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Experiences With Student Growth From Fatalism to Natural Law Concepts in High School Science Courses

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ABSTRACT

Fatalistic students devalue schooling as arbitrary and unhelpful, and see themselves as passive subjects of authoritarian adults and the whims of fate. Failure to encourage natural inquisitiveness often leads such students to view the world as capricious, unknowable, and uncontrollable. The author challenged this view in three ways: By validating alternative epistemologies (empirical, poetic, and doctrinal), by modelling skepticism and renouncing the role of information authority (inquiry and socratic formats), and by respecting data (personal experience) as a source of knowledge. The interpretation of data was used to develop the ability to "read the logic" inherent in the physical world, leading to the conclusion that it is orderly. For instance, students made generally accurate predictions about habitat, behavior, diet, and reproductive strategy from gross anatomy. After making this transition, students sought explanations that often exceeded the abilities of the teacher! The author speculates that an orderly world view may also contribute to emotional health. Participants are invited to share their own experiences.

I. INTRODUCTION

This session is not intended as a lecture presentation, but as an opportunity to share teaching experiences, offer advice or criticism, and, I hope, learn some new things by comparing experiences.

For this reason, my presentation will be narrative and

anecdotal. After I have finished, I would like to encourage all of you to describe some of your own experiences, whether or not they have been similar to mine.

II. FATALISTIC STUDENTS

I taught high school biology and chemistry in a semi-rural lower middle class school in Southern New Jersey for three years. Although the students were highly diverse by the usual criteria of racial and ethnic background, parental education, and socio-economic status, most were depressingly homogeneous in their weak intellectual development. Clearly, they had not been stimulated or served well. Typical student characteristics included:

*) Alienation from learning--Students did not expect school to deal with anything in their own experience outside the classroom.

*) Authoritarian attitude--Many students considered a "good" student to be one who is obedient, not necessarily one who learns well. The view of school and teacher as authority legitimizes the gap between student experience and curriculum.

*) Intellectual lethargy-- Under this category I group such traits as excessively concrete thinking, reluctance to apply imagination or conjecture, and weak self-confidence and curiosity. A concomitant of intellectual lethargy was the assumption of a classroom role of passive recipient of information.

This combination of characteristics brought with it additional obstacles. Because many students did not believe that they could construct meaningful interpretations of experience themselves, and did not expect their teachers to even address their experiences, they were often content to

remain mystified. When pressed for explanations of common observations, such students would often respond, "That's just the way it is.", or "That's the way God made it." These responses are not surprising or problematic in themselves. What is distressing is students' willingness to accept these tautological non-explanations as final causes, rather than points of departure for inquiry into how and why things are as they are.

These observations were not confined to the admittedly intimidating realm of science. In writing about literature they had read in English classes, and in their own gossip, students hewed closely to concrete narrative, and avoided commenting on motives, consequences of actions, or personalities, beyond the occasional abusive remark about a classmate. Here, too, one can see the lack of abstraction and the pose as passive subject of unknown powerful forces. A locally popular bumper sticker expressed this attitude in simple terms as "Shit happens."

III. CHALLENGES TO FATALISM

In approaching the problems described above, I set three goals for myself:

1) First, aside from the prescribed curriculum, which consisted largely of factual information, my primary subject matter teaching goal was to convey the concept of natural law. In order for students to take any meaning from the scientific information that they were meant to absorb, it seemed to me that they would first have to understand the idea that the physical world behaves in an orderly, predictable way, following laws that can be known and used to predict and influence the future.

2) Second, I wanted to use the factual information in

the assigned curriculum as a means of developing critical thinking skills, not as an end in itself.

3) Finally, I wanted to use the science class as an opportunity to help students develop their general academic skills, such as critical reading, and the abilities to do independent research and use mathematics. Because so much new vocabulary is taught in science courses, I also hoped to teach students enough about etymology and combining word roots to enable them to build their vocabularies by analyzing unfamiliar words.

I decided to begin by placing the canonical scientific method in epistemological context. I asked students to find out each others' names, and to select one of their number as an authority on baseball. After the sports authority had made some predictions that the class accepted, and the students had reached agreement that knowledge of people's names (including one's own) rests ultimately on the word of their parents, these kinds of information were described as doctrinal knowledge, or arguments from authority. Next, I directed the students' attention to some wildlife photos that were posted on the wall. Remarks about the cute harp seal pup, the wise owl, or the vicious predator were elicited as examples of a sentimental or romantic approach to understanding nature. Finally, I asked the class how they would seek a cure for AIDS. This presented an opening to the ideas of empirical knowledge, hypothesis building, and experimental methods. I did not present a scientific approach to knowledge as the "correct" one, but as one of a variety of ways in which people seek to understand the world.

I did not reject students' mystical and fatalistic statements as incorrect or unscientific. Instead, I made two observations about them. First, I pointed out that they may be true, but they do not say much. Second, and more importantly for science, they are not very useful because

they lead to no testable predictions. The following exchange typifies this approach:

Teacher: How can we explain the fact that even very large plants and animals are made of very small cells?

Student: That's just the way God made it.

Teacher: You may be right about that. I don't know. But even if it's true that God arranged things that way, we still don't know how it happened, or why all the big organisms that we can find today are made of many small cells. If there ever was a cell big enough to be a tree or a horse, it must not have been a very good design for survival, because there don't seem to be any left.

Several implicit points have been made here, and the foundation has been laid in this exchange for several goals that will become explicit later in the course. First, and probably most important, a connection has been established between the student's own experience and approach, on the one hand, and the unfamiliar classroom subject matter of the cell theory, on the other. This signals the students that their experiences are being taken seriously, which is only proper: The class has already learned that data should always be paramount over doctrine in science.

Second, the class has seen that science does not value a statement solely because of its truth, but seeks falsifiable, mechanistic hypotheses. The validation of student experience, then, is qualified: Everyone's data are worth considering, but no one's subjective experience is definitive. It can be compared with other people's experiences, and criticized on methodological or logical grounds. Thus, the students have now been challenged to surpass the kind of aphoristic non-response that this student

made.

Third, the teacher has implied that things happen for reasons, and that those reasons can be known. Repeated experiences of this kind helped to develop an open-minded, skeptical attitude that was very effective in pursuing an inquiry approach. When evolution was studied later in the year, many students retained their creationist sentiments, but this was not a problem. By this point, they understood that science does not so much deny the occurrence of Divine agency as ignore it in favor of mechanistic issues. Note that the answer that the student received in the example was also couched in evolutionary terms, with reference to successful and unsuccessful designs for survival. By implicitly using natural selection as a paradigm for interpreting living things, I tried to infiltrate the chaotic world view of fatalism with some structure that could serve as a framework for meaning-making.

The inquiry format was the obvious choice for conducting a course of this type. Experiment and socratic style discussion were my most important methods. Whenever possible, I tried to take a naive approach to data and factual information, and let the students handle the interpretation. Some topics were not easily amenable to original experiment in a high school setting. In such cases, we considered published results, conducted thought experiments, and engaged in logical, rather than empirical inquiry.

It has been said that every science course is also a foreign language course. This presents an additional opportunity for strengthening inquiry skills and intellectual self-confidence. I presented new vocabulary by helping students to find meanings for word cells from familiar words, and apply them to new ones. The class soon developed a

modest working knowledge of Greek and Latin roots, and the confidence that they could use this knowledge and the contextual clues to decipher most new terms that they would encounter. This is also a kind of inquiry learning.

IV. NATURAL LAW

While presenting the prescribed subject matter, I continued to stress the importance of empirical evidence, engage the class in rational analysis of evidence and ideas, and insist that all levels of analysis converge, be they biochemical, anatomical, physical, or physiological. In every organism and system that we studied, I made clear the expectation that there must be an underlying unity to every reality. In the case of biology, the most important unifying principles are natural selection and the laws of physics and chemistry. What is most important, however, is that there are such laws, and the evidence of their operation can be read in the form and structure of physical reality, in this case, organisms.

I only stated this explicitly to the class once, late in the year. The concept of natural law was repeatedly conveyed, however, through class discussions and assignments. The unity of natural law was demonstrated implicitly, for example, when students learned that they could infer diet from dentition and the structure of the digestive system, relate pulmonary and vascular physiology to habitat and metabolism, and explain why insects are smaller and more numerous than vertebrates.

Through repeated experiences of this type, the classroom gradually became a forum for a sort of ideology. The principal elements of this ideology are the belief in the existence of natural law, the desire to discover natural law, and confidence in one's own ability to do so through

experiment and rational analysis. In short, the world makes sense, and we can learn what that sense is.

V. CONSEQUENCES

How did students change during this process? As the year progressed, they warmed increasingly to the subject matter, and seemed generally to be more intellectually awake, aware, and engaged. As the class mastered the scientific approach, they abandoned the antinomian, chaotic world view, at least in class, and became willing to take risks in hypothesis formation. By the spring term, the words, "That's just the way it is" were no longer heard. Student behavior and questions were increasingly mature, inquisitive, and self-confident. As the class progressed, I found that I could replace increasing numbers of fact recall questions on tests and homework with free response and essay questions that called for higher level skills such as formation, recognition and criticism of abstract concepts.

One sign that the barriers between school and reality had been reduced was the fact that many students attempted independently to apply the skills and concepts that they had gained to their own lives. In one especially dramatic example, a genetic defect was discovered in a student's family when we had just finished studying genetics. The student helped to lead the family's discussions with the doctors, recognized several biologically novel aspects of her pedigree, and initiated an excited report to the class on the whole process. From an educational point of view, the major accomplishment was the fact that students saw this application of classroom knowledge as a natural process.

The power of the intellectual system that my biology classes had constructed became clearer when several former biology students were assigned to my chemistry classes. Many

of them had learned so well that their questions began to exceed my knowledge of the subject matter. While reviewing isotopes and the periodic chart, for instance, students wanted to know if there was a theory that would predict the mass numbers andä stabilities of the isotopes that occur. This turned out to be a surprisingly difficult question to answer, even after consulting two Ph.D. chemists. Although I never did find a satisfactory answer to this question, I counted the asking as a sign of educational success.

I believe that this initiative was a success with respect to students' intellectual development. I would like to speculate in conclusion that students' emotional health was also nurtured by their growing confidence in the existence of order in the world, and in their own abilities to discover that order. One would expect this confidence to be conducive to the replacement of a chaotic, fatalistic world view by a well articulated, robust mental structure. It often seemed to me that fatalistic students actively resisted interpretation, perhaps because it leads to personal accountability. Adolescents who prefer not to think about the consequences of their actions feel free to behave impulsively. Perhaps the development of trust in natural law can help to support the growth of the emerging adult personality.