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Whether, what, and how should we discuss evolution and faith in biology classes? insights from semi-structured interviews and a Delphi study

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ABSTRACT

This study explores the challenges of teaching evolution in the context of religious beliefs. The primary objective was to understand the perspectives of biology education experts on discussing evolution and faith in biology classes, and to provide culturally responsive solutions to the challenges encountered by students and educators. Participants included science education experts from diverse ethnic backgrounds in Israel. Data were collected through semi-structured interviews and a Delphi study. We identified three key questions regarding the discussion of evolution and faith in biology classes: Should we discuss it? What should we discuss? How should we implement such discussions? There was no consensus on how to conduct these discussions, except for the suggestion to address the evolution-faith conflict through teaching the Nature of Science (NOS). This highlights the importance of culturally responsive teaching in diverse educational settings. Several key issues related to the evolution-faith controversy can be addressed without prioritising one perspective over the other. Support for the discussions was grounded in their educational significance, while opposition stemmed from concerns about their practical implementation. Therefore, it is recommended that these topics be included in teacher professional development (PD) programmes to prepare educators for any related questions that may arise in class.

Introduction

Biological evolution is a core scientific idea. Policymakers worldwide have emphasised the importance of evolution in science education frameworks, curricula, and assessments (e.g. NRC, 2012; OECD, 2023). However, there are places where teaching evolution remains a challenge for policymakers, teachers, and students since evolution is viewed as contradicting religious beliefs (e.g. Dunk et al., 2019). In response, the science

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curriculum often shifts to its lowest common denominator to achieve an acceptable compromise to accommodate educational, political, and social concerns (Osborne et al., 2003). The outcome is that evolution education is reduced to a bare minimum.

The current study was conducted in Israel, which is diverse in terms of ethnicity and religion. Israeli society is comprised of Jewish, Muslim, Christian, and Druze populations. Within each religious group, there are various denominations, religious identities, and levels of observance ranging from secular to ultra-orthodox. Despite this diversity, there is one national science curriculum for all students in Israel. Evolution is a mandatory topic, and questions on it are included in the high school biology matriculation exam (Ministry of Education, 2015). However, a recent analysis of students' responses to these questions indicated low achievement (Ministry of Education, 2019). Teaching evolution is considered challenging for several reasons. Previous studies have pointed to specific theological and pedagogical issues affecting teaching and studying evolution in Israel as a possible explanation for these low scores (Siani & Yarden, 2020; Stahi-Hitin & Yarden, 2022a).

To address the religious objections related to evolution instruction, we suggested an innovative approach that embraces explicit discussions about the conflict between science and faith rather than ignoring it. This approach draws on what Alexander (2017) termed 'the pedagogy of difference', which exposes students to alternative perspectives and encourages critical thinking. The idea is not to find a middle way or to blur the differences between scientific and religious perspectives, but rather to encourage respectful discourse about values, beliefs, and evidence to help learners cope with their objections to evolution at the start of their exposure to the topic (Owens et al., 2018).

In this study, we aimed to understand how experts in biology education approach the relationship between evolution and faith in secondary school biology education. It is uncommon to have a single school system with the exact curricular requirements that serve schools distinguished by their ethnic and religious affiliations; consequently, our study opens a window to understanding cross-cultural views within the same system. While previous studies on issues related to teaching evolution in Israel have mainly investigated the Jewish school system, focusing on Jewish religious teachers and scientists (Stahi-Hitin & Yarden, 2022a, 2022b), our study considers the more complex picture of the Israeli education system in its greater religious diversity. The overarching objective is to contribute to fostering similar discussions in other diverse societies that can lead to better curricular design and instruction.

Theoretical background

Religious beliefs and the acceptance of evolution

The evolution controversy, over 150 years old, reflects the tension between people's beliefs and scientific knowledge (Siani & Yarden, 2020). Most disagreements stem from the apparent inconsistency between the belief in the divine creation of the species as described in the Scriptures of the three monotheistic religions (Christianity, Islam, and Judaism) and the scientific idea that species diversity results from continuous random changes. As a result, people are uncertain about whether to accept or reject the theory of evolution (Kampourakis & Strasser, 2015). 'Acceptance' refers to the inclusion

of a specific claim within a person's assumptions and does not involve any emotional component. Nevertheless, uncertainty about evolution is not necessarily the outcome of a well-informed or deliberate choice but is associated with beliefs. A 'belief' is a way of thinking that regards a certain thing as 'true' and involves an inner feeling (Smith & Siegel, 2016). Opponents of evolution may be aware of the evidence supporting the theory. However, their rejection stems from other factors, such as an inadequate understanding of the nature of science (Tsybulsky, 2018) or religious beliefs.

Generally, evolution seems to be considered a somewhat controversial issue within a number of religous Jewish groups, while much less so among secular Jews, and only among contemporary ultra-orthodox communities is a rejectionist stance largely the norm (Pear et al., 2020). The attitude of Muslims toward evolution is more diverse, complex, and influenced by individuals' religious affiliation (Clément, 2015). In addition, social contexts can often foster hostility towards evolution by associating Darwin's ideas with imperialism, Westernism, atheism, materialism, and racism (Dajani, 2015). The theory of evolution can be viewed as opposed to religion, even among those who have religious sentiments but are not religiously observant. Others may accept or compromise by accepting evolution for all living organisms except humans (BouJaoude et al., 2011). A variety of views appear among those raised as Christians as well. A study examining the acceptance of evolution in different countries found that rates are higher in Europe than in the United States. One possible explanation is the attitudes of various Christian denominations towards the Scriptures; for example, Evangelical Christianity, which is more common in the United States, sees the biblical text as a literal and accurate description. By contrast, mainstream Protestants and the Catholic Church treat the biblical text as a metaphor or myth and therefore do not find a significant contradiction between evolution and faith (Miller et al., 2006).

Educational implications of worldviews

The general attitude towards science, as well as religious beliefs, affects teaching and learning about evolution in schools. Integrating evolution into the science curriculum has been shown to have a limited impact on students' acceptance of the theory (Deniz, n.d.). In the last few decades, studies have consistently shown that learning is an active process that involves understanding, assigning significance, and acquiring a variety of skills. Social contexts and systems impact learning and play a pivotal role. Knowledge is organised around main concepts and is connected to prior knowledge through subjective experiences, values, and worldviews derived from the learner's culture and community. Sometimes, students' initial beliefs and concepts challenge the acquisition of new knowledge (Bransford et al., 2000; OECD, 2019). These difficulties come particularly to the fore in evolution education, which is related to differences in the values of social groups such as religious communities (Reiss, 2010). If a person's worldview holds that religious scriptures are the sole authority on any subject, this is likely to affect readiness to learn science (Smith, 1994). Moreover, religious students may interpret the teaching of evolutionary mechanisms based on randomness as an attempt to change their entire belief system, which thus undermines their motivation to learn this topic (Barnes & Brownell, 2016). Therefore, even though it is commonplace to make a clear distinction between scientific knowledge and religious views in science education,

students' worldviews on evolution cannot be ignored since doing so can lead to an intensification of the conflict or a fixation on misconceptions (Reiss, 2019).

Teaching evolution in culturally diverse contexts

Finding ways to teach evolution while also acknowledging the cultural or religious context is a long but feasible endeavour (BouJaoude, n.d.). 'The pedagogy of difference' (Alexander, 2017) framework provides one way to cope with these challenges by encouraging explicit discourse on evolution and faith. This pedagogy enables learners to adopt three different perspectives termed 'in', 'from', and 'about' a topic. The first perspective, 'in', recognises learners' commitment to values that shape their self-identity, which can include religious beliefs. The second perspective, 'from', exposes the learner to other worldviews and encourages individuals to adopt values they can identify with. For instance, this could involve appreciating aspects of science, such as rigour and consistency. The third perspective, 'about', examines other worldviews from an external viewpoint without necessarily accepting them; for example, merely acquiring information and understanding evolutionary mechanisms. This type of dialogue between different worldviews is not confined to the traditions a person inherits or chooses to belong to but instead promotes a respectful attitude toward viewpoints that are very different from one's own, while encouraging critical thinking (Alexander, 2018).

In line with Dagan et al. (2025), a 'sensitive teaching approach' toward students who may have a religious conflict with evolution can help manage discussions of evolution and faith. A person can be sensitive towards others concerning a specific issue without sharing the same worldview (Reiss, 2019). Culturally responsive teaching provides a framework for implementing discussions about evolution and faith while exposing students to diverse perspectives. In culturally responsive teaching, avoiding differences is replaced by addressing the complex interplay between culture and learning through various types of approaches that are informed by values, attitudes, experiences, communication, and ethics (Gay, 2002). This pedagogy assumes that when scientific knowledge and skills are taught in a context relevant to the students, the learning experience becomes more significant (Levinson, 2006). The implementation of culturally responsive methods requires teachers to understand the cultural background of their students and to design their teaching strategies accordingly (Barnes & Brownell, 2016). One of the strategies proposed in several studies, which has been applied to Christian, Muslim, and Jewish students alike, is through figures from the same society or community who have been role models for the students and accept evolution. This may positively affect students' motivation to learn evolution because it diminishes the perception that accepting evolution is the equivalent of atheism (Barnes & Brownell, 2017; Dajani, 2015; Stahi-Hitin & Yarden, 2022b). These steps may help address students' attitudes, construct new meanings (Jones & Brader-Araje, 2002), and improve their ability to formulate coherent, knowledge-based arguments that differentiate scientific and religious arguments (Erduran et al., 2019).

> Given the possible benefits of explicit discourse on the relationships between science and religion, the research question we followed is: What are the views of biology education experts on discussing evolution and faith in biology classes?

Examining the views of experts in biology education from various ethnic and religious groups in Israel may foster productive discourse about evolution and faith in secondary school biology classes.

Method

Positionality

The authors comprise a diverse group in terms of religious identity and expertise. Four are Jewish biology education researchers: two secular and two religious. There are three researchers in the philosophy of education, with a focus on religious education as well as history, philosophy, and sociology of science: two are religious Jews and one is a non-religious Muslim.

This study harnessed phenomenography (Marton, 1981) to describe, analyze, and characterise experts' views of biology education on integrating discourse on evolution and faith into biology classes. Phenomenography investigates the different ways in which people experience something or think about something. It serves here to portray the complexity of how people perceive the tension between evolution and faith. The following section presents the demographics of Israel and its education system to provide a social context for this study, and then describes the participants, data collection, and analysis.

The Israeli education system

Israel has a population of approximately 9.5 million people, and is diverse in terms of ethnicity and religion, as presented in Figure 1.

The population is also diverse in terms of self-reported level of religious observance, as shown in Figure 2a,b:
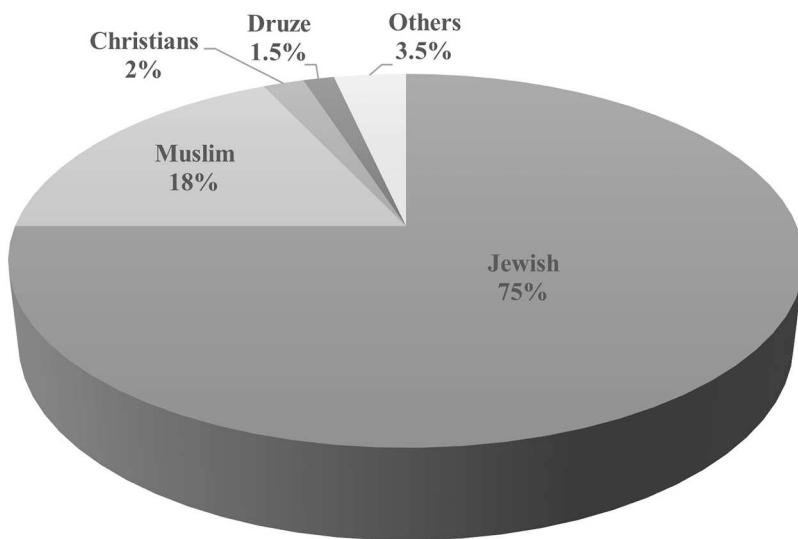

Figure 1. Religious affiliation in Israel (Central Bureau of Statistics [CBS], 2018).
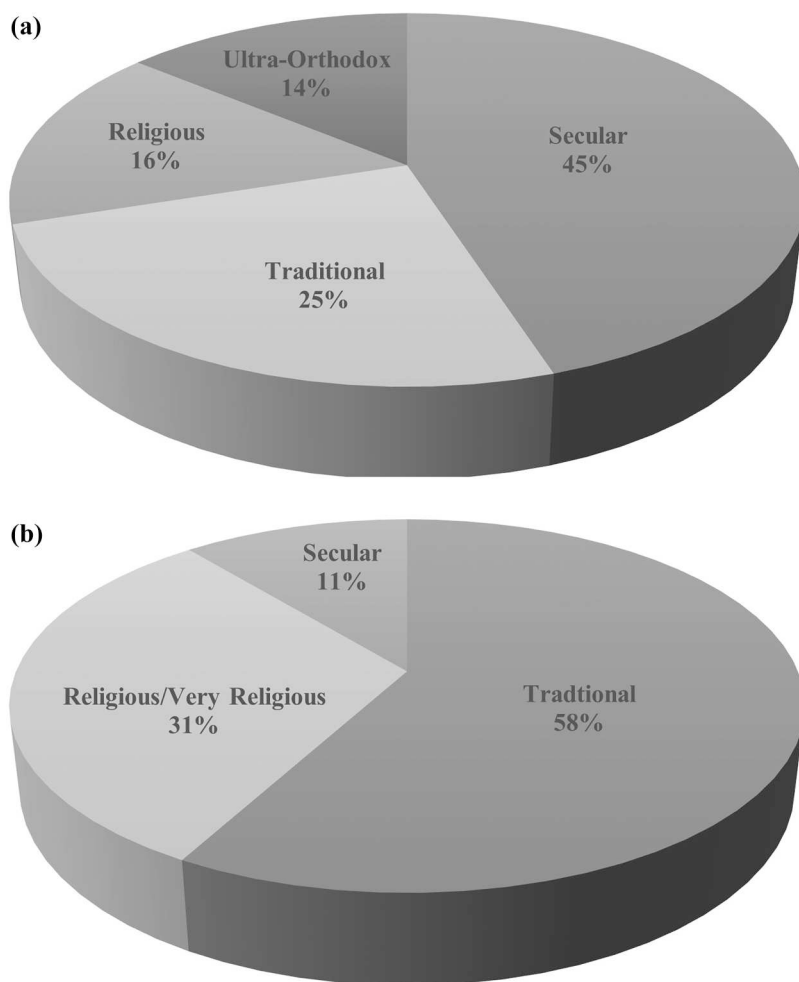
(a)

(b)

Figure 2. a. Self-reported level of religious observance among the Jewish population (Central Bureau of Statistics [CBS], 2018). b. Self-reported level of religious observance among the Arab population (Central Bureau of Statistics [CBS], 2018).

Note that people identifying themselves as traditional see themselves on a continuum between secular and religious, but are not necessarily observant.

The Israeli education system operates four different school frameworks that reflect the religious and cultural makeup of society:

A. State general schools: serving mostly secular and traditional Jewish students. Hebrew is the language of instruction.

B. State religious schools: serving mostly orthodox and traditional Jewish students. Hebrew is the language of instruction.

C. State Arab schools: Serving the Arabic-speaking population; mainly Sunni Muslim, Christian, and Druze students. Arabic is the language of instruction.

D. Ultra-Orthodox independent schools: serving Jewish Ultra-Orthodox students. Yiddish or Hebrew is the language of instruction. This group was excluded from

this study, since Ultra-Orthodox schools do not teach the mandatory national curriculum, and hardly teach science at all.

In state schools, the humanities curricula are differentiated by stream. For example, each stream has its distinct curriculum, advisory committee, and supervisors for literature, history, Bible, and religious education (e.g. Islam, Christianity). By contrast, all streams implement the same curriculum for STEM subjects and English and have similar advisory committees and supervisors, even when the language of instruction is different, i.e. Hebrew or Arabic. Evolution is part of the Science and Technology curriculum for middle school (aged 12-15), and since 2015 has also been a mandatory topic in the high school biology curriculum (aged 16-18) (Ministry of Education, 2015, 2016). It is worth noting that biology, like all sciences, is an elective subject, taught only to students who choose it as one of their majors in grades 11 and 12.

The 1967 Israeli high school curriculum included evolution as a compulsory unit. In 1991, evolution became an elective, so that only a small fraction of all biology teachers taught the elective unit on evolution (Stahi-Hitin & Yarden, 2022a). In 2015, the new (and still current) curriculum reinstated evolution as a compulsory core subject, as a subsection of the ecology unit. This means that questions on evolution appear in the biology matriculation exams, which force schools to grapple with the teaching of evolution, at least to some extent.

Notwithstanding the curricular change in Israel, a gap probably exists between 'recommended' biology curricula in which evolution education appears explicitly, and the enacted curriculum, which is influenced by students', communities', and teachers' perceptions. Such discrepancies are reported worldwide (e.g. Glatthorn, 1999). A recent study on Jewish teachers reports on classroom dynamics, showing that while there is little resistance to evolution education in secular state schools, mainly on the part of students from 'traditional homes', this was not the case in religious state schools, where many teachers reported resistance.

These authors suggested that religious studies may tend to amplify the apparent contradiction between evolution and faith, in particular as related to the explanations of the origins of life. Consequently, teachers may teach evolution as required by the curriculum, but tend to avoid addressing religious conflicts, whether their own or those of their students (Stahi-Hitin & Yarden, 2022a).

Participants

Thirty-one experts in the fields of biology education, philosophy, and biology, as well as policymakers from the Ministry of Education and teacher mentors, participated in the study. These participants were diverse in terms of self-defined religious identity, as presented in Table 1. The participants approximately reflect their relative distribution within the population, as previously indicated. They were recruited based on several inclusion criteria. They included senior biology education researchers, current and former biology national supervisors, current and former members of the National Biology Advisory Committee that advises the Ministry of Education, and a few teacher mentors from the Ministry of Education. No financial compensation was provided. Participants were

Table 1. Participants and data collection.

Expertise	Jewish		Muslim Arab		Christian Arab	
	Interviews	Delphi	Interviews	Delphi	Interviews	Delphi
Researchers	4	9	0	2	0	2
Policy makers	7	3	0	0	0	0
Teacher mentors	3	0	2	0	1	0
Total (N=31*)	14	12	2	2	1	2

* Two key policymakers participated in the interviews as well as in the Delphi survey

assured of confidentiality and anonymity. This study received an IRB approval no. 426/19 and was authorised by the Chief Scientist of the Ministry of Education.

Data collection

The data were collected by semi-structured interviews and a Delphi survey.

Interviews

Semi-structured interviews were conducted with 17 experts in biology education, including researchers, teacher educators, policymakers, and teacher mentors. The interviews took place during the COVID-19 pandemic and, therefore, were conducted via Zoom. We held three pilot interviews, followed by further refining of the interview protocol. The interview consisted of 19 questions (Appendix 1) and follow-up questions based on the interviewees' responses. The questions were first suggested by the research team and then refined following further consultation with former experts in biology education. A few questions were modified after the pilot interviews. We encouraged the interviewees to elaborate and develop ideas they wished to highlight. All interviews were recorded and transcribed. Thematic analysis was conducted collaboratively by the entire team in several rounds.

Since few studies have dealt with discourse on evolution and faith in biology classes, we could not use an existing analysis framework. The phenomenographical approach is an appropriate framework because it serves to elicit participants' interpretations of situations, based on the premise that subjective reality can take diverse forms. The interview analysis was inductive and involved a search for recurrent arguments (Charmaz, 1990) that sometimes led to identifying unexpected perspectives. Interviewees' ideas were generated from their responses to all questions, regardless of the specific focus of each question. The criteria for analysis were refined in an iterative process by the research team.

The iterative analysis yielded two main categories of reasoning: (1) conceptual – the interviewees' worldview as to the most appropriate relationship between evolution and faith, and (2) pedagogical – their opinion as to how to discuss the relationships between evolution and faith as part of biology education. The pedagogical arguments comprised systemic and classroom types of arguments. Systemic arguments refer to the inclusion of the discourse of evolution and faith in the formal curriculum, while classroom arguments refer to the teachers' practices in their classrooms and how they respond to their students' questions. The main categories and subcategories that emerged in the analysis are presented in Figure 3.
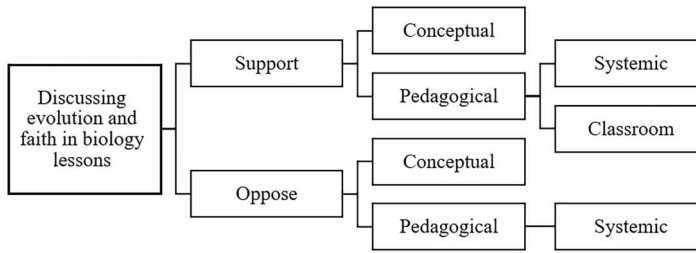
Figure 3. The category tree of experts' views.

Delphi survey

The Delphi method was developed at the U.S Research and Development Institute (RAND), which promotes the design of public policy through research and analysis. This method aims to find a consensus among participants through iterative group discussion. It is used extensively in research in education and the social sciences (Jorm, 2015).

The Delphi method is implemented without face-to-face interaction between the researcher and the respondents, or between the respondents themselves. Discussing sensitive issues face-to-face in a heterogeneous group can also elicit disagreements or discomfort. The Delphi method makes it possible for the respondents to express independent or unpopular opinions and reduces the bias due to authority or persuasion (Dalkey & Helmer, 1963). The Delphi method can also generate effective group interactions despite geographic distances and different time zones (Linstone & Turoff, 1975). The minimum number of participants in a Delphi-based study is 10, although a larger group of respondents improves the reliability of the survey (Chocran, 1983, in Clark et al., 2020). There is no consensus on the maximum number of participants, but research suggests that only a few new ideas emerge in a group of more than 30 well-chosen participants (Delbecq et al., 1975, in Clark et al., 2020). One of the hurdles of utilising this approach is its length, particularly concerning the phrasing of the questions. In addition, the group's expertise may not be fully tapped because the direct dialogue between people that can help densify the discussion does not exist (Osborne et al., 2003).

Several studies using the Delphi method have been published in science education journals. These include, for example, a study that investigated what ideas about science should be taught (Osborne et al., 2003), the essential concepts of science and technology on a nanoscale that should be taught (Sakhnini & Blonder, 2015), conceptualisation and promotion of climate literacy (Leve et al., 2023) and defining the focal point of environmental education (Clark et al., 2020). All aimed to contribute to policymaking in science education.

The Delphi method requires a few rounds of data collection and processing. In the first round, participants respond to open questions. Content analysis is then used to construct statements for a closed questionnaire. In the second round, participants rate their agreement with these statements. Sometimes a third round is conducted on a concluding statement in which the participants rate their agreement (Clark et al., 2020). Group interaction emerges from the responses in later rounds to opinions expressed in

earlier rounds. Exposure to views raised by other participants makes it possible to change one's mind, given the tendency to adhere to the majority opinion in the later stages of the research (Osborne et al., 2003).

The use of the Delphi method in this study

The Delphi survey examined the extent of the experts' agreement on the ideas identified in the interviews. A two-round Delphi survey was held, as shown in Figure 4.

1st round: The survey was emailed to 24 researchers and policymakers in biology education. All participants, except for two, were different from those who took part in the interviews.

They were asked to answer three open questions on their views about engaging in the discussion of evolution and faith as part of biology teaching:

(1) Should the relationships between science and religion be discussed while teaching evolution? Explain your answer.
(2) What conflicts between science and religion, if any, should be discussed when evolution is taught?
(3) In what way should religious narratives be addressed when teaching evolution?

1st round analysis and 2nd round development: Sixteen out of the 24 experts responded to the first-round open-ended questionnaire. Three main themes were identified in the experts' personal views:

- Whether to discuss: supporting or opposing discussion on the tension between science and religious faith in biology education.
- What to discuss: pointing to content that possibly raises a conflict between science and religious faith, and which should be discussed in biology education.
- How to discuss: the pedagogical tools for addressing religious narratives while teaching evolution: content-focused or learner-focused.

Questionnaire construction: Based on the responses obtained in the first round, 29 statements were derived to express key ideas regarding the discussion of evolution and faith: 13 statements addressed the 'whether' theme relating to discussing the relations between evolution and faith in biology class, four statements addressed the topics to
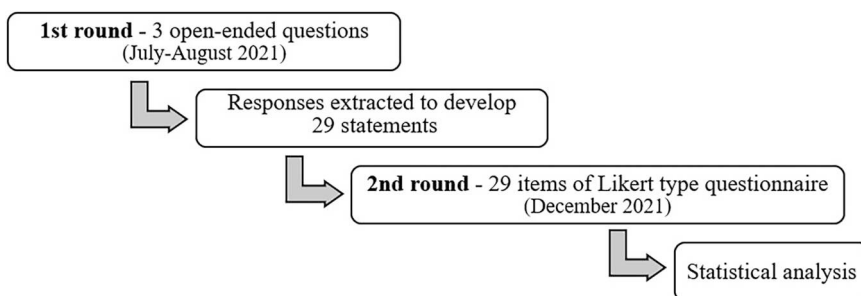

Figure 4. The process of the Delphi survey.

focus on (what) while discussing the relations between evolution and religious views, and 12 statements addressed the way to discuss evolution and faith in biology class (Appendix 2). The number of statements reflects the range of arguments raised by the participants for each theme. A cluster of statements related to each other can also reveal the participants' approach to the issue (Joshi et al., 2015). The survey was e-mailed to the experts who participated in the first round, asking them to indicate the extent of their agreement with each statement on a five-point Likert scale ranging from one (strongly disagree) to five (strongly agree). Altogether, 12 out of the 16 experts from round 1 responded (9 Jewish, 2 Muslims, 1 Christian).

Statistical analysis: Responses to the second round of the Delphi survey were analyzed using the SPSS version 28 statistical package (SPSS Inc., Chicago, IL) to calculate:

(1) The Cronbach's alpha was used to assess the reliability of the questionnaire. The internal consistency was $\alpha = 0.86$, which shows good reliability (Tavakol & Dennick, 2011).
(2) The ICC (Intraclass Correlation Coefficient) index to assess the absolute agreement among participants. The ICC value was 0.853, with a confidence interval ranging from 0.76–0.92 (95%), which indicates good reliability (Koo & Li, 2016).
(3) The ADM alternative index for each item (Average Deviation from the Mean), to examine the consensus as a function of the deviation of each statement from the mean and the median. ADM is less affected by outliers and is therefore suitable for use with relatively small samples (Burke et al., 1999). ADM value of less than indicates a high level of agreement (according to A/6, A represents the 0.833 number of response options, which is 5) (Frenzel et al., 2009).

Trustworthiness

The participants in this study represented diverse segments of Israeli society, reflecting their approximate proportions in the population. Similarly, the evolution – faith research team was diverse in terms of religious identity and professional expertise. Members of the research team were actively involved in validating the research instruments and analyzing the findings.

The semi-structured interviews were designed according to a conventional structure, including introductory questions, content-related questions, and follow-up questions, based on the interviewees' responses. Three pilot interviews were conducted, each representing one of the key participant categories: researchers, policymakers, and teacher mentors. Based on these pilot interviews, peer debriefing was carried out, resulting in minor refinement to the protocol. All interviews were recorded and transcribed verbatim.

To develop the analytical framework, an iterative thematic analysis was conducted by alternating pairs of researchers in two rounds, aimed at identifying core themes. This process was followed by a collaborative discussion among three team members with expertise in biology education, focusing on the classification of arguments.

The open-ended questions for the Delphi survey's first round were drafted by the research team. The responses were initially coded and subsequently discussed in group meetings to reach a consensus and formulate the statements for the second round. A

detailed research log was maintained to document key interpretations and decisions throughout the various stages of the Delphi process.

Finally, we cross-validated findings derived from the two primary data sources: semi-structured interviews and the Delphi survey.

Findings

The data analysis yielded three main issues related to discourse about evolution and faith in biology education: Whether, What, and How to Discuss? These are examined in detail below.

Should evolution and faith be discussed as part of biology education?

Arguments addressing this question were found in both the interviews and the Delphi survey and were classified into main categories and subcategories as detailed in Figure 3. A two-dimensional matrix was constructed as shown in Table 2, in which the arguments for the different views are categorised by their support or opposition and by the conceptual or pedagogical argument.

A broad spectrum of arguments emerged in the analysis of the interviews and the first round of the Delphi survey, among participants from different religious backgrounds. Notably, individuals with similar levels of religious observance expressed divergent perspectives. Furthermore, both religious and non-religious participants presented similar arguments, both for and against, the discussion in biology classes. Examples of arguments for each category are presented below. ADM was used to test for consensus on each statement that expressed the argument in the Delphi survey.

Arguments advocating for the discussion

Supportive arguments pointed to the possible benefits of this type of discourse. There was a consensus that discussion on evolution and faith would not mislead the students (ADM = 0.444). Table 3 presents the conceptual arguments and a few examples, and Table 4 presents the pedagogical arguments.

Overall, the arguments advocating the discussion of the relationships between evolution and faith in biology education indicated that although the issue cannot be resolved through science, the benefits of maintaining classroom discourse outweigh the drawbacks. In some cases, experts who conceptually opposed the discussion of evolution and faith in biology

Table 2. Arguments supporting or opposing discussing evolution and faith as part of biology education.

| | Conceptual | Pedagogical | |
		Systemic	Classroom
Support	Educational significance	Consideration of diversity	
	Challenges to the assumption that there is a conflict between evolution and religion	Contribution to teacher professional development	Teacher interest Addressing students' questions
	Explanations of the nature of the discipline		
Oppose	Epistemological separation between disciplines	Teachers' difficulties	
	Challenges relating to religion	Consideration of diversity	
		Higher priority for other topics	

Table 3. Conceptual arguments supporting the discussion of evolution and faith.

Argument (number of experts)		Quote	ADM value* (Delphi, 2nd round)
Educational Significance (n=15)	Encouraging expanding students' horizons	*There may be a lot of mutual contributions [between different points of view]* (E.28, Science education researcher, Delphi)	0.277
	Creating an opportunity to develop positive attitudes toward science	*The explicit discourse about science and religion may improve student attitudes towards science* (E.18, Science education researcher, Delphi)	0.486
	Exposing the students to diverse attitudes encourages respect for different worldviews	*People have different backgrounds and come with well-rooted views … Perhaps a discussion would encourage the students to listen to various views, and even if they do not accept them, at least recognize that there are different views* (E.30, Science education researcher, Delphi)	0.777
Challenging the assumption that there is a conflict between evolution and religion (n=11)	Encouraging students' critical thinking and ability to cope with conflicts	*We don't challenge students enough with conflicts …. We try to put things 'in order' for them so everything will be accepted as proven, so that there is no need to ask questions* (E.12, Policymaker, Interview) *When we ignore conflicts, we intensify them … Critical thinking about the conflict makes you understand what assumptions are at its core, as well as its historical background, which shows how the conflict became permanent* (E.17, Science education researcher, Interview)	0.666
Explanations of the nature of discipline (n=8)	Better understanding of the nature of science	*I think religion has a basic structure that differs from science's basic structure. As far as I'm concerned, science and religion have different basic assumptions and rules* (E.4, Science education researcher, Interview)	0.833

*ADM<0.833 indicates consensus; NC=no consensus

education presented pedagogical arguments to address the issue in teacher professional development courses, to enable teachers to attend to students' questions when necessary.

Arguments for opposing the discussion

Opposing arguments pointed to the possible difficulties in this type of discourse. No consensus was found in the second round of the Delphi survey. Table 5 presents the conceptual arguments and Table 6 the pedagogical ones.

The opponents' arguments prioritised the main biological content over what they saw as a marginal issue with limited value that could increase uncertainty.

Table 4. Pedagogical arguments supporting the discussion of evolution and faith.

Argument (number of experts)		Quote	ADM value* (Delphi, 2nd round)
Consideration of diversity (n=9)	Conducting the discussion proactively can serve to cope with diverse student views and beliefs	*Even in non-religious schools, there may be students from traditional families or ones who have heard or read something. Teachers must address it properly, pleasantly, and effectively. You can't just say: 'It's not relevant'...* (E.2, policymaker, Interview)	0.666
Contribution to teacher professional development (n=13)	Developing learning materials and teacher professional development are necessary	*There are sensitivities in certain sectors (e.g. religious) ... discourse should help teachers handle this. Producing adapted learning materials that will speak students' language will make it possible to teach it...* (E.5, Policymaker, Interview)	0.833
Teacher interest (n=4)	Discussing the relationship between scientific theories and religious beliefs should be the teacher's decision	*If schools acknowledge the importance of these topics, then a science teacher and a Jewish studies teacher can co-teach, answering all possible questions that arise in the discussion, making it an exceptional lesson* (E.7, Policymaker, Interview)	1.083 (NC)
Addressing students' questions (n=5)	Discussing the relationship between scientific theories and religious beliefs should take place when students ask questions	*It should be something that a teacher responds to if asked, rather than part of the curriculum* (E.20, Science education researcher, Delphi)	1.333 (NC)

*ADM<0.833 indicates consensus; NC=no consensus

What topics should be discussed in the context of evolution and faith?

The content aspect emerged in the analysis of the experts' responses to the first round of the Delphi survey. In the first round, the participants were asked to point to key issues that are controversial in terms of evolution and faith. The respondents focused on four issues: (1) The origin of humankind – evolution as opposed to creationism, (2) Speciation is a prolonged evolutionary process as opposed to the instantaneous creation of all species, (3) Random changes in processes as opposed to pre-designed processes, (4) The age of Earth: about 4.5 billion years according to radiometric dating, as opposed to about 6,000 years according to religious texts.

In the second round of the Delphi survey (Appendix 2), four statements were written to address the question of what topics should comprise the discussion of the relationship between evolution and faith as part of biology education. An ADM was created for each item tested to assess the consensus for each statement. Table 7 shows there was little agreement about what should be discussed.

The age of the Earth and the randomness of processes only appeared in the Jewish experts' arguments and were not raised at all by Muslims or Christians. No consensus was found concerning the importance of the different issues. Some of the experts explained their unwillingness to discuss any of these issues in biology education:

> There is a substantial difference between religion and science; it is impossible to take a religious description of the creation of humankind that has merely religious merit and hold a comparative discussion between views. It is like trying to solve a mathematical problem with historical analysis tools (E.7, policymaker, Delphi).

Table 5. Conceptual arguments opposing the discussion of evolution and faith.

Argument (number of experts)		Quote	ADM value* (Delphi, 2nd round)
Epistemological separation between disciplines (n=7)	Distinguishing between the disciplines in terms of epistemology and teaching goals	*In science classes, you should teach science, not refer to matters of faith, which should be dealt with in Bible class. It doesn't belong* (E.3, Science education researcher, Interview) *In science, you can't talk about beliefs. Discussing the possible connections rather than saying that it's two separate things that cannot merge, I don't think it can be done. I prefer complete separation* (E.6, Policymaker, Interview) *Evolution is derived from the sciences, while religion is a metaphysical subject. Their purpose, philosophy, and methods cannot be mixed* (E.19, Science education researcher, Delphi)	0.972 (NC)
Challenges relating to religion (n=4)	Concerns about undermining religious worldviews, both among teachers and students	*For religious teachers, in many cases, this is a red flag; it is seen as heresy* (E.14, Policymaker, Interview) *We also have religious Christians and Muslims who have issues with evolution. Even if the discussion doesn't involve human evolution, they fear that once you start, it's a slippery slope* (E.2, Policymaker, Interview)	1.055 (NC)

*ADM<0.833 indicates consensus; NC=no consensus

Some experts saw greater importance in discussing than in addressing specific content:

> All the issues listed here can be outstanding for discussing the contradictions that exist between scientific theories and religious perceptions, and the ways to bridge the gaps. I am not sure if one topic is better or worse than the others. The important thing is how you construct the discussion (E.30, science education researcher, Delphi).

Overall, the experts agreed on several core topics that may cause difficulties for teachers and students and disrupt learning. These included human evolution, speciation, randomness, and the age of the Earth, as in the first round of the Delphi survey. However, there was no agreement on their relative importance, priority, or the extent to which they are controversial.

How should the relationship between evolution and faith be discussed in biology classes?

The *how* aspect emerged from the analysis of the responses to the first round of the Delphi survey and became one of the three foci in the second round of the Delphi survey. The experts' arguments were categorised as presented in Figure 5. We observed that two of the Delphi participants consistently argued that biology class is not the appropriate setting for discussing evolution and faith, as indicated in their answers to both the second and third questions. Two other participants offered a comprehensive response that suggested an integrated approach to managing the discussion.

Table 6. Pedagogical arguments opposing the discussion of evolution and faith.

Argument (number of experts)		Quote	ADM value* (Delphi, 2nd round)
Teachers' difficulties (n=16)	Acknowledging teachers' difficulties (emotional, inadequate content knowledge or pedagogical content knowledge)	*It is difficult because this is a philosophical idea, not like the blood system or the cell …* (E.10, Policymaker, Interview) *I'm not sure that religious students will have all their questions answered after this discussion, which is not encouraged in this [religious] stream … In addition, I'm not sure that religious teachers would know how to produce a fruitful discussion as required* (E.23, Policymaker, Delphi) *There might be a clash of views that requires the teacher's intervention. I don't know if every teacher wants to deal with it* (E.11, Teacher's mentor, Interview) *I think there's a kind of unease there … in the context of evolution, there is a conflict between the teachers' identity and their profession* (E.12, Policymaker, Interview)	1.083 (NC)
Consideration of diversity (n=5)	Teaching one curriculum for all streams	*The curriculum is the same for all … There is a huge diversity, and whoever does not take it into account when writing a curriculum will not be able to implement it* (E.7, Policymaker, Interview)	1.333 (NC)
Higher priority for other topics (n=2)	Preferring to focus on core subjects in biology	*Time is so limited … this is not one of the topics I see as central* (E.2, Policymaker, Interview) *Anyway, the curriculum cannot include all subjects in biology* (E.13, Science education researcher, Interview)	No Delphi Data

Table 7. Issues to discuss in class.

Issue	Number of references (Delphi, 1st round)	AD_M value (Delphi, 2nd round)
The origin of humankind	9	(NC) 1.111
Speciation and creationism	8	(NC) 1.125
Randomness and causation	3	(NC) 1.166
The age of the Earth	7	(NC) 1.222

Content-focused arguments

Eight experts' opinions focused on the scientific content. The foci of their arguments were centred on: (a) Teaching the scientific method: '*The discussion must refer to the nature of science – what is a scientific theory, what are the limitations of the scientific knowledge, how science differs from other disciplines and ways of knowledge and religion in particular*' (E.18, science education researcher, Delphi). (b) Separation between evolution and faith: '*It is important to emphasize that these two are completely distinct, each of which has its existence, that never intersects with the other*' (E.7, policymaker, Delphi). (c) The accommodation approach: '*We should try to highlight and explain non-contradictory*
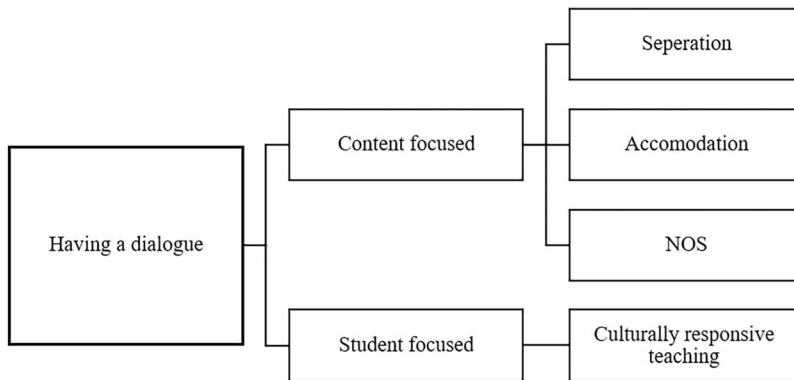
Figure 5. How the discussion should be held – main themes.

religious views. For example, it is not difficult to explain the age of the Earth according to the Jewish religious approach' (E.29, science education researcher, Delphi).

Student-focused arguments
Eight experts emphasised that the students must be considered first.

Their arguments referred to the unique contribution to all students and to modifying the discussion to fit diverse student populations because of the sensitivity of this issue, as reflected in the following quotes:

> We should begin the discussion from the students' point of view and ask them about their perceptions (E.30, science education researcher, Delphi).

> The cultural background of the students should be considered, and implementation of culturally responsive teaching is required (E.18, science education researcher, Delphi).

> We should try to offer 'bridging explanations 'by scholars who are important for the communities the students come from (E.22, science education researcher, Delphi).

> We should respectfully conduct a non-judgmental discourse to avoid creating opposition to broadening their horizons (E.31, science education researcher, Delphi).

Based on the responses from the first round of the Delphi survey, the second round included 12 statements (Appendix 2) that delved into the integration of evolution and faith issues in biology teaching. The first round revealed different approaches to this discussion, with opposing views among experts. For example, the focus could be on either the scientific or religious perspective, or on prioritising the bridging of perspectives while maintaining a clear distinction between evolution and faith. Questions also arose about whether the tone of the discussion should be more critical or tolerant toward religious views.

As with the previous questions, we looked for agreement among experts on the question of how the relations between evolution and faith should be discussed as part of biology education. Analysis according to the alternative index ADM only revealed one area of consensus: the experts agreed that any discussion about the relations between science and religion must deal with the nature of science as part of biology education (ADM = 0.555). This view was reinforced by the comments added by the experts who participated in the Delphi

survey, such as '*A respectful attitude means showing students the fundamental difference between the two disciplines. Understanding that a difference is fundamental can develop respect for the apparent contradiction*' (E.7, policymaker, Delphi).

However, other issues remained unresolved. No consensus was found on whether the discussion should centre on the content or the students. There was no consensus on whether the discussion should prioritise the separation between science and religion (ADM = 1.444) or the accommodation between them (ADM = 1.166). Despite the importance of creating a tolerant space for deliberation, the experts did not agree about the statement that teachers should present the scientific view and the religious view and address both respectfully, as the ADM indicated no consensus (ADM = 0.875). Further, there was no consensus on the implementation of culturally responsive teaching to adapt the discussion to the cultural background of teachers, students, or school type (ADM = 1.166), or according to teachers' objectives (ADM = 1.083).

Thus, overall, similar ideas emerged from the data collected by both research tools. There was a variety of opinions among the experts because of the different foci on the content or the students. In addition, the interviews revealed that over the years, there has been scant discussion in the Ministry of Education's policy-making forums about teaching controversial issues in general, and specifically about evolution in the context of religious beliefs. Ministry of Education officials address criticism of evolution education mainly in response to claims raised by the media that either point to insufficient teaching of evolution or that it is disproportionately emphasised. This lack of discourse and official policy makes it challenging to form a well-reasoned opinion on the pedagogical barriers to discussing evolution and faith.

Interestingly, the experts' views as to how the relations between evolution and faith should be discussed in biology lessons were not aligned with their religious identity. For example, although it might be expected that non-religious experts would be strongly opposed to the inclusion of religious faith issues in biology classes, we found various attitudes, ranging from respectful to more critical stances toward inclusion.

Discussion

In Israel, as in many other countries, evolution education faces challenges caused by religious conflicts among both teachers and students (Siani & Yarden, 2020; Stahi-Hitin & Yarden, 2022a). These challenges are substantial since students often struggle to accept scientific concepts and are likely to accept ideas believed to be related to their religious identities as shaped by their families and communities (Barnes & Brownell, 2016). The fact that the Israeli Ministry of Education deals with evolution education only when the media raises this issue aligns with previous research highlighting the need for compromise in curriculum development (Osborne et al., 2003). The alignment between the interview and the Delphi survey findings suggests that most experts, regardless of their religious identity, recognised the importance of discourse on evolution and faith in biology classes. Most experts expressed concerns about including discourse on evolution and faith in the biology curriculum that serves all students and teachers regardless of religion and ethnicity (Table 6). Nevertheless, 13 of them argued that teachers should be provided with knowledge and tools to discuss evolution and faith if the issue is raised by students (Table 4). Although we believe that science education should distinguish

between scientific knowledge and religious views, discourse on evolution and faith may allow religious students to learn science (Stahi-Hitin & Yarden, 2022a), create a better understanding of the nature of science, and thereby lead to greater trust in science (Reiss, 2010).

In terms of content, the experts did not indicate any specific issue to discuss regarding the conflict between evolution and faith, and they did not prioritise speciation, randomness, or other topics. More important was the consensus as to the need to teach aspects of the Nature of Science (NOS) in any discussion on evolution and faith. Assigning similar weight to scientific and religious ideas in science classes is concerning, as it may reinforce student misconceptions. However, highlighting aspects of NOS may help students justify their claims by distinguishing between scientific and other forms of knowledge (Erduran et al., 2019; Reiss, 2010). Furthermore, it may help students realise that the acceptance or rejection of a theory is based on scientific practices, including the systematic examination of reliable and valid evidence obtained over time (Smith, 1994).

There was no consensus among experts on how to discuss evolution and faith in biology classes. Here, we suggest a few strategies to approach such discourse, which, when combined, may promote learning scientific content, skills, and values. The 'pedagogy of difference' (Alexander, 2017), for example, offers three possible positions from which to examine and address the issue of evolution and faith in terms of 'in', 'from', and 'about' that are elaborated in the Theoretical Background. This kind of discourse allows learning beyond the traditions one inherits, thus promoting at least a better understanding of the theory of evolution, mainly because the student is open to other viewpoints.

The second strategy of sensitive teaching (Reiss, 2019) is based on acknowledging that students may experience conflict related to their religious beliefs while learning evolution (Barnes & Brownell, 2017). The implementation of sensitive teaching assumes that teachers can be sensitive to students' perspectives even if they do not share the same worldview. This may reduce discomfort among both teachers and students and help manage emotional issues such as evolution and faith as the student feels that the teacher respects their views.

Lastly, recognising students' perspectives can form the foundation for culturally responsive approaches that enhance learning by incorporating diverse types of knowledge and tailoring instruction to align with the cultural and religious backgrounds of the students. (Owens et al., 2018; Gay, 2002).

Evolution is an essential component of biology education, but can be viewed as a 'wicked' issue that provides an opportunity to go beyond knowledge acquisition. Most of the Israeli experts in our study agreed that the discourse on evolution and faith in biology classes can promote student learning, even if not formally included in the national biology curriculum. As indicated earlier (Tables 3 and 4), the experts recognised the importance of teachers' professional development in addressing evolution and faith in class to facilitate fruitful discussions. However, our findings indicate a lack of consensus among experts regarding what to discuss and how the discourse should be conducted, thus highlighting that adopting a one-size-fits-all set of values is impossible in diverse education systems. The only consensus was found regarding the opportunity to address the evolution-faith conflict through teaching the Nature of Science (NOS). Therefore, we suggest that elements of NOS, some of which already exist in the

science curriculum, can serve as the guiding principle for discourse on evolution and faith, as it is universal, more acceptable, and provides a common response to diverse religious and ethnic groups studying biology.

The findings highlight both the common and unique challenges of teaching evolution to different religious and cultural groups. Rather than overlooking students' religious beliefs and the perceived conflicts between science and faith, we should promote dialogue about these issues. We believe that engaging in such discussions can help students learn to respect others who hold fundamentally different beliefs, especially in diverse and even polarised societies. Although this study focuses on the complex Israeli education system and its unique religious diversity, our insights apply to multicultural societies around the world today.

Limitations and further study

As with any study, this study has limitations. First, although we compiled a long list of potential participants in the Delphi survey, not all the experts answered the survey questions. Although we met the minimal number of participants required for a Delphi survey (Clark et al., 2020), a higher number of experts could have helped to validate the findings, with a better representation of the Israeli population.

The extended analysis period of the first round of the Delphi data may have contributed to participant dropout during the period between the first and second rounds (a common hurdle in this research method). Concerned about further dropout, we decided to avoid a third round, although it is common to have a brief third round referencing comments from the second round and assessing the stability of consensus over time. In addition, in some cases, the lack of consensus stems from different interpretations of the statements by participants. This represents a limitation for using the Delphi survey, compared with interviews, in which clarification can be provided upon request.

Currently, we investigate Israeli biology teachers' views and needs concerning the issue of evolution and faith. Identifying the experts' views on the one hand and defining teachers' difficulties and needs on the other may suggest a framework for evolution education that addresses diverse students and teachers' populations to policymakers in science education. We also intend to investigate Israeli students from diverse populations to identify specific aspects that pose a unique challenge to believers from different religions. In practical terms, this should lead to the identification of these unique challenges and the development of adapted learning materials and professional development programmes for pre-service and in-service teachers.

AI statement

The authors disclose that Grammarly Pro (v.1.2.182.1722) was used for grammar refinement only. No generative AI tools were used for content creation or data analysis.

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Appendices

Appendix 1. Semi-structured interview questions

(1) Please begin by telling me a bit about your professional position.
(2) What academic training have you had?
(3) How would you identify yourself in terms of religion and culture?
(4) What does the word 'evolution' mean to you?
(5) Can you also please share what your reactions are when you hear the word evolution?
(6) How do you feel about the idea that humans and all other creatures have evolved from a common ancestor?
(7) What do you think should be taught in middle/high school regarding evolution?
(8) Do you have an opinion about the present state of teaching about evolution in schools?
(9) Should teachers be obligated to raise the topic of possible relationships between evolution and the accounts of creation in religious texts? Are you aware of resources that would help teachers do this?
(10) What are your thoughts about teachers' content knowledge and or pedagogical content knowledge (knowledge of how to teach) about the possible relationship between science and religion in the context of evolution education?
(11) What, if any, concerns do you think teachers might have regarding the teaching of evolution?
(12) Are you aware of how the teaching of evolution and its intersection with religion is perceived in any of the sectors in Israel? Please describe.
(13) Has the advisory committee in your discipline (high school biology, middle school science) discussed the possible relationships between evolutionary biology and religious narratives?
(14) If not, why not? If yes, what sorts of issues have been raised in those discussions?

(15) Has the advisory committee in your discipline considered curriculum content and/or teaching strategies on how to address the possible relationships between science and religion in the classroom?

(16) If not, why not? If yes, describe some of the content and strategies that your committee has considered.

(17) In what ways, if any, might strategies such as these create openings for considering possible synergies between science and religion, in addition to any conflict between them?

(18) At what level/s have discussions on teaching evolution taken place (pedagogical secretariat, science wing in the Ministry of Education, the biology leading staff …)? Please explain the process.

(19) Is there anything you would like to add?

Appendix 2. Likert-type questionnaire, Delphi survey, 2nd round

Discussion of the relationship between scientific theories and religious conceptions in the teaching of evolution.

(1) The curriculum does not need to include addressing the relationship between scientific theories and religious concepts.

(2) Engagement with the connection between scientific theories and religious conceptions should follow the nature of the educational institution

(3) Discussion of religious perceptions does not fit into the framework of science lessons

(4) The engagement with the connection between scientific theories and religious conceptions should follow the comfort space of the teacher

(5) A discussion of the connection between scientific theories and religious perceptions will confuse students

(6) An initiated discussion of the connection between scientific theories and religious conceptions makes it possible to address the issue intelligently

(7) It is important to present the differences between a system of scientific thinking and a system of religious thinking, and their functioning in the world

(8) It is important to have teaching materials available that relate to the connection between scientific theories and religious perceptions, to enable the teacher to address the issue as the subject arises in the classroom

(9) An explicit discourse about the connection between scientific theories and religious perceptions may improve students' attitudes toward science

(10) An explicit discourse about the connection between scientific theories and religious perceptions may contribute to broadening students' horizons

(11) An explicit discourse about the connection between scientific theories and religious conceptions allows for a respectful reference to students' existing worldview

(12) An explicit discourse about the connection between scientific theories and religious conceptions may contribute to the development of critical scientific thinking

(13) An explicit discourse about the connection between scientific theories and religious conceptions makes it clear that there is no contradiction between the fields

Topics to be discussed in the teaching of evolution in the aspect of the connection between scientific theories and religious conceptions.

(14) Age of the Earth – Science vs. Religious Belief
(15) Random changes versus design
(16) Species evolve in a long process compared to one-time creation
(17) Evolution of man versus creation of man

How to discuss the connection between scientific theories and religious perceptions in the context of the teaching of evolution.

(18) The main approach should be a separation between religion and science
(19) Addressing the connection between scientific theories and religious conceptions must include a reference to NOS (the nature of science)
(20) The teacher should compare the theory of evolution with the religious conception
(21) Students will make a comparison between the theory of evolution and the religious conception
(22) The matching approach can be combined with the approach of separation between religion and science
(23) The arguments of opponents of evolution should be presented and discussed critically
(24) Judicial treatment of one of the approaches should be avoided, as judicial treatment may create opposition to the expansion of opinion
(25) It is recommended that the teacher explain his or her perceptions of the subject
(26) The religious position must be juxtaposed to the scientific position in a way that respects both
(27) A respectful approach to the various approaches may make the student think that there is no contradiction between religion and science
(28) The starting point for any discussion should be the belief in God as a basis for knowledge
(29) The cultural baggage of the target population should be taken into account, and culturally adapted teaching based on appropriate sources of knowledge should be implemented