Teaching Geosciences in Mississippi

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Abstract

Historically, two paths have developed in an individual and communal search for understanding and meaning: The study of science and the search for a higher spirituality. Although they should not necessarily be mutually exclusive, the history of science is littered with the collision of these two pathways, for rarely have they met without acrimonious debate.

Discussion of the dichotomies between intelligent design and natural process evolution is both timely and critical in the light of: 1. Declining student competencies in scientific literacy in the United States, and 2. A burgeoning global population facing environmental, energy and natural resource crises.

In 2007, the Mississippi Science Framework revision will increase the grade school science requirement to six semesters by adding two semesters of geosciences. Statewide, more than 12,000 seventh, eighth and ninth graders will be affected each year. As profound as this curriculum change might be, educators and administrators alike are wary of tackling the issues of science and faith that will arise in the classroom.

Scientific investigation is a journey into the mysteries of the universe and a quest for higher truths. Science repeatedly demonstrates that yesterday's certainty is tomorrow's doubt. Regardless of personal belief systems, in an open and tolerant environment, science can be used as a tool for penetrating deeper philosophical questions thereby allowing students to find their own answers. Our recommendation is to offer rock solid science, encourage open discussion and enhance student achievement in the sciences. Such is the path of discovery and wonder.

Introduction

If there has been a common thread linking all cultures since the beginning of recorded history, it has been the individual and societal search for meaning. The search has led to two distinct paths of inquiry, which in turn have led to the development of two of the most important establishments of society: The Religious and the Educational. Both paths contain the potential to generate codified belief systems, and both exhibit the capacity to become intolerant and inflexible.

As a natural consequence of the evolution of human societies from ancient times to the present, the search for God in almost every generation has led to the development of different religious and spiritual perspectives as well as philosophical statements about the nature of "creation." The codified beliefs and myths of religion are preserved and passed to successive generations in the accepted religious literature of the age and in the places of worship for each religion.

Additionally, as societies have developed and acquired more understanding of the world, there has been a desire to pass on the accumulated experiential knowledge to successive generations through the medium of an education. Educational systems therefore represent archival knowledge structures concerning all aspects of the culture and science of a society.

The inherent nature of man is to seek understanding of the unknown, and at the same time to be in awe and wonder of both what is known and what is seemingly unknowable. Furthermore, it is the unknown that fuels the desire to ask more questions in search of deeper levels of both scientific and spiritual understanding. It is not surprising, therefore, that the two paths of religion and education intersect at many levels.

The origins of structured educational training systems might be seen to have evolved from mythic and storytelling traditions in tribal cultures (beginnings of religion) and also from a concurrent desire to prepare tribal children to face an uncertain and often unpredictable world (the beginnings of science). That the world is unpredictable and uncertain is demonstrated in the simple fact that life leads to death. Some religions would suggest that few of us have any cognitive awareness of deciding to be born and most of us would agree that apart from instances of suicide, we have little, if any control over the moment or nature of our own death. The space and time between birth and death is filled with a path of lifelong experimentation and learning, of ignorance and discovery, and of failure and success. The innate drive to understand the world and to discover why things are as they seem to be, has been referred to as the cognitive imperative (Newberg, D’Aquill and Rause 2001). The cognitive imperative leads individuals and societies to ask ever more elegant questions about “life, the universe and everything”, and to codify the answers to those questions into curricula of learning. Moreover, in the ongoing search for answers two things become apparent:

1. Things that were held as truth in one generation are shown to be in error or in need of modification by later generations, and
2. No single field of inquiry can be separated from any other field except by the creation of arbitrary boundaries of convenience.

By way of illustration, we might suggest that language creates a medium for expression of understanding, history records the change of understanding over time, human geography records the location of culturally biased pockets of understanding and all of them are inter-related variables that can affect the outcome of “understanding”.

A more recent illustration of the blurring of traditionally non-related, scientific field boundaries occurred when cellular material was discovered in Tyrannosaur thighbones (Schweitzer 2005), which brought together the fields of vertebrate paleontology and molecular biology. As dramatic and profound as the discovery might be to science, it has also proven to be fertile substrate in the ongoing debate between creationists and proponents of natural process evolution (Yeoman 2006).

The two-sided nature of the debate underscores a second aspect of learning, which indicates that by the very nature of experimentation, humans have created a series of dualistic positions with regard to experiences of life, for instance: Yin versus yang, in versus out, up versus down, male versus female, beneficial outcome versus unwanted outcome and so on. The dualistic worldview stems from the binary operative (Newberg, D’Aquill and Rause 2001), which evolved from the basic mandate of survival: Threat versus non-threat. Threat to life leads to fear of death and ultimately then to questions about what happens after death.

It becomes apparent then, that issues of education and religion become tied at the level of faith. A child in school takes it on faith that the world is as his or her teacher explains it. The same child takes it on faith that God exists according to the fashion explained by his or her parents and/or priests or clerics in places of worship. In a seemingly paradoxical fashion, children are also inquisitive by nature and continuously test behavioral and knowledge boundaries as they grow and learn. Parental and teacher admonitions of “because I said so”, rarely, if ever placate inquisitive young minds for very long. Children intuitively know that we cannot take things on faith alone and that intuitive awareness may ultimately prompt a child to ask questions, which lead to breakthroughs in science simply because acceptance on faith was not a satisfying enough answer. The same child may also question the tenets of a religious faith or lack thereof in search of an answer that has personal meaning.

In terms of education, students of all ages need to be given accurate information and also be allowed to experiment and question. One of the trends that is in vogue with the current generation of pedagogists is “discovery-based” or “problem-based” learning (Rimal and Stieglitz 2000; Johnson 2006), however, in science it is unrealistic to expect students to discover their way to thermodynamics, atomic theory, plate tectonics, genetics and so on (Gross et al. 2005). At some level it becomes imperative that students learn and memorize the work of some of the great scientists such as Newton, Rutherford, Wegener, and Mendel in order to be in a position to ask deeper questions that will lead to new discoveries in science. It would be somewhat unreasonable to expect a grade school student to “discover” plate tectonics, but an analogous simulation of the process involving a pan of simmering soup might be entirely appropriate. Equally, in the classroom a student might “discover” the behavior of river systems using the fractal simulation of a stream table, but would not be capable of discovering how river systems work in the real world, given the time available to discover the process. In a similar fashion students can repeat the experiments of Mendel by growing sweet peas or breeding fruit flies to generate the basic genetic rules from the results.

Science education should therefore consist of experimentation, simulation and memorization acting together in concert in an effort to adequately prepare the next generation of scientists to ask more elegant questions than their forebears. Unfortunately, in the present political climate questions of science have become the battlefield of science and faith.

The battlefield is perhaps nowhere more apparent than in the earth sciences, where natural resource stewardship, management, conservation and exploitation affect every member of society on the planet. The opposing views taken by environmentally conscious scientists and those taken by Christian Conservatives regarding strategies for earth resource management and the political impact of environmental issues are illustrative of the battle lines (Carter, 2005; Hendricks, 2006). A 2004 poll indicates that more than 56% of Americans believe in a literal interpretation of the Book of Revelations in the Bible and that humanity has entered the “end times” (Hendricks 2006). From such a position, little need exists to protect or conserve natural resources (either renewable or non-renewable) for future generations (Hendricks 2006). Environmentalists and natural resource managers recognize that the Earth’s resources are finite and that the carrying capacity for humankind on the planet can be tied to resources like potable water. Conversely, Conservative Christians take the view that in God there is no lack, and therefore no cause for concern for humans, since, if these are the end times, when the resources are gone Christ will return (Hendricks 2006). That this debate creates division in both church and state can bee seen by the 2005 statement made by the National Council of Churches (Hendricks 2006) and by Carter (2005), himself an evangelical Christian, both of whom reject the notion that there is no need to care for the environment or show restraint in the use of natural resources. Carter (2005) is particularly strident in his discussion of educational and environmental crises facing America today.

In summary it comes to this: Where science finds a question, scientists look for an empirical answer, a better model, a refinement of a theory or perhaps a new theory entirely. Where religion finds a question, it is adequate to find an explanation in whatever manner is consistent with the ideology of the religion. A place exists for both positions, but not in the science classroom. The science classroom is a place to prepare young minds to ask questions about science, to accept the notion that humans do not have all the scientific answers and that successive generations will likely prove many of our currently held beliefs to have been false.

So here then, is our thesis: Discipline boundaries in the educational curricula of the grade school system serve the purpose of allowing students to penetrate the so-called certainties and mysteries within discrete packages of knowledge. In each classroom, teachers lay out the archival knowledge base to the students and allow the students to manipulate the information through successive years enabling them to build new insights for themselves and for society. Teachers should also enable and equip their students further, by teaching them the appropriate methodologies of enquiry for each subject discipline. For the students actively involved in the process of learning, the knowledge base of a discipline is refined using the specific methodologies of enquiry appropriate to the discipline. Each classroom is therefore a crucible for a specific field of inquiry. It is our contention then, that questions of science and religion are not intended to be answered in the same classroom. Consequently, we would argue that:

1. Educational success for each student is a two-part process: Content-based (hypotheses, theories and facts) and process-based (discipline-appropriate learning methodologies).
2. Science education must include sufficient experiment-based, simulation-based and memorization-based content for students to understand the world in which they live from an empirical perspective, without being required to adhere to the position that science has discovered all the answers.
3. Given an open learning environment, students will naturally ask questions and seek understanding. It is the role of the teacher to provide the information to the best of his or her ability, while respecting the integrity of the subject matter and without resorting to personal bias.
4. The codification of science into a curriculum of learning creates a belief system that is taken largely on faith because none of us have the time to independently prove all the scientific truths that have been handed to us through the history of science.
5. Acceptance of any given scientific postulate can be tested and accepted or rejected on the basis of the evidence garnered from *continued* research that generates independently verifiable results.
6. What we accept on faith, however, is ultimately an individual choice and not something that can be dictated from the front of a classroom or a place of worship.
7. While parents, clergy, teachers and peers undoubtedly influence what children come to accept as a personal belief system, an autonomous, free thinking adult

capable of finding his or her answers to "life, the universe and everything" is one who has developed adequate tools for asking independent questions.

8. Equally such an adult can hold the apparent paradox of conflicting belief systems without demanding the acceptance of a personal position by all other members of any given society.

Science Education in Mississippi

Under the current educational guidelines in the State of Mississippi, science is taught at the seventh and eighth grade levels and presented as four semesters of "Integrated Science." Integrated sciences include life and physical science, but no earth sciences. The earth sciences were removed from the Mississippi science curriculum in 1988 in response to three factors:

1. The lack of qualified earth science teachers.
2. The numbers of school coaches who were being required to teach science classes.
3. The implementation of Instructional Management Planning (IMP) by the Mississippi Department of Education, which defined clear learning objectives, tracked individual performance and gave students three chances to achieve mastery of material. IMP was discontinued after about five years due to litigation concerns.

Because Mississippi State University is located within the Starkville City School District, which is surrounded by the Oktibbeha County School District, we explored the Mississippi Curriculum Test (MAARS 2006) performance in these two school districts for the sixth and eighth grades in reading and mathematics (Table 1) and the Statewide Area Testing Program (MAARS 2006) for performance in algebra and biology at the ninth grade and english at the tenth grade (Table 2). No data exist for science proficiency in the Mississippi Curriculum Test and the only current measure of science proficiency in Mississippi is the biology cluster for the Statewide Area Testing Program at the ninth grade.

The Mississippi MCT and SATP scores, which appear promising, do not bear scrutiny when compared to the most recent set of science proficiency comparisons published by the National Center for Educational Statistics (NCES 2002). The NCES data indicate that the percentage of Mississippi students performing at the proficient level or higher in the fourth and eighth grades is well below the national average (Table 3). Additionally, in the State of State Science Standards 2005 study (Gross et al. 2005), sponsored by the Thomas B. Fordham Institute, fifteen (of the fifty) states, including Mississippi, failed to pass an investigation of statewide science standards. A failing grade (“F”) indicated that the fifteen states either had no real standards for science education or that the standards were so vague as to lack any meaning (Gross et al. 2005). Of particular significance regarding the Mississippi Science Framework, 2001, (Mississippi Department of Education 2006) were the comments regarding the teaching of earth sciences and the avoidance of using the word “evolution” in life sciences (Gross et al. 2005, p.46-7).

A review of test scores at the local, state, national and international levels reveals that the passing percentages of the SATP (Table 2), may be as much a reflection of the nature of the test preparation at the state and local level as they are a function of the actual performance ability of the students. Under the current Mississippi guidelines, teachers have input into the questions used on the SATP and the Department of Education distributes practice exams containing a high proportion of actual test questions to the local school districts. The net result is that a student-teacher relationship develops in which the students are being prepared to pass the test. As a result, student mastery of the curriculum of knowledge can be compromised. Statistical analysis of student test scores (Levitt and Dubner 2005), indicate that some teachers in the United States inflate test scores for their students and are “teaching to the test” because they feel pressured to turn in scoring profiles that will keep them and their schools off of probation.

Taken together, the test score data seem to imply that students who graduate from Mississippi high schools and enter levels of higher education do so without a sufficiently broad or deep knowledge base with which they could manipulate scientific information or understand the implications that issues of science might have upon their lives. The result of the current education policy at the national and state levels appears to be that politically mandated standards for classroom performance compromise the quality of education for the students.

The results of an investigation involving the acquisition of knowledge concerning water resources (Beasley, May and Schmitz 2005), supports the contention that the Mississippi Science Framework is not preparing students to understand basic earth science concepts leaving them unable to make informed decisions concerning earth resource management. It is significant that of the groups tested, 92% of eighth graders and 72% of college undergraduates had “naïve” conceptions concerning groundwater (Beasley, May and Schmitz 2005). The figures are all the more disturbing because potable water is the limiting resource for human population on Earth and water is essential for sustaining life on Earth. Awareness of the handicaps created in basic scientific knowledge by the current science curriculum has led the Mississippi Department of Education to revise the Science Framework as a proactive step towards addressing the needs of students.

Moreover, Mississippi should not be singled out for criticism; the State of State Science Standards 2005 study (Gross et al. 2005) cited only nineteen states as having earned a grade of

"A" or "B" for the quality of their science education. It is also heartening to note that the Mississippi Science Framework document contains "evidence of an effort to produce workable and meaningful standards" (Gross et al. 2005). In testament to that effort, the Mississippi Science Framework Revision (to be published by the Mississippi Department of Education in June, 2006) will be piloted in 2007 and 2008, going into effect in 2008 and 2009. All 300 school districts in Mississippi will be affected and the revised program will impact the educational experiences of 12,000 seventh through ninth grade students each year. The revised framework will include four semesters of life and physical sciences and two semesters of earth sciences. The revision will therefore address the need for a broader investigation of the sciences by the inclusion of earth sciences in the science curriculum.

Unfortunately, bringing Mississippi up to the national standards for the United States will not be sufficient. The Program for International Student Assessment (PISA) indicates that American high school students were outperformed by their peers in the other industrialized countries in the areas of mathematics and science (PISA 2004). The report states more than 5,000 high school students from 262 schools in the United States were part of a population of 250,000 students being tested worldwide. The results placed American students 24th out of the twenty-nine countries in the Organization of Economic Cooperation and Development with respect to mathematics and 22nd with respect to science (PISA 2004). Data from the 2003 Trends in International Mathematics and Science Study (TIMSS) place American fourth grade students 12th in mathematics and 6th in science out of twenty-five countries with above average scores. Standings fell somewhat at the eighth grade, where American students, again with above average scores, placed 15th in mathematics and 9th in science, out of forty-five participating countries (NCES 2006).

The international data are skewed by the fact that not all countries require children to remain in school after the equivalent of eighth grade. Moreover, although standardized testing is still the norm in the United States, several countries have moved away from standardized tests. Consequently, it should be expected that American test scores would not compare favorably with those from countries where school attendance is not mandated beyond the eighth grade equivalent or where standardized tests are not being used. In countries where attendance is not mandated beyond eighth grade equivalency, the remaining student population is likely to be more motivated and/or talented academically. Moreover, in countries where non-standardized testing methodologies are employed, students are more likely to be taught for understanding and an ability to manipulate the curriculum rather being prepared to pass a specific test instrument. Consequently the problems that teaching-to-the-test can create in reducing overall subject mastery are less likely to arise in countries where there is little standardized testing. Notwithstanding the ambiguous nature of the PISA and TIMSS results, room for improvement clearly exists, especially when compared to the Asian and European educational powerhouses.

Summary and Conclusions

We live in a world where exploration of our planetary neighbors, medical research, environmental issues including natural hazards and conservation issues as well as natural resource management are featured in the media on an almost daily basis. Students who graduate from the educational system deserve to be given sufficient information to enable an understanding of how matters of science will affect them and how those same issues will impact their children.

Our major concern is that students are not being adequately prepared to understand or manipulate scientific data and yet at the same time are being caught in a battlefield between science and faith. Our contention is that students need to be given clear, unequivocal, empirical scientific information in the classroom. The information should be learned through experimentation, simulation and memorization and should equip every student with an ability to formulate hypotheses and answer questions about scientific "truths". Students should be given an opportunity to recognize that science is not a static thing, but something that has evolved, and will continue to evolve as our understanding deepens.

We believe that scientific truth is not carved in stone and therein lies part of the issue. Where matters of faith and science collide there is a sense of rigidity and a lack of tolerance on one or both sides. When either science or religion is perceived as having all the answers or when the requirement exists for one to *challenge* the other, there will be only discord. In both scenarios students become myopic and are hampered in their ability to think freely due to the constraints of an inflexible doctrine.

It is no surprise to us to find that scientists are often people of faith. They may have faith in God or they may have faith in science, or both, because faith in both should not be seen as mutually exclusive. In a somewhat satirical work, C.S. Lewis (1942), writing in the Screwtape Letters, creates a scenario in which a senior devil (Screwtape) writes mentoring letters to his young apprentice (Wormwood). Screwtape warns Wormwood not to use science as a tool to corrupt the human he is attempting to convert, because God is frequently found in science. Scientists work in environments that often inspire awe and wonder, and their work may lead them to contemplate the deeper spiritual questions of "life the universe and everything."

Spiritual and/or religious convictions, however, should not be used to replace the scientific method.

So what is truly at issue here is the scientific method, which is to ask questions of the universe and to test hypotheses through experimentation and discovery in an effort to seek clarification and advance understanding. Integral to the process of scientific inquiry is the requirement that hypotheses only become theories when a body of supporting data consisting of reproducible and verifiable results has been generated by continued research.

We feel strongly that students have the right to discover the strengths and weaknesses in science without, at the same time, being forced to accept either scientific or religious dogma. Questions of science belong in the science classroom. Questions of spiritual and religious significance should be asked in the philosophy and religion classroom. The boundary between these two fields of inquiry is necessary for developing minds so that children can acquire the necessary skills to ask valid questions for their own lives, free of the prejudices of their parents, teachers and clergy.

Finally, there *are* two paths in forest and each child should be given the opportunity to walk along each of them. Education should not be an either/or proposition with regard to science or religion. The binary operative (Newberg, D'Aquill and Rause 2001), does not have to influence the path of education. We believe that children:

1. Should be given the opportunity to learn about all religions and spiritual paths;
2. Should be given the opportunity to learn about science, unencumbered by the requirements for adherence to religious or scientific traditions;

3. Should thereby be given the opportunity to develop the skills to make informed decisions about the world in which they live in matters of both faith and science; and finally, that they

4. Should be allowed to hold opinions that are consistent with their personal belief systems, without being censured or ostracized by others.

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Table 1: 2004/5 Mississippi Curriculum Test Scores for the 4th and 8th Grades.

	Mississippi Curriculum Test Academic Year 2004-2005					
	6th Grade			8th Grade		
		% Passing Proficient or better			% Passing Proficient or better	
	Number tested	Reading	Mathematics	Number tested	Reading	Mathematics
Mississippi	37647	74.8	67.2	36577	56.8	53.1
Starkville City	289	80.6	64.2	312	54.5	51.0
Oktibbeha County	73	57.5	60.3	47	34.0	31.9

Table 2: 2004/5 Subject Area Testing Program Test Scores for the 9th and 10th Grades.

	Subject Area Testing Program Academic Year 2004-2005			
		9th Grade		10th Grade
			% Passing Proficient or better	
	Number tested	Algebra	Biology	English
Mississippi	29145	91.6	91.8	82.8
Starkville City	272	91.4	91.5	75.9
Oktibbeha County	56	94.6	90.2	67.2

Table 3: 2000 National Assessment of Educational Progress Test Scores for the 4th and 8th Grades.

	National Assessment of Educational Progress 2000					
	4th Grade			8th Grade		
	% Passing Proficient or better			% Passing Proficient or better		
	Mathematics	Science	Reading	Mathematics	Science	Reading
National	35.0	27.0	30.0	28.0	30.0	29.0
Mississppi	19.0	14.0	18.0	14.0	15.0	18.0