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Science teachers' views of science and religion vs. the Islamic perspective: conflicting or compatible?

NASSER MANSOUR

Graduate School of Education, University of Exeter, St. Luke's Campus, Exeter EX1 2LU, UK

Abstract

This paper reports a study that explores Egyptian science teachers' views on religion and science within the context of Islam. It also highlights an ontological and epistemological consideration of these views, particularly the ways through which Egyptian Muslim teachers understand such a relationship with reference to the Qur'anic/Islamic attitude toward science and knowledge. The study built upon Barbour's categorization scheme to guide the data collection and analysis and to guide the interpretation of the teachers' responses in the interviews. Informed by a multi-grounded theory of the teachers' views of science and religion and using Roth and Alexander's analytical framework to interpret how teachers accommodate the relationship between science and religion within their belief system, the findings suggest that participants' views of the relationship between science and a specific religion (Islam) confirmed the centrality of teachers' personal religious beliefs to their own thoughts and views concerning issues of both science and Islam. This centralisation, in some cases, appeared to lead teachers to hold a conflicting relationship, hence to a creation of a false contradiction between science and Islam. Therefore, it could be concluded that teachers' personal Islamic-religious beliefs inform their beliefs about the nature of science and its purpose.

Introduction

Religion has a profound impact on many societies, where individuals' religious beliefs primarily inform their actions. Religious belief systems have certainly been a powerful source of moral guidance for humans, and, for many, there are no other systems of restraints and no other sources of inspiration that come close to motivating people to respond as powerfully as do the systems of organized religion (Katz, 2002). The impact of religion on the lives, beliefs, and practices of contemporary teachers, therefore, remains a question that should be considered when building an understanding of their work in the classroom. Such a consideration is a significant one, especially when teachers respond intelligently and effectively to the challenges of a science curriculum that occupies the science-religion spectrum (Fysh & Lucas, 1998).

Unlike in the Western context, through which the religion and science relationship as it applies to teaching (or teachers) has been studied (e.g., Roth and Alexander, 1997; Cobern & Loving, 2002; Shipman, Brickhouse, Dagher & Letts, 2002; Colburn & Henriques, 2006; Stolberg, 2007, 2008; Deniz, Donnelly & Yilmaz, 2008), such a relationship remains highly unexplored within the Islamic context. The present study may provide new insights into or new interpretations of this under-researched area within the context of Islam, a non-Western religion. The study has particular significance when one acknowledges the conflict between the implications of a scientific study of some issues such as evolution, cloning, abortion and genetic engineering, and the Islamic view, and that these issues pose problems for science teachers (Roth & Alexander, 1997; Brickhouse, Dagher & Shipman, 2000; Cobern & Loving, 2002; Shipman, Brickhouse, Dagher & Letts, 2002; Colburn & Henriques, 2006; Stolberg, 2007, 2008; Hokayem & BouJaoude, 2008), especially in Islamic countries (Dagher & BouJaoude, 1997; Hokayem & BouJaoude, 2008; Nieswandt & Bellomo, 2009). Additionally, some other science-oriented issues may not formally conflict with Islam, such as scientific and pharmaceutical experiments on animals, but do conflict with teachers' personal religious beliefs, or the way teachers interpret the Islamic view regarding these issues (Mansour, 2008b). This study argues that there is not only a debate between religion (Islam) and science, but also a debate between religion and science education. However the specific questions that this study addresses are: 'How do Egyptian science teachers view the

debate between Islam and science? Which side (science or religion) do they support and how do they interpret the relationship between Islam and science?'

Socio-cultural perspective of teachers' beliefs

The model or the combination of models that a person adopts for relating science and religion is likely to depend heavily on the individual's upbringing, as well as on the fundamental presuppositions they bring to the topic, which are shaped in one way or another by sociocultural contexts (Roth & Alexander, 1997; Fysh & Lucas, 1998; Loving & Foster, 2000; Reiss, 2004). Context-specific features of particular beliefs in terms of the connection of these beliefs with other belief systems and cultural issues are worthy of investigation (Pajares, 1992; Roth and Alexander, 1997). An example of such an investigation might be analyzing the discourse of two students enrolled in a junior-level physics course, in an attempt to understand their perceptions of the relationship between science and religion. Among these two students, the role of socially constructed knowledge remains a strong factor in perceiving a conflict between religion and science. Where one student might acknowledge the fact of scientific and religious knowledge as socially constructed but does not see the relationship between science and religion as in conflict, the other student might regard knowledge as absolute and the relationship between the two as a conflicting one.

Personal religious experience is one of the most influential social factors in gaining new experiences, or interpreting these experiences, and this, in turn, influences teachers' pedagogical beliefs and practices (Roth & Alexander, 1997; Shipman, Brickhouse, Dagher & Letts, 2002; Colburn & Henriques, 2006; Stolberg, 2008). Roth and Alexander (1997) explain that one's personal experience is mediated by the discursive practices of the community within which one lives, and they use this mediated experience as an example of the social construction of the personal dimensions of religion. Dagher and BouJaoude's (1997) study of college biology seniors revealed how students' worldviews, including their personal religious beliefs (PRB), aesthetic values, and understanding of the nature of scientific theories, shaped their understanding and acceptance of the theory of biological evolution. Mansour (2008a) argues that PRB was one of the most powerful factors influencing science teachers' performance in the science classroom. PRB is a social construct, based broadly on the various experiences including in particular religious experiences that a person lives through (p. 1608). PRB is defined as "views, opinions, attitudes, and knowledge constructed by a person

through interaction with her/his socio-cultural context through her/his life history and interpreted as having their origins in religion. The PRB works as a framework for understanding events, experiences and objects on an individual level" (p.1608).

Teachers with particular personal religious beliefs may understand the situation or the experience in question very differently from those without such beliefs (McIntosh 1995; Knowles 1992). Reiss (2004) argues that within a particular society there are certain characteristics among individuals (such as gender, religious beliefs, ethnicity, age, power, wealth, and disability) that cause them to vary in their scientific understanding and conception of the world. Teachers' worldviews regarding science and religion also inform their own roles, practices and approaches to classroom teaching (Dagher & BouJaoude 1997).

The debate between Islam and science

The debate over the compatibility of Islam and science still continues to raise two opposing views: one rejects the vision and feasibility of a compromise between science and religion, while the other sees a compromise as not only reasonable but necessary (Kamali, 2003). The conflict is due to the misapprehension that both interpret the same data of experience (Iqbal, 2005).

The application of the modern natural sciences to everyday life experiences has a deep impact on how people in the Islamic world relate to the question of science on the one hand, and their culture's intellectual and scientific tradition on the other. Regardless of what particular position one takes, this debate about Islam and science in Islamic societies has two important components. The first is associated with the practical needs and concerns of Muslim countries. Keeping pace with modern science and technology is the supreme priority for governments in the Muslim world. The second concerns the intellectual domain in which the Islamic scientific tradition is seen as an alternative to modern science and its philosophical foundations in the study of nature (Kalin, 2006).

Debate about Islam and science extends to a discourse on the relationship between Islam and science education. Loo (2001), highlighting an aspect of this debate, maintains: "Islamic science, for better or worse, impacts upon science education to the extent that it humanizes or

marginalizes science education in Muslim-majority countries" (p. 64). Science, for its part, has removed many unknowns and has repeatedly pushed back the frontiers of knowledge in ways that challenge the mystery in many religious explanations (Katz, 2002). Science is also ongoing and dynamic, a complex activity in which both comprehensiveness and simplification/parsimony are aims (Kimball, 1968). In addition, as reported by Glasson and Bentley (2000), the National Research Council NRC (1996) included both 'Science as a Human Endeavour' and 'Historical Perspectives' as part of the 'Nature of Science' content standard. As explained in the National Science Education Standards guide to this standard, "Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separated from society but rather science is a part of society". (NRC, 1996, p. 201) In this sense, the scientist whose deep regard for nature embraces a dimension of moral responsibility and respect is not far from religion. Similarly, the religious person whose belief in the deep significance of understanding how the world works or, for theistic religions, believes the world is rooted in God, leads him or her to wish to live harmoniously with nature, is not far from science (Hefner, 2002).

The Islamic conception of knowledge does not confine knowledge of reality to that obtained through experimentation and theoretical reasoning alone, and does not consider the scientific study of the world exhaustive. Rather, by accommodating revelation and intuition, it encompasses spiritual as well as physical aspects of culture, the natural world, and the cosmos, and it claims that there is more to reality than meets the human eye (Golshani, 2007).

The Qur'an calls for the study of nature not for its own sake, but rather as a means to bring one closer to God. Islam advocates scientific enquiry, and encourages the investigation of the universe and its nature as a method to explore the creation of God. Early Muslim scientists believed that God's wisdom is reflected in His creation. The following verse of the Quran addresses this issue:

> *"Do they not look at the sky above them? How We have built it and adorned it, and there are no rifts therein? And the earth - We have spread it out, and set thereon mountains standing firm, and caused it to bring forth plants of beauteous kinds (in pairs). An insight and a Reminder for every slave who turns to God. And We send down from the sky blessed water whereby We give growth unto gardens and the grain of crops. And tall palm-trees, with shoots of fruit-stalks, piled one over another." (Quran 50:6-10)*

Scientific knowledge comprising the natural sciences was vigorously pursued and developed by Muslim scientists and mathematicians commencing from the last decades of the first

century of Hijra[1]. The Qur'an and Hadith[1]encourage Muslims, and even make it obligatory for them, to pursue the truth (*hakikah*) freely from all possible sources; they also contain certain guiding principles that could provide a secure foundation for the development of religious and secular sciences. Some Prophetic traditions even give priority to learning over performing supererogatory rites of worship. There are several Islamic traditions that indicate that a scholar's sleep is more valuable than an ignorant believer's journey for pilgrimage (hajj) or participation in holy war, and that the drops of a scholar's ink are more sacred than the blood of a martyr (Akhtar, 1984). Religion needs science for its worldview if its interpretations are to be credible and process vivid actuality, and science needs religion to incorporate its knowledge into a meaningful world (Hefner, 2002).

Theoretical models of the relationship between science and religion

Literature regarding science and religion provides different ways of understanding the relationship between the two (see Davies, 1983, 1992; Barbour, 2000; Stolberg, 2007). Davies (1983), for example, argues that science and religion constitute two major systems that govern and inform human thought. For the majority of people, religion is the predominant influence in the conduct of their affairs. Ian Barbour (2000) categorized the relationship between science and religion by four key terms: conflict, independence, dialogue, or integration. Building on Barbour's categorization the current study used his work to guide the data collection and analysis and to guide the interpretation of the teachers' responses in the interviews, alongside Roth and Alexander's (1997) analytic framework. Barbour's four key terms not only classify the ways in which science and religion interrelate, but also perform a didactic function, since there is a conceptual, historical, and developmental relation between science and religion. Barbour explains at the outset that he is proposing his four-fold taxonomy in order "to give a systematic overview of the main options today" (p.77). According to Barbour, conflict arises from a pairing that may at first seem strange. This is because scientific materialism and biblical literalism both claim that science and religion make rival literal statements about the same domain, 'the history of nature', so a person must choose between them. Science and religion are independent because they can be distinguished according to the questions they ask, the domains to which they refer, and the methods they employ. One form of the dialogue between science and religion is a

[1] Hadith refers to narrations originating from the words and deeds of the Islamic prophet Muhammad.

comparison of the methods of the two fields, which may show similarities even when the differences are acknowledged. Dialogue may also arise when science raises questions at the outer limits of its boundaries that it cannot answer itself. Furthermore, dialogue occurs when concepts from science are used as analogies for talking about God's relation to the world. Proponents of the integration thesis seek a closer correlation of particular religious beliefs with particular scientific theories than is advocated by exponents of dialogue.

The rationale and the purpose of the study

Religion in Egypt frames many aspects of social life. Islam is not a religion in the same sense that Christianity or Buddhism are. Islam, for Muslims, is much more than a moral philosophy of life, system of belief, or spiritual order; it is a 'complete and comprehensive way of life'. The great increase in trade between Egypt and the West and the growth in communication through travel, books, the press, cinema and more recently through satellite television and the internet, have been bringing gradually to the people in Egypt some of the new discoveries in science and new advances in technology made in the West. Also, European colonial expansion into the Muslim world, beginning in the early 19th century, initiated a cultural crisis in the unity and identity of the universal Islamic community (*umma*) and has since generated a vigorous internal debate as to the situation of the umma in the modern world. This influence of Western culture raises a question related to Islam and science in Egyptian society: How much Western culture and technology can be assimilated without compromising the integrity of Islam? (Mansour, 2009)

Supported by well-established literature review, this study argues that the relationship between modern science and Islam needs to be distinguished from Muslim views and attitudes toward modern science. The former is concerned with an explanation of metaphysical underpinnings of the enterprise of science in modern times in the light of revelation; the latter reflects time-dependent, historically constructed interactions between individuals belonging to a faith tradition and equally time-dependent human enterprise entrenched in social, political, and economic conditions (Iqbal, 2007). In this sense, the study argues that Islam is not monolithic but exists as a broad spectrum of beliefs from liberal to more conservative fundamentalist approaches that are taken up and expressed in different ways.

The above arguments reflect an ongoing debate between proponents of Western secularization and the Egyptian Islamic culture, and how this debate should contribute to Egyptian science education. This study focuses on the influence of this ongoing debate on forming Egyptian science teachers' views about science and religion, their attitude toward Western science's 'Euro-centric' nature of science, how they view the Islamic perspective toward science and how far these teachers' views are matching or conflicting with the Islamic perspectives of science. This study argues that there is not only a debate between religion (Islam) and science, but also a debate between religion and science education. Yet the specific questions I address in this paper are:

1. What are Islamic science teachers' views of the relationship between religion and science? Which side (science or religion) do they support?
2. What are Islamic science teachers' views of the Islamic epistemology and ontology of science? And how do they interpret the relationship between Islam and science?
3. How far do these teachers' views match or conflict with the Islamic perspectives of science?

In the next section, I provide a brief account of my stance on the relationship between science and religion and show how my position might influence the course of the study. Then, I give a portrayal of the questionnaire and interviews, which were developed in the light of Barbour's taxonomy and used to answer the research questions. After that, I move on to discuss the two analytical tools that were used to analyse the data including a Multi-Grounded Theory (MGT) and Roth and Alexander's (1997) analytic framework of interpretive repertoires. Subsequently, I present the findings in two sections: teachers' views of science and religion, and teachers' views of the Islamic epistemological and ontological positions on science. Finally, in the discussion section, both the 'explicit grounding stage' of the multi-grounded theory approach and Roth and Alexander's (1997) analytic framework will be used to discuss the findings of the study. In this section, using a theory-matching process, the empirically derived theory, including two emergent themes, 'Teachers' views about science and religion (theme one)' and 'Teachers' views of the Islamic perspective of science (theme two)', are discussed using Roth and Alexander's (1997) analytic framework and contrasted within theoretical frameworks found in the literature related to science and religion. In addition, the study discusses teachers' attitudes toward Eurocentric scientists and

sciences. Furthermore, the study discussed and compared the epistemological and ontological foundations of teachers' views about science and religion with the Islamic epistemology and ontology of science and knowledge. This process in turn led to the responses to research question three which stated "How far do science teachers' views of the relationship between science and religion match or conflict with the Islamic perspectives of science?"

Background to the Educational System in Egypt

Egypt is a predominantly Muslim country, with 90% of its population being adherents of Islam and the remaining 10% comprising followers of Christianity, Judaism, or secular views of the world. Almost all of Egypt's Muslims are Sunnis. A significant number of Muslim Egyptians also follow native Sufi orders, and there is a minority of followers of Shi'a. Christians are mainly Coptic Orthodox, though there are also followers of the Coptic Catholic Church**.** Religion in Egypt is a framework for many aspects of social life. Islam, for Muslims, is much more than a moral philosophy of life, system of belief, or spiritual order; it is a way of living.

Two separate educational systems exist in Egypt: a secular system for technological, practical, specialized training, and a non-secular Islamic system called *Al-Azhar*, which is based on spiritual and cultural instruction. The two systems have several parallel phases. This study focused on science teachers working in preparatory secular schools. Table 1 shows the current secular education system in Egypt.

Table 1

The Secular education System in Egypt

<table>
<tr><td colspan="4">University, higher and intermediate institutes</td></tr>
<tr><td>Secondary stage</td><td>General secondary schools (age 15-18)</td><td>Technical secondary schools (age 15-18)</td><td>Grade 10-12</td></tr>
<tr><td rowspan="2">Basic education</td><td colspan="2">Preparatory stage (age 12-15)</td><td>Grade 7-9</td></tr>
<tr><td colspan="2">Primary stage (age 6-12)</td><td>Grade 1-6</td></tr>
</table>

Science has been a basic subject in the secular, central National Curriculum (NC) since the 1960s, having traditionally included integrated science at primary and preparatory levels, and separated science (chemistry, physics and biology) at the secondary stage.

About the Author's stance on the relationship between science and religion

It would seem absurd to attempt a study on this topic (the relationship between science and religion) without acknowledging the effects of the personal beliefs or background of the researcher. It is inevitable that these beliefs will influence the direction and interpretations of any study, but especially so in a study that deals with such emotionally charged issues (Fysh & Lucas, 1998).

Coming from the Middle East, Egypt, I find it very difficult to deal with the relationship between science and religion. It is a very complex and sensitive issue for any Muslim, not just for people who deal with science in their professional lives. Consequently, I found it crucial to articulate explicitly my epistemological and ontological positions concerning the relationship between science and religion.

My beliefs lean strongly toward the integrationist position. I do believe that science and religion are compatible and that any perceived conflicts are only apparent and arise because of a misunderstanding of the nature of science and the Islamic perspective of science.
I grew up believing and understanding that seeking knowledge is obligatory for every Muslim. The main sources of Islamic teachings, the Qur'an and the Sunnah (Prophet Muhammad's sayings and actions), encourage Muslims to seek knowledge and be scholars, since this is the best way for people to know Allah (God), to appreciate His wondrous creations, and to be thankful for them. Thus, understanding the nature of science is a part of my Islamic life.

For me, the Islamic religion is concerned with the entirety of existence both in this world and the next, whereas science concerns itself with this world alone. Science is that branch of knowledge that deals with the material world. Religion is not opposed to science, and neither is science opposed to religion. Science would reject religion only if religion were presented as science. They are not in opposition, nor even in competition. However, I do understand and believe that religion and science are not in total harmony. Also, I believe that human beings can remain spiritual and religious at the same time as enjoying the benefits of technology and science. As a Muslim researcher exploring the relationship between science and religion, I acknowledge that my view and my participants' views of religio-scientific issues reflect a personal understanding which I call a 'personal religious belief'.

Methodology and data collection

The study adopted an interpretive approach (Bell, 1993; Calderhead, 1996) in an attempt to gain an in-depth understanding of Egyptian science teachers' views about science and religion, and why they hold differing views. The research was guided by the teachers' beliefs about science and religion, which I regarded as their socially constructed worldviews.

Sample

Because the topic of the study is very sensitive for Egyptian people, it was important to gain the trust of teachers to talk openly and express their religious beliefs in relation to science freely. Therefore, the geographical location of the schools in which the study took place (the Gharbia Governate in Egypt) was chosen because it was an area in which I know the science teachers and the schools very well. Seventy-five Egyptian science teachers were chosen at random and asked to respond to the open-ended questionnaire. The teachers were chosen from fifteen preparatory schools and ten secondary schools located in Gharbia Governate. Each school has between five and nine science teachers. I asked the principal of each school to select three teachers using a simple random sampling technique, which involved putting all the science teachers' names for each school in a bucket and then pulling out three names. The sample included 45 men and 30 women, aged from their mid-30s to early 50s; the number of years' teaching experience varied from five to 25 years. Because the sample was drawn from several preparatory and secondary schools the teachers had experience of teaching different age groups and different subjects within science education. The sample included 45 preparatory science teachers who taught the science curriculum for three grades (7-9) and 30 secondary science teachers, including nine chemistry teachers, eight physics teachers, and 13 biology teachers.

Research procedure

An open-ended questionnaire and interviews were used in consecutive steps to collect data (see Appendix A and Figure 1):

In step one, an open-ended questionnaire was used to collect preliminary information to aid in choosing the interviewees and developing the interview protocol. This questionnaire was designed to collect a sample of teachers to be interviewed, with diverse views about the relationship between science and religion and about the teaching/learning of science and religious issues. My decision to use the open-ended questionnaire was influenced by the context of the study (Egypt) and the nature of the research topic (science and religion). My experience of researching Egyptian science teachers' beliefs and practices about Science-Technology-Society STS issues (Mansour, 2007, 2008a) has revealed the difficulties of gaining access to teachers, especially to interview them; the interview technique is not a familiar form of research in Egypt. However, as the use of questionnaires is a popular form of research there, taking this approach at first proved to be a distinct advantage for this project to get access to follow-up for in-depth interviews. It should be noted that I did not use a closed-ended questionnaire, because such questionnaires risk not revealing the deeper meaning of the responses; if a closed-ended questionnaire is used, the response options provided may affect or restrict participants' views (Frazer, 2000; Oppenheim, 2001). Therefore, an open-ended questionnaire was used in this study, which has the advantage of giving the respondents a chance to express their views freely, without being cued or directed with bias.

Based on the quantitative and qualitative analysis of the questionnaires, twenty-five teachers were identified as potential interviewees. The selection of the sample was based on their diverse views about science and religious issues as revealed in their responses. Out of the twenty-five teachers, fifteen volunteered to be interviewed, including five preparatory science teachers, two chemistry teachers, three physics teachers, and five biology teachers. The selection of interviewees was guided by a 'maximum variation strategy' (Patton, 2002), which included the following criteria: teachers' backgrounds, subjects taught, gender, and teaching experiences, as well as teachers who held representative views or contradictory personal visions about the relationship between science and religion, or 'conflict-independence-dialogue-integration'. The selection also considered their enthusiasm for being interviewed. The participants' real names will not be revealed; participants will be referred to by pseudonyms.

In step two, a series of three to four interviews with each interviewee were the main research tool. The interviews were audio-taped and then transcribed immediately after each interview.

The transcripts were returned to each of the interviewees before the beginning of the following interview for their scrutiny, confirmation or criticism. In addition, I carried out an initial analysis of the interview after each one, and made notes on a covering sheet to act as a framework for subsequent questions. Thus, the process revealed 'the unique, the idiosyncratic, and the wholly individual viewpoint' of each participant (Guba & Lincoln, 1989, p. 155). Each interview lasted approximately 30-45 minutes.

In both the questionnaire and the interview responses there was potential for the teachers to respond to questions in ways that they believed to be the most acceptable, rather than giving a personal opinion. All respondents were told that their responses would be kept anonymous and confidential which is the standard method used to facilitate honest responses. Due to the lack of suitable rooms, interviews sometimes had to be carried out in settings where other teachers were present. This may have influenced the opinions that were being expressed. Whilst carrying out these interviews I also had to ensure that I did not upset the interviewees by appearing to criticise their views.

The validity of the instruments of the study

Guba and Lincoln (1989) emphasized the significance of the credibility of an instrument's ability to measure the constructed realities of the participants. Researchers have self-defined, theoretical constructs, which they believe an instrument actually measures, and data obtained from such instruments are interpreted in terms of researchers' own theoretical constructs. This is clearly a subjective process and researchers must establish whether the instruments employed in their research actually measure their theoretical constructs. The consideration of this issue is called construct validity (Dalgety, Coll, & Jones, 2003). In this study Barbour's taxonomy of the relationship between science and religion was used as a theoretical construct, which informed the construction of the open-ended questionnaire and the semi-structured interviews.

Guided by the procedures of Dalgety, Coll & Jones (2003) for developing a valid questionnaire, I used Trochim's (1999, p. 66) definition of construct validity, namely, 'the degree to which inferences can legitimately be made from the operationalisations in a study to the theoretical constructs on which those operationalisations were based'. According to

Trochim (1999), an instrument has a high construct validity if it has both translation and criterion validity. Translation validity is concerned with the link between an item's design and its administration. Do instrument items cover all aspects of the construct, and do participants ascribe the same meaning and interpretation to the items as the researcher? An instrument is deemed to possess translation validity if the theoretical constructs are well-defined and inclusive (content validity), and if questions are good translations of the theoretical constructs (face validity). Criterion validity considers the operationalism, and an instrument is deemed to possess high criterion validity if the operationalism gives conclusions that are expected, based on the theoretical constructs. For example, if the instrument gives results similar to another method that measures a similar construct (convergent validity) (cited from Dalgety, Coll, & Jones, 2003, p. 651).

To achieve the content validity as defined above, three science education experts in Egypt were involved in the development of the open-ended questionnaire and the interview protocol; their assistance was particularly useful for developing its content validity. Each expert was asked to establish the adequacy of the questions and to identify inappropriate wording or ambiguities. They gave some helpful feedback that was used to improve the questions in both the questionnaire and the interviews.

To achieve the translation validity, the researcher gave clear explanations of his research to the participants. This was to minimise the influence of the factors that affect accurate data-gathering. The teachers participating in the study were also told that they would remain anonymous. Walcott (1994) gives a detailed explanation of the concept of validity within qualitative research by outlining a list of steps, which this study followed during and following the study in order for the research to be considered valid. The main points that I followed were:

- Accurate records. "Try to record as accurately as possible, and in precisely the participants' words" the responses given (Wolcott, 1994, P. 249). When notes are taken they should be made as soon as possible after the event, if not during the event.
- Early rough analysis. The researcher should start a rough analysis of the data while still in the process of conducting the study. This helped me to identify the gaps in the data I obtained, and enabled me to acquire more information from the participants before the data collection was over.

- Respondent validity. This is considered important for understanding that the research represents a shared reality (Cohen & Mainon, 1989). Therefore, in order to provide respondent validity, interpretations of interviews were sent back to some participants to confirm that the researcher's interpretations were accurate.

To achieve convergent validity, the content of the questionnaire and interviews was developed through a search of the current literature on studying teachers' or students' views about science and religion (e.g. Aikenhead & Ryan, 1989; Roth & Alexander, 1997; Barbour, 2000; Cantor & Kenny, 2001; Lederman et al., 2002; Cobern & Loving, 2002; Shipman et al., 2002; Abd-El-Khalick & Akerson, 2004; Stolberg, 2007; Mansour, 2008a)[3]. In addition, the results of the questionnaire and interviews gave results similar to those obtained using another method that measures a similar construct, which showed that the questionnaire and interviews used in this study are valid (see Roth & Alexander, 1997; Dagher & BouJaoude, 1997). The questionnaire included three open-ended questions:

- What is your point of view regarding the relationship between science and Islam? Could you please give some justifications to support your view?
- How do you think religion can influence scientific explanations?
- Does religion affect the way you deal with science concepts, the way you teach science, or the way you view aims of teaching science? How?

Moreover, given the concern with the views that participants expressed about the relationship between science and religion, and the researcher's interest in clarifying his understanding of the participants' views of science and religion, it was imperative to avoid misinterpreting their responses to the open-ended questions. As such, individual semi-structured interviews were used to validate the researcher's interpretations of participants' responses, as well as to establish the face validity of the questionnaire items. The interviews also aimed to develop an in-depth understanding of participants' views of religion and science. During these interviews, participants were given their responses to the open-ended questionnaires and asked to read, explain, and justify them. By asking respondents to elaborate on and/or justify their answers, the researcher was able to assess not only the respondents' positions on certain issues related to the relationship between science and religion, but the respondents' reasons

for adopting those positions as well, which helped to define their epistemological and ontological positions (Lederman et al., 2002, p. 503).

Data analysis

In this study two analytical tools, a Multi-Grounded Theory (MGT) and Roth and Alexander's (1997) analytical framework of interpretive repertoires, were used to analyse the data and to answer the research questions.

1) A Multi-Grounded Theory (MGT) approach is a sophisticated model of Grounded Theory (GT) that deepens both inductive and deductive methods of theory generation (Ezzy, 2002). Analysis of the data occurred in two stages (Figure 1).

Stage One, the 'theory generation stage' aimed to develop an 'empirical theory' about two issues: a) teachers' views of science and religion (research question one), and b) the epistemological and ontological foundations of different views held by teachers about science and religion (research question two). The analytical processes of this stage, which mostly followed GT, included:

1. Inductive coding which corresponds to open coding in GT
2. Conceptual refinement where critical reflection on empirical statements is conducted
3. Categorical structure development, which involves combining categories into theoretical statements corresponding to axial coding in GT
4. Theory condensation, which matches selective coding in GT.

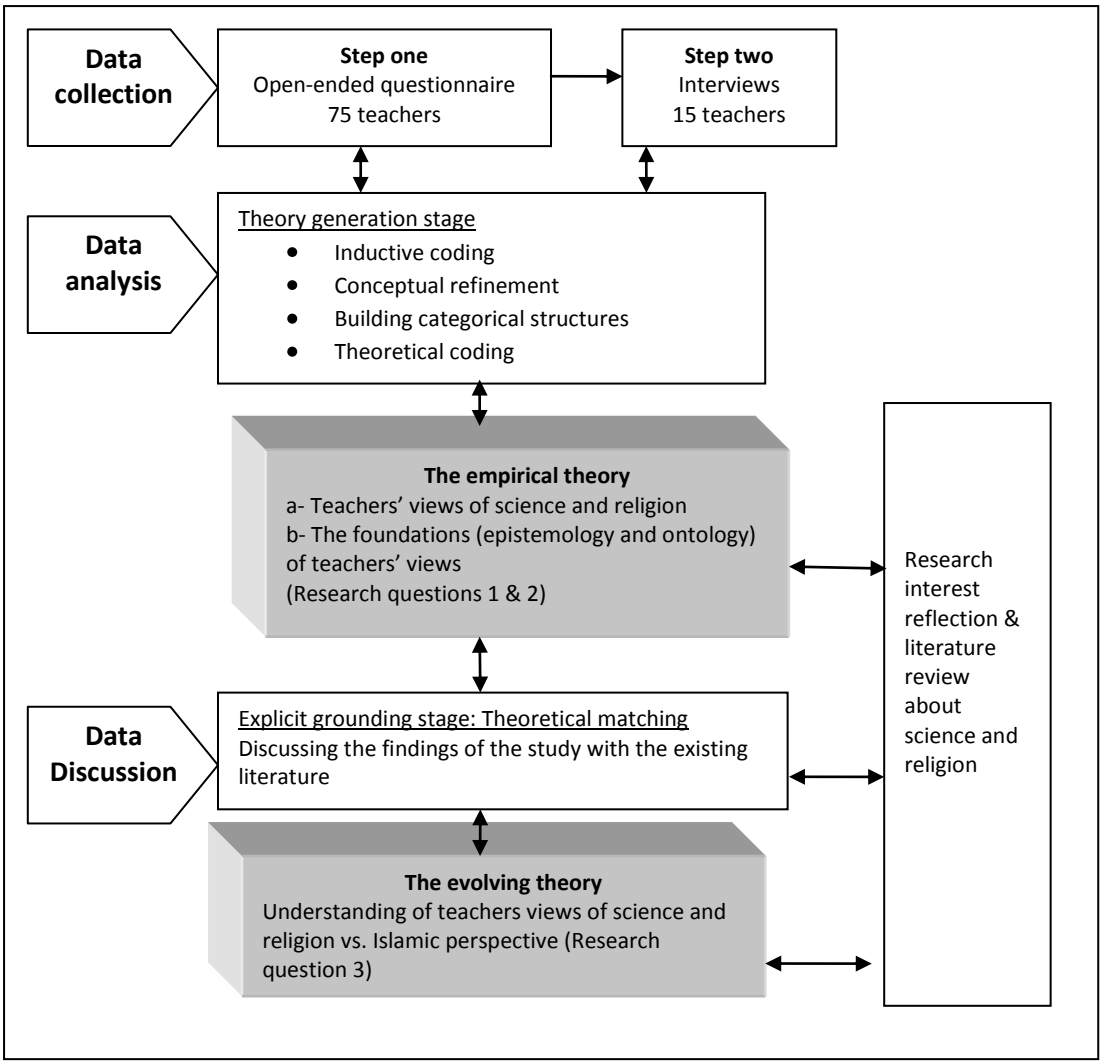

Figure 1. **Procedures of the study using multi-grounded theory**

Table 2 illustrates the first stage of the analysis and outlines how the theoretical coding emerged from the data. The initial process of data analysis was done inductively by using an incident-to-incident coding technique (Charmaz, 2006). In 'conceptual refinement', a critical stance was adopted to examine the views that participants had expressed. At this point, a crucial one in the data analysis phase, every category that was developed was reflected upon with regard to its ontological status (Lind & Goldkuhl, 2006).

Table 2

Some Examples of the Coding Using Multi-grounded Theory

Inductive coding 'Open coding'	**Conceptual refinement**	**Building categorical structures 'Axial coding'**
God creates everything including science	Teachers view science as part of religion	The clash between science and the Islamic religion
Science is concerned with material things and Islam is interested in everything	Teachers' religious beliefs are reflected in how science is part of Islam	

Western scientists don't care about ethics	Teachers explain the conflict	
Science and religion are different, but Islam provides a role for science	Understanding the Qur'an precedes studying science	Science and religion as two domains
Religion is an evaluator of science in an Islamic context	A dominant view of Islam	
Qur'anic guide to science	Teachers' religious condition for searching in science	
Scientists should seek advice from religion	The importance of the need for religion to develop a proper science	Dialogue under the authority of religion
Science is destructive without religion's guidance	A dominant view of science on religion	
Explaining the supernatural nature of God through science	Spiritual aim of science	
Religion needs science to explain the power of God	The use of science for a religious demand	
Science explains the natural phenomena in the Qur'an	Science as part of Islam	Compatibility between science and religion
Islam encourages science for research and to benefit people	Islamic orientation of science	
Science is the creation of God	A part cannot conflict with the whole body	
Science is a guide to a good Muslim	Religious attitude toward the role of science	
Research in science	Islam encourages the use of the scientific process	Teachers' religious epistemology and ontology
Stability of religion	Science is not as valid as religion is	
God creates the laws of nature	Humans should reveal the secrets of nature to be good religious followers	
Religion comes first, science comes second	The religious information about science is valid and reliable	
No religion, no valid science	Religion puts the foundation of research in science	
Religion gives the truth and science can be part of this truth	A dominant view of religious guidance for science	

Stage two, the 'Explicit Grounding Stage', was based on matching 'the empirical theory' (the foundations of teachers' views about science and religion) with existing theories in the literature related to a) science and religion and b) the Islamic perspective of science. This stage is part of the discussion section.

2) Roth and Alexander's (1997) analytical framework

The study used Roth and Alexander's analytical framework to interpret how teachers accommodate the relationship between science and religion within their belief system. Roth and Alexander's analytical framework includes two repertoires: a rational, which was used to classify statements that referred to the rationality of scientific and religious pursuits, and subjective, which was used to classify statements that referred to social and personal attitudes which make scientific and religious knowledge claims less than reliable.

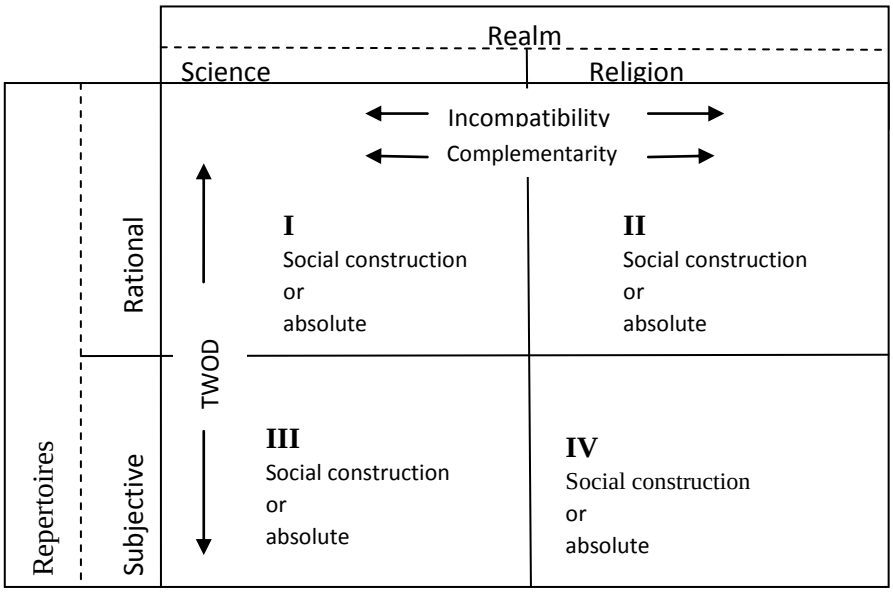

***Figure 2*. The analytical framework of interpretive repertoires used by Roth and Alexander (1997, p.133)**

As shown in Figure 2, the analytical framework consists of four quadrants. In each of these, knowledge claims are absolute or socially constructed. Quadrant I refers to rationality in the scientific enterprise, quadrant II refers to the rational in religious discourse, and quadrants III and IV represent the personal and social beliefs that influence people's claims about scientific and religious knowledge; these last two quadrants represent claims that cannot be publicly accounted for in rational terms. Truth-Will-Out-Device 'TWOD', 'incompatibility', and 'complementarity' are devices that mediate the relationship between cells in order to avoid the conflict apparent between two contradictory knowledge claims. To mediate conflicting statements that arise from two statements—such as 'scientific knowledge is true' (Quadrant I) and 'society influences scientists' knowledge claims' (Quadrant III)—some individuals use discursive mediation devices. These discursive devices allow scientists to claim the objectivity of their knowledge claims while maintaining influences of a contingent (subjective) nature. When two repertoires lead to conflict, discursive mediating devices are invoked. These devices included the TWOD and incompatibility devices, and, in the case of some scientists, the complementarity device (Roth & Alexander, 1997).

Roth and Alexander's analytical framework was used mainly to interpret how teachers accommodate the relationship between science and religion within their belief system. As shown in Figure 3, teachers holding conflict, independent, dialogue, or integrative views about science and religion combined two interpretive repertoires in which they viewed science as a social construction (Quadrant I and III, Figure 3) and looked at religion as if it is absolute (Quadrant II and IV, Figure 3).

		Realm	
		Science	Religion
Repertoires	Rational	**<u>Social construction</u> I** • Not all scientific knowledge can be reliable • Science changes every second. • Science is concerned just with material things • Science is a means of understanding what religion advises us to do • Methods of science are not reliable sources of discovering the truth • Theories and premises are still an object of study and are not yet facts	**<u>Absolute</u> II** • Allah is able to know and do everything • Everything around us in this universe shows the superlative work of Allah • Religious methods are more valid than science • The Holy Qur'an is not a science textbook; it is a guide for all humankind • Religious descriptions must be taken into consideration because they are more reliable source[s] of truth
	Subjective	**<u>Social construction</u> III** • Scientists do not believe in the existence of God. That is why there are a lot of contradictions between these discoveries and religion • Most of the discoveries in science come from Western scientists who assume that things happen just because of natural causes • Non-Muslim scientists do experiments without any consideration for religious principles or social morals • The of applications of genetic engineering alter the creation of God in plants or animals • Scientists should get guidance and ethics from the Holy Qur'an. • Religion demands that scientists search for and think of every phenomenon • Science continuously comes to show clearly what we don't understand about religion • There is no discrepancy (conflict) with the Islamic religion	**<u>Absolute</u> IV** • Believing in the absolute power of Allah is very important and is the basis for studying any scientific phenomenon • The Islamic religion, as is clear in the Qur'an, encourages us to use our minds • The Holy Qur'an has included all kinds of sciences on the earth

***Figure 3*. Examples of the interpretive repertoires of the participants in this study**

Findings[2]

This section presents the results of analysing the questionnaire data from the seventy-five teachers, as shown in Table 3, followed by the fifteen interviews. The findings are illustrated by quotations from the interview transcripts and questionnaires of the fifteen interviewees, who provided full and free-ranging information about their views of science and religion.

The data analysis of the questionnaires and interviews showed that the participants' views of the relationship between science and religion confirm the centrality of their personal religious beliefs to their thoughts and views concerning issues of science and religion. Teachers' personal Islamic-religious beliefs informed their understanding of what science is and what science should be used for. The analysis found that teachers' interpretations of Islamic religious beliefs served as the criteria or bases for their interpretations of new experiences. The findings set out below will present teachers' views of science and religion. Then the data will show teachers' interpretations of Islamic epistemological and ontological positions on science.

I. Teachers' views of science and religion

The findings set out below show teachers' views of science and religion including their perceptions of the causes of the clash between the two, teachers' views of science and religion as two separate domains, teachers' views of the dialogue between science and religion, and teachers' views of the possibility of compatibility between the two domains.

Table 3

Responses to the Open-ended Questionnaire

Theme	Category	N	%
Ways of relating science and religion	Conflict	5	6.7
	Independence	10	13.3
	Dialogue	14	18.7
	Integration	46	61.3

[2] Due to the limited number of the words dedicated to the manuscript, the author gave one or two examples of the teachers' responses (from the interviews) under each category.

a) Perceptions of the clash between science and the Islamic religion

As shown in Table 3, only five teachers out of the seventy-five respondents (6.7 percent) perceived a conflict between science and religion.

Conflict due to an 'anti-Eurocentric-scientists' view: Teachers felt that the conflict arose from the scientists who failed to consider religious viewpoints in their work, especially in Western societies. Ahmed commented that:

> "These scientists do not believe in the existence of God. That is why there are a lot of contradictions between these discoveries and religion; for example, issues or theories involving cloning and evolution." (T/Ahmed questionnaire)

From Ahmed's point of view the conflict of between science and religion is always due to the scientific discoveries, experiments, and practices that are carried out in Western societies, e.g., transplantation and cloning. These discoveries cause a conflict on the cultural level between Western and Islamic cultures. Also, Ahmed refers to the Western ontological position that causes a gap between science and religion. He said, "Most of the discoveries in science come from Western scientists who assume that things happen just because of natural causes" (T/Ahmed, Interview 3). Ahmed's view of the role of the ontological position of Western scientists can be explained by understanding that all Muslims believe that One God (Allah) is responsible for the creation of the world and the natural laws that control this world. In addition, science teachers who hold the view that there is a conflict between science and religion have seen this as a reason for the distance between Muslim and non-Muslim scientists and for the negative attitudes the teacher holds towards non-Muslim scientists. For example, Eman made the following comment:

> "All the problems of this world come from Western society and from non-Muslim scientists who do experiments without any consideration for religious principles or social morals." (T/Eman, interview 4)

Conflict due to creationism vs. evolutionism: The Qur'an and its interpretations heavily influence teachers' understanding of how the Universe, the Earth, and living beings came into existence. Thus, the teleological clash between Darwinian evolution and the Qur'anic verses regarding creation is a major obstacle that causes many science teachers to reject evolution as a scientifically valid theory. For example, Sami expressed an anti-evolution perspective; he

rejects evolution on the basis that it is problematic from an Islamic religious standpoint: "I do believe as a Muslim that God creates everything. That is why I don't believe in science so much." (T/Sami, interview 2)

Ahmed agreed with Sami that the Qur'anic account of creation was incompatible with humans having evolved. They both believe the account given in the holy Qur'an that the first ancestor was Adam (upon whom be peace), who was created by Allah. Ahmed expressed his disagreement with the 'theory of evolution' that all the organic beings that have ever lived on this earth have descended from one primal form. Some teachers are compelled to reject evolution because they think that acceptance of evolutionary theory and belief in God cannot coexist. For example, Ahmed supported his anti-evolution perspective with verses from the Qur'an:

> "It is He Who created you from a single person, and made his mate of like nature, in order that he might dwell with her (in love). When they are united, she bears a light burden and carries it about (unnoticed). When she grows heavy, they both pray to Allah their Lord, (saying): If Thou givest us a goodly child, we vow we shall (ever) be grateful". (Qur'an 7:189)[3]

Conflict due to the negative application of science: Teachers felt that Islam encourages scientific research, but feel that some applications of science conflict with Islam. For example, Sara identified a conflict between science and religion due to the negative applications of scientific discoveries in society, such as genetic engineering:

> "I do think, but I am not certain, that there are a lot of applications of genetic engineering that conflict with religion because it alters the creation of God in plants or animals." (T/Sara, interview 1)

From the points of view of teachers Ahmed and Sara, Islam considers the ethical aspects of any scientific discovery, but science does not consider any ethics. For example, Sara said:

> "Of course there is to some extent a conflict between science and the Islamic religion. It's nothing to do with Islam as a religion, but is to do with scientific thinking, which works without any consideration of any ethical perspectives or for the consequences for humanity." (T/Sara, interview 2)

a) Science and religion as two domains

Only ten respondents to the questionnaire (13.3 %) agreed that science and religion should be kept separate because their aims and methods were different. They viewed science and

[3] The English translations of the Qur'anic verses used in the entire manuscript are based on Ali (2004).

religion as being independent of one another, seeing them as two independent domains. They felt that each was asking a distinct type of question, employing distinct methods, and serving distinct functions in human life. The teachers' view that science and religion are independent domains is based on the different ontological positions of the two. For example, Eman made the following statement:

> "Science is concerned just with material things while religions such as Islam are concerned with everything as well as the material and how we use it." (T/Eman, interview 2)

Dalia agreed with Eman that science and religion stem from different ontological positions:

> "For me, science does not interfere with religion, and religion does not interfere with science. From my point of view, science gives us the laws of nature, and religion gives us the laws of social life." (T/Dalia, questionnaire)

Dalia explained this position further in the interviews:

> "For me science and religion are two faces of one coin, as both of them give us different information. Science gives us scientific details and religion gives us values, morals, and ethical beliefs." (T/Dalia, interview 3)

Some other teachers also viewed science and religion as two independent domains. Fatma said the following in the first interview:

> "I do believe in God, as a Muslim; however, I view science and religion as two different disciplines that look at the issues from two different perspectives. I do like science because it is ultimately based on observation, which I can do by myself; however, as a Muslim, I do believe that we have our own morals that organize our life."

Eman agreed with Fatma about the separation between science and religion, while maintaining the idea of the supremacy of religion. He emphasised that for ethical purposes, religion should be the dominant power when we think about science:

> "We can study whatever we need to study in science, but religion at the end is [the] evaluating factor in whether to accept the application of this scientific work or not. This is because religion has responsibility for the moral and ethical aspects [of life] and religion is the organizer of people's lives." (T/Eman, questionnaire)

b) Dialogue under the authority of religion

As shown in Table 3, the positions of fourteen of the seventy-five teachers are represented by the 'dialogue view'. These teachers believed that science by itself was limited and could not answer all the questions, and that religion could suggest possible answers to questions science could not address on its own. They thought that the more science moved towards religion, the more successful science would be in benefiting humankind. Gamal explained this partnership:

> "The relationship between science and religion is a strong and firm one because without religion there is no science. Qur'anic verses stimulate and encourage us to learn, and [the] noble Hadiths show us how to pay attention to science and relate it to religion because there are issues that cannot be applied except after coming back to religion." (T/Gamal, interview).

Ayman agreed with Gamal in regarding science as a servant to religion:

> "Science is a means of understanding what religion advises us to do and the reason behind this advice. I don't think that religion is complementary to science since what the latter teaches (proves), is there in the Holy Qur'an and Sunnah; science comes only to explain what seems obscure or unrecognizable." (T/Ayman, interview 2)

Some teachers felt that there should be a religious supervision of science. These teachers emphasized that religious interpretation (explanation) could not be discounted, but on the contrary had to be the gateway through which any phenomenon was researched. They argued that the Islamic religion can act as a lead for science and scientists. For example, Hesham, a biology teacher, says the Islamic religion not only encourages scientific research, but also guides it, supported by the truths revealed through Islam:

> "The Holy Qur'an has included all kinds of sciences on the earth. There are no details, because the Holy Qur'an is not a science textbook. It is a guide for all humankind. So, scientists and ordinary people must study it to carry out their research safely. Scientists should get guidance and ethics from the Holy Qur'an. This can save much time, effort, and money." (T/Hesham, interview 1)

c) Compatibility between science and religion

As shown in Table 3, in contrast to the minority holding conflict or independence views, a majority (forty-six teachers) expressed the integration view of the relationship between

science and religion. These teachers take the approach that there must be some kind of integrated way of making sense of the universe, an integration that makes sense of the scientific approach to our world in light of religion (Shipman *et al*., 2002). These teachers feel that the compatibility between science and religion is based on a reciprocally beneficial partnership and a respectful dialogue between them that will lead to spirituality. In contrast with dialogue ideas about the dominance of religion in communications between scientists and religious scholars, these teachers expressed the view that such communication should be based on respect and equality, as Mahmoud explained:

> "The scientist is required to explain and verify some phenomena that are mentioned in religion. Religion demands that scientists search and think of every phenomenon." (T/Mahmoud, interview 2)

Teachers holding the view that science and religion are compatible explained that the Islamic religion provides an accurate account of how life and the universe came into being. Hend further expanded on this belief as follows:

> "I agree that scientific knowledge is the truest form of knowledge in the field of natural phenomena in cases where there is no discrepancy (conflict) with the Islamic religion. Also, science continuously comes to show clearly what we don't understand about religion." (T/Hend, questionnaire).

These forty-six teachers confirm that science can help in understanding many of the phenomena mentioned in the Holy Qur'an, which will help prove some of the 'truths' of religion. Heba explained this reciprocally beneficial relationship by citing a verse in the Surat al-Gashiyah, which shows that Allah invites man to ponder and investigate the natural world with the following words:

> Do they not look at the Camels, how they are made? And at the Sky, how it is raised high? And at the Mountains, how they are fixed firm? And at the Earth, how it is spread out? (Surat al-Ghashiyah: 17-20)

In addition, these teachers emphasized their epistemological belief that science can deepen their understanding of the scientific phenomena of nature created by God. For example, Heba said, "The more mankind goes deeper into science the more he grows aware of things around and the more he knows about the power of Allah, who can never be disabled by anything in earth or heavens. Consequently, this will affect how much man is religious" (T/Heba,

Interview 2). Hend mentioned the unity between science and religion in terms of it being a main target for well-being in life: "The more mankind learns about the natural world, the more he realizes that there is a great Creator for this world and that there is a need for a kind of religion to make this world ordered (disciplined). There is a need for religion to rule the world." (T/Hend, interview 2)

II. Teachers' views of the Islamic perspective of science

a) Teachers' interpretations of the Islamic-epistemological position of science

The main epistemological and ontological issues related to knowledge in Islam are based on what is mentioned in the Qur'an and the Prophet's sayingss *(Ahadith).* And if, after searching these texts, there is nothing found that is directly to the point of the argument or the enquiry, Muslims can do *ijtihad*, which means doing one's best in searching and making up one's mind logically. This is mentioned in the Qur'an and is called *tafkir* (thinking). Most of the teachers emphasized that science is an endeavour on the part of humans to understand nature. However, God created nature and knows everything about it and its laws. Our role is that of *ijtihad*, i.e., to think, and thereby to discover these laws. We may get these natural laws right, or we may get them wrong. Scientists are human beings and they can make mistakes. In this study science teachers were split into two groups: those who felt there is a close relationship between science and religion, and those who feel that the two domains must remain separate.

In the first group, the teachers who contemplated a dialogue or integration between science and religion; many of these teachers emphasized that Islam encourages scientific methods of research and quoted many verses from the Qur'an to explain this idea. In the third interview, Ayman commented:

> "I can't see any conflict between science and religion in terms of the ways of gaining knowledge. The Islamic religion, as is clear in the Qur'an, encourages us to use our minds and to use what is called in science education, 'scientific processes'. For example, the Qur'an mentions the use of *tabassur* (understanding and reflection)."

Ayman supported his argument with the following verse from the Holy Qur'an:

> Behold! in the creation of the heavens and the earth, and the alternation of night and day – there are indeed Signs for men of understanding. (Qur'an 3:190)

The teachers in the second group, those who perceived a ***conflicting*** or an ***independent*** relationship between science and religion, however see science as suspect, either because of the unreliability of scientific methods or the need to use different methods to consider something from an alternative viewpoint. Sara explains her reservations regarding scientific methods as follows:

> "Methods of science are not reliable sources of discovering the truth. There are religious descriptions that must be taken into consideration because they are more reliable source[s] of truth." (T/Sara, interview 3)

b) Teachers' interpretations of the Islamic-ontological position of science

All the participants in this study argued that the Islamic religion is the main source of truth. They believe that science must be active in proving (verifying) these facts and in discovering what it has not yet been able to discover, and explaining it through religion. Teachers again took sides, according to their views of reality and of the relationship between science and Islam.

Some teachers who saw a conflict between science and religion argued that the two discourses deal with entirely separate realities. This argument shows that some teachers who hold the conflict perspective subscribe to *naïve* views of the nature of science (NOS), and they seem not to have a sense of how scientific knowledge is generated at the epistemological, practical level. For example, Ahmed gives the following statement:

> Not all scientific knowledge can be reliable. What we can prove reliable is only facts, while theories and premises are still an object of study and are not yet facts. There are also some other theories and premises (hypotheses) that can't be subjected to notice or direct recognition on the part of scientists. Consequently, in this case, experimental science can't pass the stage of theorizing, as in the example of how the universe evolves." (T/Ahmed, interview 3)

Sami is another example who argues his views of the nature of science from a position related to his views of reality and truth. Sami does not agree with the scientific methods that claim that their results and measures are one hundred percent accurate; he is particularly suspicious of the consequences of such methods. He viewed truth as not based in science but on the Qur'an:

> "I do believe in Islam and the reality of Islam… Religious methods are more valid than science, which changes every second. The Islamic religion explained many issues about 1400 years ago." (T/Sami, interview 2).

Ahmed also argues the truth of science in relation to his personal religious views. In the questionnaire he says that since science is human work, it may be wrong; however, he sees religious description (Islam) as infallible because it comes from Allah, the Creator, who "knows His creatures well" (T/Ahmed, questionnaire). However, teachers who hold *dialogue* or *integration* views about science and religion find harmony in applying ethical theological concerns from Islam to the processes and outcomes of science.

Hesham explained this position as follows:

> "I do believe that there [is] no conflict between science and religion, for at least one reason which is that *el-Tabeaa* (nature) is the creature of God. That is why whoever studies science should apply it according to religious guides, because these are part of the laws of nature. (T/Hesham, interview 3)

Teachers holding views similar to Hesham argued that science and religion stand in relation to each other; religion is the primary domain and science the secondary. Science proves a lot of things from the time of the Qur'an and Sunnah that were verified a long time ago. So, scientists can't live without religion:

> "Believing in the super power of Allah is very important and is the basis for studying any scientific phenomenon." (T/Hesham, interview 4)

Some other teachers with more extreme views argued that science could be used to prove either that Islam is true or, at the very least, that certain Islamic theological statements are true. These teachers argued that the foundations of nature are in the Holy Qur'an and the role of the scientists is to study these foundations and use them to guide their discoveries. They

supported the perspective that religion should have authority over any scientific work, as explained by Kamal:

> "…we find new discoveries there in the Holy Qur'an after more than one thousand and four hundred years of Islamic faith and steady belief in the fact that religion (Islam) is *haq* (true), and that what the Prophet Muhammad has said is true too; for example, proving the fact that the earth is (irregularly) circular (round) and not completely round. This fact comes in the Qur'an." (T/Kamal, interview 3)

Mahmoud agreed with Kamal when he made the following statement:

> "Allah is able to know and do everything. Everything around us in this universe shows the superlative work of Allah." (T/Mahmoud, Interview 2)

Mahmoud supported this opinion with verses from the Qur'an:

> We shall show them Our signs in the universe and within themselves until it will be manifest unto them that this is the Truth. Does not thy Lord suffice, since He is witness over all things? (Qur'an 41: 53)
>
> Those who have been given knowledge see that what is revealed unto thee from thy Lord is the Truth. (Qur'an 34: 6)

Discussion

This section presents the 'explicit grounding stage' of the multi-grounded theory approach. Using a theory matching process, the empirically derived theory, which consists mainly of teachers' views about science and religion and the epistemological and ontological foundations of teachers' views about the two domains, were compared and contrasted within the theoretical frameworks found in the literature related to science and religion.

The teachers viewed any conflict between science and religion as 'science conflicts with religion', rather than as 'religion conflicts with science'. This understanding of the conflict is based not on a separation between scientific materialism and Qur'anic literalism, but on an understanding and respect towards science from the Islamic-religious side, and on conflict and ignorance over religious values and morals from the science side (Al-Hayani, 2005). Shanavas (1999) argues that if the assertion that the Qur'an inhibits (conflicts with) science is correct, science should have been dead soon after the advent of Islam and the Qur'an. However, science flourished during the first centuries of Islam. In this respect, Strassberg

(2001) argues that some people might see conflict between religion and science on the level of knowledge (e.g. creation and the big bang), but appreciate the contact between them at the level of norms (religion reinforcing the legal system). Lederman *et al*. (1998) argued that science and religion were different systems for generating knowledge and, thus, could not be compared using a single framework.

The findings of the current study concur with those of Cobern and Loving (2002), concluding that some science teachers value science, but they do not place science at the top of an/the epistemological pyramid, nor do they consider science more important than religion. In the current study, science teachers' views of the importance of religion over the empirical sciences are not in line with the Islamic view of empirical science. Islam never maintained that only theology was useful and the empirical sciences were useless or harmful. I think these views have their roots in the history of Islam, as an interpretation by some politicians. This view [conflict] was proclaimed by semi-literate clerics who wanted to keep common Muslims in the darkness of ignorance and blind Islamic faith so that they would not be able to oppose unjust rulers and resist clerics attached to the courts of tyrants (Akhtar, 1984).

The findings of the study corroborate Hokayem and BouJaoude's study (2008) in which a number of the participants considered science and religion to be independent and others thought that a conflict existed between religion and science. However, the current study does not concur with Hokayem and BouJaoude's finding that some of their participants thought scientific explanations were more valid than religious ones; in the current study, the teachers who hold conflict or independent views expressed the opinion that religious explanations were more valid than scientific ones. However, the independent view as expressed by the teachers in the current study is not quite in line with the Islamic epistemology of knowledge, which encourages the pursuit of knowledge in different fields of science and with different research methods. In the history of Islamic sciences, there are three sources for the acquisition of knowledge: reason, experience, and the evidence of transmission from a reliable source (Ahmed, 1999). The Qur'an asks, "Do they not look at the sky above them? How We have made it and adorned it, and there are no flaws in it?" (Qur'an, chapter 50, verse 6). The Qur'an goes on to say, "… No want of proportion wilt thou see in the creation of (God) Most Gracious. So turn thy vision again: Seest thou any flaw?" (Qur'an, chapter 67, verse 3). In this sense, the Islamic view of exploring natural phenomena encourages the

scientific reasoning which focuses on the process of knowledge construction using reflective thinking skills. This view matches Dewey's philosophy of the scientific reasoning represented in his book 'How We Think'. Dewey's method presented a universal means of approaching any situation from a scientific point of view without having to bother with formal rules of logic (Rudolph, 2005).

All of the participants claimed they held a very strong belief – the key religious belief for Islamic worldviews – that the Qur'an was a book for guidance, not just for scientists, but for all humankind in all aspects of life, including how humankind should seek scientific, empirical knowledge, what methods he should use, and what ethics he should follow. This explains why Islamic science teachers used a dominant-religious argument to support their views of the relationship between science and religion. Most of the arguments they put forward were based on religious evidence or on logical thinking without any scientific evidence. In this study, teachers' use of a dominant-religious argument guided their epistemology about science. They emphasized that scientific explanation may be wrong because it is, after all, a human work. The teachers' beliefs that scientific knowledge is socially constructed and always tentative are characteristic features of the epistemology. This explains why scientific explanations do not conflict with the teachers' religious discourse. This case is represented in the analytical framework of Roth and Alexander (1997) as Quadrant III (see Figure 3). Teachers in this study used religious texts or religious guidance to resolve any problems arising in their relationship with science and religion. These texts or guidance are what Roth and Alexander call a mediating device; they suggest that such mediating devices could help resolve intellectual conflicts among various discourses. Teachers' use of these religious mediating devices disagrees with the position of the teachers in Hokayem and BouJaoude's (2008, p. 411) study, which found that 'Adopting a non-literal interpretation to a religious text is a mediating device in case of possible conflict of science with religion'. In this sense, teachers' personal religious beliefs (PRBs) work as a 'schema' which influences what teachers perceive (McIntosh, 1995). Teachers' PRBs might influence their views of social-scientific issues related to religion (e.g. cloning and abortion). The religious schemas of these teachers influence the way they perceive science and how science is produced. A teacher with PRBs or religious schemas is more likely to force a religious interpretation on an experience than a teacher without such beliefs.

Teachers described scientific knowledge as socially constructed (Quadrant I and Quadrant II, Figure 3). While scientific knowledge is socially constructed (an epistemological claim), teachers make absolute statements about the creation of the world, including science, by God (an ontological claim) (Quadrant III and Quadrant IV, Figure 3). Because the notion of social construction allows multiple viewpoints of the same 'object', teachers did not experience conflict bringing the two realms of 'science and religion' together in the process of rational discourse. In some instances, teachers expressed conflict between science and religion, when they talked about controversial issues (e.g. cloning, evolution, creationism, etc.) in which both realms 'science and religion' might be concerned, and they usually decided to privilege the religious realm over the scientific one (Roth & Alexander, 1997). Therefore, teachers in the current study did not need a mediating device such as TWOD, incompatibility, or complementarity (see Figure 3). Teachers' religious orientation together with their social construction view of science provided them with an important device to keep a balance between their religious beliefs and their views about science (Roth & Alexander, 1997). The teachers' use of both the social construction of science and the absolute truth of Islam illustrates why some science teachers in the study hold negative attitudes toward non-Muslim scientists, which will be discussed in the following section.

The findings of the study showed that some teachers held negative attitudes about certain aspects of science just because non-Muslim scientists had discovered this knowledge. This attitude does not correspond exactly with the Islamic epistemology of knowledge, which encourages the gaining of knowledge from everywhere at any time. To support this view, one need only refer to the *hadith* (saying of the Prophet) that advises the individual "to seek knowledge even in China", a direct invitation to learn and gain knowledge from a non-Muslim country. What knowledge was available in China at the time of the Prophet? Certainly there could not have been more knowledge about Islam than there was in Mecca and Medina, in Arabia where Islam had its origins. The knowledge that could be acquired in China would have been non-religious knowledge, since China at that time was already advanced in papermaking, ceramics, explosives, and the practice of administration and of war. Clearly, Islam also wants Muslims to learn about subjects that are not specifically linked with religion, even if the source of knowledge is not Muslim (Mohamad, 2002). In this regard, Kamali (2003) argues that the Prophet Muhammed could not have considered knowledge as an extension, or even a concomitant, of the beliefs, *aqida*, of Islam; he also maintains that the

Prophet's sayings take a pragmatic and utilitarian view of knowledge, which can be sought outside Islam if necessity demands it. Here, the great and underlying message from the *hadith* is that a Muslim's loyalty and commitment to Islam is unaffected by his or her attempt to seek knowledge from a non-Islamic source, though knowledge obtained from non-Islamic sources may not be 'rooted in God' or necessarily lead to Him.

The attitude of science teachers towards non-Islamic Western scientists reflects the teachers' concerns about the ethics and values of science. In this case, teachers' views reflect part of the Islamic epistemology of science. This epistemology is based on Islam's perception of knowledge as being value-oriented and informed by ethical and theological concerns. Kamali (2003) argues that this epistemology leads to a basic pattern of harmony, rather than conflict, between Islam and science. Ahmed (2002), too, maintains that any revitalization of Islamic science would require the critical integration of modern Eurocentric knowledge into the new Islamic knowledge, just as the early Muslims freely evaluated and assimilated numerous foreign bodies of knowledge. In this case, it is unlikely that teachers who ascribe to naïve conceptions of NOS would be able to help their students develop informed views of the nature of science (Akerson & Abd-El-Khalick, 2003). Aikenhead (1996, 1997) argues that the task for students in this situation is that of 'cultural border crossing'. The effective teacher in this situation is described as a culture broker. Thus, in countries with unique cultural milieus, helping students develop awareness of the assumptions and sensibilities of Western intellectual cultures becomes a necessary component that deserves special attention when developing curricula or designing instructional materials and approaches aimed at addressing student conceptions of NOS (Dogan & Abd-El-Khalick, 2008).

The findings of this study concur with Ahmed's view (2002) that even today there are a number of science teachers who have not yet demonstrated a full acceptance of Western scientists. However, a possible cause of the anti-Western sentiment about sciences in the Islamic context may be that when modern Western scientists make discoveries about the natural world, they claim that their representations (e.g., hypotheses and theories) are telling us something about a partial reality as it is in itself (Gross & Levitt, 1994: 262) and science teaching continues to convey what many scholars see as mythical images of realism and positivism (Abd-El-Khalick and Lederman 2000). However, Al-Hayani (2005) argues that the colonization of most Muslim countries by the West has caused Muslims to resist the onset of modern Western science's 'Eurocentric sciences', and that given their distrust of Western

colonizers, Muslims were convinced that the science initiated and encouraged by the West was a secular endeavour, intended to undermine Islam's theological base (p. 569). Another possible cause of the anti-Eurocentric sciences argued by Aikenhead and Ogawa (2007) is the nature of the conservative culture of school science that is not conducive to teachers rising above the scientific method, realism, and positivism. As a result, school science generally fails to inform students about the authentic Eurocentric sciences that permeate their everyday lives.

In this study, some teachers ascribed to naïve views on the nature of science and they seemed not to have a sense of how scientific knowledge is generated at the epistemological, practical level. In this respect, research has shown that teachers' views of the NOS are not consistent with contemporary conceptions of the scientific endeavour (Duschl, 1990; Lederman, 1992; Abd-El-Khalick et al., 1998). Similarly, results reported by Roth and Alexander (1997) and Abd-El-Khalick and Akerson (2004, p. 807) showed that teachers who viewed science and religion as two opposing schemes (conflict view) or two separate schemas (independent view), did not demonstrate growth in their NOS views. These teachers seemed to approach scientific ideas and evaluate their applications in society from religious perspectives and the associated criteria of 'credibility'. These included a dualistic 'right/wrong' perspective and the criterion of 'truth'.

In this study, some teachers did not just ascribe to naïve views of the nature of science, but also to naïve views of the Islamic perspective of science and scientific investigation. They argued that science is an ever-changing phenomenon and scientists' assumptions and predictions may be wrong, whereas the teachings of Islam are eternal and not subject to human error. The purpose of doing research in science, they argued, is to validate the Qur'an or establish the truth of the Qur'an. But if we look at the Qur'an we find that in Islam there is a space of freedom and creativity for scientists to research. The Qur'an instructs Muslims to engage in science, with the expectation that "signs in the earth and heavens and in your own self" will be comprehensible to them (Shanavas, 1999):

> There are signs in the earth for those who are firm in their faith, and within yourselves. Can you perceive? (Qur'an , chapter 51, verses 20-21)

> Say Muhammad: 'Travel in the earth and see how God originates creation; so will God produce a later creation: For God has power over all things'. (Qur'an, chapter 29, verse 20)

These verses from the Qur'an guided early Muslims to investigate nature and the creation of human and other life (Shanavas, 1999). Moreover, according to the tradition of the Prophet (*pbuh*) (*Hadith*):

> "When a judge gives a decision, having tried his best to decide correctly and is right, there are two rewards for him; and if he gave a judgment after having tried his best (to arrive at the correct decision) but erred, there is one reward for him." (Al-Bukhari)

Like the judge discussed in the above quotation, Muslim scientists are allowed to 'take chances, make mistakes, and get messy' in the investigation of nature as long as the intention and efforts are to arrive at the correct meaning and a fair judgment in any matter (Shanavas, 1999).

Conclusions and Implications

The study argues that when exploring individuals' views of the relationship between science and religion, the influence of culture on their understanding of the interpretation of religious perspectives of science should be considered carefully. The findings of the study argued that in a culture based on religion, science teachers' views about what science is, and what science should be for, depend on their interpretations of religious principles. The findings of the study showed that as a result, when teachers' interpretations of religion are related to science, they form an array of views and attitudes about science and the purpose of teaching and learning about science.

As a result of dealing with science teachers who hold widely differing views about science and religion, many students might perceive science as being completely disconnected from the bigger issues of their lives and their religious beliefs. Worse still, some students may perceive that the science being taught in schools is an attempt by the teacher to promote a particular truth or belief. Here, the key question is 'What can a science educator do about all these conflicting voices?' As a broad answer to this question in relation to the findings and the

context of the study, I emphasised the argument made by Aikenhead and Ogawa (2007) of the significance of the need by science educators to be aware and understand the cultural influence on both science teachers and school science achievement by students whose cultures and languages differ from the predominant Eurocentric culture and language of science. These teachers and students may live in a non-Western country (e.g., Egypt, Lebanon, or Saudi Arabia) or they may live in a Western country (e.g., USA, Australia, or UK), but in any case, they do not feel comfortable with the culture of Eurocentric science embedded in their school science classes.

The present study clearly showed the confusion among the teachers regarding the presentation of the Islamic worldview of science, and suggested that this confusion is due to the fact that their knowledge of the link between science and religion was coming from informal sources. This conclusion concurs with a similar finding by Hokayem and BouJaoude (2008) that the students who were uncertain about the theory, or those who rejected it, held a strong position against the scientific nature of the evidence supporting the theory. Therefore, science educators should take into consideration the distinction between the cultures of science and religion (Aikenhead & Jegede, 1999; Abd-El-Khalick & Akerson, 2004). In this sense, science teacher education should, therefore, prepare teachers to be knowledgeable about the domain of science and religion and to engage in discourse on either subject in an informed and knowledgeable manner, so that they can discuss any issue from both a scientific and religious standpoint. This preparation will help teachers to make decisions about the orientation of the argument in the classroom. For example, science teachers are much more likely to encounter questions that require them to determine whether the question should best be answered using the methods of science, or religion, or politics, and so on, or a combination of these methods. Having made that assessment, a teacher can then decide what kinds of evidence are relevant (and what is irrelevant) and how to evaluate such evidence (Smith & Scharmann, 1999).

This teacher education would enable science teachers to acquire a thoughtful and sophisticated understanding of the Islamic worldview in relation to science and technology and its clarification, in terms of cognitive, pragmatic, and axiological directions for empirical and technical research in the challenging global context of contemporary scientific and technological enterprise (Setia, 2005). This interdisciplinary discourse would provide a

comprehensive view of the relationship between science and religion, based on the Islamic and Western philosophies of science. This is essentially the same argument made by Pope John Paul II when he recognized that individuals need not choose one way of knowing as an exclusive representation of their worldview. Individual worldviews, instead, are framed using multiple, simultaneous ways of knowing the world that inform and enrich each other (Smith & Scharmann, 1999).

Appendix A

Examples of the semi-structured interviews:

- How do you see science? Its nature, aims, roles?
- How do you see the relationship between science and religion?
- Can science affect your religious beliefs? Why? Does religion affect the way you: deal with science concepts; how? Teach science; how?
- In the questionnaire you expressed that there is a conflict between science and religion; what do you mean by a conflict? Do you have some experiences or some evidence that lead to this view? [Depending on the interviewee's responses, I replaced the word conflict with others such as independence-dialogue-integration]
- In the questionnaire, when you say, 'Scientists should seek advice from religion', what kind of advice do you think religion can offer scientists? To what extent should scientists follow religion?
- If the scientific phenomenon that scientists study is not mentioned in the Holy Qur'an, what do you think the scientists should do? How do you evaluate their results?
- To what extent do you believe in evolution? Why?
- Is there a conflict between science and religion? If no, why not; and if yes, how could you introduce or explain this conflict?
- Do you think it will make a difference to a science if it is developed by non-Muslim Western scientists or by Muslim scientists? Why?
- If you were offered two explanations to the same phenomenon, one scientific and one religious, which one would you consider more valid? Why?
- When you say 'valid science', what do you mean by that?
- How do you think scientific knowledge is produced?
- How does science progress? Do you think there is a role for religion to play here?
- What type of evidence does science rely on? Do you think there is a role for religion to play in this evidence?
- Do you think science can investigate the supernatural and, possibly, explain it? How far do you think science can do this?

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