additional information about these participants can be found in Table 1 at Stahi Hitin and Yarden (2022b).

Research design

Scientist’s survey

In order to understand what the attitudes of scientists are towards relating to religion in a science class, we published a survey in a closed Facebook group of biologists from different universities in Israel (active researchers or at least MSc). The Facebook group included ~600 participants, thus the response rate was 20%. The survey included one closed ended question, similar to the one that appeared in the teachers’ questionnaire: “Should biology teachers relate to religious issues in a science class (when teaching evolution)?”. The possible answers were: 1) Yes, if it will promote students’ understanding; 2) No, in a science class we learn only science. 3) It depends/ other. In addition, the respondents were asked to explain their answer as a comment to the survey. A limitation of the survey is that the scientists were not requested to state their own sector (secular/traditional/religious).

Interviews with teachers and scientists

Religious biology teachers and scientists ($n=20$, see Table 1 in Stahi-Hitin and Yarden 2022b) were interviewed in a semi-structured in-depth interview of 90 min (on average). The goal was to obtain in-depth explanations of their attitudes toward relating to religion in a science class and in an evolution class in particular, and the practices the participants believe teachers should use when relating to religion while teaching evolution (The detailed interview can be found in the supplementary materials of Stahi-Hitin and Yarden 2022b). A possible limitation of the interviews is that the interviewer was religious, and this could be easily recognized by the participants. One of the interviewees also answered the scientists’ survey.

Data analysis

The qualitative analysis of the interviews with the teachers and scientists was inductive analyses (Cho and Lee 2014). Inductive analysis was used in order to identify the participants approach toward relating to religion in a science class, and their suggested practices of how to do it in class. First, the transcripts were read by the first author, who also performed an open coding process by writing memos on themes emerging from the data. Then, both authors read 10% of the transcripts and created initial categories from these themes. Citations that answered the categories were pulled out into a table that enabled a crosswise analysis of each question. In addition, 10 biology education researchers read some of the excerpts and offered additional themes. Subsequent reading of each transcript enabled to identify additional themes. Then, all the transcripts were coded according to the initial codes.

Validity and reliability

To minimize any bias due to prior assumptions or experiences, the data were validated by two researchers to capture a wider view of the data analysis. Initially, the authors conducted an open coding process, in which each author identified the sub-categories emerging from the data; a discussion was then held between the authors. During the interrater reliability process, the second author independently coded 15% of the coded interview excerpts, using the coding rubric. When disagreements occurred, the researchers discussed the code until reaching an agreement. This process was held twice, at first the Cohen's Kappa (that represents the level of agreement between coders (Fleiss 1981)) was 0.8, after a discussion between the coders 100% agreement was achieved, with Kappa = 1.

Results

Scientists' and teachers' attitudes toward relating to religion in a science class

In order to answer the first research question, 124 scientists answered the survey question—"Should teachers relate to religion in a science class?". As can be seen in Table 1, 92% of the scientists answered "No, in a science class we learn only science", while only 7% of the scientists answered "Yes, if it will promote students' understanding". One representative response of a scientist is as follows: *"Even if the audience is religious or traditional, we must not combine science with anything which is not scientific. Scientific interpretation is fine, scientific disagreement based on evidence—OK. But to try to combine faith/tradition/myths etc. into science? Defiantly not. Anyone who wants will make his own accommodations at home."*

Table 1 Distribution of teachers' and scientists' responses to the question whether teachers should relate to religion in a science class (N (teachers) = 97, N (scientists) = 124)

	Teachers (%)	Scientists (%)
Yes, if it will promote students' understanding	82	7
No, in a science class we learn only science	13	92
It depends/other	5	1

In a previous study, we showed that most surveyed teachers (N=97) indicated their willingness to relate to their students' religious faith in class if it would promote their understanding (Stahi-Hitin and Yarden 2022a). When comparing the attitudes of the teachers to the attitudes of the scientists, an opposite pattern can be seen (Table 1). While most of the teachers (82%) agreed to relate to religion in a science class if it will promote students' understanding, most of the scientists rejected the idea. The difference between the populations was statistically significant ($\chi^2_{(\text{degrees of freedom} = 2, n = 221)} = 143.96, p > 0.0001$).

Religious scientists' and teachers' attitudes toward relating to religion in a science class

In order to answer the second research question, religious scientists (S 1–10) and teachers (T 1–10) were interviewed and asked whether teachers should relate to religion when teaching evolution, and why. The participants' responses are presented in Table 2, in an ascending order according to the willingness to relate to the issue. S8 was the only participant that rejected the idea of relating to religion, as religion and science should remain separate entities. When S8 was asked what if the issue arises by the students in class, he answered: *"than there better be a response"*. It is important to note that S8 was surprised to hear that opposition to evolution exists in Israel: *"This is very weird. I know opposition is common in the USA, but in Israel? I had thousands of students, many of them were religious, and this issue never came up, maybe they were shy? But they did ask questions... I don't know. It is unpleasant to say that there may be a segregation between populations, and those who arrive to the university are at a different place"*.

Three scientists (S1, S2, S4) said the issue can be related to in class, with hesitations based on the possible challenge for the teachers, the importance of emphasizing the differences between science and religion, and the reliance on students' interest. S5, S6, S7 and S9 said that it is important to relate to religion, but as a pre-lesson to learning evolution. One doubted the ability of the students to understand the complexity, and 2 scientists

Table 2 The participants' responses to the question: Should teachers relate to religion when teaching evolution? (n = 20)

Response	Why?	Said by
Basically no	<i>"If I oversaw the curriculum, I wouldn't want science and religion to appear together since they are two separate things, and when you talk about religion in a science class you interrupt the ability to understand that they are unrelated"</i>	S8
Yes but...	<i>"On the one hand, I don't think the issue should be ignored. But on the other hand, how a teacher is supposed to deal with such a sensitive issue?"</i>	S1
	<i>"I don't think it's problematic if the differences between religion and science are emphasized"</i>	S2
	<i>"If the students will be interested - I will relate to the issue"</i>	S4
Important but...	<i>"In order to decrease antagonism, I think there should be a pre-lesson –science, philosophy, Jewish thought, you name it"</i>	S6
	<i>"In order to investigate the relationship between science to religion you need to be mature enough. So, I'm not sure how much students will understand, but it is important they will know that there is not a war between science and religion"</i>	S7
	<i>"I don't think that biology teachers should relate to this issue, since they represent science. And this separation must be preserved"(S5)</i>	S5, S9
Absolutely yes	<i>"I think you must relate to this issue, otherwise you don't fulfill your mission and you won't be able to teach evolution. I generally agree with teachers that reject the idea of relating to such ideas in a science class, but you can't ignore it when discussing evolution and issues with ethical dilemmas. I think it is important also for general education of secular students, since they will be exposed to the idea of the conflict somewhere in the future, so they should know there are solutions to this question." (T4)</i>	S3, S10, T1-T10

emphasized that the issue should be related to by a guest or by someone qualified, not by the biology teacher. All the teachers, together with two scientists (S3, S10) answered yes without hesitations, and were very decisive in their answers that it is very important that the teacher relate to religion.

The participants explained their willingness to relate to religion mainly because of three main reasons (Table 3). Some of the participants related to more than one reason in their answers. The first is the importance of connecting to the students' inner world, which was mentioned by 11 participants. The participants emphasized that by relating to the students' thoughts, feelings and cultural baggage, learning in class can be more meaningful for the students. Eight participants said teachers should relate to religion in order to prepare the students for the future. They emphasized that since the students will probably encounter this conflict somewhere in the future, it will help them if they understand that this conflict has some

possible solutions. Two scientists (S2, S7) mentioned people who used to be religious, that after leaning evolution their religious perception was undermined, as no one taught them that there are religious solutions to this conflict. Five participants explained that the issue should be related to in order to decrease students' opposition. Note the fact that this reason was mentioned only by teachers, which may indicate that scientists are less aware of the opposition in class.

Although most of the participants agreed that religion should be related to in a science class, some of them raised possible challenges of doing so. Three participants emphasized the influence of the teachers' own religious sector as perceived by the students, while T3 and T9 leaned on their experience as religious teachers, and S5 described a possible situation in which the secular worldview of the teacher may be an obstacle.

"The ability of the students to bridge the gap is much

Table 3 The participants' responses to the question: Why should teachers relate to religion when teaching evolution?

Category	Example	Participants
Connecting to student life\inner world	<i>"I want the students to understand that science is not external to their lives but an important thing in their lives, and in order to do that I must connect it to their life" (T3)</i> <i>"In the learning materials it says that a certain organism is 5 million years old, while the students' world view is 5000 years old. We must relate these unsuitability's, that why I always relate this issue" (T8)</i>	T2, T3, T5, T7, T8, T9, T10 S1, S4, S9, S10
Preparing the student for the future	<i>"I want the students to leave the lesson with a confidence, so that if they will be asked about the issue in the external world, they will be able to cope with it because they learned it". (T9)</i> <i>"I know people who left religion because they discovered evolution in a later stage in life and said that's it, we don't believe in god. They dismantle their family, left their home". (S7)</i>	T3, T4, T5, T7, T8, T9 S2, S7
Decreasing students' opposition	<i>"I think that we should relate to religion, since there is no chance I will teach say "evolution" in class, and there will be absolute consensus without any opposition from the students" (T1)</i>	T1, T2, T4, T6, T7, S6

easier when the person standing in front of them has a similar way of life that they have” (T9)

”When the students see that I, as a religious person, teaches evolution, it is first surprising for them, but it is also decreasing their opposition.” (T3)

”If the teachers themselves do not perceive religion as important, the explanation may ridicule religious faith, or won’t be precise enough, or won’t reach to the students’ soul – it may push away the students” (S5)

The concern raised by S5 is supported also by a description of T8, that described a professional development (PD) course she attended, in which the issue of discussing the compatibility between science and religion in a science class arose. Secular teachers objected and one of them said: *”There is evolution, and there is creationism. They are completely different, and you can see the world only in one of the ways. There can’t be a scientist who is religious”*. If the perception of a conflict is the only one the teachers know, they cannot be blamed for not mentioning other approaches.

Five participants (S8, S9, S10, T4, T7) emphasized that relating to religion in class according to the Coalescence approach (that claims there is an overlap between the scientific findings of evolution and the creation story, following Yasri et al. 2013) may hold an educational challenge. Their arguments relied on the idea that each discipline is substantially different and there cannot be a complete fit between them, and that this approach always relies on the present science, while science is tentative.

”I don’t search in the scriptures anything that we might have discovered in science. If someone finds and tries to do this mix – it is first an intellectual lie, since this is not science and not religion. And second – an educational danger for our children. You say that the world has existed for so and so years, there were dinosaurs, etc. but eventually if the scientific conclusions would change – than what? you are in trouble if you built your religious view on foundations from a different discipline.” (S9)

”My research focused on RALBAG (Jewish philosopher, 14th century), who matched one by one the Torah to the Aristotle science (laughs). So, he did this in the 14th century, and now there are people who do the same with modern science... You can say that the Torah has many faces, and each generation can discover in it the science of that time, you sure can. But you may also say: what in the torah have different message to us, rather than how things actually

happened?” (T7)

Four scientists (S1, S3, S5, S9) and one teacher (T9) suggested that teachers should be qualified to deal with this issue. Perhaps if teachers will be familiar with the different approaches to the conflict, they may help their students ease their opposition. S9 raised a difficulty of teachers’ qualification: *”How will you prepare a science teacher to relate to this issue? I think that it may lead to indoctrination”*. Another challenge that was raised by S9 was that teachers may bring to the class solutions that will be too technical, while the real problem is essential: *”I think we should delve into the essential question, which is if we, as religious people, want to explore, use our brains and deal with issues which are not per-se religious? Or not? Because in my perception, everything is part of god’s world – so dealing with science is part of man’s duty in the world”*.

What practices should be used when relating to religion in a science class?

In order to answer the third research question, the religious scientists and teachers were asked how religion should be related to in class, and T7 said that: *”This is a different kind of lesson that should be conducted differently. Not even a Jicxo (a method for cooperative learning). It requires a discussion, uncomfortable questions, and the teacher may not have answers. That is a much challenging position for a science teacher.”* The rest of the participants were also aware of the complexity, as T7 presented it, and suggested nine teaching practices (Table 4). As previously, most teachers related to more than one category.

The first practice that was suggested by 6 teachers and 1 scientist, is the idea that the teachers can present the issue, but must not try to convince the students since they have a free choice and the teacher cannot force his/her worldview. As S9 also warned from indoctrination, this essential suggestion should be in the background of all the others. The second practice was suggested by 4 teachers and 1 scientist, emphasizing the importance of adaptation of the lesson and the materials to the students’ culture, remembering that when the teacher wants to make something accessible for the students, they must think about the other side. The third practice was suggested by 5 scientists and 1 teacher, is defining the borders between religion and science during the discussion in class. Note that the first and second practices were suggested mostly by teachers, and focus mainly on the students, while the third was suggested mostly by scientists, and focuses on the attempt to maintain science as a separate entity than religion.

The fourth practice was suggested by 5 teachers and 4 scientists, is collaboration with an expert—another

Table 4 The participants' suggested practices that should be used when relating to religion in a science class

Practices	Example	Participants
1. Presenting the issue but not trying to convince the students	<i>"I present a few attitudes toward the conflict, but I don't have unambiguous answers. The students are mature enough to consider and think about what I taught them, choose what they agree with – and decide for themselves". (T7)</i>	T4, T5, T6, T7, T9, T10 S10
2. Adapting to the students' culture	<i>"We should approach the students from where they are. The fact that you have a certain knowledge, which you perceive as truth, doesn't mean someone else can access it without opposition. In order to make it accessible, we have to structure this knowledge with cultural sensitivity" (T2)</i>	T2, T5, T9, T10 S6,
3. Defining the borders between science and religion	<i>"The teacher should emphasize the differences between science and religion and not to mix between the two" (S2)</i>	S2, S5, S6, S8, S9 T3
4. Collaborating with an expert– teacher in school or a guest	<i>"The bible teacher and I conducted a few parallel lessons about evolution, in which the bible teacher gave the religious approach, and I gave the scientific approach." (T4) "Most of the biology teachers have no clue about this philosophical issue, so I think that the most qualified person in school – whether it is the Jewish philosophy teachers or the biology teachers – is the one who should deal with it." (S9)</i>	T2, T4, T5, T7, T8 S1, S5, S8, S9
5. Referring to the creation story*	<i>"I tell the students that according to my perception, the bible is not a book of science. Is the purpose of the bible to describe scientifically how the world was created? No! The purpose is to teach us ethics, moral, etc.... Therefore, there is no contradiction since science and religion are separate dimensions." (T3)</i>	T2, T3, T5, T8 S5, S10
6. Presenting various religious approaches to the conflict, especially compatibility	<i>"When I was first exposed to the different approaches that discuss this issue, it made me feel very good. Suddenly I understood that many figures discuss this issue for hundreds of years, I'm not the first and probably not the last. There are answers". (S6) "If we give the students a printed page with different rabbinical reference that discussed the issue – they have what to lean on. Not "the teachers said that... why should I believe that?"; but rather "rabbi Kook said". It gives them much more confidence." (T5)</i>	T1, T2, T4, T5, T6, T7, T9, T10 S1, S4, S6
7. Mentioning religious figures that accept evolution	<i>"Religious person's soul leans on tradition... The fact that I present to the students that there is a Jew with a big beard that doesn't think evolution is heresy – it eases the students' opposition" (T6)</i>	T5, T6, T7, T9 S1, S7, S8
8. Discussing the students' personal views	<i>"After studying evolution, I ask the students what difficulties they have with what we learned, and we list all their questions, wonders and conflicts. Afterwards, I present to them the various ways of answering them" (T7)</i>	T2, T7, T8
9. Relating to the nature of science	<i>"Before I teach evolution, I first try to describe the background of the findings that lead to the discovery of evolution... I go deeply into how and what was explored, what we know and what we don't, I explain what a scientific theory is – many important principles that prepare the students to the understanding of the theory of evolution"(T2)</i>	T2, T7

*The participants emphasized they refer to the creation story as a religious explanation and not as a scientific one – it's not creationism or intelligent design

teacher in school or a guest. It is important to note that the teachers who suggested this solution emphasized they also discuss the issue in class, and the additional lessons function for deepening and expanding the issue. The scientists that suggested this solution emphasized that the guest should lead such a lesson, as in most cases the teachers themselves are not qualified to do it themselves.

The fifth practice that was suggested by 4 teachers and 2 scientists, is referring to the creation story. It is

important to clarify that the creation story is emphasized as a religious source, and not as a scientific explanation, so this is not meant to relate to creationism or to intelligent design. Those who suggested this practice said that the source of religious based opposition to evolution is the simplistic understanding of the creation story, that according to many canonic Jewish commentators and rabbis– this is a misunderstanding of the message of the creation story. Three participants (T3, T5, S5) suggested

to mention this idea briefly, while 3 others (T2, T8, S10) said that only if they teach it in a religious school, they will read with their students the religious sources, from a new perspective. T8 emphasized that when she taught in a secular school, she felt it is not proper to discuss it *“I didn’t want anybody to say I tried to convince the students to be religious”*. S10 suggested to deep into religious sources that go against simplistic reading of the story and try to find other messages in the creation story. T2 and T8 also refer to the creation story, but their purpose is different. They are trying to present to the students that there is an overlap between the scientific findings of evolution and the creation story) the Coalescence approach, Yasri et al. 2013).

The last 4 practices were suggested before as part of the ReCCEE practices of Barnes and Brownell (2017), and came up inductively also here. The sixth practice emphasizes the need to present the multitude of approaches to the relationship between evolution and religion, especially the compatibility approaches that some rabbis represent (e.g. Rabbi Kook, Rabbi Sacks, etc.). This practice was suggested by 8 teachers and 2 scientists. The participants emphasized that they want their students to understand that in such complex issues, there is no right answer. T7 described the experience of her students: *“After a lesson in which various approaches to the conflict were presented, the students said they were impressed by the presentation of alternatives rather than one absolute truth, as they usually taught.”*

The seventh practice that was suggested by 4 teachers and 3 scientists, is emphasizing religious figures that accept evolution. Note that it is different from the sixth practice that suggested to present various religious approaches: here the idea is only to mention that there are certain figures (rabbis, religious scientists, etc.) that accept evolution. S7 for example, mentioned that one lecturer in an evolution course mentioned that Darwin was a religious person: *“the lecturer said that we discuss here two dimensions that won’t necessarily meet, and from that*

moment it solved many problems for me. I put this issue aside and study evolution.”

The eighth practice that was suggested by 3 teachers, is discussing the students’ personal views, that emphasized the importance in understanding the students’ difficulties by allowing them to present them in class, which may enable the teacher to address their specific difficulties better. The ninth practice that was suggested by two teachers, is relating to the nature of science (NOS).

Nine participants (mainly teachers) related to the proper time in the sequence of the teaching to relate to the religious issue (Table 5). T6 said he relates to religion *“Once opposition appears in class”*, and S10 said, *“I think that both religion and evolution should be related to, but I don’t know which one should be related to first”*. Four participants said the issue should be related to before learning evolution, in order to decrease students’ antagonism and to calm their opposition that according to some teachers, appears whenever the word evolution is said in class. That’s probably why two teachers (T2 and T7) said they prefer to teach natural selection without mentioning the word evolution, and after the students have a basic knowledge—then they start discussing evolution. Three teachers said they relate to religion only after learning evolution, since knowing evolution is the basis for the subsequent discussions. T7 said that before starting to teach evolution she tries to ease the students’ discomfort by mentioning that there are religious figures that accept evolution, which will be taught later on, after learning evolution.

Discussion

According to some among the scientific community (Dawkins and Coyne 2005, NABT 2019) religion should not be discussed in a science class. Previous studies have found that teachers do relate to religion when teaching evolution (Stahi-Hitin and Yarden 2022a) or are willing to relate to the issue if they would have had more knowledge and tools (Siani and Yarden 2021). Thus, there is a seemingly gap between the academy (scientists) and the field

Table 5 The participants’ suggestions regarding the proper timing in the sequence of teaching for religion to be related

Suggestion	Explanation	Participants
Before learning evolution	<i>“In order to decrease antagonism, before starting to teach evolution, I would say this: let’s put the things on the table (relate to the things as they are): this is the Torah. This is science. There are certain approaches that reject evolution, that claim this and that, and approaches that accept it, that claim this and that. When understanding the complexity of the issue we can study evolution” (S6)</i>	T1, T8, T9 S6
After learning evolution	<i>“In order to discuss whether evolution and religion can complement, we first have to understand what evolution is. Knowledge is the basis for everything. (T3)</i>	T2, T3, T4 T10
Before shortly, after in details	<i>I tell the students we are about to learn evolution, and to ease the discomfort I tell them that there are rabbis that discussed the issue and there are various approaches to deal with the conflict and we will talk about everything after we learn evolution.” (T7)</i>	T7

(teachers) when discussing the issue of relating to students' religious faith in a science class. In order to examine this gap between scientists' and teachers' attitudes, we surveyed Israeli scientists, and asked them whether teachers should relate to religion in a science class. In contrary to most of the teachers that were willing to relate to religion in a science class, mainly because of the importance of connecting to the students' inner world and preparing for the future (Stahi-Hitin and Yarden 2022a), most of the surveyed scientists are not willing to do so—even if the students are religious, since anything that is not scientific should stay completely outside of the science class. This significant difference between teachers' and scientists' attitudes may be explained by two possible explanations: First, studies found differences in religious cultures and religious beliefs between scientists and the public: scientists are more secular, in terms of beliefs and practices, than the general populations (Ecklund et al. 2016). Graffin and Provine (2007) found that evolutionary biologists have the lowest rate of religiosity among any discipline polled. Whereas the public may struggle with how to situate their religious beliefs with claims of evolutionary theory, many biologists are unlikely to experience the same struggles (Alters and Nelson 2002). Thus, the differences between the attitudes may be attributed to a secular/atheistic point of view that scientists tend to hold more than the general public or teachers.

A second possible explanation to the gap between teachers' and scientists' attitudes may be that scientists are less aware of the needs that appear in classrooms and the consequences of ignoring the subject, as the teachers are. That is why it is so important to relate to the teachers' point of view in this discussion. Reiss (2013) distinguished science from science education, emphasizing that non-scientific issues such as ethics are being related to in a science class, and offered religion should be related to as well. Further research may examine whether scientists are against relating only to religion or also to ethics in a science class (such as animal testing, eating meat, etc.), in order to examine whether their opposition derive from an attempt to maintain "sterile" science, disconnected from the society and the culture, or an atheistic point of view that may cause to rejection of everything religious.

In the second part of this study, we compared the answers of religious teachers and scientists to the question whether teachers should relate to religion in a science class, and have noticed a few main differences: all the religious teachers said they should relate to the issue in their class. Their justifications were mainly the importance of relating to the students' inner world, preparing them for the future, and decreasing their opposition to

enable meaningful learning. These explanations were also mentioned by teachers in a previous study (Stahi-Hitin and Yarden 2022a). In contrary, religious scientists were more restrained than religious teachers, although most of them agreed the issue should be discussed by the teachers. Their answers contained hesitations, mainly about the teachers' qualifications, the complexity of the issue, and students' ability to understand the issue. These results may support the second explanation to the gap between scientists and teachers that was revealed in the first part of the study. Since religious scientists had more hesitations and concerns toward relating to religion in a science class, compared to the religious teachers, the source of the rejection may not be an anti-religious perception of scientists, but a disconnection from the challenges that appear in the field. As some of the participating religious scientists do teach or taught evolution in the academy (as instructors to large classes or practitioners to smaller classes), the difference in their experiences may be attributed to the different characteristics between teaching in the academy to teaching in schools. For example, high school teachers get to teach wider parts of the population than those who eventually attend college/university. Another example may be the difference in educational qualification teachers are required to have (which makes them aware of learning theories, developmental stages, etc.) in contrary to academic instructors which are usually not required to have such qualification (Hébert 2001).

According to the religious scientists' and teachers' answers, all of them (except S8) acknowledge that some students may feel a conflict between evolution and their religion. Acknowledging this idea is the first practice of the ReCCEE framework (Barnes and Brownell 2017) as in order to provide a solution, teachers must acknowledge that their students might have a problem. S8 is the only participant that denied the difficulty and was surprised to hear teachers encounter opposition to evolution, as he teaches evolution in a religious university and had never encountered any opposition. Respectively, S8 was the only one among the participants who rejected the idea of relating to religion in a science class, as he didn't acknowledge there may be a conflict. This emphasizes the importance of informing teachers about the students' possible conflict, as research has shown that college instructors wrongly estimate, and usually underestimate, the number of students in their class who reject evolution (Barnes and Brownell 2016).

When considering how to relate to religion in class, the participants suggested nine practices. The first educational practice was that the teacher should present the issue but should not try to convince the students—the students will decide if to accept it or not. The teachers

may be more aware of their restrictions as educators, they may offer ideas to their students and may try to adapt the ideas to their students' culture, but eventually, the students have their free choice to decide how to relate to this issue. Barnes et al. (2022) found that when the instructor gave students autonomy over their decision to accept evolution, students agreed with evolution more at the end of the instruction. It is important to note that the first two practices that consider the students' point of view (students' free choice and adaptation to the students' culture) were mentioned mostly by the teachers, while the third practice (defining the borders between science and religion) was mentioned mostly by the scientists. This finding may emphasize the concerns of each group—while the religious teachers are concerned to maintain their students' free choice and make the learning accessible to them, the religious scientists' concern is to make sure the students understand the borders between the disciplines. Note that precepting religion as science is one of the main concerns of those who oppose relating to religion in a science class: "...If supernaturalism will be recognized as an authentic part of science... that would be the end of science education in America" (Dawkins and Coyne 2005). Thus, emphasizing the borders and differences between science and religion may answer this concern. It was previously suggested that teachers should make a clear distinction between religious and scientific knowledge, thus promoting the understanding of scientific theories and avoid attempting to change religious beliefs (Teixeira 2019).

The fourth practice that was suggested by both teachers and scientists, was to collaborate with an expert in the issue. However, while the teachers take responsibility to deal with the issue in their classes, even when they suggest collaborating with a guest lecturer—they suggested it as an expansion of what they already discussed in class. In contrary to the teachers, the scientists assign the responsibility of dealing with the issue to other experts rather than the teachers themselves, from various reasons they pointed (e.g. teachers are not qualified enough to deal with such philosophical issues, the teachers' different culture, etc.)—which all lead to the conclusion that the issue should be related to by someone else rather than the biology teacher. Although it may be perceived as if scientists underestimate the qualification of the teachers, many teachers indicated they lack qualifications in this issue (Siani et al. 2022, Stahi-Hitin and Yarden 2022a).

The fifth practice was to refer to the creation story, as according to many canonic Jewish commentators and rabbis (Pear et al. 2015; Sacks 2011) the simplistic understanding of the creation story is a misunderstanding of the message of the creation story, which may cause the religious based opposition to evolution. This

practice is very different from teaching intelligent design or creationism (Pennock 2003), since the creation story is referred to as a religious rather than scientific source, and the participants emphasized that by relating to the creation story, they highlight the differences between science and religion. Moreover, the participants emphasized that this practice may probably fit religious schools, and not secular schools.

Practices 6–9 were previously suggested in the ReCCEE framework (Barnes and Brownell 2017). Interestingly, these practices came up inductively from the participants' attitudes, which support the idea that the ReCCEE framework may fit also religious Jewish students. Ten of the participants emphasized the importance of presenting various approaches to the conflict, especially compatibility (sixth practice). As the most known viewpoints are atheistic evolution and creationism, the idea to present diverse approaches to the relationship between evolution and religion, especially compatibility, has been shown as an important practice that increases students' acceptance of evolution (Ferguson and Lensen 2021; Barnes et al. 2022). Moreover, we previously presented that in this study population, participants that used to reject evolution in the past indicated that they eventually accepted it after they were exposed to the sources that discuss the compatibility between science and religion (Stahi-Hitin and Yarden 2022b). A few studies in Israel have presented educational programs in which the Jewish sources are deeply discussed in science classes (Allouch 2010; Pear et al. 2015) or in teacher's PD programs (Pear et al. 2020; Alkahar et al. 2020). These programs were effective at decreasing students' opposition to evolution, but were best suited for religious schools, where the students are familiar with the study of religious texts.

As religious people tend to rely on tradition, the participants suggested to mention various Jewish leaders that accept evolution, or religious scientists that can be seen as role models (seventh practice). Ferguson and Jensen (2021) found that one of the factors students mentioned as reasons for a change towards evolution acceptance was the presence of a role model. In another study, once students saw someone who reconciled evolution and religion, the conflict they felt with evolution decreased (Holt et al. 2018). It is important to note the difference between this practice, that suggests mentioning role models, to the previously suggested practice to present different approaches to the conflict. As some religious teachers indicated, once their students see that they are religious and yet accept evolution, the teachers indicated it eases the students' conflict, so as if the teachers are the role models for the students. As mentioning different religious figures is easy to implement, we encourage teachers

to look for role models that may be appropriate for their students' culture and religion (Zimmerman 2018).

Three teachers suggested to discuss the students' personal views on evolution and religion (eighth practice). The need to consider students' prior knowledge is one of the principles of constructivism, and is necessary to enable meaningful learning, which may lead to a deeper understanding (Jones and Brader-Araje 2002). Some researchers claim that relating to evolution education through the lens of constructivism may cause students to accept pseudo-science explanations and deny them a proper science education (Mugaloglu 2014; Taşkın 2020). However, it was found that when instructors did not acknowledge students' religious beliefs, the religious students in the class felt left out. This may lead to students deciding that biology and their religious value systems are incompatible (Hermann 2012). Sandford (2020), a science communicator, stated that "*The key to effective science communication isn't the science. It's communication*". Sanford further emphasised three important principles in science communication, that may be very relevant to science teachers: do not argue with beliefs, and listen to, and learn about what people think (Sandford 2020).

Many studies discussed the importance of relating to the NOS when teaching evolution (Lombrozo et al. 2008; Nehm and Schonfeld 2007), while here, two teachers mentioned the importance of relating to the NOS prior to the introduction of evolution (ninth practice), as was also offered by Scharmann (2018). Interestingly, these two teachers hold a PhD in science teaching (T2) and Philosophy of science (T7) (Stahi-Hitin and Yarden 2022b) which may explain the importance they perceive to the teaching and learning of the NOS, generally and especially when teaching evolution.

The proper timing in the teaching sequence to relate to religion was mentioned mainly by teachers. While some prefer to relate to religion prior to the teaching of evolution, some after, and some shortly before and deeply after. Thus, the teacher can choose according to her/his personal preference and the students' needs (for example, if the students' opposition is too severe that the teacher cannot teach evolution, than an answer should be provided before teaching evolution).

Three participants indicated that the teachers' own religious sector may influence the students' acceptance of evolution—and one emphasized that teachers' secular worldview may be an obstacle toward the acceptance of religious affiliated students. In Israel, the teachers' sector and students' sector are not always similar (especially in national state schools with a traditional students population), therefore there must be a solution for that challenge. Studies have suggested that students' rejection of evolution and their feelings of exclusion in the biology

classroom are, in part, the result of cultural differences between mostly secular instructors and mostly religious students (Barnes and Brownell 2016; Hermann 2012; Southerland and Scharmann 2013). This idea is also supported by our finding in which secular teachers in traditional schools tend to experience higher opposition to evolution than religious and traditional teachers (Stahi-Hitin and Yarden 2022a). It was found that Christian instructors perceived that their own religious backgrounds have guided their decisions to teach evolution in a culturally competent way, which according to their perception, led to a safe environment for students, that subsequently led to an increase in students' acceptance of evolution and reduce student conflict between evolution and religion (Barnes and Brownell 2018). Thus, it emphasizes the importance of considering the experiences and perceptions of religious people toward the presumed conflict, as was done here, and the need for PD programs that will expose non-religious teachers to the possible challenges and will offer practices to cope with them in class.

Implications for teachers' professional development programs

Despite the opposition of scientists described in the first part of the study, religious teachers and scientists agreed that teachers should provide a response to the religious conflict in class, while the challenges that were raised here should not hinder the creation of proper PD programs for teachers, but should be considered when designing such a course. In addition to the important ReCCEE practices that should be introduced to teachers, we offer 5 additional educational practices that a PD program may include. Note that we suggest that the practices will be offered following an explicit discussion with the teachers regarding their educational goals when teaching evolution.

1. Teachers should consider that their students have a free choice and a personal belief system, and by trying to convince students that they should accept evolution teachers may achieve the opposite result and may decrease students' acceptance of evolution. This practice may also answer the concern of indoctrination that was raised by some scientists, as the teachers will present the students different approaches without trying to convince them.
2. The need to adapt to the students' culture may be challenging in a multicultural classes, but a PD course should include searching and examining the different solutions to the conflict that each culture has, as the majority of teachers may encounter students from different sectors and cultures.

3. Defining the borders between religion and science is a very important practice, as the perception of religion as part of science is one of the main concerns of those who oppose relating to religion in a science class. This study emphasizes the importance of defining the borders between both. One of the ReCCEE practices is to relate to the nature of science, but in the PD course teachers should also be exposed to the nature of religion, which may enable them to distinguish between the two with their students.
4. As in many classes the students' religious sector may be different from the teachers' sector, this study suggests considering a collaboration with experts. One of the goals in a PD course may be to find such experts, thus the course instructors may offer a pool of religious leaders and scientists who will be willing to cooperate with teachers. This suggestion may also answer the ReCCEE important practice of presenting the students with role models.
5. Relating to the creation story in a science class may sound controversial, but as the main source of rejecting evolution is the literal understanding of the creation story, although according to many Jewish rabbis and commentators it should not be understood literally. Thus, teachers should be aware of the possible religious perceptions of the creation story, and they can even discuss it with their students, if they think it is appropriate and helpful in their classes.

In a previous study we tried to implement the practices suggested here in a teacher PD course. In this course a quarter of the total time of the course was dedicated to students' religious based opposition. Following the course, the participating teachers indicated it made them feel more confident in relating to religion in class (Siani et al. 2022), although it wasn't enough and a comprehensive course that will fit the Israeli Jewish population is still needed. A lack of proper qualifications was mentioned previously by teachers in Israel (Stahi-Hitin and Yarden 2022a), and teachers are willing to invest time and effort into seminars and teacher PD courses to enrich their knowledge, and obtain tools to deal with the opposition to learning evolution (Siani and Yarden 2021).

To summarize, as it was found that students' perceived conflict between evolution and religion is a stronger predictor of evolution acceptance than understanding or religiosity (Barnes et al. 2021), we suggest that the conflict should be related to in class. Here we demonstrated the gap between scientists and teachers regarding the question of relating to religion in a science class. We offer the opposing scientists to consider the experience of public school biology teachers, as they are at the front line of the public controversy surrounding the teaching

of evolution (Friedrichsen et al. 2018), and as they teach a wider segment of the population than those who teach college students. Therefore, the teachers' perspectives on the issue are very important, and a proper PD program should prepare them to cope with the challenges. Moreover, half of the participants indicated their teachers had influenced their acceptance of evolution (Stahi-Hitin and Yarden 2022b), which emphasizes the important role teachers may have in shaping their students' approach toward evolution, and the importance of preparing the teachers to deal with this challenge toward better evolution education for all.

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