Science and Religion in the Context of Science Education

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An overarching commitment of many science education researchers is to examine how students learn science. This entails, among other things, an understanding of the nature of scientific knowledge and the ways in which students conceive of scientific knowledge in relation to their other ways of understanding the world. As stated by Shipman, Brickhouse, Dagher, & Letts (2002), "A person sitting in a science classroom is not just a science student; she or he is a thinking human being who sees the world in terms of a variety of other contexts" (p. 528). This statement is particularly significant because it reflects current conceptions about science learning. For example, the work of Toulmin (1972) as well as Demastes-Southerland, Good, and Peebles (1995) has described the importance of the student's conceptual ecology. In addition, Cobern's (1996) work on worldview theory provides support for the importance of understanding the number and diversity of perspectives that students bring to any science learning situation. One of the dimensions of a student's conceptual ecology or worldview would be his or her commitment to religion. The purpose of this symposium is to discuss the interface between science and religion, particularly with respect to how students understand science and religion as epistemological systems.

The characterization of science versus religion implies that science and religion are distinct systems. While some (e.g., Dawkins, 1987; Gould, 1999; Sagan, 1980) have argued that science and religion are distinct, others (e.g., Davies, 1992; Goodenough, 1998; Townes, 1995) would suggest that the systems need not be described in such exclusive ways. Perhaps a useful way to frame the issue is to consider how students and teachers negotiate the apparent congruencies and inconsistencies between their conceptions of science and religion. Related to students conceptions of science and religion is the issue of how to broach this topic in the classroom. Some would argue that science and religion are incompatible and that "a religious education is detrimental to a scientific one" (Mahner & Bunge, 1996, p. 102). Further, as argued by Mahner and Bunge, "if a religious method were applied in science, and the scientific method in religion, the result would be complete mutual destruction. Science and religion are not only methodologically different but incompatible….Science and religion can only coexist if one of them is distorted" (p. 115). Some people have taken exception to the perspective presented by Mahner and Bunge (see Matthews (1996) for a more detailed discussion). For science educators a concern is that students' conceptions of science are potentially influenced by how they understand and relate to religion. What should students understand about the compatibility and/or incongruity of science and religion? One of the purposes of this symposium is to discuss the ways in which students work to reconcile and/or contest these epistemological systems.

The discussion presented in this symposium is significant in the sense that students' religious and/or scientific identities are themselves complex phenomena. Further, the ways in which these epistemological stances interact when placed in proximity creates yet another level of complexity. In order to appreciate the depth and complexity of the various epistemological commitments present in science teaching and learning situations it is important to explore how various epistemological systems (e.g., science and religion) mesh and/or collide and how this relates to students' understandings of science.

Structure of the Symposium

For the purpose of this symposium we will use the undergraduate science and religion course taught by Shipman and Jordan, which will be described in Shipman's section of the paper, as a foundation from which to discuss the topic of science and religion. According to Shipman and Jordan, "the goals of the course are threefold. We hope that students, first, will gain an understanding of some methods and concepts (such as confirmation, models, and paradigms) found in science as well as some found in religion (such as miracles and creation). Second, we will expose students to certain tools useful for inquiry into the plausibility of claims found in science or religion. Third, we hope students will develop an appreciation of several ways of relating science and religion." While these are reasonable aspirations, another interesting issue is to consider whether these are goals that should be intended for a general audience of students.

In response to Shipman and Jordan's course panelists were asked to consider the following questions:

- If you were to teach a course on science and religion would you approach it in a similar manner?
- Are there other questions related to the general topic of science and religion which might also be useful in framing a course? If so, what are they?
- What is or could be the objective of teaching a course like this in the first place?
- What would be important to elicit from students about science and religion as epistemological systems?
- If you were to choose a set of issues to deal with in a course like this, what would they be and why would you choose them?
- How does this course relate to your own scholarly interest in science and religion?
- If this course were to be given at your institution, are there additional barriers that the instructors would face?
- Are there other issues that you would like to address?
- How can we engage students who are not going to make a career out of science, but still need to learn science (to become scientifically literate)?
- How can we draw people of faith into science careers?

As will be seen in the sections that follow, the panelists raise interesting issues about the nature of scientific knowledge, what it means to learn science, and what students bring to classrooms.

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Science and Religion: An Interdisciplinary, Team-Taught Course

Harry L. Shipman

NOTE: If you wish to quote from or cite this paper, I would appreciate it if you would contact me for an updated version or reference (harrys@udel.edu).

ABSTRACT: This paper describes a course which frames the symposium. I begin with a brief description of how the course works. I then discuss our rationale for selecting the four issues that frame the course, including a discussion of the reason for selecting such a narrow focus in the first place. The final section of this paper analyzes students changing intellectual positions on science and religion, using as data their final group products and two paired, identical assignments, which students did at the beginning and at the end of the course.

THE COURSE

Science and Religion is a rare, team-taught course which has become part of the regular curriculum of the university, the regular teaching assignments of both professors, and several required curricula. From the very beginning it has been an issue-oriented course, focusing on particular topics rather than on general descriptions of science, religion, the philosophy of religion, or the relation between these disciplinary areas which have occasionally been rather distant. Students work together in permanent groups, and collaborative group learning has become increasingly important in the course in the years since the fall of 1998, when it was first taught. I have taught it with Jeff Jordan of the philosophy department four times. We both intend to team-teach it for the forseeable future. The course has a website: http://www.udel.edu/physics/scen344 where further information can be accessed.

The course plays an important role in the University. It enrolls a mixed group of students from all parts of the university. One group that stands out is a collection of philosophy majors, who can use this course as one of the advanced philosophy courses that they take as part of their regular course of study. Another, less cohesive group is formed from the science majors who take the course (biologists, physicists, engineers, and students in other disciplines). It fulfills one of the general education requirements of the University of Delaware, wherein students are required to take some number of courses in Analysis and Appreciation of the Creative Arts and Humanities. It is considered a pathways course, one of several interdisciplinary courses which are part of a pilot project to reform general education at the university.

The course is focused around four major issues:

- Does the Big Bang picture of cosmology allow for, or even offer some support for, the idea that a Supreme Being created the Universe?
- Can a rational person accept the reality of miracle reports?

- What is our conception of a human being, in light of recent scientific advances?
- Is a belief in Darwinian Evolution compatible with a belief in God?

Shipman leads the class discussion for the first and last of the issues, and Jordan leads the class for the second and third issue. We hit upon this arrangement in order to minimize the amount of adjusting that students have to make between two teaching styles. (For example, Jordan uses handouts extensively in his classes, and Shipman uses overheads.) Nevertheless, both instructors are present in the classroom for almost all classes, facilitating student conversation in groups and contributing to the class discussion.

Course Pedagogy

While the class meets two or three times per week in the usual kinds of classroom, there are a number of pedagogical features which are somewhat unusual: group work, weekly papers, and an exam structure which encouraged more thoughtful, lengthy answers than is often the case. I discuss these in turn.

Group work: Students work in permanent, collaborative groups. As each of us has become more comfortable with group work since 1998, we have now gotten to the point where nearly every class does group work. Usually, groups submit brief written reports, completed in class, to document their group work (and to earn participation points). In the fall of 2002, of a total of 28 classes, one was an hour exam, 24 included group work where groups submitted a written product, and only 3 classes did not result in a written group product. So there were at most 3/28 (10 %) of the classes where group work was not a credited part of the class. It is quite possible that some brief, informal group work was part of the class on those dates.

The groups are permanent groups, established near the beginning of the semester. We use a preliminary questionnaire and some observation of students during the first two weeks of classes in order to choose the groups. We use groups of four based on University of Delaware experience, tradition, and the recommendations of Johnson, Johnson, and Smith (1991/1998). We start with a random selection of groups but then make adjustments based on three criteria. The student's religious background is taken into account; we do not want all the atheists in one corner and all the evangelical Christians in another. The student's academic background is another criterion; ideally, each group should have at least one person with a science or engineering background and one person with a philosophy background. A third criterion is habitual absenteeism. Every year we have taught the course, there are a few people who seem to think that it is possible to earn a decent grade in a course like this by skipping most classes and writing vague but apparently creative generalities on exams. While these students do not succeed in the course, they also do a disservice to their group by not showing up. The first year we taught the course, we had one group which had a concentration of such students (along with one of the strongest students we have ever had in this class). We take a couple of weeks to observe the students attendance patterns and distribute the habitual absentees among groups.

Exam structure: Even when there are 50 students in the class, there are two of us to grade the exams and so essay exams are manageable. A typical exam will consist of several short-answer questions, asking for students to answer in a few sentences, and some longer questions. One of the attractions of philosophy is that it involves deep questions, and ideally an exam would ask students to address those questions. However, experience has shown that when students are asked to compose a five-paragraph essay under time pressure, the results are not good. The current generation of students, who have learned how to write with word processors, finds in-class writing of extended answers even harder when the output device is a pencil rather than a laser printer and where cutting and pasting is impossible. Consequently, we distribute a number of possible essay topics a few days before the exam. The actual exam will contain a subset of these topics, and they have some choice on the exam. For example, for a final exam that is nominally 2 hours, we will distribute 5 essay topics, print three of them on the exam, and ask students to choose two questions to write on. We find that as a result of this practice, we end up grading much more coherent essays.

Weekly papers: Based on Shipman's experience as a student in some graduate courses in science education, we ask students to write reaction papers once per week, reducing the frequency later in the semester. Sometimes these weekly papers are used explicitly as the basis for a group assignment. We have developed a very simple rubric to grade these papers (see Appendix A) and have found, after some experience, that we can assess student work quickly and fairly. We do add comments to the papers which are often of a somewhat general nature. We offer students the opportunity to rewrite these papers if they wish; each semester, a few students take advantage of this opportunity.

Assessment consistency: The first time we taught this course, we both graded a set of ten weekly papers. We discovered that our grades were extraordinarily similar as I recall, on a 10-point scale, only one of the ten was different and that one only by one digit. As a result, we divide the grading evenly, no matter who is responsible for that part of the course. We do make the effort to make sure that each individual student is graded by both professors, not just one, by keeping track of who has graded what and taking appropriate action if one of us has played an overwhelmingly large role in the assessment of a particular student.

Focus on issues

We focus on issues and only on a few of them. In this respect our course differs from many other courses on science and religion. We became familiar with these courses through our participation in the John Templeton Foundation's one-week summer institutes for the science and religion course program. The two of us participated together in the summer of 1998, and one of us (HS) participated in follow-up workshops as facilitator of a session on how to use collaborative groups in teaching this kind of course. Many other courses treat many more issues and also offer a substantial introduction. For an example, see Landry and Van Wenzveen (1998).

When we first taught the course in the fall of 1998, we had a short introduction which dealt in general terms with what science was and what religion was. We have eliminated this section because we have found that it is much easier to deal with these topics once students have understood a number of issues. Furthermore, philosophers of

science have found it extraordinarily difficult to come up with a general definition of what science is. Various attempts to draw a line become sufficiently overloaded with exceptions and qualifications so that a general definition is not useful. And if a definition is too complex to be useful for philosophers of science, it is certainly too complex for our students (see Curd and Cover 1998). For a substantive introduction to the differences between science and religion see the first few chapters of Barbour (1990).

For example, at the end of our discussion of Fine Tuning, we summarize the issue by asking students, in their groups, to list some ideas that are strictly scientific, some issues that are strictly religious, and issues which blend the two. Student groups have no difficulty in deciding that the use of the microwave background radiation to confirm that the Universe has a hot beginning lies within the realm of science. The notion of God as a Creator lies within the realm of religion. But the most important and interesting issue, whether the existence of a definite beginning to the Universe provides support for the idea that God created the Universe, is not easily characterized as being either science or religion.

A second characteristic of our course is the amount of time that we spend on particular issues. We could have followed the practice of some other courses we knew about and spent only a few classes on each major topic. Olson's (1997) course, for instance, spends a few days on most topics, but follows our practice and spends three weeks on biological evolution. We believe, in keeping with the general philosophy of the K-12 reform movement, that a deep understanding of a few issues is preferable to a superficial understanding of many (see, e.g. National Academy of Sciences 1996 and AAAS 2000).

We arrived at a list of issues in the summer of 1998 when we participated together in the Templeton workshop. They have worked for us every time we offered the course.

Fine Tuning: One of us (Shipman) is an astronomer and so this issue was a natural one. There is considerable current interest in this topic. Because of the fit with Shipman's expertise, and the popular interest in astronomy, it has worked for us. Some specific references on fine tuning that we use can be found in the course website. While the work
of John Leslie has been very useful as background, we have found that his writings are a bit opaque for our students. Most classic texts (e.g., Haught 1996, Barbour 1990) contain an adequate treatment of this topic. We and our students have been particularly impressed by other readings from authors like Dyson, Gingerich, and Polkinghorne.

Miracles: This issue provides a very natural introduction to the way that philosophers deal with the question of evidence. Our treatment of this issue has varied from year to year. We have always begun with Hume's classic treatment (Hume 1734/1955). In some years we followed the philosophical thinking on this through Mill (1874/1957) and to Stephen Davis (1991), a contemporary philosopher. Last fall we moved from Hume to a treatment of mysticism, using a novel (Salzman 2000). Both treatments seem to work. We selected this issue because it introduces scientific and religious approaches to the same question. It leads naturally to a treatment of scientism, also known as philosophical naturalism. Philosophical naturalists take the position that physical objects like matter and its constituents, light, and energy, among others, are the

only objects in the Universe. They explicitly reject the notion that God is actively involved in any way in the way that the universe functions.

The Nature of the Human Being: This section of the course could be considered rather amorphous, though we try to bring it into focus. It includes a discussion of a variety of issues which have received considerable attention in the community of philosophers: free will, artificial intelligence, the role of chance in the Universe, determinism, and the search for extraterrestrial life. Incidentally, what we mean by artificial intelligence (AI) is the AI that philosophers worry about: whether computers can become minds like the human mind. Sometimes the discussion of chance has been made part of the miracles section of the course.

Biological Evolution: To us, this is a no-brainer. How can you teach a course on science and religion and not say something about biological evolution? We did, however, deliberately arrange the course to put this topic at the end. We feel by this time that our students will understand that we really mean it when we say at the beginning of class that we will respect everyone's religious views and that other students will do the same. Somehow, the first three issues that we discuss don't seem as personally threatening as the issue of evolution does.

We recognize that a course could deal with a variety of issues. While the Templeton Foundation terminated its Science and Religion Course program a few years ago, their web site has a number of sample course syllabi which can be consulted for ideas (see, as examples, Landry and Van Wenzveen 1998 and Olson 1997). We decided not to deal with quantum mechanics and the ultimate nature of reality (see, e.g., Barbour 1990, Ferguson 1994) because our course is for non-science majors, and teaching them enough quantum mechanics so that they could really understand the issues would take several weeks. We did not even discuss whether to include ethics because we obtained funding for this course through the Templeton Foundation and we were told, at the time, that they would not support a course which had a lot of ethics in it. Readers who are interested in constructing a course can consult some of the major texts that exist in this area (Barbour 1990, Haught 1996, McGrath 1999).

Student Responses to the Course

To a greater or lesser extent, we have a tremendous archive of data from this course. Particularly for the fall 2002 offering of the course, we saved all group reports, several sets of weekly papers, the final group project, and the course examinations. Since the focus of this paper is on the extent to which students engaged the issue of science and religion, we focus the present, preliminary data analysis on a subset of the data which directly addresses this issue.

The first writing assignment asked students to react to the suggestion that someone who was interested in, but relatively unfamiliar with, science and religion should read Stephen Jay Gould's (1999) book which advocates Non-overlapping Magisteria, a viewpoint that science and religion should be thought of as two distinct windows on the

world. The assignment (Appendix B) briefly summarized Gould's approach. Our interest was not just in whether they would or would not recommend the Gould book, but the richness and depth of the reasons that they gave for this approach.

For the purposes of this paper, I randomly selected 12 of the 42 usable responses to the paired-writing-prompt exercise. There were 50 students in the class; of the other 8, one submitted a final response which was partially plagiarized from the first response, one rewrote her first response, and the other 6 were missing either a first or last response. We classified these response according to the categories described in Shipman, Brickhouse, Dagher, and Letts (2002) as being confrontational, distinct, transitional, or convergent in their approach to science and religion. The only difference between the present classification and the Shipman et al. (2002) classification none of our distinct students show a disinterest in the relationship between science and religion, as would be expected. We added a classification of unclear where the response was not clear enough to, by itself, permit a reliable classification.

Table 1: Student Positions on Science and Religion

Category	Number in initial classification	Number in final classification
Confrontational	3	0
Distinct	2	1
Transitional	3	5
Convergent	2	6
Unclear	2	0

Table 1 shows a clear movement in the direction of the course goals through the semester. If the spectrum of opinions is collapsed into a 1-dimensional continuum ranging from confrontational on the one hand to convergent on the other, then there is clear movement towards the convergent end of the spectrum. Not a single student moved in the direction of confrontation. The two students whose position was unclear managed to articulate their views considerably better at the end of the semester. The same comment could be made about some of the students whose classification remained the same; they articulated their position better at the end of the course.

Another view of the data comes from an attempt to quantify the number of separate ideas that were mentioned in each of these papers. Separate ideas were identified in each student response. For example, Helen's* final response began with several sentences that argued that each discipline may embark on a different path but eventually both are an

* All names used in this paper are pseudonyms. Not only are the pseudonyms different from the actual names of the students; the pseudonyms are different from the names of all the other students in the class.

attempt to explain this world. Those sentences were identified as dealing with one idea. She then turned to an argument about faith:

> Furthermore, both disciplines exist faith [sic]. Science exists on a kind of faith that universe is rationally ordered. Even more interesting is the idea that scientists have faith that the human mind can even comprehend the universe in its totality. [Helen, final response, p. 1].

These sentences were classified as representing a separate idea.

With a single exception, the number of ideas mentioned by our students increased from their initial response to their final response (Table 2). The mean number of ideas in September was 2.0 and in December was 3.1. Since the nominal length of the assignment was one paragraph, these numbers of ideas are quite reasonable. To triangulate the data, I analyzed it in a way which is not terribly defensible from a research viewpoint but has the advantage of being impartial: measured the length of the papers. The results from the paper-length analysis supports the somewhat less objective results from the idea-count analysis.

Table 2: Idea Counts

Change in number of ideas; December - September	
-1	1
0	3
1	5
2	2
3 or more	1

Sue: a mini-case study

A student whom we call Sue is not presented here as a typical student, but an analysis of her two responses illustrates what can happen to students who take this course. (She is the student whose number of ideas increased from 2 in her initial paper to 7 in her final paper.) In the remainder of the data which is not analyzed here, we can identify 1-2 other students whose written work illustrated a similar development of richness.

Sue's initial response was classified as being confrontational. She wrote a short paragraph, 12 lines of text, whose second sentence read:

> Sue: The idea that science and religion can coexist together without conflict is a view that has the counterargument that the two cannot coexist together at all because there are too many discrepancies.

She goes on to argue that:

> Sue: From a scientific perspective it [the earth] was created through the big bang, but most religious people would say that it was created by a higher power who was God. [Sue, first assignment, page 1]

Her final paper is quite different. Her summary statement states that:

> Sue: Now it is quite evident that while religion is not by any means to be used as God of the Gaps to explain science, it does work alongside science. Science and religion can coexist because their goals are different. [Sue, final assignment, page 1]

She goes on to explain her argument with several examples. She begins with fine-tuning, stating very reasonably that science is used to explain how these dials were set just right (example: the perfect composition of the carbon nucleus) and religion is used to explain by whom the dials were set. (Sue, final assignment, page 1]. She goes on to discuss miracles (another distinct idea) and then has a very deep, though brief, argument about evolution. She recognizes biological evolution as one of the toughest areas, but admits, in contrast to her first paper, that evolution has proved that life has evolved over millions of years from a single celled organism. Apart from some discomfort with her use of the word proof, I couldn't say it better.

She then goes on to cite two ways in which various people have reconciled biological evolution with theism. God may have helped humans to evolve so they can follow the right path as humans help God carry out the divine hopes for the world. She also referred to an interesting possibility, not brought up specifically by either instructor, that specific events could have multiple causes. She closes her paper with a brief reference to ethics.

The richness of Sue's paper may stem in part from a remarkable final report that Sue's group did on biological evolution. About a week before the reports were due, I had a conversation with this rather diverse group, which included the most conservative Christian in the class along with a very articulate and outspoken atheist. (Sue is neither of those individuals.) At that point, they seemed stuck. Rather reluctantly, I suggested that the group might have to submit a report that included two diverse viewpoints. Somehow the group struggled through to come up with an absolutely magnificent report that all parties could sign their names to.

Discussion and Summary

The most important point in this paper is that Jeff Jordan and I have been able to team-teach this course over a period of several years and have even managed to institutionalize it. In the first part of this paper we discuss the nature of the course, its pedagogy, and its goals. It has become one of several course models for a new kind of General Education course at the University of Delaware, an interdisciplinary pathways course intended for liberal-arts students.

A course similar to this could be taught about a whole range of issues. We could have followed the recommendations of my undergraduate adviser, Owen Gingerich, and

included an extensive discussion of the Galileo affair (in which Gingerich is an expert). Someone teaching this course could go more heavily into the philosophy of mind than we have. A science and religion course could delve into ethics. Indeed, I have previously team-taught a course on Ethical Issues in Scientific Research with a philosopher and a biologist.

The study of student work presented in this paper is a preliminary look at a much larger data set. I have of course looked at the rest of the data as a grader, though not through the lens of a science education researcher. The sample presented here is entirely consistent with the papers I have read, indeed those I have read each time the course is offered.

ACKNOWLEDGMENTS

First and foremost I thank Professor Jeff Jordan for agreeing to go on this journey with me. I've learned a great deal about several areas of human thought that are completely new to me, and our students have learned a lot in the process.

I also thank the John Templeton Foundation for financial support and for putting on a series of conferences in the Science and Religion Course Program. Especially at the beginning, these courses provided a great deal of information and support. The atmosphere at these conferences was very open, non-dogmatic, and supportive. Readers should be aware that the Science and Religion Course program is no longer operating.

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Appendix A

Rubric used to assess the weekly papers

WEEKLY PAPER SCEN 344/PHIL344

1. Insightful ideas presented. . . . . ._____/5.
   shows understanding
   reflects critical thought on topic
   sufficiently comprehensive

2. Written well (ESWE)*. . . . . ._____/4.
   typos
   grammar, punctuation
   style
   organization

*ESWE is "Edited, Standard, Written English" - a term used by teachers of composition to describe the way that English is expected to be expressed in business and academic writing.

3. Follows the directions. . . . . ._____/1.
   on-time
   proper length

TOTAL. . . . . ._____/10.

Appendix B

Paired Writing Prompts

A mini-weekly paper should be one long paragraph or two short paragraphs.
It will be graded on a simple 5-point scale and must be responsive to the topic suggested.

You are talking to two friends, Jennifer and Michael. Jennifer has heard that you are taking a course in science and religion and is asking you to suggest a book for her to read.

Michael jumps into the conversation and suggests a recent book by Stephen Jay Gould, Rock of Ages. You do not need to read his book or anything about it to answer this question. While the book is quite long, its thesis can be summarized in two words: "Non-overlapping Magisteria." In simpler words, Gould's view is that science teaches you about the natural world and religion deals with a number of other issues like ethics and the nature of God, and that these two views of the Universe do not overlap.

Based on what you know now in this course, what is your response to Michael's suggestion? Write one paragraph, which should be word-processed and handed in at the BEGINNING OF CLASS on September 10.

The identical writing prompt was used at the end of class, with the material due at the beginning of the final exam.

Evangelicals and Science Education

Jeffrey Jordan

In the fall of 1998 an experimental course, "Science and Religion", was first offered at the University of Delaware. Co-teaching the class with Harry Shipman, a Professor of Astronomy, I approached that semester with a bit of hesitation. Most of that hesitation was due to prepping for a new course and a new subject, especially since my area of specialization was not the philosophy of science. A bit of that hesitation, I suspect, was something of a residual suspicion left over from a Southern Baptist childhood. Southern Baptists, like other evangelicals, tend to view science, most especially, I think, science educators, with a good deal of distrust.[1] The prospect of one's child leaving for the university as a good evangelical, but returning home an erstwhile evangelical, is culturally threatening. In what follows I suggest that educators can assuage that distrust by carefully distinguishing between methodological naturalism and philosophical naturalism. Writers like Richard Dawkins and Peter Atkins proceed as though no distinction is needed.[2] But the distinction is important, and recognizing it and publicizing it will go a good distance, I think, in lowering the distrust evangelicals display toward science education. Still, whether we like it or not, the evangelical distrust of science is not entirely misguided, since it is grounded on an intuition that's not wholly wrong: a full and adequate scientific explanation of a phenomenon crowds out a religious explanation of that phenomenon. If science can successfully explain X, little or no explanatory role is left for religion. Science can render God superfluous. While it may be true that a full scientific explanation of X is logically compatible with a religious explanation of X, the religious explanation seems explanatory excess, which can be excised with no significant loss. So, while the evangelical distrust can be lessened, it cannot be entirely eliminated.

METHODOLGICAL NATURALISM v. METAPHYSICAL NATURALISM

Let's understand methodological naturalism as a conjunction of two propositions:

1. there are physical, even if unobservable, causes for all observable phenomena. And,
2. matter is all there is.

Proposition (1) we might dub the "provisional realism" principle; and (2) the "presumptive materialism" principle.

Methodological naturalism, (MN), is, arguably, a presupposition necessary for the effective working of science.[3] MN, that is, is a working supposition useful for a time that may be discarded when its task is done. It is something like a lab coat worn while in the lab but taken off and left in the lab and not worn out on the street of everyday life. Importantly, we're nowhere close to having conclusive evidence for thinking that either (1) or (2) is true; or they deserve a status greater than that of working suppositions. Moreover, MN does not entail what we might call Metaphysical (or philosophical) naturalism (PN). PN is the conjunction of four claims:

1. nature alone exists.
2. nature is eternal.
3. nature is uniform.

4. every event is explicable.[4]

Clearly enough PN implies atheism. MN does not entail PN, nor atheism.[5] PN is a claim about the nature of reality; while MN might be seen as a research project that may be discarded when its task is done. While it's true that the two principles of MN entail that there is no immaterial reality, that consequence is of little significance as long as we keep in mind that MN is a working supposition only; it is not misleading to characterize MN as a kind of faith necessary in some contexts but not in others.

Suppose it is true that MN is a presupposition of effective scientific research. There's little surprise that one might, if she's not careful, slide from MN to PN. But such a slide is unwarranted. Why think that MN is a working supposition of effective science? Couldn't one bring theology into the lab rather than MN? There's reason to think not. Consider that theology can *corrupt* science. Theological beliefs can cause mistakes in scientific findings. Both Copernicus and Galileo held incorrectly that the orbits of astronomical bodies must be circular because of a theological belief: the circle was the perfect and God would create only the perfect. Second, theology can *thwart* science. Theological beliefs can function as a kind of "science-stopper" by making it seem that no naturalistic explanation is needed. Newton, for instance, suggested that God periodically adjusts the orbits of planets so there's no need to seek a better naturalistic theory of rotation. Finally, science can be done by anyone regardless of creed, theology, ideology, or faith.

By keeping the difference between MN and PN in mind, and by resisting the easy but fallacious slide from MN to PN, science educators will make science education less threatening to evangelical students.

EXPLANATIONS AND EVANGELICAL DISTRUST

But even though scientific education can become less threatening to the evangelical student, the distrust of evangelicals typically direct toward science cannot be entirely dispelled. Allow me to offer a much too brief suggestion why that is so. Science, or at least one vision of science that we might baptize "Science Triumphant," is a genuine threat to religious belief. Consider the claim by the Oxford chemist Peter Atkins that "…there is nothing that cannot be understood, that there is nothing that cannot be explained, and that everything is extraordinarily simple."[6] If Atkins is right, that there's no fact beyond the reach of science, then the threat of Science Triumphant is obvious: if every fact in the universe admits of a scientific explanation, then there is no mystery which even our best science cannot penetrate. With no mystery, there's also no explanatory space left, I think, for the divine. Think of the issue this way. Suppose we're in possession of an adequate scientific explanation of, say, why some persons report mystical experiences. An explanation is a true causal account. An adequate explanation is one that explains all the relevant facts. So, to say that we're in possession of an adequate explanation of mystical experiences implies that we understand the causal conditions of mystical experiences, and perhaps even that we can replicate those experiences. Now of course having a scientific explanation of MEs does not imply that MEs are delusive. Perhaps MEs are overdetermined; perhaps they admit of both a scientific explanation and a religious one. But while an adequate scientific explanation does not logically exclude a religious explanation, it does undercut it.[7] The scientific explanation, because it is simpler than the religious one, renders the latter superfluous.[8]

There's no need of a religious explanation if we're in possession of a scientific one.[9] Perhaps something like this is what the astrophysicist Steven Weinberg meant with his famous claim that "the more the universe seems comprehensible, the more it also seems pointless."[10]

One might respond that this is nothing but "God of the gaps" reasoning, and that "Gog" reasoning is fallacious. But why think that? "Gog" reasoning, as I understand it, typically takes the form of postulating divine action simply to fill up gaps in scientific knowledge.[11] I've not suggested that. But rather if nothing is beyond the explanatory reach of science, then there's good reason to reject religious explanations. In other words, the evangelical distrust of triumphant science is well placed. If Science Triumphant obtains, then there's good reason to think that PN obtains.

NOTES

1. Like Justice Potter Stewart with pornography, I cannot concisely define "evangelical" but I know it when I see it. Roughly, by evangelicals I mean religious believers, typically Protestant, who are members of religious groups that stand in historical lineage to either John Wesley or Jonathan Edwards, and which emphasize conversion, Biblical authority, and personal piety. Importantly, evangelicals are religious realists – they believe that God plays an objective and active causal role in the world. God is, in other words, the causal explanation of certain events. Included here would be Baptists, Wesleyans, and Reformed churches.

2. Dawkins has suggested that religious belief is a "virus of the mind". See his "Viruses of the Mind" in *Dennett and His Critics*, ed. by B. Dahlbohm (Oxford: Blackwell, 1993). See also *The Selfish Gene* (Oxford: Oxford UP, 1976): 189-201.

3. Alvin Plantinga argues that MN is not a necessary presupposition of effective science. See his "Methodological Naturalism?" in *Facets of Faith and Science*, ed. J. van der Meer (Lanham, MA: University Press of America, 1996).

4. My characterization of PN comes from Stephen Davis, *Risen Indeed: making sense of the resurrection* (Grand Rapids, MH: Eerdmans, 1993): 17-20.

5. Perhaps it's best to formulate provisional realism principle and the presumptive materialism principle as indexed to a particular domain (the domain of science). Something like:

2. for our purposes, there are physical, even if unobservable, causes for all observable phenomena. And,

3. for our purposes, matter is all there is.

With the phrase "for our purposes" indicating that (1) and (2) are working suppositions for scientific inquiry.

6. Peter Atkins, *Creation Revisited* (NY: W.H. Freeman & Co., 1992): 3.

7. Perhaps an adequate causal account of religious experiences would in fact logically exclude a religious explanation: if we could replicate (not simulate but replicate) religious experiences, we'd have reason for thinking they're not genuine experiences of the divine. A genuine or veridical experience of God would be a revelation of God. By definition, God is sovereign; He cannot be made to reveal Himself. But if we could really replicate REs, and since we cannot cause or compel God to reveal himself on demand, then that's reason to think that replicated REs are not genuine experiences of God.

8. We can say that one explanation E_α of X is better than another explanation E_β of X on the grounds of <u>simplicity</u> just in case both E_α and E_β adequately explain the relevant facts about X, and E_α posits fewer types of things than does E_β.

Why is Simplicity in theories preferable? All other things being equal, the simpler carries less risk of error because it has fewer steps that can go wrong.

9. For a contrary argument see William Alston, *Perceiving God: the epistemology of religious experience* (Ithaca, NY: Cornell UP, 1991): 228-34.

10. Steven Weinberg, *The First Three Minutes* (NY: Basic Books, 1977): 144.

11. For more on "God of the gaps" reasoning see Robert Larmer, "Is There Anything Wrong with 'God of the gaps' Reasoning?" *International Journal for the Philosophy of Religion* 52/3 (2002): 129-42.

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Summary

Shipman and Jordan's course provides an interesting and engaging context in which to frame the demarcation of science and religion. Their use of specific science concepts about which to center this course gives the discussion that much more appeal and gives the student the opportunity to see a real example of how science and religion work differently. The controversial nature of Big Bang cosmology also allows the course to explicitly address the nature of science and religion, rather than implicitly address it or only give these concepts an occasional mention. At the same time, my feeling is that there is a need for coursework to be even broader in its approach and treat the nature of knowledge itself. My vision of a course in "practical epistemology" would use case studies in science, religion, and other ways of knowing to directly compare and contrast these different purposes, methods, and outcomes of "knowing."

- *If you were to teach a course on science and religion would you approach it in a similar manner?*

If I were teaching my own course on science and religion, I would incorporate several components from the Shipman/Jordan course that I believe are especially innovative and potentially effective. First, I appreciate the fact that the course is very focused in its content. Rather than trying to be a very broad survey course which covers "everything" in science, it focuses on key concepts that can easily be delved into at such a level that they require a semester's worth of thought. Too many general science courses have not been thought out carefully in terms of why they exist in the first place, and they simply cover material because it is part of a standard, generic curriculum. The Shipman/Jordan course also places explicit emphasis on science and religion, rather than assuming or hoping that students would reflect on these issues on their own. Research is quite clear on the point that learners do not inherently reflect upon and conceptualize the nature of science. This course challenges students to think about the origin of both scientific and religious concepts. This is an exciting prospect when the central concept at hand is existence itself. The question, "Where do we come from?" can be asked and answered in different ways, and this course gives students an experience with this.

What I would do differently in my own course would be to emphasize the concept of epistemology itself more. I believe that a fundamental issue that students and citizens run into is the notion that only one way of knowing (i.e., epistemology) can exist. I suppose that, in order to function as humans, we are predisposed to imagine that only one epistemological stance is even possible, and we naturally filter our world through one epistemological lens. A course that I intend to teach would focus more on how we "do" science, religion, and other ways of knowing. Students would engage in scientific inquiry projects as well as a project in which they design their own belief system; and these students would additionally experience other ways of knowing (e.g., literature) and compare and contrast these[1].

[1] The course I am designing for Spring 2004 will be co-taught by me and a professor in the English department. A draft of the course is being developed at <http://physics.weber.edu/johnston/knowing/>.

- *Are there other questions related to the general topic of science and religion which might also be useful in framing a course? If so, what are they?*

I believe that there is a misnomer that we must approach these issues from a stance of science "versus" religion. Instead, I think that great gains can be made if students begin to see knowledge itself as something which is produced, rather than obtained. Students need to see where both science and religion come from and what they each are used for. They need to realize that science is not only strengthened by the evidence it uses, but enslaved to such evidence; that religion is at the same time empowered and unconfirmed via its basis on faith.

- *What is or could be the objective of teaching a course like this in the first place?*

To understand either the concept of "science" or "religion" is not particularly practical unless we can view both of these as a human construction. Thus, it is the concept of the construction of knowledge that is really at the heart of the science/religion dichotomy. We should not be contrasting these to see which is "correct" or even which is "better" in a general sense. Rather, we need to understand where each of these originates and how each of these is used. What questions can I pursue with religion? What is the purpose of science? How will a piece of fiction help me understand the human condition? Why am I possessed by a fugue by Chopin? These all contribute to an understanding of ourselves, one another, and our environment, yet all in different ways. I want students to recognize this and be able to make sense of knowledge in general and what the validity and usefulness of a specific knowledge could be.

- *What would be important to elicit from students about science and religion as epistemological systems?*

When specifically conceptualizing science and religion, I want students to understand that these are neither compatible nor are they at odds with one another. They each exist independently on their respective epistemological foundations. They each have their own purpose, method, and answers. I want students to be able to recognize epistemology as a defining characteristic of a particular knowledge. I do not want students to fall into a pit of relativism and begin to think that there is no truth whatsoever; but instead I want students to see that seemingly contradictory truths can coexist once we realize that the foundations of these truths – the epistemologies – all exist independently of one another.

- *If you were to choose a set of issues to deal with in a course like this, what would they be and why would you choose them?*

The issues or concepts that a science and religion course (or a general course in practical epistemology, as I imagine) could be quite varied. Big Bang cosmology is an exciting choice because it both tackles concepts in cutting edge science and addresses fundamental issues regarding our existence. The provocative nature of cosmology makes it engaging, and I would be happier to have a student who was immediately and adamantly bothered by the concept than one who might be indifferent. This feature gives the issue greater importance to the individual, making them potentially more motivated to engage in the material and resolve their own disequilibrium regarding it.

I would not necessarily use Big Bang in my own course, however. (I do make sure that I spend a great deal of time in an introductory astronomy course to uncover Big Bang Theory and its development, but in designing a wholly new course addressing science and religion I would not necessarily see the need to include Big Bang.) I would tackle similar issues from a different angle, looking at how we construct a science in the first place. I imagine having students creating their own belief systems in order to see their construction firsthand. I would also have students engage in and consider other ways of knowing, specifically contemplating the fine lines between science and non-fiction literature, non-fiction and fiction literature, literature and belief systems, and belief systems and religion.

- *How does this course relate to your own scholarly interest in science and religion?*

As a researcher, I am interested in how a learner's conceptual ecology impacts his or her construction of concepts. The conceptual ecology – the mental milieu for the learner – frames all of the concepts within it and gives the learner a lens by which to understand new and old ideas. My fascination in concepts regarding science/religion/epistemology stems from the fact that these very concepts are not just pieces within a conceptual framework, but are major players in how all other concepts become understood and incorporated into the conceptual framework in the first place. There should be a circular nature in how these ideas are learned, then. How does one's initial understanding of religion and science impact the learning of new concepts regarding science and religion and their comparison and contrast? What epistemological foundation does one learn the concept of "epistemology" from? I see students, teachers, and colleagues wrestling with this all of the time, and I think that imbedded in this wrestling process is something fundamental about how we learn.

- *If this course were to be given at your institution, are there additional barriers that the instructors would face?*

Finally, we should all acknowledge that the amount of time and effort being put into the Shipman/Jordan endeavor must be immense. Team teaching a course takes a certain collaborative and cooperative effort that is fundamentally different from teaching a course alone. I admire the efforts of Shipman and Jordan and I admire their institution for supporting such efforts.

At my own institution, courses like this one would generally only fit into our Honors Program, rather than being housed and listed in any individual department. In this setting, instructors are given more freedom to teach a course such as this, yet these "honors seminars" are also more difficult to design, as there are no established course descriptions, and there is generally little departmental support. It will be my own privilege to teach one of these courses in the near future (Spring 2004) in a collaborative effort with an instructor from the English department. At that point I will have a better feeling for the hurdles (as well as the rewards) of a cross-disciplinary course that attempts to focus on the blurs between epistemological stances.

Negotiating the standoff: NOS as a Vehicle for Intentional Conceptual Change?

Sherry Southerland

Abstract

I argue that that intentional level constructs (such as epistemological beliefs/conceptions and learning dispositions such as comfort with ambiguity and belief identification) have been shown to play important role in shaping a learner's conceptual change in controversial topics. Indeed, if conceptual change requires that students compare rival explanations, then such comparisons may require a relatively sophisticated epistemological view, particularly in terms of students' scientific epistemologies, awareness of these views, and relatively open-minded, non-absolutist personal dispositions. But how can such intentional learning be fostered in a science classroom? The most productive avenue for allowing students who might hold opposing views (religious or otherwise) to their scientific counterparts is to lay out the distinction between understanding a concept and believing or accepting that construct (allowing the affective "room" to grapple with the issues, followed by an explicit focus on their epistemological views and learning dispositions.

I come to this symposium interested in enhancing our ability in teaching scientific knowledge, particularly the learning of potentially controversial content—biological evolution. It could be argued that learning about biological evolution may be significantly different than learning about many other topics in high school biology. For many topics, students may be able to simply incorporate new ideas into their existing knowledge structures. This type of learning has been called *assimilation, accretion, addition,* or *weak restructuring* (Chi, 1992; Rumelhart & Norman, 1981; Vosniadou & Brewer, 1992). As an example, students may readily add new knowledge about osmosis into their existing knowledge about water and membranes without much struggle.

However, new concepts presented in the classroom may conflict with conceptions that students already hold. In such cases of conflict, the process of learning is not a simple one, as students cannot easily assimilate the new information into what they already know. They may be hesitant to consider the new ideas, they may distort them, or reject them altogether (Chinn & Brewer, 1993). The process of knowledge restructuring in this case has been described *as radical restructuring* (Vosniadou & Brewer, 1992), *radical conceptual change* (Chi, 1992), or *conceptual revolution* (Thagard, 1992). By whatever name, the accommodation process that characterizes knowledge change is quite different than assimilation learning. To achieve such a change, students must juxtapose their existing conceptions against new ideas, they must weigh the similarities and differences, and then question their personal views (see for example, Chan & Bereiter, 1992; Dole & Sinatra, 1998; Posner, Strike, Hewson, & Gertzog, 1982). It is no wonder that radical change is difficult to achieve. Indeed, changing a conception has been found to be a far less likely occurrence than several other alternatives when a learner is faced with conflicting information (Chinn & Brewer, 1993).

How do students evaluate new conceptions? Our ideas of this process were largely shaped by the conceptual change theorists (Posner, Strike, Hewson, & Gertzog, 1982; Vosniadou & Brewer, 1992; White, 1994) who described the role of prior conceptions in learning. These existing conceptions are understood to serve as scaffolds--and sometimes barriers--to learning new concepts. Yet, it is fair to raise at least two critiques of the traditional conceptual change perspective. First, this view depicted learners as overly rational. That is, the assumption that learners are logical and rational in their analysis of information and approach to learning tasks has been overstated. Put another way, the change process itself has been viewed as largely cognitive rather than affective. Pioneering theorists of conceptual change (Strike & Posner, 1992) have readily acknowledged this point. Second, the mechanisms of change have been depicted as essentially external to the learner. That is, whether or not change occurs has been attributed primarily to forces outside the learner's control, such as the epistemological merits of the content, or the structure of the instructional activities in which students engage.

Recently, a new view has emerged which depicts conceptual change as both an *affective* (Strike & Posner, 1992; Tyson, Venville, Harrison & Treagust, 1999) and an *intentional* process (see Sinatra & Pintrich, 2003). Sinatra and Pintrich have defined *intentional conceptual change* as, "goal-directed and conscious initiation and regulation of cognitive, metacognitive, and motivational processes to bring about a change in knowledge" (Sinatra & Pintrich, 2003, p. 6).

Researchers from this perspective have begun to explore the impact of constructs such as epistemological beliefs, belief identification, and willingness to question one's beliefs on learner's acceptance and understanding on the change process (Pintrich, 1999). They argue that affective constructs can be brought intentionally to bear on the process of learning. That is, rather than the learning being controlled solely by external factors (i.e., nature of content or instruction) conceptual change theorists are beginning to understand that the learner plays a significant role in choosing whether to consider alternative points of view.

This is what I understand the role of epistemological awareness to be in science learning. The way in which students understand knowledge and the way it is constructed, the manner in which they understand science contributing to knowledge construction may well impact their *intentions* toward what may seem to be controversial topics.[2]

Empirical support for the role of epistemology and other intentional level constructs

In an empirical study of undergraduate non-science majors, Sinatra, Southerland, McConaughy, & Demastes (in press) examined the intersection of students' understanding and acceptance of a potentially controversial topic (biological evolution) and their epistemological beliefs and related cognitive dispositions. Based on previous research, we hypothesized there would be a relation between understanding and acceptance of evolution. We also hypothesized those students who viewed knowledge as changing and who have a disposition toward open-minded thinking would be more likely

[2] It is important to recognize that in this paper, I am discussing students understanding of biological evolution, not their acceptance or belief in this construct. For a more full discussion of this distinction and a rationale for the emphasis on understanding see Southerland, Sinatra, and Matthews (2001) and Southerland & Sinatra (2003).

to accept the scientific explanation of human evolution, and that beliefs and dispositions would not be related to acceptance of a topic that is generally perceived as non-controversial (in this study, photosynthesis). For this study, 93 undergraduate students enrolled in a non-majors biology class completed measures of their a) content knowledge of evolution and photosynthesis and respiration, b) acceptance of theories of animal evolution, human evolution, and photosynthesis, and c) epistemological beliefs and cognitive dispositions. Although our findings did reveal a significant relation between knowledge and reported acceptance for photosynthesis, there was no relation between knowledge and acceptance of animal *o*r human evolution**.** Epistemological beliefs were related to acceptance, but only to the acceptance of human evolution. There was no relation between students' epistemological beliefs and their general acceptance of animal evolution or photosynthesis. Most importantly, three subscales, *Ambiguous Information, Actively Open-minded Thinking* and *Belief Identification*, were found to be significantly correlated with understanding evolutionary theory.

The role of the instruction that examines the epistemological assumptions of science

The findings of Sinatra et al. (in press) support the argument that intentional level constructs are implicated in learning about evolution. However, it should be acknowledged that for learners to use their epistemological beliefs, goals, and dispositions productively towards learning and thinking they must be aware of these beliefs and tendencies when learning. Yet, learners *are often not aware* of their epistemological beliefs and *are often not in control* of their dispositions toward engaging with information. When learners are not aware of their beliefs or goals, they cannot and do not act intentionally in that their action is not determined by their beliefs or goals. This problem is particularly acute for NOS issues, as much of learners' beliefs in this area are implicit and fragmented (Johnston & Southerland, in review). However, when beliefs, knowledge, and goals are brought into conscious attention, *they can be used intentionally to achieve learning outcomes*. Here in lies the promise of intentional constructs for learning about biological evolution.

The difficulties associated with comparing scientific and religious constructs suggest that engagement in conceptual change about evolution (and other controversial topics) may demand more intentional processing than knowledge restructuring in other domains. Indeed, if conceptual change requires that students compare rival explanations in a controversial area, such comparisons require a relatively open minded, non-absolutist cognitive disposition. Intentional constructs that may need to be invoked include learners' general epistemological beliefs, specific epistemological beliefs about the nature of science, learning goals, personal dispositions toward engaging with cognitively complex ideas, and the willingness to be open minded toward change.

Interactions that support the close examination of the epistemological assumptions of science in comparison to other knowledge frameworks would serve to allow learners to be explicit about their own epistemological beliefs and dispositions (an necessary but often overlooked first step in changing such beliefs), may then allow students to change their epistemological beliefs, and, most importantly for this argument, to invoke these beliefs and learning dispositions when learning about controversial content.

Helping students become intentional learners: What aspects of epistemology need to be addressed?

If a learner finds information to be controversial, particular epistemological beliefs and learning dispositions need to be invoked in order to allow the learner to fully consider and explore that information. But how can such intentional learning be fostered in a science classroom? The most productive avenue for allowing students who might hold opposing religious views to come to understand evolutionary theory is to explicitly focus on their epistemological views and learning dispositions. The instruction to be described in this section, although it has been developed through a series of authors not necessarily mindful of the role of intentionality in learning, can indeed allow for the development of evolutionary knowledge because of its initial development of a learner's intentional level cognition.

Scharmann (1990), in his description of a diversified instructional approach to the teaching of evolution, addresses two aspects of our model of intentional learning—the role of emotions and epistemology. The basis of Scharmann's proposal is that students need "a place to stand between two extremes" (p. 98) when learning about evolution. Scharmann explains that students need to be aware that consideration of evolutionary theory does not require that they turn away from long held, firmly entrenched religious beliefs. Such a "place to stand" ensures that students' emotional reactions to instruction do not prevent them from further engaging with the material.

But how does a teacher create such a place in her classroom? Scharmann suggests that a diversified instructional strategy that targets not only evolutionary constructs, but also focuses on students' understandings of the nature of scientific knowledge, allows for students to consider scientific concepts without forcing them to turn away from culturally-based understandings. This need to ensure that students understand that science cannot and should not replace students' cultural knowledge is echoed by Southerland (2000) and National Academy of Sciences (1998) who emphasize the importance of detailing the *limits* of scientific knowledge. Teaching about evolution requires that students become familiar with the methodological principles of scientific knowledge (i.e., a realist ontology, rejection of metaphysical explanations, premium placed on parsimonious explanations) that by their very nature set boundaries on what science can address. As has been described by Poole (1996):

> Science is the study of the world of nature. Religion includes questions about whether there is anything *other than* nature (e.g., God) to which nature owes its existence. As a matter of logic it is no use pointing to science, the study of nature to find out whether there is anything other than nature.....There are certain questions which science, as the study of physical observables, is unable to address (p. 165).

Thus, through such a nonscientistic, diversified instructional approach, students' epistemological views can be developed to a point that they can begin to consider rival explanations, an important step incoming to understand those explanations.

Helping students become intentional learners: What instruction should instruction look like?

Although such a sophisticated understanding of the nature of science seems to be an overly ambitious goal for science instruction, a variety of educators offer specific suggestions for achieving this goal. The course described by Shipman and Jordan

portrays employs much of what we know is important in teaching NOS: it needs to be explicit and reflective as described by Lederman, et al., (2002), and it needs to be situated within a science content area (Abd-El-Khalick, 2001; Olsen & Clough, 2001; Johnston & Southerland, in review; Smith & Scharmann, 1999). To this, I would add that instruction needs help learners, at the outset, identify their own epistemological beliefs, both for science and for other ways of knowing, because like much of the rest of students' science knowledge, NOS conceptions can be expected to be fragmented and poorly integrated throughout a broader conceptual framework.

As an example of instruction that may employ each of these requirements, Duveen and Soloman (1994) argued that the intersection of science and social concerns can be taught through role plays of the evolution-creation controversy. Although such discussions allow students to recognize the limits of various forms of knowledge claims, the National Academy of Sciences (1998) describes how the history of the development of a specific scientific theory is also useful for demonstrating the tentative nature of scientific knowledge, the process of how a theory is challenged, what counts as scientific evidence, and how the cultural context influences a theory and its refinement. This instruction, therefore, would target the intentional level construct of students' disposition toward ambiguity. As scientific knowledge is portrayed as tentative and constantly open to change and revision, this knowledge may allows students to gain some degree of comfort with ambiguity, thus allowing for closer and more serious consideration of evolutionary theory.

Scharmann (1990) also offers an account of how explicit deliberation of the methods and assumptions of science as well as an explicit exploration of areas in which science conflicts with religious beliefs are essential in allowing students to develop a more contemporary understanding of the nature of science. Through the use of controversial readings in natural history, small group peer discussion about these readings, and reflective writings, students explore and develop their conceptions of the nature of science. Scharmann argues that an explicit understanding of the tentative, contextual, powerful nature of science, one that is bounded in terms of the topics it can address, is essential to students.

I argue that such activities are essential because they allow for the development of students' intentional level constructs of epistemological views, the role of beliefs, and the learning disposition of being comfortable with ambiguity—each of which Sinatra, et al. (in press) have found to be linked to the development of students' evolutionary knowledge. Because these intentional constructs are the explicit focus of instruction, they are brought into conscious attention, and so *they can be used intentionally to achieve learning outcomes*—thus allowing for a greater understanding of evolutionary theory.

It is important to note, here, that the goal of such instruction is not to change students' religious beliefs or persuade them to accept evolutionary theory (although we must acknowledge that both sophisticated epistemological beliefs and dispositions do have a strong bearing on a learner's acceptance of evolution). Instead, the goal of such instruction is to help students understand how science does not provide the only answers important in their lives. This, in turn, decreases potential aversion to concepts and may help to avoid the negative emotions that can impede instruction related to evolution, allowing for intentional level constructs to be invoked. Then, through the deep processing (Chinn & Brewer, 1993) or what Dole and Sinatra (1998) call *high*

engagement required by activities such as conducting inquiries, writing personal reflection, and justifying one's reasoning, the learner can examine her own conceptions and compare them to the content of evolution. Thus, intentional level constructs can allow for a deeper understanding of many controversial topics, particularly biological evolution.

Beyond the learning of evolution: What else will NOS impact?

For years cognitive psychologists have pursued the idea of broader epistemological knowledge—that is *what* a learner understands knowledge to be and what processes she recognizes as being important in the development that knowledge (discovery, construction, …) (Belenky et al., 1986; Moore, 2003; Perry, 1998). These researchers describe a state of cognitive development through which learners are understood to pass. The names of the stages or positions vary, but they typically include *dualism, multiplicity, contextual relativism,* and *commitment within relativism.* These stages or positions of epistemological development are thought to reflect a cognitive and affective journey toward more complex understandings, of the world and of one's self. Thus, these global epistemological views, broader in their reference than NOS, are thought to impact all of students' learning, not just their learning of science. Given the topic of this conversation, I am wondering how our focused approach to NOS knowledge interacts with, or influences, learners' more global epistemological development. Can courses like that described by Shipman and Jordan accelerate the development of students' NOS knowledge? How does that impact their more global epistemologies? And to what ends?

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The Shipman/Jordan Model for Introducing the Relationship between Science and Religion: Commentary from One Perspective and Possible Extensions

David F. Jackson

Abstract

Shipman and Jordan's explicitly interdisciplinary, liberal-arts-oriented course at the University of Delaware is clearly exemplary in many ways. I offer comparisons and contrasts, drawn partly from my own inexpert efforts as a teacher but largely from my past experiences as a student, with how the same topic has been or might be approached in different but related ways in other educational contexts, including courses in specific undergraduate fields, both undergraduate and graduate professional courses in education, and at the high school or middle school level.

Introduction: Relevant Background in Personal Experience

The perspective I bring to this symposium is colored by three experiences, two (long ago and of short duration, but of lasting influence) as a student and one (recurring over many years and current) as a teacher, in courses that dealt, in whole or in part, with the issue of science and religion.

While a high school student, I took a "Senior Honors" course entitled simply "Seminar in the Humanities," taught by Vincent Falcone, a social studies teacher. The basic content of this course has since been published (Falcone, 1992). While the course might simply be labeled an introduction to philosophy (primarily through secondary sources), it was similar to Shipman and Jordan's in frequently using an issue-oriented approach and small-group discussions and assignments, and many of the classic ideas and positions examined (e. g., those of Aquinas, Bacon, Descartes, Spinoza, Hume, Spencer, Buber, Wittgenstein) had their basis in, or clear implications for, religion, science, or the relationship between the two. In many ways it foreshadowed the emphasis, often heard in discussions of teaching the Nature of Science today, on differentiating and appreciating diverse "ways of knowing" (e. g., Eisner, 1985; Moore, 1993).

While a college student (and Geology major), I took as an elective an undergraduate seminar course in the History Department, "Science and Religion Since 1600," taught by Jon H. Roberts. A cultural historian, he has always taken a special interest in science and religion, and in Darwinism in particular (e. g., Roberts, 1988, 1999). More recently he has reflected specifically on this topic as an exemplar of more general issues in the influence of culture on university-based research, teaching, and their role in society (Roberts & Turner, 2000). His recent work in teaching, like Shipman and Jordan's, has been supported by the Templeton Foundation.

Finally, in my own teaching of a (primarily undergraduate) Science Education course for prospective middle school teachers in the Southeastern U.S., it became apparent that

issues of science and religion are clearly relevant to my own students' learning in Geology (in which they take a course that is a corequisite to mine), as well as to their developing conceptions and attitudes about their future as teachers (my explicit responsibility). My interactions over the past ten years with these students and some influential colleagues, and what they have taught me, may be familiar to science educators who have followed this strand at NARST from our initial explorations to some more coherent analyses in recent years (Jackson, Doster, Meadows, & Wood, 1995; Meadows, Doster, & Jackson, 2000; Jackson, 2000, 2002).

Commentary on Focus Questions for the Symposium

If you were to teach a course on science and religion would you approach it in a similar manner?

Yes, in several ways:

1. Co-teaching. Having two or more instructors is a huge advantage in two very different senses.
    a. Multiple areas of formal training and expertise: True polymaths are vanishingly rare in our time. As much as I loved him, I would have to say that even the late, unbelievably eloquent and well-read Dr. Gould does not truly qualify in a rigorous sense. Yes, there are scientists who are personally highly religious and/or may have done considerable serious scholarship in the area of religion. Yes, there are religious scholars and/or philosophers of religion who have painstakingly studied science and/or its history and philosophy. But there is no substitute for the presentation of comparisons or contrasting views by two or more people whose intellectual/academic/professional "souls" (please forgive the expression!) are very different, such as a scientist long active in research and a professional philosopher or theologian, each of whom has earned the respect and trust of the students.
    b. Multiple personal perspectives, beliefs, or values: If a student perceives that a single instructor simply has a worldview vastly different from her/his own, s/he may "tune out" at least part of the instructor's "message" from the beginning, despite an interest in the overall topic.
2. Issue orientation. There are enough highly abstract ideas and terms inherent in the subject that a highly abstract and general initial presentation might be confusing as well as boring for many students. An issue orientation is not only a affective benefit but also a cognitive one.
3. Historical perspective. In both Mr. Falcone's and Dr. Roberts' courses, ideas that might otherwise seem immediately implausible were made more immediately palatable and therefore more potentially productive of interesting and thoughtful discussion by being placed in their historical context, in terms both of cultural milieu in which they were produced and significantly, the language in which they were expressed. While Shipman and Jordan's course, unlike these, makes absolutely no pretense of being an historical survey, it seems clear that they pay attention to the context in which their readings were intended to be understood.

Are there other questions related to the general topic of science and religion which might also be useful in framing a course? If so, what are they?

Another issues-based approach in either a science, philosophy or interdisciplinary liberal arts context would center on specific currently "hot" ethical questions that are widely perceived to have a scientific or technological component. This is often done in a very slipshod and ineffective manner in the implementation in middle or high schools of Science/Technology/Society curricula, but could perhaps be achieved much better at the undergraduate level. A particularly accessible set of issues, with a futuristic bent that might appeal to college students, can be found in Dyson (1997). This would provide an entreé to the variety of general ideas about the relationship of ethics to science, religion, or both. As noted in the description of the course, Shipman and Jordan were constrained not to do this by the guidelines of their support from the Templeton Foundation.

In a professional course (such as one in education), a serious consideration of the separate issue of the relationship between personal views and professional practice is crucial to the relevance for science teaching of the more general intellectual debate. I might (and do) find the Driving Questions of the Delaware course personally very interesting, and perhaps some of my students would as well, but my rationale for entering this arena at all in my Science Education courses at the University of Georgia has to be clear relevance to professional issues. Shipman and Jordan note that the inclusion of evolution/creationism is a "no-brainer," but that there are good reasons for saving it for last, after students have built up a level of trust in each other and in the instructors when studying and discussing topics that, while not easy or comfortable, do not pack quite the emotional punch of evolution. In my course, we begin the several-week-long unit on Controversial Issues in Science Curriculum with other specific issues on which teachers (and/or administrators or school board members) must make public, professional policy and practice decisions, including the use of animals (e. g., dissection), environmental education, and sex education.

What is or could be the objective of teaching a course like this in the first place?

I can think of no better example of what liberal arts education is supposed to be about! Entire classic books have been written on this and I will not try to elaborate on such generalities.

Based both on my experience in Dr. Roberts' class and on my experience as a teacher in recent years, the primary objective might be to expand the awareness (of both students and instructors!) not just of the variety of ideas on these topics, but of some "real," respected, and memorable people (the students in the class) who hold them. As pointed out in the article recently suggested to our group by Lee Meadows (Brooks, 2003), we should constantly remind ourselves that this is only the "tip of the iceberg" when compared to the "real world" outside of university settings and, especially, outside of U.S. or Western culture.

What would be important to elicit from students about science and religion as epistemological systems?

A crucial aspect that may possibly have been overlooked in the Delaware course (and in many of our discussions) is the nature of not just the plausibility, but the practical relevance (or lack thereof) of these ideas and their academic discussion. In unrecorded

but memorable discussions with my own students, I found many of the same understandable fears as those systematically gathered and recently reported by Brem, Ranney, & Schindel (2003). While I many of these negative connotations are based on clear misconceptions, they are real and must be faced, and they are only fed by the semi-popular rhetoric of many scientists, notably those in the newly burgeoning field of evolutionary psychology.

Among the many useful clarifications made in the theoretical work of Mike Smith and his colleagues (e. g., Smith, Siegel, & McInerny, 1995; Smith & Siegel, 2003) are not only the distinction between students' understanding (our goal as science teachers) and belief (in science class, not strictly any of our business), but the connection of this distinction to ideas as motivations for action. In life (and perhaps in interdisciplinary courses, and unlike in science class) beliefs and the actions motivated by them *matter,* in a way that understanding may not. In order to critically discuss ideas in the way that Shipman and Jordan set out to do, the connections and constraints that students feel as a result of practical considerations are relevant. As one of my students once quoted C. S. Lewis, perhaps paraphrasing, "If Christianity is false, then it is trivial. If it is true, then it is all-important."

If you were to choose a set of issues to deal with in a course like this, what would they be and why would you choose them?

As Shipman notes, the omission of a strong focus on the classic example of Galileo and the medieval Roman Catholic Church is surprising but, I infer, highly thoughtful and thoroughly defensible. In my own occasional use of Galileo as a teaching case, I frequently encounter the accusation from students that the case is now archaic rather than instructive, that both science and religion have changed. Thus the focus on the Big Band and Evolution, clearly still important and controversial among living people and religions, is highly appropriate.

How does this course relate to your own scholarly interest in science and religion?

Many of the readings listed on the web site are sources from which I have drawn excerpts for my own students (e. g., Barbour, 2000; Gould, 1999; Haught, 2000; McGrath, 1998; Miller, 1999; Polkinghorne, 1998; Raymo, 1998; Ruse, 2001). While polemics written by scientists or creationists arguing against each other are easy to find and easy to use as initial discussion-starters, the more complex views of one or more of these authors might serve as a model for some students to clarify their own points of view, perhaps moving away from the despair engendered by strictly polarized views. As in Loving's (2000) work with graduate students in science education and the work with Delaware astronomy students described by Shipman, Brickhouse, Dagher, & Letts (2002), I am seeking a means of presenting to my undergraduate students the wide range of points of view that are held by scientists and other scholars on these issues, in the hope of facilitating more thoughtful, critical evaluation and decision-making on their part about their personal beliefs, their professional practice, and the relationship between them.

If this course were to be given at your institution, are there additional barriers that the instructors would face?

There would be no institutional barriers, and, in fact, I am strongly inspired by the success story of the Delaware course to try to organize an interdisciplinary group to explore offering such a course as a Freshman Seminar (a relatively recent innovation at UGA). Another member of my department recently developed a course (with a biologist) around the development of evolutionary theory, but it did not seek to deal with the science/religion issue as such.

A factor that might be, perhaps, labeled an internal political complication, rather than an institutional barrier, is the presence on our campus of several scientists who, either publicly or privately, have let me know that I am "barking up the wrong tree," both intellectually and professionally, with the modest and self-contained work I have done in my own Science Education course. One is a prominent and (apparently) very well-respected scientist (although in neither biology, geology, nor astronomy) who is an outspoken creationist and openly uses the physical resources of our public university for sectarian religious meetings of both students and other faculty. Another is a biologist who has a number of non-refereed but professionally prominent publications on science/religion/education issues, essentially voicing the opinion that explicit rejection of personal, religious-based views conflicting with the scientific consensus about evolution should be a "litmus test" for qualification as any kind of teacher. It is not that I perceive any real threat to academic freedom, or that either of these colleagues is in any position of power in relation to me, but the influence that they and like-minded colleagues have on many of our undergraduate students might significantly mitigate interest in an interdisciplinary, dialogue-oriented course.

[A question not asked, but I will answer it!] What questions would you like to ask Shipman and Jordan, or do you think our audience would like to hear them ask, that they do not address in their description or their course or its web site?

What are their personal views on these issues? Do they share them with their students? Why or why not?

In a way, of course, the personal views of the instructors are irrelevant, and there are also many good arguments for why it would be inappropriate to share them with the students, either in terms of teaching strategy, formal academic or legal policy, or personal professional ethics. BUT…if the students are asked to "open up" about their personal beliefs [as they clearly are], as well as to discuss the abstract characteristics and merits of various points of view, is it psychologically essential (or at least highly desirable) for the instructors to do the same (at least at some point, if not from the beginning)?

Possible Extensions to Younger Students

Could all of this really work at the high school or even the middle school level?

Science educators have openly ventured to say so only infrequently, based on small-scale empirical studies of science students (Roth & Alexander, 1997) or theoretical analysis of principles of curriculum (Anderson, in press), building substantially on the more general theoretical work of Nord (1995, 1999) and elaborating on the practical model of Nord & Haynes (1998). As I will critically discuss in some detail in another

session at this conference (Jones, et al., 2003) this proposal is fraught with practical difficulties, some possibly legal but others reducible to the fact that there are not many Vinnie Falcones or Harry Shipmans around!

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Lee Meadows

My unique perspective:

I bring to this symposium the perspective of Reformed Christianity, a fairly unique view among the NARST community. Reformed Christians point to the religious views of the European Reformation as their golden age of theological understanding. Reformed Christians are typically conservative in interpretation of scripture, yet also thoughtful and deeply academic. Reformed Christians look to prior scholarship, especially that of the Reformation age such as the writings of John Calvin and Martin Luther, as expert views against which current theological understanding should be checked. This theological position stands as a middle ground between the interpretive principles of Catholicism, which views church writings as authoritative, and Fundamentalism, which ignores scholarly writings and focuses instead on individualistic interpretation.

My background:

I grew up in as a Fundamentalist. As I was raised in Southern Baptist church in a small town in Mississippi, I was told that I was supposed to believe things, "Because the Bible says so." When I asked deeper questions, I was either told, "You just have to believe it," or "Son, that kind of thinking can lead you straight to Hell!". My childhood was lived in a Fundamentalist sub-culture, which held a distrust of anyone, Christian or non-Christian, outside of Fundamentalism. Over a 10-year period, I exited Fundamentalism through the intellectual and theological rigor of reformed Christianity. In it, I found a system of thinking that honored the truth of my faith while giving me the freedom, tools, and support to think deeply about what I believed.

My perspective on the symposium issues:

Following is a chart laying out my understanding of the interplay of science and religion. I originally planned to do a Venn diagram showing the common thinking between the two systems and the ways in which they differed. As I begin to work through the issues, I saw much more overlap than differences. The table shows this by focusing on common features between the two worldview systems and how each feature is expressed in science and in religion. This table represents my understanding as a practitioner of both views who has been mulling these issues for years.

Common Feature	Scientific Expression	Religious Expression
Valid Way of Knowing	Evidence from and explanation of natural events	Meaning from supernatural events, including events appearing to have only natural causes
Fundamentalist danger of excluding other ways of knowing	Epitomized by the arrogant scientist	Epitomized by narrow-minded Fundamentalists
Seeks to evangelize the young	Science literacy Increase pipeline of scientists College science honoraries	Chatechism Sunday school Campus Crusade for Christ

	and clubs	
Warnings about the other	Science is objective; religion is not. Don't let your religion interfere with your science.	To parents: Scientists have a vendetta against religion. Protect your child. To scientists: Your eternal destiny is based on your faith. Don't let science steal your soul.
Standard required accommodation strategy	Check your religion at the laboratory door.	Check your science at the chapel door.
Balanced view	Supernatural events are possible, but science can't consider them. As humans, we should be open to the supernatural because there are many problems that science can't address.	Many of the issues in life are not addressed by religion. As humans, we should be open to scientific thought because it helps us solve problems and create new possibilities unaddressed by faith.
An integrated practitioner	Respectfully follows the rules laid down by the scientific community, but points fellow scientists past the borders of science.	Engages with heart and mind in faith, but also points fellow believers to the richness that science brings to life.

Course specific questions:

Most of my thinking about embedding the interplay of science and faith into specific courses has focused on middle and high school classrooms, not college. Therefore, I don't have a lot to say about how teach these issues in a college science class. The core of my advice to middle and high school teachers is summed up in the thinking David Jackson & I already have published [insert Hearts & Minds and Managing the Conflict] when we advised teachers to treat fundamentalist Christians with the respect and dignity they would afford to any other group.

Our advice has two key caveats. The first is that evolution, whether cosmologic, geologic, or biologic, is the only accepted scientific view. Children with religious belief systems must understand this. Creationism is not a valid scientific explanation, and nothing about the science classroom should give credence to supernatural explanations of origins as in any way scientific. I hold to this caveat dogmatically because I want Christian students to be prepared to enter the scientific community. Because of the biases against faith they may face in the scientific community, they need to absolutely clear that a scientific view of evolution does not consider supernatural events or causalities. The second caveat is that science teachers should never challenge, either overtly or surreptitiously, children's worldview. Faith can add beauty and richness to life, and science teachers should never use the conclusions of science as levers to pry children away from their religious views. Middle or high school science teachers have no right to challenge their students' religious world views , and doing so continues the arrogant notion that science is the only, or even worse, the truly valid way to know the world.