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ORIGINAL PAPER

Crossing borders between science and religion: Muslim Indonesian biology teachers' perceptions of teaching the theory of evolution

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Abstract
Teaching the theory of evolution has often faced various challenges, including teachers' internal conflict between the theory of evolution and their personal religious beliefs. This multiple case study examined the perceptions of and approaches to teaching evolution of six Indonesian Muslim biology teachers who were working in three different teaching contexts: public, Islam- and Christian-based schools. Major data sources included interviews, lesson plans, and a survey on the teachers' acceptance of evolution and their positions on the relationship between evolution and religion. Interviews and lesson plans were analyzed using constant comparative methods, and each participant's average scores on the survey were calculated and compared descriptively. Findings indicated that most of the teachers rejected human evolution, but accepted microevolution. Although the teachers rejected the idea of human evolution, they still taught it because it is mandated by the national curriculum and thus considered teaching evolution as a representation of teachers' accountability. To reconcile the conflict between the theory of evolution and religious beliefs, they adapted their personal goals for teaching evolution, for example, helping students appreciate human thinking. Particularly, teachers in Islam-based schools believed that strengthening students' religious beliefs is part of their goals for teaching evolution. In addition, we found that teachers might use multiple border crossing approaches to help them teach evolution. This study underscores the importance of contextual factors, including school settings, mandated national curricula, and high-stakes examinations, in shaping teachers' perceptions of and willingness to teach evolution.

Keywords Perceptions of teaching evolution · Religious beliefs · Indonesia · Muslim teachers · Multiple case study

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The theory of evolution is the only scientifically accepted theory that explains the diversity of life on Earth, which provides foundations to explicate scientific phenomena, especially in the biological sciences (Mayr 2000). Research has indicated that understanding evolutionary processes and concepts is essential to making informed decisions on socioscientific issues, such as antimicrobial resistance (Berendonk et al. 2015), genetically engineered food (Knott and Doudna 2018), and personalized medicine (Alizon and Méthot 2018). Rodger Bybee (1997) argued that people could not be scientifically literate if they do not understand and accept the theory of evolution. In a similar vein, Vaughn Cooper et al. (2019) posited that strong evolutionary knowledge is critical to pursue and excel in advanced STEM degrees and careers.

Therefore, evolution has been a core component of the science curriculum in most countries in the world (Deniz and Borgerding 2018). For example, in the United States (US), key scientific and educational organizations, such as National Association of Biology Teachers (NABT 2011), National Science Teachers Association (NSTA 2013), and the American Association for the Advancement of Science (AAAS 2011), have published statements emphasizing evolution as one of the essential theories of science in general and of the biological sciences in particular. Specifically, the NSTA (2013) "strongly supports the position that evolution is a major unifying concept in science and should be emphasized in K–12 science education frameworks and curricula" (p. 1).

In Indonesia, a secular democratic country with more Muslims than any other country, 13% of the total number of Muslims worldwide (Pew Research Center 2011), evolution is one of the mandatory topics to be delivered in K-12 education. The latest Indonesian national curriculum clearly states that students should be able to "explain the theory, principles, and mechanism of biological evolution and the current views on speciation" and "provide an overview of the possibilities of diverse and alternative views on biological evolution" (Mendikbud 2018, p. 7). The alternative views mentioned in the curriculum refer to both scientific ideas prior to Darwin's theory and non-scientific popular evolutionary theories, such as from anti-evolutionist, Harun Yahya.

Teaching evolution at both secondary and undergraduate levels has encountered various challenges around the world including Austria (Eder et al. 2011), Canada (Ashgar 2013), the US (Barnes and Brownell 2018), and Lebanon (BouJaoude et al. 2011), as well as Indonesia (Rachmatullah et al. 2018). The challenges associated with teaching and learning evolution that research has identified can be classified into four domains: conceptual, epistemic, religious or worldview, and sociocultural (Deniz and Borgerding 2018). The conceptual domain refers to students' and teachers' conceptual ecologies, as well as the way they learn and conceptualize evolutionary theory. Hasan Deniz and Lisa Borgerding (2018) describe that this domain "includes both scientifically accepted evolutionary concepts and students' nonscientific conceptions related to the evolutionary theory" (p. 4). The epistemic domain consists of personal epistemological beliefs and understanding of the nature of science. The religious/worldview domain refers to the two philosophical views of the world and reality, materialism and theism. Lastly, the sociocultural domain includes students' and teachers' milieu and responsiveness to their surroundings.

Among those challenges, Aaron Sickel and Patricia Friedrichsen (2013) reported that teachers face more challenges in religious and sociocultural domains. This finding is echoed by Amanda Glaze and Jenice Goldston's (2009) study showing that teachers attempted to avoid teaching evolution due to conflicts between their religious beliefs and the theory of evolution. Research has indicated that religion greatly influences one's acceptance of evolution. For instance, in another study, Amanda Glaze et al. (2015) found that teachers' religiosity negatively predicted acceptance of evolutionary theory. Their study also

indicated that the influence was more potent than teachers' understanding of the nature of science (NOS). Similarly, Randy Trani (2004) reported a high negative correlation ($r = -0.80$) between teachers' acceptance of evolution and their religious convictions. From these results, it can be inferred that teachers' religious beliefs are closely related to their instructional decisions in teaching evolution as well as their acceptance of evolution.

In this regard, to gain insight into how to support biology teachers to effectively teach evolution, a key concept of science, it is critical to understand how teachers with religious beliefs perceive the theory of evolution and teaching evolution, and how they navigate between their religion and the theory of evolution. To date, most research on teaching evolution has been conducted with American Christian teachers. Hence, little is known how teachers from different countries and religions view and approach teaching evolution. In addition, considering that teaching is highly context-dependent, teachers' perceptions and experiences of teaching evolution might depend on their teaching contexts, especially whether they teach in schools where their students hold the same religion as or different religion from theirs.

Keeping these in mind, the present study explored Indonesian Muslim biology teachers' perceptions of and instructional approaches to teaching the theory of evolution, with these teachers working in three different school settings, namely public, Islam- and Christian-based schools. The research questions that guided this study are:

1. What are Indonesian Muslim biology teachers' perceptions of the theory of evolution?
2. What are Indonesian Muslim biology teachers' perceptions of teaching the theory of evolution?
3. How do they negotiate the conflicts that occurred between evolution and religion while teaching the theory of evolution?

This study will contribute to advancing our understanding of the nature, challenges, and dilemmas of teaching evolution across diverse contexts by adding empirical findings with an under-researched population, Muslim teachers, in the unique context of Indonesia where Islam is deeply intertwined with the local culture (Lubis 2013). By examining Muslim biology teachers' approaches to teaching evolution, this study will also provide significant insights into complex interactions among religion, acceptance of evolution, and pedagogical decisions related to teaching evolution.

Theoretical background

Sociocultural constructivism and cross-cultural theory

Lev Vygotsky's sociocultural constructivism (1978) and Olugbemiro Aikenhead and Glen Jegede's (1999) cross-cultural theory guided this study as the theoretical frameworks. Sociocultural constructivism considers learning as a social process, with humans' intelligence and reasoning originating in culture and society (Vygotsky 1978). Rogoff (1991) indicates that learning is the result of "guided participation" (p. 146) that includes "mutual involvement of individuals and their social partners … as they participate in sociocultural collective activity" (p. 146). Thus, learning occurs through "complex social negotiation" (Brown, Collins and Duguid 1989, p. 33) or "enculturation" (Packer and Goicoechea 2000, p. 229) that requires learners' adoption of a specific belief system to be a member of a particular

culture. According to Aikenhead and Jegede (1999), however, teaching and learning science, including evolution, often results in cultural clashes. This is because the culture of constructing scientific knowledge in science class tends to differ from students' daily lives and their indigenous cultures both in Western and non-Western cultures. For instance, when students and teachers learn or teach the concept of heredity, they may find it difficult to fully grasp the concepts if they are unable to relate it to their daily lives, such as through a family tree. In this regard, to embrace a more culturally sensitive curriculum, under the tenet of cross-cultural theory of learning, Aikenhead and Jegede (1999) proposed four border crossing types: smooth, managed, hazardous, and impossible.

In the context of the current study, *smooth border crossing* refers to when teachers flexibly move between the understandings of and beliefs about evolution considered as correct by both cultures (i.e., religion and science). *Managed border crossing* occurs when the teachers hold conflicting ideas between their religious beliefs and the theory of evolution, but still manage to embrace the contradictory ideas, albeit without a stable resolution. The third category, *hazardous border crossing*, takes place when the teachers resist accepting a conflicting idea about evolution but still teach it for the success of their classes. Lastly, *impossible border crossing* occurs when the teachers chose to avoid teaching the theory of evolution without resolving any cognitive conflicts they experience.

Sociocultural constructivism and cross-cultural theory guided this study in several ways. First, considering that teachers' perceptions of the theory of evolution can be highly influenced by culture and religion (Mansour 2010), we purposefully selected teacher participants to maximize variations in surrounding religious beliefs and culture of schools in which they were teaching. Second, the cross-cultural theory inspired the development of interview questions that could elicit and capture the participants' thoughts on the influence of religious beliefs and culture on their pedagogical approaches. Finally, the two theoretical frameworks guided the selection of analytical approach —inductive analysis methods—and interpretations of the results. Specifically, we considered that the teachers' instructional approaches pertaining to the theory of evolution are meaning-making processes inevitably influenced by their cultural and religious beliefs. With this in mind, we were cautious not to be judgmental about the quality of their instruction of evolution, their fidelity to the national curriculum, and their informed scientific knowledge of the theory of evolution. Instead, we attempted to understand the tensions between teachers' personal religious beliefs and mandated curriculum that often require crossing cultural borders.

Teaching evolution in K-12 education

Evolution is essential to the science curriculum and scientific literacy not only because of its power to explain the origin and development of life but also because of its practical value and relevance to daily life (Bybee 1997). Kathryn Green (2019) posited that understanding and accepting the theory of evolution has a significant influence on economic development because, through an evolutionary lens, scientists can invent and produce novel products, such as stem cells and genetically modified foods and crops of economic value. Therefore, all students should have opportunities to learn evolution at least once in their lifetime, and that time may only be in K-12 education (Long 2012).

Renia Gasparatou (2017) identified three major goals for teaching science: preparing future scientists, developing educated citizens, and promoting scientific habits of mind and practical skills. Jason Wiles and Brian Alters (2011) asserted that those goals could be attained through teaching evolution as it provides the necessary habits of mind for pursuing

advanced STEM degrees and careers and for creating more educated citizens. Craig Nelson (2008) also suggested that examining the underlying constructs of the theory of evolution could nurture critical thinking skills. This is because while learning evolution, students are deeply engaged in the interconnected ideas, including science and religious ideas, which enables them to detect inconsistencies and irrationality and actively evaluate their arguments, justifications, values, and beliefs (Nelson 2008).

Challenges to teaching evolution in K-12 education

As aforementioned, research has identified conceptual, epistemic, religious and worldview, and sociocultural challenges that K-12 students and teachers encounter when learning and teaching the theory of evolution (Deniz and Borgerding 2018). Although these four domains of challenge impact both teachers and students, research has shown that students encounter most obstacles in the first three domains (Deniz and Borgerding 2018), whereas teachers face more challenges in the last two domains (Sickel and Friedrichsen 2013).

There have been several studies on teachers' dilemmas and struggles when teaching evolution. For example, by interviewing biology teachers in Arizona, Joyce Griffith and Sarah Brem (2004) found that teachers experience internal and external conflicts and pressures while teaching evolution. The sources of these conflicts are either religious or sociocultural. Similarly, Glaze and Goldston's (2015) extensive review of research on US teaching and learning of the theory of evolution revealed that religious and sociocultural factors create the most difficult challenges to teachers when they are teaching evolution. They also found that teachers in several studies deemphasize and avoid teaching the theory of evolution due to religious and sociocultural reasons, such as incongruence between evolution and their religion. In a similar vein, Terry Bramschreiber (2013) reported that, sometimes, parents, colleagues, and members of the clergy challenge teachers by bringing in creationist ideas and literature, demanding that the teachers answer their questions related to evolution.

Taken together, it is clear that the surrounding culture and religion greatly influences teachers' perceptions of and approaches to teaching evolution. However, all of the studies mentioned above were conducted with American Christian teachers. As a result, little is known about what and how teachers from other countries and religions perceive and experience when teaching evolution and, more importantly, how they overcome difficulties and challenges, if encountered, when teaching evolution in their unique contexts. This study intended to fill this gap in the literature by exploring biology teachers' perceptions of and experience with teaching the theory of evolution in one of the world's largest Muslim majority democratic countries, Indonesia.

Factors influencing teachers' perceptions of teaching evolution

Research has identified several factors that impact teachers' perceptions of evolution and teaching evolution, such as religious beliefs and contextual factors. In a study that investigated science teachers' conflicts when teaching evolution in Egyptian Islamic communities, Nasser Mansour (2011) reported that teachers attempted to adapt their views on evolution based on personal religious views, i.e., Islamic views, which caused internal conflicts. In contrast, Rahmi Aini et al.'s (2020) study with Indonesian Muslim biology professors and pre-service biology teachers found that the participants did not see any conflict between

evolution and religion and tended to seek more harmony between evolution and religion when teaching evolution units.

Saouma BouJaoude et al.'s (2011) study on Lebanese secondary science teachers' and professors' views on evolution education showed that some participants emphasized "the role of God in creation during instruction on evolution" (p. 979). In the same vein, studies of teachers in Christian (Mangahas 2017) and Jewish (Siani and Yarden 2020) communities revealed a similar result in which the teachers stress their personal religious beliefs in the teaching of evolution. However, a study conducted by Anila Ashgar (2013) with Pakistani and Canadian Muslim teachers found that teachers taught evolution because it is a mandatory topic included in both the curriculum and the biology textbooks, even though they did not accept the theory. Although research on the impact of cultural, social, and religious contexts on teaching evolution has started to emerge, this line of research needs to expand into more diverse contexts to understand better the complexity of teaching evolution that continually interacts with a myriad of internal and external factors.

Evolution in Islam

Although the followers of some major world religions have been found to possess less positive acceptance toward the theory of evolution (Deniz and Borgerding 2018), Muslims may have different perspectives because, as Khadija Fouad (2016) commented, they may have various interpretations of the sacred texts, the Quran and Hadith. The Quran or Al-Quran is a holy book consisting of God's word dictated to the Prophet Muhammad. The Hadith composes the traditions attributed to the Prophet Muhammad (Fouad 2016). The Quran discusses the creation of the universe and the first human, who is Adam. Muslims' understanding of the creation of the universe is teleological. God creates the universe for a particular purpose: to worship Him, as mentioned in the Quran's chapter Al-Anbiya verse 26. In addition, Muslims also believe, as stated in the Quran chapter Al-Baqarah verse 255, that God is the one who is responsible for maintaining all the life in the universe.

With respect to the time taken for the process of creation, the Quran describes that it occurs in six days that refer to a specific period rather than six days of 24 h. Fouad (2016) translated the relevant Quran verse as "God is He Who created the heavens and the Earth and whatever is between both of them in six eons" (32:4, p. 10). With all of these verses, some Muslim scholars argued that most Muslims should not have a problem accepting the theistic view of evolution and the old age of the Earth (Fouad 2016).

Muslims may find a discordance between the scientific theory of human evolution and their understanding of Adam's creation. In the Quran, Adam is depicted as the first human created by God, so Adam could not have evolved (Huda 2019). Some example verses from Quran related to this are:

> And when your Sustainer said to the angels, "Indeed, I am One Who creates a human being from clay dried from stinking dark mud. So, when I have proportioned him and I have breathed into him from My Spirit, then all of you fall down in prostration to him." (15:28–15:29, translated by Fouad 2016, p. 11)

It becomes highly predictable that Muslims may experience conflict with the idea of human evolution (Kazempour and Amirshokoohi 2018). However, Fouad (2016) contended that Muslims would not have a problem with the theory of evolution of other creatures, such as plants and animals. Fouad (2016) supported this assertion citing a verse from Quran regarding Noah's flood, which Muslims understand only happened to Noah's

people, not to other creatures or other regions in the Earth. With the same logic, the idea of plants and animals' evolution does not present any problem to Muslims, and they may easily accept it.

Research on evolution education in Indonesia

Most studies on evolution education in Indonesia focus on the impact of different teaching methods on either high school or college students' understanding and acceptance of evolution. For instance, Ahmad Ghorib (2017) examined the impact of argumentation or active debate on high school students' understanding of the theory of evolution. Although Ghorib (2017) found a positive impact of the intervention on students' understanding of the theory of evolution, its impact on students' acceptance of evolution was minimal. Lukita Putri (2016) compared high school students' acceptance of the theory of evolution between public and Islam-based schools and reported no significant difference between the two groups. A few studies examined teachers' perceptions of evolution in Indonesia. However, these centered on pre-service teachers (Rachmatullah et al. 2018) and university instructors (Aini et al. 2020). No previous study has investigated in-service teachers' perception of evolution and their pedagogical approaches to teaching evolution, which would provide important implications for improving the instruction of evolution in Indonesian K-12 classrooms. Our study directly responds to this need by investigating how high school biology teachers think about evolution, negotiate conflict, and approach teaching the theory of evolution.

Methods

Research design

This study employed a multiple-case research design to develop an in-depth understanding of a bounded phenomenon (Yin 2018). The cases in this study were six Muslim teachers who are teaching biology to 12th graders (ages of 17 to 18) across various school settings (i.e., Islamic, Christian, and public) in Indonesia. A multiple-case study can increase the variability of the cases, leading to more compelling and precise interpretation (Merriam 2009). By creating meaningful analysis and comparisons across the six case teachers (Creswell and Poth 2018), this study will develop a fuller understanding of how the teachers' perceptions of teaching the theory of evolution might intersect with their views on the theory of evolution, their religious beliefs, and various contextual factors.

Research context

Education, culture, and religion in Indonesia

Indonesia is an archipelagic country located in the southeastern part of Asia. With approximately 260 million citizens, Indonesia is the third most-populated democracy in the world (Central Intelligence Agency [CIA] 2016). Indonesia is also the most ethnically and linguistically diverse country in the world, with 300 ethnic groups and 700 living spoken languages (Skutnabb-Kangas 2000). Each linguistically and ethnically diverse group comes with its own customs and rituals, which are interestingly intertwined with the practices

of the world's most prominent religions—Islam, Christian Protestantism, Roman Catholicism, Hinduism, and Buddhism. Thus, religions in Indonesia are unique and often different from the practices of the religions in other countries (Parker 2017).

Religion is central to Indonesians' lives, a feature well-reflected in the Indonesian ideology and constitution, Pancasila. Pancasila was created in 1945 when Indonesia obtained independence from Japan. It consists of five pillars that are taught in K-16 schools: (1) Belief in the One and only God; (2) A just and civilized humanity; (3) A unified Indonesia; (4) Consultative democracy; and (5) Social justice. The importance of religion is evident in the first pillar because it is obligatory to believe in and adhere to a religion in Indonesia. However, only six religions—Islam (87%), Christian Protestantism (7%), and Roman Catholicism (3%), along with Hinduism, Buddhism, and Confucianism (3% collectively)—are acknowledged by the Indonesian government, and Indonesian people must identify themselves with one of these six religions (Parker 2017). Despite a dominant Muslim population, Lyn Parker (2017) emphasizes that Indonesia is not a Muslim country, but a religious country.

Religious and cultural values are also an essential part of the Indonesian national curriculum, including the science education curriculum. All public and some private schools have used the 2013 national curriculum (Rachmatullah et al. 2018). Revised in 2018, the national science curriculum requires teachers to address four components of learning in every topic: spiritual, social, knowledge, and skill. These four aspects, particularly spiritual and social competencies, need to be addressed by connecting science subject matter to the spiritual and social contexts that most students encounter or to the contexts that schools value.

Generally, Indonesia adopts a 6–3–3 system of education in which students spend six years in elementary school and three years each in middle and high schools. Indonesia has one national curriculum for each educational level that is developed by the government. Teachers have flexibility to develop their own curriculum so long as it addresses all topics included in the national curriculum. Before 2020, for students to move from elementary to middle or to high school, they needed to pass a national examination at the 6th, 9th, and 12th grades, respectively. The national examination is high-stakes and held once a year in all schools in Indonesia.

The place of evolution in the Indonesian national curriculum

All Indonesian schools, unless private schools, must use the national curriculum. Many private schools have developed a hybrid curriculum combining the national curriculum and their adapted curriculum. The era of colonialism, and thus western ideas, profoundly influenced the initial development of the Indonesian educational system and its curriculum (Wangsalegawa 2009). The influence of western ideas has persisted, explaining the presence of and emphasis on evolution in the current national science curriculum in Indonesia.

The evolution unit is taught exclusively in the second semester of the 12th grade. Explicit teaching of the theory of evolution does not occur in the previous grades. Rather, students learn some topics related to evolution, such as biosystematics, genetics, and biodiversity. Evolution is also one of the topics covered in the high school national examination, claiming two or three questions out of forty-five in the biology portion. In higher education, a course on evolution is mandatory for students pursuing a degree in general science education, biology education, and other biological sciences. Therefore, teachers in

Indonesia are likely to have taken the evolution course during their teacher education program in college.

Participants

Six Indonesian biology teachers from six different schools located in Java Island of Indonesia participated in this study. These teachers were from three different school types, i.e., public ($n=2$), Islam-based ($n=2$), and Christian-based ($n=2$) high schools. They were purposefully recruited and selected by identifying the best informants for the phenomenon being studied (Creswell and Poth 2018). For the purpose of this study, three criteria were used for participant selection. First, they had to be a Muslim who was teaching in one of the three school types mentioned above. Second, they had to be teaching 12th grade, given that evolution is taught only in this grade. Lastly, they had to have taught evolution for at least three years by the time of this study, so that the teachers would be able to provide richer information about their thoughts, practices, and experiences with teaching the theory of evolution.

As shown in Table 1, five teachers were male and one teacher was female. The female teacher taught in a Christian-based school. The participants' experiences of teaching the theory of evolution ranged from three to ten years. While two of the teachers had a master's degree, the other four teachers held a bachelor's degree. All of the participants' names and schools used in this paper are pseudonyms.

Data collection

Major data sources for this study included semi-structured individual interviews, lesson plans, and a survey. Our interview protocol was developed by adopting several questions from the interview protocols used in Jenice Goldston and Peggy Kyzer (2009) and Elizabeth Barnes and Sara Brownell (2018) that explored biology teachers' and professors' views on teaching the theory of evolution. Our interview questions mainly focused on eliciting teachers' thoughts and ideas on the theory of evolution, teaching evolution, pedagogical approaches, and conflicts they experienced while teaching the theory of evolution. In addition, several questions asked about school culture and context and the teachers' views on its alignment with their evolution instruction (see Appendix A for the interview protocol). All interviews were conducted in the teachers' native language, i.e., Bahasa Indonesia, and they lasted from 50 to 80 min. Interviews were audiotaped, transcribed verbatim, and then imported to Atlas.ti for further analysis.

We also collected the teachers' lesson plans for the evolution unit prior to the interviews. We then used the preliminary analysis results from these lesson plans during the interview process as a means to facilitate their thinking regarding their pedagogical approaches to teaching the theory of evolution. Additionally, the lesson plans were analyzed for triangulation purposes. A survey was administered to the teachers to examine their acceptance of the theory of evolution and position on the relationship between evolution and religion (see Appendix B for the survey items). This survey consisted of 15 questions including 14 4-point Likert-type questions validated by Mike Smith, Scott Snyder and Randolph Devereaux (2016) and one checklist item borrowed from instruments developed and validated by Pratchayapong Yasri and Rebecca Mancy (2016). As original survey items were written in English, they were translated into Bahasa Indonesia by two graduate students fluent in both English and Bahasa. Specifically, one graduate student involved in this study

Table 1 Demographic information of the participants

Participant (Pseudonym)	Education	Gender	Teaching experience	Teaching experience for evolution	School type	Ethnic group
Jerry	B.A. in Biology Education	Male	12 years	3 years	Public	Javanese
Wirman	B.A. in Biology Education	Male	7 years	7 years	Public	Javanese
Asep	B.A. in Biology Education	Male	4 years	4 years	Islam-based	Sundanese
Zulkifli	M.S. in Biology	Male	8 years	8 years	Islam-based	Sundanese
Zakaria	M.Ed. in Biology Education	Male	8 years	8 years	Christian-based	Sundanese
Seria	B.S. in Biology	Female	10 years	10 years	Christian-based	Sundanese

translated the survey into Bahasa; then, the second graduate student, who had not seen the original English version of the survey, translated the Bahasa version back into English. Following this step, the two graduate students compared the original English survey to the back-translated English survey for accuracy and adequacy. They then made the necessary changes to the Bahasa version.

Data analysis

We analyzed the interview data using the constant comparative analysis method (Strauss and Corbin 1998) to identify emerging patterns and key features that span across the six teachers (Creswell and Poth 2018). Specifically, the analysis consisted of three phases. In the first phase, we did multiple rounds of open coding, mostly line-by-line (Strauss and Corbin 1998), to capture the essence and meaning of each data segment. Next, we grouped the open codes into more abstract concepts, i.e., categories and subcategories, by constantly comparing and contrasting their similarities and differences (Strauss and Corbin 1998). Through this axial coding process, a codebook was established as shown in Appendix C. To estimate the reliability of coding, a second coder, an Indonesian graduate student in science education and familiar with the constant comparative method, was asked to code 20% of the data. The second coder was given a subset of segmented data, the codebook, and the description of coding rules. Initial inter-coder agreement percentage ranged from 92 to 99% per subcategory, and the average agreement was 96%, which was acceptable (Krippendorff, 2004). Any differences were discussed until an agreement was reached, which led to modifications to the codebook.

The last phase was selective coding (Strauss and Corbin 1990). Here, a central phenomenon was deduced, and the interrelationship of categories, subcategories, and properties were used to generate a constructive story (Saldaña 2013). The interrelationships were displayed in the form of a network and were discussed through peer debriefing (Patton 2002). Throughout the entire analysis procedure, we recorded memos that contained initial thoughts of methodological decisions, analytical ideas, and possible emerging themes (Charmaz 2002).

Participants' responses to each of the acceptance of evolution items in the survey were scored on a Likert-scale with points ranging from 1 (strongly disagree) to 4 (strongly agree). An average was generated for each participant and compared descriptively to other participants. Responses to the last question about the teachers' position on the relationship between evolution and religion were analyzed based on Sarah Brem, Michael Ranney and Jennifer Schindel's (2003) eight categories presented in Appendix B.

Limitations

We acknowledge that our study is limited in several ways that one should be aware of in interpreting the findings of this study. Although this study aimed to explore Indonesian biology teachers' views on the teaching of the theory of evolution, this study only included teachers from one island and two ethnicities in Indonesia. Indonesia comprises more than 18,000 islands, 300 ethnic groups, and more than 700 spoken languages (CIA 2016). Considering complex interactions among one's perception, religion, and local culture, the findings from this study cannot be generalized to the entire biology teacher population in Indonesia. The disproportionate gender distribution of the participating teachers is a clear limitation of the study. In Indonesia, female teachers outnumber male teachers, making our

sample unrepresentative of the Indonesian teacher population. However, we had limited control of this factor as our sample consisted of biology teachers who met our selection criteria and agreed to participate in the study. Still, we are aware of the potentially significant role of participants' gender in their perceptions of the theory of evolution, as demonstrated in previous studies (Fiedler et al. 2019). Additionally, while interviews were conducted and transcribed in Bahasa, for this paper, some of the excerpts were translated into English. The English translation might not precisely capture the subtle contextual expressions of the participants, but we tried to provide detailed contextual information for each excerpt to help readers better understand their meaning.

Findings

Teachers' perceptions of the theory of evolution

Regardless of school context, the teachers' perceptions of the theory of evolution shared three major commonalities that mainly stemmed from their personal religious values and educational backgrounds: (1) religion offers absolute knowledge, (2) microevolution is more acceptable than macro- and human evolution, and (3) humans evolve from and into other humans. Each shared perception is described in detail below.

Religion offers absolute knowledge

Most teachers believed that knowledge taught by religion is absolute; thus, God creates and controls living beings, including the process of evolution. The teachers considered religious ideas as being beyond human knowledge, and scientific knowledge as a kind of human knowledge that aims to reach and align with religious knowledge. Jerry described this notion, saying:

> Religion is truthfully absolute and contains the ultimate truth. That is why when something is different [from religion], I always tell my students that human reasoning can only reach this point for now, and someday probably a new theory that aligns with what is written in our holy book will be developed.

Similarly, Zakaria, who was teaching at a Christian school, stated that whenever his students asked about the relationship between evolution and religion, he always attempted to convince them that evolution and religion are two incomparable dimensions, supposing that religion is a dogma that contains a set of undeniable principles. Zakaria said, "I always said [to them], "Why are you comparing something unchanging with something that is constantly changing?" What I mean by "changing" here is not within the period of one or two years." This view that religious knowledge is absolute appeared to greatly influence the teachers' perceptions of the theory of evolution, especially human evolution, discussed in the next section.

Microevolution is more acceptable than macro- and human evolution

As shown in Table 2, which depicts the teachers' positions on the three contexts of evolutionary theory (microevolution, macroevolution, and human evolution), all the teachers strongly accepted the idea of microevolution. Table 2 summarizes teachers' acceptance of

Table 2 Teachers' acceptance of evolution and position on the relation between evolution and religion

Teacher (Pseudonym)	Position on the relationship between evolution and religion	Score on acceptance of evolution (max 4)	Position on microevolution	Position on macroevolution	Position on human evolution
Jerry	Literal creationism	2.93	Accept	Reject	Reject
Wirman	No position	2.93	Uncertain	Uncertain	Reject
Asep	Literal creationism	2.50	Accept	Reject	Reject
Zulkifli	Progressive creation	2.93	Accept	Accept scientifically	Uncertain
Zakaria	Theistic evolution	3.50	Accept	Accept scientifically	Reject
Seria	Agnostic evolution	3.29	Accept	Accept	Partially accept

the theory of evolution based on interview and survey, as well as their positions on the relationship between evolution and religion.

As evidence of microevolution, teachers often cited the need for continually changing antiviral and antibiotic drugs because of the evolution of viruses and bacteria, as well as examples of antibiotic- and pesticide-resistant bacteria and insects. This is well reflected in the following excerpt from the interview with Seria:

> I do think that microevolution is happening, especially now when the Earth and environment are changing to trigger mutation leading to evolution ... for example, the medicine we used in the past is not effective for the same virus nowadays ... and this also applies to bacteria.

Additionally, Zakaria affirmed that some scientific developments, such as genetic engineering, made him more willing to understand and accept the idea of microevolution, saying:

> To me, evolution is more probable and makes sense for lower-level organisms or simpler organisms such as bacteria. Bacteria genomes or those of other unicellular organisms are easily engineered and thus could lead to the birth of new species.

However, concerning macroevolution, Zakaria expressed his belief that cumulative microevolution leading to the evolution of more complex organisms is less probable than microevolution in lower-level organisms. Furthermore, he believed that evolution might occur in more complex organisms but would not lead to speciation, explaining, "If the final end of macroevolution is speciation … in which, for example, a species or population creates a new population that cannot breed anymore … it would be really hard to explain." Interestingly, both Zakaria and Seria scored higher points on the survey about acceptance of the theory of evolution than the other four teachers, as indicated in Table 2. Moreover, these two teachers exhibited more developed positions on the relationship between evolution and religion (i.e., theistic and agnostic evolution, respectively), which implies that they believed that evolution is occurring. However, Zakaria believed that God controls the evolution process.

We found teachers who either took a position as literal creationism or did not take any position on the relationship between evolution and religion based their reasoning on religious beliefs. For instance, Asep used his religious beliefs to explain why he rejected macroevolution and human evolution:

> I don't think they [animals] evolve … all animals that are present today have the same form as what they were when they were first created by Allah … so I do not think they have evolved. Also, there are many other evolutionary ideas that I cannot accept. For example, we, in Islam, believe that the ancestor of humans is Adam … not primates, as many evolutionary theorists have said.

A factor impacting the teachers' rejection of macroevolution and human evolution may be limited knowledge of and evidence for macroevolution and human evolution. According to Jerry:

> My understanding is that Darwin talked about humans evolving from non-humans for a long period of time. However, we see now that there is no monkey which evolves to be human … So, I don't accept it because I think the idea still lacks evidence.

Unlike Jerry, Zulkifli expressed that his educational experiences in college and graduate school had helped him accept the theory of evolution, reporting:

> Scientifically, I agree with macroevolution, because when I was taking an evolution class taught by [name of professor], she showed me evidence of traits that mostly Pisces [jawed fish] have, but those traits are also in Amphibia [amphibians].

This implies Zulkifli's graduate study in biology, and thus greater exposure to scientific evidence for evolution, might contribute to his advanced views on evolution. Based on the analysis of his survey responses, he was identified as a progressive creationist (see Table 2). Yasri and Mancy (2016) describe this position as having a belief that "[a]ll forms of life were gradually created over time by a deity in more or less their present form" (p. 386) which is the position or phase before one accepts the theory of evolution.

Humans evolve from and into other humans

The teachers accepted the idea of human evolution only in the context of humans evolving from and into other humans, not from or into non-human organisms. Particularly, most of the teachers believed in the evolution of human thinking, such as the invention of science and technology, and human evolution from and into different ethnicities. However, all of them did not believe that speciation had occurred. Asep said:

> According to my religion, all living beings evolve into the same species. In the case of humans, they evolve from and into humans, not primates … For example, we know that Adam was very tall, much taller than all humans that are living now. So evolution seems to have happened and resulted in shorter humans, but still we are human, and we are not different from Adam.

Although most of the teachers did not accept the idea of speciation and human evolution, Zulkifli and Seria expressed uncertain perceptions towards human evolution. Citing evidence, such as rudimentary organs like the appendix and coccyx (i.e., the tailbone), they were partially conflicted with the idea that humans evolved from lower animals. Even so, Zulkifli said that this conflict motivated him to enrich himself by studying more about human evolution as well as religion.

Perceptions of teaching the theory of evolution

Our analysis revealed that the teachers generally thought that teaching the theory of evolution is a challenging task due to students' lack of interest, conflicts with religious beliefs either within themselves and/or their students, and insufficient teaching resources compared to other biological units. In addition, they believed that their teaching the theory of evolution demonstrates accountability because the national curriculum mandates it.

Teaching the theory of evolution is a challenging task for teachers

Every teacher expressed that teaching the theory of evolution is always a challenging task for them. One reason is that some of the concepts taught in the evolution unit do not align with teachers' religious beliefs, especially the topics related to human evolution and origin of life. For instance, Asep mentioned that these topics challenge his personal religious beliefs, and result in his instructing students to follow religious teachings and to only understand or apply evolution concepts for examination purposes. Likewise, Zakaria

thought that teaching evolution in a religion-based school or environment is challenging because the scientific ideas taught in evolution do not always align with the school's goals:

> I always find teaching evolution is a challenging task, especially when I started working in this [Christian] school ... because the vision and goals of this school are towards religion, and most of the students and my colleagues think that religion and evolution do not go well together. So, I always keep this in my mind and try not to teach it [evolution) too deep to avoid any clash with religion.

Students' interest and insufficient teaching resources are other challenges teachers mentioned for the evolution unit. The teachers explained that they need to be creative to develop several approaches to teaching the theory of evolution to make sure their students are engaged and understand it. These approaches included using analogies, mind maps, models and simulations, the Internet, which is used to expose students to the broader arguments around the theory, and presenting role models. Seria specifically expressed that she felt challenged every time she taught the theory of evolution:

> You know, evolution is kind of like a very boring unit because you need to teach the history of biology there, and I don't want my students to fall asleep during this time and not understand the concepts. So this unit has always challenged me, making me think about what methods and media I need to use. That is why last time I leveraged students' interests, as they are interested in art, so I asked them to draw mind maps or other things related to evolution.

Seria mentioned that she derived most of her teaching practices from her understanding of the curriculum, so she chose to exclude her personal religious beliefs as she developed her lesson plans for evolution units. However, Asep and Zulkifli felt uncomfortable if they did not present the conceptualization of human evolution from a religious perspective. Therefore, they usually showed students a video of Harun Yahya, a Turkish author and an anti-evolutionist, who describes the idea of human evolution based on religion.

Teaching the theory of evolution is a representation of teachers' accountability

All teachers considered teaching the theory of evolution to be a representation of their accountability. Despite expressing some difficulties with understanding and accepting the scientific ideas of the theory of evolution, such as speciation, the teachers were still required to follow the standards set by the national curriculum and to prepare their students for success on the national examination which includes questions about the topic. Asep delineated this point in this way:

> It [the standard] is written in the national curriculum, and I just need to be professional by following it and developing a lesson plan that aligns with it … So, the goal is to teach the content so students know what the theory of evolution is, and then they can answer questions related to evolution on the national examination.

Wirman echoed this sentiment during the interview, confessing, "the ultimate target of students' learning about evolution is to pass the national examination. That's it."

To better understand how the teachers' perceptions were reflected in their evolution unit lesson plans, we asked them to explain their plan and their pedagogical reasoning behind their choices. However, we found that rather than developing their own lesson plans, the teachers used lesson plans developed by a group of teachers within the school district. The

teachers used those lesson plans without major modifications because they were concerned that this would change the content and impact students' performance on their national examination. These decisions indicate that following the standards is a powerful driving force for Indonesian biology teachers to teach evolution. Despite conflicts with their religious beliefs, the teachers strive to help students succeed in their academic life, actions that reflect their commitment to education. The teachers' approaches to reconciling the conflicts between religion, evolution, and teaching are presented in the next section.

Teachers' approaches to reconciling conflict between religion, evolution, and teaching

The above findings indicate that while the Indonesian Muslim biology teachers of this study largely rejected the theory of evolution, they still taught the subject because of three external driving forces: national curriculum, school goals, and national examination. To negotiate between these three obligations, the teachers tended to adjust their perceptions of the purpose of teaching the theory of evolution. As a result, the teachers believed the goals of teaching evolution are: (1) to learn to appreciate human thinking, and (2) to strengthen students' religious beliefs.

The goal of teaching the theory of evolution is to learn to appreciate human thinking

Most teachers perceived that the primary importance of teaching the theory of evolution was not related to the scientific concepts associated with it, but the thinking process involved in its creation, which reflects their view of the nature of science. They considered helping students understand the nature of science and further appreciating the human thinking process to be a primary goal of teaching evolution. Also, teachers wanted to help their students become more open-minded and respectful of others' opinions. Some teachers emphasized the tentativeness of scientific knowledge to convey to their students that evolution is "just a theory" that can be changed. As such, students do not need to accept or believe it. Jerry elaborated on this point:

> Students need to understand that science is developing … probably now is Darwin's theory, and later a new theory that is more valid, complete, and better will occur and could be in a different direction from what Darwin's theory says … I always tell my students … "Your source should always be the holy book, if science is not yet the same as the holy book," so that is the limitation of humans.

Similarly, Zakaria stated,

> I think the most important thing in teaching the theory of evolution is not the evolutionary concepts, but the construction of the theory, how it is generated. I always tell my students that it is only a theory which is subject to change and replacement.

Zakaria further explained that by teaching the theory of evolution, teachers could help students develop constructive thinking skills, which can help students minimize the friction between science and religion.

Some teachers also believed that teaching the theory of evolution could help students develop an appreciation for others' opinions. For example, in the following excerpt, Zulkifli expressed his hope that, through learning about the theory of evolution, his students could become more open-minded and accept that there are a variety of different perspectives, opinions, and ideas in the world apart from their own religious beliefs:

> I always go to class and teach the theory of evolution with the hope that my students later will be more open-minded. Based on my experience teaching in this [Islam-based] school, they [students] always think from one perspective, which is the religious perspective, and rarely consider other perspectives, especially in science. So, I believe that evolution can make my students at least more accepting of others' opinions … given that in the evolution unit, they learn how one evolutionary theory is generated, developed, rejected, and accepted.

The teachers reconciled the clash between religion and evolution by shifting their perceptions from evolution as a conflictual topic to evolution as a topic that encourages open mindedness. Implicitly, this suggests that the teachers believed their students could benefit from learning about the theory of evolution.

Strengthening students' religious beliefs is the goal of teaching the theory of evolution

This theme was most salient in the teachers who taught in Islam-based schools. These teachers believed that their pedagogical practices needed to reflect the goals of their schools, which included strengthening students' religious beliefs. Teaching the theory of evolution was not an exception. In this regard, Zulkifli often "tried to find some verses from the Quran or Hadith that can help me to explain the concepts" of evolution. He would also ask his students to "recite the verses from the holy book … that can help them understand, for example, the development of embryo and comparative biology." In doing so, he believed that his students would form connections between science and religion and see scientific knowledge as applicable to religious life. Similarly, Asep, the other teacher from an Islamic school, expressed his concern that biology textbooks did not align well with the school's religious aims, stating:

> Because all students here are Muslims, and this is an Islamic school, automatically the goal [of teaching the theory of evolution] is to strengthen students' religious beliefs … to be honest, I find it difficult to teach in this way, because we follow a curriculum and use textbooks that are for general students, not specifically for students in Islamic schools … That is why there is a lot of information about evolution that does not align with Islamic teachings.

He elaborated, stating that the textbook figure that illustrates humans evolving from primates always makes him and his students confused about religious teachings. Therefore, he always tells his students the following:

> Do you want to be told that you were from primates? And I tell them that God has created us directly from ground soil as the most perfect living beings … I do this to strengthen students' religious beliefs, while also teaching them scientific concepts behind evolution theory.

These actions imply that another goal of teaching evolution is to strengthen the students' religious beliefs.

Discussion

In this study, we explored Indonesian Muslim biology teachers' perceptions of the theory of evolution, teaching the theory of evolution, and approaches to reconciling the conflicts that can occur between evolution and personal religious beliefs. Our findings indicated that teachers' religious beliefs, perceptions of evolution, and contextual factors, including national curriculum and standards, were closely related to their perceptions of teaching the theory of evolution. Interestingly, our findings demonstrated the role of contextual factors as powerful driving forces for teachers to decide to teach and help their students understand the theory of evolution even though they themselves did not fully accept the theory of evolution. Furthermore, those driving forces helped teachers to cross the borders between science and religion by shifting their own goals for teaching the theory of evolution. In terms of Aikenhead and Jegede's (1999) four crossing border types, this shift might signify that most Indonesian teachers in our study implement the hazardous border crossing, especially in teaching human evolution and macroevolution. However, the teachers did not always utilize this hazardous border crossing, especially when they taught about non-human evolution or microevolution. The teachers seemed to use either smooth or managed border crossings when they teach macroevolution or plant evolution. This finding aligns with Fouad's (2016) contention that Muslims may not see any contradictory ideas around non-human evolution. Therefore, our results highlight the content effects on types of teachers' border crossings in which teachers may leverage multiple types of border crossing when they teach evolution.

Regarding teachers' perceptions of the theory of evolution, most of the teachers in this study believed that religion provides absolute knowledge, whereas evolution is subject to change and refinement. This led to their partial rejection of human evolution and macroevolution, and the acceptance of microevolution. This seems natural, given that Muslim's religious books explicitly present an account of the origin of humans that differs from scientific and popular hypotheses. Our participants' views on human evolution resemble perceptions of those Muslim Canadian (Ashgar 2013), Middle Eastern (BouJaoude et al. 2011), and Turkish (Tekkaya, Akyol and Sungur 2012) teachers and professors in previous studies. Like previous studies, these teachers also supported the religious creation of humans by citing verses from the Quran or other religious texts. Research has shown that the concept of human evolution can cause many people, including teachers, to develop misconceptions and to reject the entire theory of evolution (BouJaoude et al. 2011). However, while Muslim teachers in this study rejected human evolution, they partially accepted macroevolution and microevolution. This implies that evolution acceptance is multidimensional and progressively structured, which is consistent with findings from Louis Nadelson and Sherry Southerland (2012) and Gena Sbeglia and Ross Nehm (2019). Some researchers have suggested that people find it easier to accept the ideas of microevolution compared to macroevolution, and find human evolution the hardest to accept (Sbeglia and Nehm 2019). Additionally, Kevin Padian (2010) suggested that university instructors and science teacher education programs focus on teaching macroevolution because of its potential ability to improve acceptance of evolution. In this regard, future research needs to examine evolution acceptance in multidimensional and multi-contextual manners, such as human vs plant vs animal (Nehm and Ha 2011) or scale of evolutionary change (short vs long terms) (Nadelson and Southerland 2012).

Although most of the teachers in our study partially rejected the theory of evolution, it did not keep them from teaching the theory of evolution to their students. We identified two

driving forces that played a role in aiding the teachers to overcome the frictions and conflicts between personal religious beliefs and evolution. Notably, the national curriculum and the high-stakes national examinations hold teachers accountable and require teaching evolution. Ashgar (2013) also indicated national curriculum and textbooks as the important considerations for Canadian Muslim teachers to teach evolution.

Another interesting finding is that some teachers, such as Asep, Jerry, and Wirman, were hesitant and uncertain about the credibility of the evidence supporting the theory of evolution. This reiterates the findings from Gülsüm Tekkaya and colleagues (2012) on Turkish science teachers' and Fayadh Alanazi (2019) on Saudi Arabian students' uncertainty about the theory of evolution. Several researchers have argued that a person's lack of understanding of the nature of science can cause the person to perceive that the theory of evolution lacks credible evidence (Cofré et al. 2018). Although the teachers in our study seemed to have some understanding of the nature of science (e.g., the tentativeness of the theory, the likelihood of change, and the human thinking process), it was still not sufficiently nuanced. For example, when talking about the tentativeness of the theory, they hardly considered that scientific theories, including the theory of evolution, are built upon significant credible and warranted evidence (Ayala et al. 2008). However, the teachers still indicated that they told their students to appreciate and follow the scientific thinking process with regards to evolutionary theory. This resonates with Michael Kohut's (2019) finding on the situational aspect of NOS deployment. Kohut emphasized that people tend to change the rhetoric of NOS depending on the situation, either to make others understand it or to justify their own beliefs. Most of the teachers in the current study tried to make students understand the thinking process within the theory of evolution by changing the rhetoric to one that students should still learn it even though they do not agree with the theory. Further studies are needed to gather more evidence for how teachers use different metaphors when they convince students to learn evolution.

Regarding different school settings, it is interesting that teachers in Islam-based schools believed that the goal of teaching the theory of evolution is to strengthen their students' religious beliefs in addition to helping them understand the scientific ideas behind the theory. This feature is similar to Barnes and Brownell's (2018) study that reported that Christian university instructors in the US adopted more inclusive teaching approaches that enabled students to freely express their religious beliefs to reduce conflicts while learning evolution. In contrast, the Muslim teachers in the public and Christian schools in our study attempted to limit the impact of their religious beliefs on teaching evolution. This finding is consistent with Barnes and Brownell (2016), who showed that instructors in US public colleges in which their religious beliefs and cultures were likely to differ from their students managed to disconnect religious beliefs and the teaching of the theory of evolution. Barnes and Brownell (2016) asserted that students might struggle more in the classes that avoid the discussion around the conflict between science and religion than in classes that explicitly discuss the conflict. They also noted that discussing the conflict between evolution and religion may provide a place for students to grow and reflect on their understanding of the theory.

Conclusion

Our findings expand the literature on evolution education by adding evidence supporting the critical role of contextual factors, including school setting and the national curriculum as forces that can be more potent than religious beliefs. These contextual factors resulted in the diverse perceptions of teaching the theory of evolution among Indonesian Muslim

biology teachers, and further diversify approaches to reconcile conflicts between evolution and religion. Moreover, this study sheds light on the importance of the opportunity to discuss religion during evolution instruction as a means to cross the border between science and religion. Such an opportunity will enable students to navigate and negotiate dilemmas originating from their own religious beliefs while constructing their understanding of the theory of evolution. Finally, engaging students in the discussion of religion and evolution can lead to the advancement of one's habits of mind, such as caution about presumption and biases and openness to different ideas and interpretations. These thinking habits can contribute towards achieving scientific literacy for all students.

Appendix A

Interview Protocol Adapted from Goldston and Kyzer (2009) and Barnes and Brownell (2018)

Demographics

1. How large is the school in which you work?
2. How would you describe some of the social and cultural aspects of the school where you work?
    a. What do you consider unique about your school?
    b. What are good things about your school?
    c. What areas do you feel need to improve?
    d. How would you describe your school culture?

Curriculum, pedagogical and personal perspectives

Perceptions of teaching evolution

1. Can you describe what you feel about teaching evolution? Do you find it easy or difficult to teach? What biological topics do you find easy/difficult to teach?
2. What topics do you teach or introduce that you consider controversial?
3. Describe your personal perspectives on evolution (human evolution)? How about microevolution (evolutionary change within a species or small group of organisms, such as pesticide resistance, herbicide resistance, and antibiotic resistance) and macroevolution (major evolutionary change, mainly to the evolution of whole taxonomic groups over long periods of time, such as the evolution from reptiles to mammals)?
4. What are your goals/objectives when teaching evolution? What is that you want your students to learn and achieve when teaching evolution?
5. Our national biology curriculum requires you to help students to be able to explain the theory, principle, and mechanism of biological evolution and the current views on speciation. Do you agree with this goal? Can you elaborate more the reasons you agree or not? Do you think you should aim for students to become more comfortable and accept evolution beyond understanding evolution? Why? Or why not?

6. How do you usually plan your lesson on evolution to achieve the goals you described before? What factors/aspects do you take into consideration into planning lessons?
7. What do you think is the best way to address a controversial issue like evolution?

Pedagogical approaches to conflicts associated with teaching evolution

8. Your school is (Christian/Islam/Public) based and many of your students are Christians/Muslims/diverse in religions. Do you consider this aspect when you teach evolution? Why? Or Why not?
9. Have you experienced opposition to evolution from your students? What was it? How did you handle it?
10. Do you or your students ever bring up creationism in your course? Elaborate. How did you handle it?
11. What are some of the comments and questions you have gotten from students regarding evolution that stand out? What are the typical questions?
12. Based on your experiences, describe the kind of exposure to evolution students may have had prior to coming into your class?
13. Do you discuss the spectrum of viewpoints that exist about the relationship between religion and evolution? If no, why not? Would you?
14. Do you discuss that evolution does not mean atheism/evolution is compatible with religion? If no, why not? Would you?
15. Do you provide students with religious scientist role models who accept evolution? If no, why not? Would you?
16. If a student says they accept common ancestry and natural selection but they believe god started or planned evolution, does that student accept or reject evolution? Why or why not?

Approaches to negotiating conflicts with school communities while teaching evolution

17. Have you ever had anyone in the community give you information opposing evolution? Have you had any confrontations with school administrators, other teachers, community members or parents regarding evolution?
18. If you had had confrontations with administrators, colleagues, parents or other community members, do you think it influenced your presentation of evolution or other controversial issues? If so, how? If not, why not?

Approaches to navigate personal conflicts due to religious backgrounds

19. What, in your opinion, are some of the factors that affect a teachers' decision to teach or not to teach evolution?
20. Have you experienced any conflicts because of your religious beliefs when teaching evolution? How did you resolve the conflicts?

Teaching evolution and local context

21. According to Pancasila (five principles of Indonesian ideology), the very first pillar is "Belief in the Almighty God," do you think our curriculum does or does not reflect our national ideology by teaching evolution mandatorily?
22. As you are a Sundanese/Javanese/Others (local ethnic groups), are there any issues about teaching evolution that do not align with the way of living and values upheld by Sundanese people? If any, can you describe it? And can you describe how you resolve this kind of conflict when you are in the classroom?

Appendix B

Acceptance of Evolution and Position on Relation between Evolution and Religion Surveys.

Demographics

1. Name
2. Gender
3. Degree
4. Years of teaching
5. Years of teaching evolution

Acceptance of evolution survey

Smith et al. (2016). The GAENE—generalized acceptance of evolution evaluation (4-points Likert scale 1 = strongly disagree, 4 = strongly agree).

1. Everyone should understand evolution.
2. It is important to let people know about how strong the evidence that supports evolution is.
3. Some parts of evolution theory could be true.
4. Evolutionary theory applies to all plants and animals, including humans.
5. People who plan to become biologists need to understand evolution.

6. I would be willing to argue in favor of evolution in a public forum, such as a school club, church group, or meeting of public school parents.
7. Simple organisms such as bacteria change over time.
8. Nothing in biology makes sense without evolution.
9. Understanding evolution helps me understand the other parts of biology.
10. I would be willing to argue in favor of evolution in a small group of friends.
11. Evolution is a good explanation of how humans first emerged on the earth.
12. Evolution is a scientific fact.
13. Evolution is a good explanation of how new species arise.
14. Most living things have some very basic similarities

Position on the relationship between evolution and religion (Yasri & Mancy, 2016).

Which of the following best fits with your view on evolution and creationism? (Choose one).

Statement	Position (not shown to participant)
A. All forms of life were first brought into being by a deity in more or less their present form at the same time	Literal creationism
B. Some forms of life evolved from earlier forms created by a deity, but higher taxonomical species such as reptiles, birds, and mammals were created in more or less their present form	Higher genera created
C. Some forms of life evolved from earlier forms created by a deity, but human beings were created in more or less their present form	Humans only created
D. All forms of life were gradually created over time by a deity in more or less their present form	Progressive creation
E. All forms of life evolved from earlier forms, but a deity intervenes from time to time to shape or override the evolutionary processes	Theistic evolution
F. All forms of life evolved from earlier forms, but life and evolution were first set in motion by a deity and then left running without any additional intervention	Deistic evolution
G. Life emerged from non-living particles and then all current forms evolved from these earlier forms. A deity may exist, however, this is out of scope of evolutionary theory	Agnostic evolution
H. Life emerged from non-living particles and then all current forms evolved from these earlier forms. No deity has ever played any role in the evolution of life on Earth	Atheistic evolution
I. I do not know	No position
J. Other	

Appendix C

Codebook generated from axial coding process.

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
Position on macro-evolution	Rejecting macro-evolution	When teachers express that macroevolution does not happen	"I don't think they [animals] evolve … so all animals that are present today have the same form as when they were first created by Allah … so I do not think they have evolved …" [Asep] "… If the final ends of macroevolution is speciation…in which for example a species or population then creates a new population that cannot breed anymore… it would be really hard to explain …" [Zakaria]	Strong rejection Mild rejection

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
	Accepting macroevolution	When teachers express that macroevolution does happen	"I think evolution is happening. For example, Aves have some rudimentary organs that resemble the organs in Reptiles."[Seria] "Scientifically, I agree with macroevolution, because when I was taking evolution class Prof. [name of professor] showed me the evidence of traits that mostly Pisces have, but those traits are also in Amphibians." [Zulkifli]	Plausibility
	Neither accept nor reject macroevolution	When teachers express that they are unsure about macroevolution	"If we are talking about the evolution of Amphibians from fish … then reptiles, then Aves … I am not sure about it because I feel I don't have enough understanding of it. Sometimes, I still think that Amphibians have been created in the same form from the beginning." [Wirman]	High level of confusion/uncertainty

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
Position on micro-evolution	Accepting micro-evolution	Teachers talk about how and why they accept microevolution	" … pesticide-resistant micro-organism for example evolves as the result of the physiological responses to the chemical compound in the pesticide … so that they [bacteria] can adapt and being resistant." [Asep] "Mutation leads to evolution, and I agree with that. For example, the medicine for influencing viruses in the past might not be useful to treat today's influenza … because viruses and bacteria keep mutating." [Seria] "To me evolution is more probable and makes sense in the lower level organism or simpler organism, such as bacteria. Bacteria genome or other unicelulares are easily engineered and thus could lead to the birth of new species …" [Zakaria]	High level of acceptance due to easier to comprehend and contextualize

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
Position on human evolution	Rejecting human evolution	Teachers talk about their rejections on human evolution and their reasons of rejecting it, including religion- and science-oriented reasons	" … there are many evolutionary theories that I cannot accept. For example, we, in Islam, believe that the ancestor of human is Adam … not primate as what many theorists said …" [Asep] " … after a very long time, we see now there is no monkey that evolves into humans …" [Jerry] "Personally, I cannot accept if humans are from monkey/primate' [Seria]	High rejection of human evolution
	Accepting human evolution	Teachers talk about why and how they accept human evolution	"What I understand according to my religion is that all living beings evolve into the same species. In the case of humans, it evolves from and into humans, not primates …" [Asep]	
	Uncertain about human evolution	Teachers talk about their uncertain feelings and understands of human evolution	"Humans also evolve, but I am not sure that the direction is towards speciation, or even starts with speciation …" [Zakaria]	

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
Perception of teaching the theory of evolution	Perceived difficulty of teaching evolution	Teachers talk about whether they think teaching evolution is easy or hard, including other feelings they have about teaching evolution	" … I think it is quite hard to teach evolution, because as I said, students here have very strong religious beliefs and misconceptions about evolution …" [Zulkifli] "What I feel during teaching evolution is confused … whether evolution is happening…especially on human." [Jerry] " … because it [evolution] is usually connected to religion, it becomes a sensitive topic … So, I need to be really careful when teaching it." [Wirman] "To me, teaching evolution is easy and challenging … it makes me think more about how to teach it …" [Zakaria]	Hard to teach evolution because misconception and cannot be proven directly High creative teaching methods and challenging No much time to teach evolution

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
	Goals of teaching evolution	When teachers talk their goals of teaching evolution, including national examination, understanding the concepts and acceptance of evolution	" … the ultimate target students learn evolution is to pass national examinations. That is it …" [Wirman] "Because all students here are Muslims, and this is an Islam-school, automatically the goal [of teaching evolution is to strengthen students' religious beliefs." [Asep] "I always tell my students 'you just need to know [understand] this … it is up to you if you want to accept it or not." [Seria]	Understanding is definitive, accepting is choice
Approach to teaching evolution	Teaching resources	Teachers talk about resources they usually use or need to teach evolution, including students' textbooks, access to the internet, and other media	"First, the source is the Internet… particularly YouTube … the second one is students' biology textbook." [Zulkifli] "For example, the origin of living beings, because it is necessary that everything should be based on Islamic values … I always orient my teaching to that direction and supported by the Quran …" [Zulkifli]	Improving teaching evolution through self-enrichment Internet as the source of students' misconceptions

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
	Teaching methods	Methods used to teaching evolution, and how teachers obtain such methods	"In class, I usually avoid connecting evolution to religion … because it will make students more confused." [Seria] "I always start with asking students questions, such as what are controversial things students know about evolution, and then do class discussion." [Zulkifli] "I ask my students to analyze the scientific theories of evolution … and find out whether there is conflict between the theory and what the Quran says, or our religion …" [Asep]	Worry about students' feeling Afraid about what students will tell to people outside schools Not frequent to present role models
Perceptions of religion	Religion is an absolute knowledge	Teachers talk about the absolute nature of the knowledge from religious scripture, holy book, as well as their interpretation of religious knowledge	"I always tell my students that …"your source should always be holy book [religion], if science is not yet the same as holy book, so that is the limitation of humans …" [Jerry] "I tell my students … Bible is dogma, and science is the explanation of scientific phenomena … they cannot be compared…" [Zakaria]	Religion is not comparable to science

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
	God as creator	When teacher talks about God who creates the world and living beings, as well as human, and how God controls evolution	"Aristotle said that the origin of life is non-from dead things, and this is very wrong, because it is clear in Al-Quran that life starts from when the spirit is blown when an organism is in the womb …" [Asep]	God is the one who creates the everything
Relationship between religion and evolution (science)	Evolution and secularism	When the teacher talks about the connection between evolution, atheism, and western ideas	" … I think if we teach about the topic for example the origin of living beings are from non-living-beings, I think that teaches atheism." [Seria] "Evolution is a western idea … like Darwin … and to be honest I do not agree with his idea." [Asep]	Evolution is in the spectrum of atheism
	Reconciling conflict between science and religion	When teachers talk about how they reconcile the internal and external conflict between evolution and religion	"I usually just seek for more knowledge by reading books … both science and religious books … then I try to make sense and find the connection between Adam and the origin of men …" [Zulkifli] "To me, science and religion are different … we can have both and just situate myself depending on the surrounding." [Zakaria]	No conflict due to compartmentalizing science and religion Conflict because of insufficient knowledge

Categories	Subcategories	Descriptions	Examples of excerpts	Dimensions
Community influences	Community questions	When teachers talk about their experiences of colleagues or community asking them about evolution	"I never had any serious questions about evolution from my colleagues … but they always joke at me like 'so you are the friend of Darwin? The monkey man…" [Jerry]	Mostly no severe questioning
			"I was once having a debate with my spiritual teacher about evolution …" [Wirman]	
	Alignment of local culture and evolution	When teachers talk about how teaching evolution reflect the teaching of national ideology and local culture values	" … I think teaching evolution … aligns with Sundanese culture, especially in terms how it increases the awareness of protecting nature, like Baduy people do …" [Zulkifli]	Low connection to culture Connect in some degree to ideology

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