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**WAR AND PEACE: STUDENTS’ SCIENTIFIC AND RELIGIOUS DISCOURSES**

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**Abstract**

When students come to school they often bring understandings which actively interfere with the curriculum offered by the formal educational setting. Although the discourses of science and religion have often been incommensurable at the institutional level, religious discourse has rarely been studied as a potential interference with the learning of scientific discourse at the individual level. In a two-year study with 23 students, we identified different interpretive repertoires on which pupils draw to talk in sometimes contradictory ways about controversial issues (abortion, euthanasia, origins of humankind). These contradictions may interfere with students’ science learning. We illustrate in detail two students’ scientific and religious discourses.

When students come to school they often bring understandings which actively interfere with the curriculum offered by the formal educational setting. Much research has been conducted to understand how everyday talk about phenomena developed prior to instruction interfer with the science talk students encounter in the school.¹ This literature is commonly associated with the labels of "misconceptions," "alternative frameworks," "naive conceptions," "phenomenological primitives," and "conceptual change." Other sources of interference with science instruction are less charted. Thus, although the discourses of science and that of fundamentalist Christians have often been incommensurable at the institutional level, religious discourse has rarely been studied as a potential interference with the learning of scientific discourse at the individual level.

¹ Because of the problems associated with mapping talk and text onto underlying cognitive representations (Edwards & Potter, 1992), this study takes as its central tenet the primacy of language as a reality-constituting practice. Rather than focusing on underlying "beliefs" and "conceptions," we studied students discourse. This aspect of our approach is explained in greater detail in the section on interpretive repertoires.
We engaged in this study to construct an understanding how religious discourse interferes with scientific classroom discourse in some students but not others. Some students made conflicting claims in their scientific and religious discourses which they could not resolve. These conflicts interfered with learning science. Other students developed mechanisms which allowed them to eschew such conflicts. Yet another kind of students did not experience any conflicts. We expanded a framework developed for the analysis of scientists’ discourse to make it suitable for the analysis of scientific and religious discourse. Although there appear to be marked conflicts between scientific and religious discourses in other cultures (e.g., conflicts between Islam and science [Anees, 1995]), "religion" in this study refers to public and personal dimensions of Christian faith. Because of the personal nature our topic, we chose an alternate literary device that mixed authorial and personal voices distinguished by different type faces.

Background

The boundary between science or technology and religion has long been the site for individual, institutional, and cultural conflict. In order to minimize the conflict at the institutional level, some countries, such as the United States of America, have elevated the separation of church and state to a fundamental principle enshrined in their constitutions (O’Connor & Ivers, 1988) while other countries such as the now defunct USSR have consistently suppressed any role for religion. This separation at the institutional level was also formally pronounced on behalf of organized science by the National Academy of Science (NAS) (1984) in Science and Creationism. NAS took the position that “religion and science are separate and mutually exclusive realms of human thought whose representation in the same context leads to misunderstanding of both scientific theory and religious belief” (p. 6).

Although the differences between scientific and fundamentalist Christian discourses have been argued repeatedly in court, little research exists whether or not such differences might interfere with students’ appropriation of school science talk. Inspite of the formal separation between science and religion, many people do not make such separation at the personal level. Hence, when their scientific and religious knowledge claims conflict, students have difficulties learning the subject matter of their curriculum. Students with strong commitments to creationist discourse about the beginning of the universe are less prone to understand evolutionary biology than their peers (Lawson & Weser, 1990; Lawson & Worsnop, 1992). It is alarming then that a large number of students and university administrators favor the teaching of creationism. Research conducted in several public universities in Ohio showed that 80 and 94% of the students favored the instruction of creation science (Bergman, 1979; Fuerst, 1984); and a survey of approximately 28% of the Ohio school board presidents revealed that more than 52% want creation science taught favorably and do not believe that this means introducing religion (Zimmerman, 1991).

In schools, we can then expect the presence of students who employ religious discourses that they and their parents regard incompatible with canonical scientific classroom discourse. These religious discourses may be even more problematic for science instruction than students' intuitive and mundane discourse about natural phenomena ("misconceptions") which are not linked to religious explanatory schemes. This study arose from these concerns. In the context of high school science, we wanted to understand the interaction of scientific and religious discourse, and students’ management of conflicting knowledge claims within and across discourse domains.
Study Design

This study was co-authored by a science teacher and one of his high school students according to guidelines developed to assure the "credibility" of qualitative research (Guba & Lincoln, 1989). To counter possible charges of subjectivism, we describe our procedures and the school context in more than usual detail. Different type faces distinguish personal voices from the voice of the joint authors.

Participants and Setting

The present case study was developed from a data base established over a two-year period in the context of the longitudinal Epistemology Study. This study investigated physics students’ ontological and epistemological discourse about the nature of physics and their views on learning (for initial results see Roth & Roychoudhury, 1993, 1994). From a cohort of 46 students enrolled in a junior level physics course, 23 enrolled in and completed a senior level physics course. Seven students, according to their own accounts, had strong religious commitments. One of these students, Todd\(^2\), co-authored this study.

Science and Religion at School

At the time of the interviews, we were associated with a private all-boys’ school in Central Canada. Boarding was compulsory for juniors and seniors. Daily chapel attendance was compulsory for all students (Grade 4-13) irrespective of religion or denomination. Although the chaplain was an ordained minister of the Anglican Church (Church of England), the services were non-denominational and deemed appropriate for the collective of faiths in the student body which included Christians, Muslims, Hindus, Sikhs, Jews, and Buddhists. Each morning, the 15-minute service was constituted by a hymn (from the Anglican hymn book) and reflections, presented at least once per week by a senior student. Senior students constituted the group of chapel wardens, responsible for assuring order and keeping attendance. The chapel choir was constituted by students from all levels. Each year until their junior year, students attended a compulsory course in religion. These courses, part of the requirements stipulated by the Ministry of Education, focused on various world religions without prioritizing any one of them.

The senior author, as about 50% of the faculty, also resided on school grounds associated with a residence which provided the authors with many opportunities to meet formally and informally after school to complete this project. Like the majority of faculty (circa 90%), he did not attend the, for teachers optional, chapel services.

The 23 students in this study all attended the elective junior and senior level physics courses taught by the senior author (WMR). In both the junior and senior physics courses, about 70% of class time was devoted to experimenting. Most of the research questions for experiments were student-framed; students planned and conducted the experiments, interpreted their data and submitted reports. The only constraints for the research projects were that they had to deal with the content matter specified by the Ministry of Education and that they were convincing (not necessarily "right") in terms of design and results. The remaining class time was spent on reviewing textbook materials and questions, preparing collaborative concept maps, and discussing supplementary readings. The latter included essays, chapters, and books such as "Objectivity in Science" (Suzuki, 1989), "What Every School Boy Should Know" (Bateson, 1980), or "Inventing

\(^2\) Todd, the co-author of this article, is identified by his real name throughout the manuscript. Brent and Ian are the pseudonyms for two other students.
Reality: Physics as Language" (Gregory, 1990). These teacher-selected texts questioned the objectivity and rationality of scientific inquiry and knowledge taken for granted in the students’ science textbooks. Finally, to meet the provincial requirements for proficiency in physics content, the students read the pertinent textbook chapters on their own and completed about 6 end-of-chapter questions per week.

Teacher and His Beliefs

It has been argued that students’ and teachers’ epistemological commitments interact and contribute to the classroom climate (Roth & Roychoudhury, 1993, 1994). Here, the teacher (WMR) talks about his beliefs.

(WMR:) My discourse was an important aspect of the setting in which students developed over the two years. To avoid the dangers of merely labeling my discourse as agnostic or atheist, we decided that I provide a brief description.

The knowledge which we take as shared with others is socially constructed and legitimated within and across cultures. As an educator and social scientist, I am a member of a culture which engages in a continuous and continuously changing discourse to establish new explanatory resources. The meanings of concepts are not fixed, nor can they be considered as the same for all people. Idiosyncratic variations in our discourses (used to account for "scientific concepts" or "religious beliefs") have to be considered the norm rather than the exception. There is no need for the notion of god as a discursive resource to explain the origin, purpose, and destiny of mankind. On the other hand, although I do not use god as a discursive resource, I consider myself (and am considered by others) as spiritual. Through mankind, the universe inspects itself self-reflexively.

In my physics courses, I discussed with students the problematic of objectivity, the occasioned character of scientific knowledge, the discursive practices of scientists, and the historical changes in scientific discourses. From these discussions, the students constructed my spiritual/religious commitments in different ways. Some, like Todd, felt that I was committed neither to formal religion nor to atheism, but that I was deeply spiritual. Others, like Brent, thought that I was a "complete atheist."

Science and Religion: Psychosocial Setting

The case studies are based on the interviews and essays of two students, Todd (as second author presents himself) and Brent.

(Todd:) Having been brought up in a household where science and religion were both part of daily life, it was easy for me to bring the two beliefs together. This co-existence of science and religion continued at our school where both chapel services and science are part of the daily experience. Thus, for me the notion of God became all-encompassing including science and the knowledge constructed through its procedures. At the school, I liked very much and did well in all my subjects, including the sciences biology, chemistry, and physics. Besides sciences, I also took a keen interest in philosophy, poetry, and fine art all of which were part of my course work towards graduation. I was one of the chapel wardens, and member of the chapel choir. In my conversations with Michael, the senior author, I came to know that my discourse could be labeled "social constructivist." While this might be surprising, I do have a significant spiritual-religious life. These labels, however, like so many, do not express my specific discourse at the time of the study. (I will elaborate on science and religion below.)

3 It was also implicit in the conceptualization and design of the study, was part of the ecology of the interview situations, and unavoidably determined the reading of the data sources.
contribution also presented us with a problem which we had to resolve as we wrote this article. I often felt tempted to change or add to my earlier written and spoken statements. Michael, on the other hand, felt that the article should be about high school students' discourse rather than a story of my changing discourse in the process of our inquiry. This is a different story which I would like to tell in another place. So we decided to present my views as we reconstructed them together from the essays, formal interviews, personal notes, and informal conversations at the time I attended Grade 12.

Brent. In his last two years at school, Brent was a moderately successful student; his grade point average was about one-half standard deviation below the mean. He was less successful in his two sciences, chemistry and physics, of which he just passed one and failed the other, respectively. Brent had selected these science courses in part because of his parents' wish that he become a medical doctor ("My parents sort of pushed me"). In order to enter the prerequisite science programs, he had to complete the senior-level physics and chemistry courses. He had a keen interest in theater arts, a subject in which he received an A, and which encouraged him to be actively engaged in several play productions at the school. During the two years at the school, he repeatedly talked about his deep religious commitments and the conflicts he experienced as he learned chemistry and physics. His peers also knew him as an avid debater with respect to religious issues. Brent was also chapel warden and member of the chapel choir.

Brent's parents had a very strong influence. Brent indicated that both in his church and home he was "scared into" the belief that he had to go to hell unless he believed in God. Physics and chemistry, on the other hand, taught him that he was merely made of atoms, indicating that there was no afterlife. He considered science teachers to be atheists who refuse to believe in God and who indoctrinate students, attempting to make them believers of science. On the basis of such tensions, paired with the observation that some of the high achieving students were not religious at all, he concluded that science was only for atheists. He constantly felt caught between his parents and church on the one hand, and school science on the other. For as long as he could remember, his parents did not help him to overcome the conflicts he felt between scientific and religious knowledge claims, and merely told him to believe.

Data and Analysis

The data sources for each of the 23 students included three formal interviews which lasted between 45 and 75 minutes and nine reflective essays on the nature of scientific and personal knowledge, the nature of physics, and views on learning science. We transcribed the interviews and used these transcripts as data sources rather than the original tape-recordings. Over the two years we developed a close relationship and met up to three times per week. We kept personal notes and journal entries, which became part of the data sources. In our conversations we talked about epistemology, literature and poetry, cosmology, religion and philosophy. In addition to these artifacts, we included in our data base articles by scientists publishing in Zygon (from the Greek meaning yoke), an interdisciplinary journal with the mission to bridge science and religion. We used these to test the applicability of our grounded theory of interpretive repertoires beyond high school students.

4 Incidentally, Feyerabend (1991) suggested that scientific discourse shares some essential features with orthodox discourse in some Christian denominations.
We independently read and annotated all data sources, then met to discuss our emerging constructions. This process was repeated, followed by the construction of a first draft of the manuscript which became the basis for further discussions. The present article emerged as the product of recurrent cycles of writing and collaborative reflections. During our reading of the data sources, we realized the variability of students’ discourses, which led in some cases to seemingly contradictory statements. For example, Brent stated that knowledge is socially constructed and that it is absolute. From a traditionally psychological and sociological perspective, this made him an unreliable source of information. However, developments in social psychology and sociology of scientific knowledge during the past 10 years allowed us a different reading of such variability in discourse.

Interpretive Repertoires

Ordinarily, views and attitudes are treated as unitary constructs which should lead people to answer specific interview questions (or questionnaires) in consistent ways across time within the same context, or at the same time but across contexts (Edwards & Potter, 1992; Potter & Wetherell, 1987). The notions of internal reliability and test-retest validity of questionnaires are built on this assumption. However, recent discourse analytic research of scientific discourse provided ample evidence for the variability of scientists’ views and accounts within and across contexts (Gilbert & Mulkay, 1984). These interpretive variations in participants’ discourse arise as different accounts are produced to do different things in the context of talk. Accordingly, speakers’ accounts should not be taken as evidence for the nature of social action and belief. Rather than attempting to identify participants’ (elusive) unitary attitudes we constructed explanations through the analysis of the organization of discourse in relation to its function and context. Participants’ discourse are thus to be understood as interpretive reconstructions that are public statements of what counts as ideas, beliefs, and prior actions (Potter & Wetherell, 1987; Edwards & Potter, 1992). These depend in many different ways on the particular interpretations which speakers try to accomplish in their present context. The resources on which participants draw to construct their discourse are interpretive repertoires. This analytic framework because, in contrast to all others with which we are familiar, is commensurable with our pragmatist view of knowing (Rorty, 1989) and does not do violence to participants by constructing them as "irrational," "illogical," or "inconsistent."

In developing our framework (Figure 1), we made sure that it was consistent within our data (on 23 students) by means of the constant comparative method (Strauss, 1987). We took our analysis one step further by applying it to four articles in Zygon. Based on these analyses, we modified the framework (by including an additional component, see below) so that it was also applicable to the writings of these scientists and practicing Christians.

Credibility

Research such as this study is subject to criticisms of "extreme subjectivism." However, there are a number of techniques recognized by educators, sociologists, and anthropologists, which allow researchers to establish the credibility of their knowledge claims. In research motivated by constructivist discourse, the notion of ‘internal validity’ is replaced by that of ‘credibility’ (Guba & Lincoln, 1989). It substitutes the isomorphism between constructed realities of the participants and the reconstructions attributed to them for the equivalent isomorphism between objective reality and findings in traditional research. Among the techniques are prolonged engagement, persistent observation, peer debriefing, progressive subjectivity, and member checks (Guba & Lincoln, 1989). As we both lived at the school, interacted with each other and students in
relations other than teacher-student, and built the rapport of trust between ourselves and other students, we satisfied the criterion of prolonged engagement. As part of the two-year Epistemology Project, we interacted extensively to identify the pertinent issues which afforded the depth due to persistent observation. A university science educator and a fellow science teacher with no interest in the project served as peer debriefers who engaged with us in extended discussions to formulate and refine our knowledge claims. Through our collaborative work in the interpretation of the data sources and the writing of the project, as well as through other conversations concerning art, philosophy, religion, science, literature, and poetry, we ascertained our mutual positions and constructions. As a result, we present joint constructions arising from the progressive subjectivity in our interactions. Being participant and co-investigator allowed Todd to ascertain the emerging constructions as a member check. As a final check, Brent read the manuscript and subsequently discussed it with us. He fully agreed with our representation of his views, and expressed his hope that this manuscript could lead to changes in science teaching that would help other students like himself.

Accounting for Students' Scientific and Religious Discourse

Past research in science education treated beliefs, attitudes, and attributions as unitary psychological constructs which can be measured by means of appropriate instruments (questionnaires, survey, interview, etc.). Variations in participants’ discourse (or selections of items on questionnaires) were then treated as unwanted phenomena. They also let investigators to construct their participants as irrational, illogical, or as holders of compartmentalized knowledge and beliefs (Potter & Wetherell, 1987). We took a different route here. Rather than granting the existence of unitary beliefs a priori, we avoided the construction of irrational participants by using interpretive repertoires to account for all of the discourse, including variations.

When we asked participants to talk about controversial issues (evolution versus creation, abortion, euthanasia) they drew on two realms for answers, science and religion. When we asked participants to characterize the knowledge claims made by the authorities in the two realms, they pointed us to two types of warrants, rational and subjective. The rational was introduced to account for students' arguments that certain scientific and religious knowledge claims are rationally warranted. The subjective dimension was introduced to account for students' claims that there are social and personal influences which make scientific and religious knowledge claims less than reliable. Realms and dimensions span a grid that leads to four repertoires for each individual. Each cell takes one of two values for the kind of knowledge claims made, absolute or socially constructed (Figure 1). To mediate conflicting statements that arise from two discourse repertoires—such as "scientific knowledge is true" (Quadrant I) and "society influences scientists' knowledge claims" (Quadrant III)—some individuals have available mediating devices used to account for contradictory claims. Our students used two such devices.

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5 We both lived in the same residence. One of us (Todd) was head boy, the senior student representative, the other (WMR) served in an advisory and supervisory position. Our positions entailed daily contacts which often evolved into prolonged discussions on topics that were from strictly academic to personal, aesthetic, and ethico-moral in nature.

6 This framework is a further development of Gilbert and Mulkay's (1984) work. These authors had introduced the empiricist and contingent repertoires to account for scientists' claims that scientific knowledge is true and impartial and that there are contingent influences on these knowledge claims. To
The truth-will-out-device (TWOD) mediates the conflict between rational and subjective
claims within the science; the incompatibility device mediates the conflict between
rational truth claims between the realms of science and religion.

This framework is sufficient to account for the evidence of the conflicts in
scientific and religious discourse which we set out to understand. It does not account for
the variability within each repertoire (other than assigning a value of absolute or socially
constructed)—and was not designed to do so. We first illustrate the two types of
knowledge claims for each of the four repertoires and then present an extended case study
of two students' scientific and religious discourses mapped onto our framework.

Over the 2 years of the study, many students shifted in their epistemological
commitments with respect to the knowledge claims made by formal science. While there
was initially a large number of students who talked about the absolute truths created
through the scientific effort (about 70%), only a small number adhered to such discourse
toward the end of the second year (about 17%). The remaining students talked about
scientific knowledge as negotiated and accepted because of its descriptive power not its
truth value. The following quotations illustrate the two types of claims to rationality in
the scientific enterprise (Quadrant I, Figure 1).

(Socially constructed:) [Physics] tries to model the universe because scientists understand that they can't
really know what nature and science really is, but, so I guess the closest they can get is to make a model of
it, a representation of what it is. And I think as long as the math part of it, as long as that is accurate and
your predictions that you get from using your mathematical model, as long as those are accurate, it doesn't
-- I don't think it matters.

(Absolute:) I cannot agree with the fact that the world is the subjective creation of individual observers
while there is nothing subjective about the method of physics. The reason is, that physics must be made
up of theories which many physicists can agree on, or at least with similar topics of physics. Scientists had
created several proposals of something and another states his opinion about that issue, whether it is valid or
not. Therefore, the world is not made up of individual observers.

Students talked about the Christian God and formal religious organization.
Typical student statements that illustrate the rational in religious discourse (Quadrant II,
Figure 1) were:

(Socially constructed:) In contrast to the personal experience of God, there are also the socially constructed
organized religions and their practices. Because of their negotiated character these practices vary across
denominations and religions.

medicate this incompatible claims, they used a form of argument Gilbert and Mulkay called truth-will-out-
device (TWOD); thus, although there are contingent influences, truth will eventually come out.
(Absolute:) God exists, because of all the miracles that he has done and everything from the past and the history says in the bible... When I hear what other people think how the Earth was created, I say, "well that is wrong."... I would think that religion is completely by the book of God, is not artificial, because I have grown up that way.

The existence of a subjective dimension is based on the observation of that students talked about personal and social influences on scientific and religious knowledge claims that cannot be publicly accounted for in rational terms. As before, these knowledge claims may be absolute or socially constructed. Examples of the subjective dimension in students' talk about science (Quadrant III, Figure 1) are:

(Socially constructed:) Well thats—the social environment will create the biases—its the way a scientist or any person has been brought up that will shape his thoughts, his mind and this will influence. There was—last year we read this essay by David Suzuki. And he cited an example of thinking that I think it was, white man are more intelligent than black men because [they had bigger brains].

(Absolute:) Science is based on fact and the knowledge will not change because of his or her social environment. Man constantly searches for numerical answers. Therefore if he is affected by his surroundings, he will no longer be scientific.

Students who talked about the personal dimensions of religion did so in absolute terms. Thus, a typical statement was "I think truth lies within ourselves, in no one else; you can’t run your life based on a book, you just have to look within yourself." Among the students, there was nobody who felt that the personal experience in the religious-spiritual domain was a matter of construction. However, the teacher's view (stated in the design section) that even one's personal experience is mediated by discursive practices of the community within which one participates is an example of the social construction of personal dimensions of religion.

Previous research showed that scientists simultaneously claimed scientific knowledge to be objectively accountable—thus absolute—and subject to local contingencies (Gilbert & Mulkay, 1984). In order to accommodate this conflicting talk, they employed what Gilbert and Mulkay called the truth-will-out-device (TWOD). Scientists argued that although there are contingencies of social nature that affect their and their peers' work, truth will eventually come out. This discursive device allows scientists to claim the objectivity of their knowledge claim while maintaining influences of contingent (subjective) nature. We found that some of our students used the same device to mediate conflicting claims. The following student statement is an illustration of TWOD:

Presuppositions do, I mean, they do delay scientists finding the absolute truth. Scientists are approximating truth, I think, and then such as more recent, scientists they are getting more and more close, and eventually we could [could know the truth] if the world doesn't end before. An example, see Bohr's model of the atom. He had this model that had orbitals, like the set distances; it had orbitals, and they were all circular. And the mechanical, the quantum mechanical [model], it disproved it. But I mean, it took a long time to disprove it.

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7 For an interesting account of the discursive construction of Self see Edwards and Potter (1992).
When we included the second discourse domain, religion, we found that there was a new potential conflict in knowledge claims. Students argued that both scientific and religious authorities made claims to absolute knowledge. In some instances, these knowledge claims were contradictory. Brent, for example, was so torn by these contradictions that it interfered with his learning. Others had developed a device similar to the TWOD. We called it the incompatibility device (Figure 1). Accordingly, two knowledge claims were incompatible so that an individual drew either on one or the other realm to deal with controversial issues. For example, Ian talked about institutional science and religion was incompatible and he kept the domains clearly separate in his accounts. When he talked about issues in which both realms might be concerned, Ian usually decided to privilege one realm over the other. On abortion and euthanasia, he used a religious argument to support his pro-life stand. On issues connected with genetic engineering he talked about the potential good emerging form the scientific enterprise. In this separation of the two realms, Ian chose the solution of many scientists.

Of the seven students with strong religious commitments, Brent’s interpretive repertoires presented one mediated and one irreconcilable conflict (Figure 2b); two student used incompatibility as discursive device, while the others appeared in transition from viewing scientific knowledge claims as absolute (in which case they drew on incompatibility as discursive resource) to viewing all public and shared knowledge claims as socially constructed (in which case they experienced no conflict between scientific and religious knowledge claims). While we cannot make causal inferences, the change in students’ discourse about science toward that of their instructor during the two years of physics was striking. Associated with these changes was the decreasing need for the incompatibility device to deal with the conflicting claims to absolute knowledge by scientists and religious institutions.

To test the applicability of our framework, we analyzed four articles on the topic published in Zygon (Pannenberg, 1988; Peacocke, 1991; Reich, 1990; Sperry, 1991). We found that all four authors talked about scientific and religious knowledge claims in absolute terms. To mediate the potential conflict, two used the same device to maintain their adherence to conflicting knowledge claims arising from their work as scientists and practicing Christians. Thus, a brain-behavior specialist and practicing Christian wrote, "when matters of moral, religious, or related humanistic concerns were involved, my scientific convictions had to be set aside. Conversely, in matters of the laboratory, any mental and spiritual explanations were emphatically excluded" (Sperry, 1991, p. 241). Incidentally, the Pakistani Nobel Laureate physicist Muhammad Salam with a professed Islamic concept of knowledge, uses the same discursive device to keep the two realms separate (Anees, 1995). Here, the incompatibility device was used to make the discourse about scientific and religious knowledge conflict-free.

The analysis of published articles revealed that our model was not entirely sufficient to explain all forms of discourse. Some scientists used one other device to deal with conflicting claims of science and religion not used by our students. The complementarity device (Figure 1) allows an individual to look at the object of inquiry (such as abortion or euthanasia) from two, mutually exclusive viewpoints and integrate these through a dialectical and hermeneutic process. However, it appears that this scheme is not available until people are in their late twenties or mid-thirties (Reich, 1990). Consistent with Reich’s contention, we did not observe the complementarity device in students’ discourse.

Our analyses showed that students—as the scientists publishing in Zygon and those interviewed by Gilbert and Mulkay (1984)—used interpretive repertoires to manage their discourse. These repertoires also generated problems of their own. It was
to be expected that conflict would arise if two repertoires led to conflicting discourse. However, discursive devices mediated these conflicts. These include the TWOD and incompatibility devices, and, in the case of some scientists, the complementarity device. To flesh out how discourses about science and religion interact, we now present two case studies.

Two Case Studies of Scientific and Religious Discourse

The variability in the students' discourse was an immanent feature of the interviews with, and essays by, Todd and Brent. We observed discourse variations which in some cases became apparent as contradictions in one and the same interview. In the following sections, we will first account for Todd’s discourse under the heading of "Science and Religion at Peace." Todd presented his views about knowing in science and religion, and finished by outlining how he integrated both discourses. As joint authors, we situated his views in a cultural, historical, scientific, and spiritual context. In a similar structure, we accounted for Brent’s scientific and religious discourses under the heading of "Science and Religion at War." The selected excerpts in both instances are—with minor stylistic variations from the original—from our data sources. Todd and Brent read the excerpts to make sure that they accurately represented what they intended to say.

Science and Religion at Peace

Science

Over the course of his junior and senior year, Todd’s views about science and scientific knowledge changed. Whereas he initially talked about the existence of scientific truths, the absoluteness and infallibility of scientific knowledge, and the possibility of objectivity, his current discourse was radically different. His view of the nature of science as an effort to construct explanatory schemes which are negotiated in a social forum of the scientific community is not unlike that presented in recent developments in the history and philosophy of science, social studies of science, and epistemology (Hesse, 1980; Knorr-Cetina, 1981; Rorty, 1979; von Glasersfeld, 1987). Thus, although there is a world which is experientially real, it is impossible to know such a world as it really is. He argued that constructions are useful in dealing with this world, but we can never know the functional relationship between this knowledge and the world. As a community, scientists construct language games (Wittgenstein, 1968) which they deconstruct when they are no longer viable in the light of sufficient new experimental evidence. In terms of our framework, Todd described scientific knowledge as socially constructed (Quadrant I, Figure 2a).

(Todd:) Science is a language game. It allows us to talk about the world in community of knowers which shares a common language. This language allows us to create tools—concepts and theories—to talk about this world, predict and explain events, and thus create our knowledge of this world. We are now forced to ask ourselves what shape do these tools and truths take and how are they used by us? The answer takes us to the beginning of one of my essays where I stated that it is "with words, with sounds, all joyful, playful and obscene" on which scientific knowledge is based. The language we create and use to describe our observations becomes the tool itself. By changing the language we not only change the law and principles science is stating but we also change a previously accepted truth and effectively make a new one. Thus, it is language and the way in which we choose to define the phenomena we observe that is at the core of our knowledge; it is through these words that we arrive at the images and ideas that allow us to predict and explain our observations. This holds true for everything in our lives, it is through our language that we communicate our ideas, thoughts, and feelings, and it is
also through them that we are able to learn through the recreation of our perceptions within our minds.

According to Todd, when the personal and subjective come to bear on the realm of science, measurements, procedures, and interpretations will be constructed open to deconstruction in the light of new evidence, or it impacts on the socio-culturally generated interpretation of scientific experiments. In this latter group of interpretation would fall, for example, some of the results of science in communist USSR or Nazi Germany. But the subjective also accounted for the shifts in "social truths" over time. That which was accepted today as valid knowledge may be error tomorrow (the shift in status of women), and the outrageous and unacceptable ideas of today become the truths of tomorrow (acceptance of de Broglie's matter as wave formalism). Because knowledge is socially constructed, such variations in truth value are irremediable features of the epistemology; they do not conflict within Todd’s discourse (Quadrant III, Figure 2a).

(Todd:) I find myself asking continually, does not the way in which we choose to describe what is occurring in fact create our reality? Now that we have progressed in science to a point that we are determining the relationship of things that are no longer visible to us and are at times almost unimaginable, it seems that reality becomes what man makes it. The way in which we describe things and think they are becomes what is real for us, until a time that a new and better way is thought of to replace the old; this in turn becomes our new reality. But this language has not only such a descriptive quality to be used in understanding the phenomenal world, but can also be used reflexively, to think about our thinking, language, and knowledge. It lets us conceive of our knowledge as being constructed, and as having a precarious relationship with that which it describes, including language itself.... Although I believe that the world is constructed, a construction mediated by language, figural models, and perceptions, I do not consider myself a solipsist. I believe that there is a world in which we are thrown, a world which we sense as experientially real, about which have no doubt.

Religion

For Todd, knowledge claims shared within organized churches are like those of other institutions; they are negotiated within communities. That is, these knowledge claims bear the same marks as those in other public areanas such as science, art, or music (Quadrant II, Figure 2a).

(Todd:) In contrast to the personal experience of God, there are also the socially constructed organized religions and their practices. Because of their negotiated character these practices vary across denominations and religions.

The subjective dimension of religious knowledge allowed Todd to take account of the personal experience of God. There was no doubt that these relationships with God are experientially real and thus take on an absolute status ("absolute" in Quadrant IV, Figure 2a). With his religious discourse, Todd took a position which Christian theology began to develop during the Age of Enlightenment, and then in England particularly during the second half of the last century. According to this position, the Bible should not be read literally, but as an allegory or account of the universe from the perspective of a people at the time of the writing of Genesis, about 3000 years ago (Kenkel, 1985; Pannenberg, 1988). Accordingly, creation and evolution are not incompatible, but rather complement each other. In fact, the evolutionary changes in the animate world can be
viewed as a continuous creation of a world in which God is immanent (Peacocke, 1991). But in this view, God is not some kind of spiritual gas permeating the universe like the nineteenth century ether, but "all-that-is in its actual processes is God, manifest in his mode as continuous creator...we could say that the world is in God, that there is nothing in the world not in God" (p. 462). Such an understanding of God and his relationship to the world is called panentheism which views God as including and penetrating the whole universe so that every part exists in him, but that God transcends this world, is more than, and not exhausted by, the universe. As for evolution, it is a process of emergence in which God’s work can be seen at work, continuously creating in and through the material world.

(Todd:) Religion and God are part of a spiritual realm of human beings. Our experience with God is always a personal one. This experience has an ontology similar to the reality of material objects and events phenomena: it is experientially real. But in addition, this personal experience is also the only source of truth and permits me to make truly ethical and moral decision. The experience of God is a spiritual one which includes all the wonders of human existence; it includes all those things like love, beauty, truth, and goodness which cannot be explained by science, and may have no place in science. I mean, just look at intangible things, like love and beauty. I think that equates to God for me. You do not understand why, but you know that these things exist. You know certain things are beautiful, and you know you love certain things, but you cannot explain why, you just do. It’s like beauty: if you are sitting at night down by the lake, having a beer or a smoke or whatever. All of a sudden the sun goes down, and the colors appear in the sky and on the horizon. It is beautiful, that is IT, that is beauty, you cannot say why, you can’t define it... In my view, God is not a material or physical being, and cannot be perceived or described in any way. Whenever I think of God I get a picture of nothing, but try to think of nothing, and that’s God, and that’s: well think of nothing that’s as close as you can get to everything, and that gives you God... If you are infinite then there is no such thing as change, but is all-encompassing, so we can’t apply change to infinite things. I mean that’s like saying is God good-looking, or is God plain, or, I don’t know tall, we can’t apply the term to infinite things... The essence is that things came from God, and they are part of God, God doesn’t have two hands, doesn’t have a face, doesn’t have a mind, God just is.

Integration of Science and Religion

Because the notion of social construction allows multiple viewpoints of the same "object," Todd did not experience conflict bringing the two realms together in the process of rational discourse. He could draw on all repertoires without experiencing conflict for answers to difficult decisions; therefore, Todd did not need a mediating device such as TWOD, incompatibility, or complementarity (see Figure 2a). The religious discourse provided Todd with an important spiritual resource for making difficult decisions in this world. Like others (Postman, 1992), Todd indicated that a scientific or technological rationality cannot provide the necessary ethical dimension for making informed choices about dealing with issues such as abortion, euthanasia, AIDS, or genetic engineering. Scientific and technological rationality always are subservient to market or political pressures, while the religion-informed, personal ethic provides "true" standards. With a number of theologians, particularly those in the tradition of his own Anglican Church, Todd believes that any ethic has to be contingent on the particulars of each situation. Thus, rather than seeking an absolute, immutable, and dogmatic ethic, he favored a situational ethic (Fletcher, 1966). This ethic is not informed by either scientific or religious dogma but by the specific relationships of the individual case in its socio-cultural, economical, scientific, and spiritual context.
(Todd:) I believe that my non-literal understanding of the Biblical creation story interfaces with my conception of an immaterial God that revealed itself to Moses as an entity without image. God’s presence is immanent in the universe as creation, and evolution is the process by which the world is continually transformed. Although in this view, God does not actively intervene in the physical world, God and the associated spirituality are resources for me to deal with ethical problems. As a scientist or a doctor, I will draw on these resources within myself where I relate to God. I find that when we have problems, we draw on our religion not on science. Science is there just for man to use, but there is not the energy in it: like when we have problems and difficulties we draw on our religious and spiritual sides, and when we have a problem we look at our religious side. We are not looking for a textbook, we do not read a book about it: we look into ourselves.

Science in and of itself does not have an ethic, it is value neutral ready for man to use for the betterment of man. To overcome this lacunae of value neutrality in decisions involving man and the world, we have to use our personal, religious and/or spiritual resources for dealing with the ethical and moral dimensions of decision making. Because of its personal nature, this spirituality leads to an ethic which is very case based and differs from decision maker to decision maker. Euthanasia and abortion need to be case related, that is the only way that decisions would be made for one person on a case. As a doctor, I will know before an operation. I can see both sides, all the arguments, and I ride the fence pretty much to all of them; if I disagree with an abortion then I would not perform it; if I disagreed with euthanasia then I would not perform it. I would make a decision case by case because these are not black and white issues. Just like with genetic engineering, it is not a black and white subject. Here too, every decision would be very situational. I mean, it is totally situational, both are prime examples, with huge gray areas and I think for me I would be very internally very case related.

Science and Religion at War

Science

Brent described science as a human effort that yields absolute truths (Quadrant I, Figure 2b). Brent used subjectivity in the realm of science to account for the errors due to the emotional engagement and personal investments of the scientists in the products of their labor (Quadrant III, Figure 2b). Here, Brent encountered a problem; he had to account for the difference between the absolute truths generated by scientists and the erroneous knowledge they produce because of their personal engagement. In this case, like the scientists Gilbert and Mulkay (1984) interviewed, Brent made use of the TWOD which assures that the constructed aspects of scientific knowledge will be weeded out. He suggested that erroneously accepted scientific work will be re-evaluated in the future. The facts will decide and weed out wrong explanations so that the truth will come out. This has the effect that over time, "scientific knowledge will more and more approximate truth."

(Brent:) The statement "the social environment of a scientist will influence the content of the knowledge he or she proposes" is debatable but I would have to agree because of the fact that wherever a scientist will live, he or she will alter their observations and knowledge...

We talked about Suzuki’s essay on objectivity in science. People seemed to assume that there is no truth. But I disagree. Science does approximate truth. It only adds on to more questions which need to be answered. As days have passed from Socrates to Newton, thoughts which have been expressed in public, slowly make us realize that THIS IS WHAT THE WORLD IS MADE OF. More and more people begin to add on, or reliably explain a dilemma precisely as the days flow by. Science is what people say how
the world is built. To a degree, science may lead a path towards truth, but are we accurate enough to say that science is a true fact? We can say that science provides us with true facts, explanations to what the truth really is; and science is but one way to resolve a question which needs to be answered. Yes, in fact I am saying that science is reality and no other belief more and more approximates truth.

Religion

Brent said that religious knowledge claims are rationally accountable and based on the bible and the existence of God. Knowledge claims shared by the members of churches therefore have an absolute status (Quadrant II, Figure 2b). These claims are supported by the bible and members' knowledge of God's existence.

(Brent:) We know of God because he reveals himself in a very understandable way. We know that God exists, because of all the miracles that he has done in the past. History and the bible say that He is the person that made the Red Sea go apart, He is the one who multiplied the bread and the wine. This is why we believe that there is God. This is the reason why Christianity is probably one of the most popular religions there ever was. There are a lot of people, even Muslims and others believing in God. All in all, God in any religion has become the main focus point and that's why people assume that there is a God, because more people believe it.

Religion, I find it very hard to understand how I believe in God; I can't touch him, I can't see him. But then the bible says, "this woman was blind, and she touched his clothes and she was able to see again. She touched him, and she was able to see again." I want something like that, I want something to believe in.

God put Adam and Eve on Earth, so that is one reason that there is logic behind the existence of [physical] forces. There are forces and similar things, created by God, that keep Adam and Eve down there, gravity and whatever, they stay, that's all...

In accordance with his need for concrete experiences, Brent took most of the Biblical accounts as literal descriptions. In this, he resembled many fundamentalist Christians who engage in the legal debate of science versus religion although his own, Presbyterian church does not promulgate such beliefs. Besides the literal truth of the Bible, Brent’s discourse shared two other features with that of those fundamentalist Christians who argued against science in court: the irreconcilable differences between religion and science, and the superiority of biblical wisdom over scientific knowledge (Gieryn, Bevins, & Zehr, 1985). First, religion stands against science as in an engagement of two armies trying to conquer each other, or like two orators vying for the audience’s approval. Any positive acknowledgment of the viability of a scientific account for the present state of the universe could only come at the expense of Biblical authority, a victory for science and ultimately the devil. He often used military metaphors to describe his discussions on science and religions ("I put up a big fight", "I shot down his argument") or qualified statements as more or less persuasive ("I put up a pretty good debate", "his argument would be a lot more diverse than mine", "the listener would find it more convincing"). Second, faith in the Bible is more valuable than scientific knowledge because only religion is able to provide man with purpose and ethico-moral standards. However, Brent’s own accounts were little informed by the ongoing discussion of creation science versus evolution (such as his own account about the age of the earth) so that he did not and could not make use of fundamentalists’ discursive strategies (O’Connor & Ivers, 1988; Overton, 1983). He recognized this lack of persuasiveness, and for that reason always found himself in the position of the underdog in discussions with teachers or groups of peers. Comparing Brent’s and Todd’s talk about the God’s relationship with creation, we notice that the former stressed the externality of the
creative acts — He is creating something external to Himself — while the latter held a reformed view (Peacocke, 1991), where God is immanent in and of the creation.

Brent's discourse about his personal religious experience was populated with talk of certainty. His knowledge claims equal the absolute status of the church's public knowledge claims (Quadrant IV, Figure 2b).

(Brent:) I need to see or touch in order to believe, and this causes me some pain. For I have asked God for signs or something like that. Moses and people like that they got their sign. Whereas I am just a little boy—I feel like I am a little boy now—who does not have a God because he didn't give me the sign. I believe in God—I think I believe in God—and that there is an afterlife for me. There is actually something there for me, so that I wouldn't go to hell and I will be up there with the angels, or something like that... To be 100% sure that there is God or something from physics, to be a 100% sure that there is something, I need to touch it. If it is something like that, I want to see it, I want to touch it.

Science and Religion

The following excerpts from Brent's interviews and essays illustrate the conflicts arising from the absolute truth claims of science and religion as rational enterprises.

From my perspective there are no similarities between science and religion at all. Science says that something else did it, and my religion says that God did it all. That is what I find hard to associate with between religion and science, they do not connect. People might say that they do, but they don't connect at all. If you believe in religion, they don't logically connect. It is really like an apple and an orange, or an apple and a coconut whatever you want to take; science and religion don't just connect in a way that they can work with each other. There is nothing in science that says anything about God, there is nothing in science at all; and there is nothing in religion that says anything about science. So how can they associate if they don't mention anything at all? For myself, that is logically enough. There is nothing at all. Chemistry and physics, however, they do connect, because chemistry needs physics and physics needs chemistry in some ways; religion never says anything about science and science never says anything about religion, that is the way I think.

Physics offends my beliefs, probably because of something that I have grown up with all my life. Science completely goes against what God has created, the so called power person who created everything; and people who are in the sciences are saying that 'you know, it wasn't him at all.' To me that is a direct insult. Which, in a way, I could take very lightly, but I just can't accept the fact that science and religion go together... In science, I feel like I am drawn away from religion and that really worries me a lot, because I feel like I am being taken away from that I have been a part of, which is religion. If I go towards religion, I feel like I am not giving science a chance and I can't see myself doing that, because I am a person of morals.

I have to refute your claim that the universe was created 4 billion years ago. I think that the earth has been created 50,000 years ago, by my belief that is probably the only firm foundation that I have, I think it is 50,000 and not 5 million. I don't see what possible proof scientists could have that the earth is like 500 billion, I don't see how long, how they can see it takes 500 billion years for fossils, I don't actually know what proof they could have... When I hear you and other people talk about how the Earth was created, by referring to the theories of Big Bang and evolution, I say, well that is wrong. I believe that you are wrong and I am right—I am right because, God has taught me so; and you
are wrong because God did not bring you up that way, you are misinterpreting what the world actually is.

Brent’s scientific and religious discourses both included accounts of concrete experiences. Lacking concreteness easily led Brent to doubts and disbelief. While he accepted scientists' (and technologists') authority, he found himself at a loss when it came to abstract concepts or theories. He associated many of his problems in learning science with the irreconcilable conflicts between the religious discourse—which he learned at home, from his parents and in church—and the scientific discourse to which he was introduced at school.

To rule out alternative, Piagetian and Neo-Piagetian explanations proposed by previous research which could account for Brent's discourse (Lawson & Weser, 1990; Lawson & Worsnop, 1992), we used the Classroom Test of Scientific Reasoning (Lawson, 1987) and the Juice-Mixing Test (Noelting, 1980) to established Brent’s reasoning level. On both tests he scored at the formal level. Thus, Piagetian and neo-Piagetian theory could be ruled out as explanatory resource for the conflicts between scientific and religious discourse in Brent’s case.

Conclusions

This study allowed us to explore the complexities in students' scientific and religious discourse. Our analysis in terms of interpretive repertoires accounted for students’ talk in different contexts. The strength of our scheme lies in the fact that it accounts for the conflicts in discourse without constructing individuals as "irrational;" and it accounts for the discursive strategies used to resolve these conflicts. We briefly showed that this scheme was also applicable to individuals other than the students in this study.

Our analysis showed that the critical issue in teaching science in the context of students’ religious discourses must be to facilitate the development of discursive devices which allow students to deal with conflicting situations. Cobern (1993) pointed out that science classroom learning environments "can be improved, especially with regard to students who typically do not well or who do not like science, if teachers are aware of students' world views" (p. 949). The questions are whether science teachers recognize the necessity of incorporating teaching strategies—or have the required time—that allow students to develop the incompatibility or complementarity devices. An alternate solution would be for schools to offer a special course that allows students to engage in a philosophy-of-wisdom inquiry in which the discourses of music, literature, drama, politics, science, religion, and philosophy are treated at the same level (Maxwell, 1992); that is, none of the discourses should dominate at the expense of the others. Such a course would allow students to discuss some of the key problems we face, but which are traditionally addressed only from a scientific-technological perspective without yielding viable solutions. Among these problems are all those which potentially threaten the survival of mankind on our planet.

At this point, we deem it important to assert the most serious danger for both science and religion which comes from the corruption of both scientific and religious habits of thought. Science and religion, particularly those in the Jewish, Catholic, and many classical Protestant traditions, share the traits that they "make objective demands upon self, require discipline and method, and rigorously attack self-deception" (Novak, 1983, p. 34). These virtues are all but abandoned by a new rising culture which shows a blatant naïveté with respect to the purpose and method of science and indulges in the occult, magic, astrology and other, similar pursuits to substitute for science and religion.
We notice that decline in traditional religion has not resulted in a decline of superstition, totemism, and magic, but has given rise to new forms of pursuing them. By providing students avenues and opportunities to integrate traditional scientific and religious discourses, we may yet turn the tide to help both survive.

It needs to be emphasized that we are not advocating for every student, or every scientist to become a Christian, or follow some other credo. As was indicated throughout this paper, we have chosen different ways, critical scientific humanism and a scientific panentheism, to deal with the complex problems of our society. But we wanted to point out that there are ways in which science and religion can be accommodated by one and the same person without leading to problematic and incoherent constructions of Self. Although we are not claiming that science should be replaced by religion and ethics, there is a definite place for a high school course in which science, religion, philosophy, arts, and others are treated as parallel forms of inquiry towards a "good world." Such a course would also allow students to experience science as but one form of inquiry, with a limited realm of applicability. Such a course needs to be truly interdisciplinary, in which no single discourse is privileged, such as in some "science in society" courses, where scientific discourses dominate to the expense of the social and humanistic discourses.
References


Captions

Figure 1: The analytic framework of interpretive repertoires. In each quadrant, knowledge claims are absolute or socially constructed. "TWOD," "incompatibility," and "complementarity" are devices that mediate the relationship between cells in order to avoid the conflict apparent between two contradictory knowledge claims.

Figure 2: The interpretive repertoires of two students, Todd and Brent. Brent does not have a device to mediate the conflicting claims in Quadrants I and II. TWOD permits him to reconcile conflicting claims arising from the repertoires in Quadrant I and III.