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ABSTRACT

Noting that traditional approaches to biology education do not take full advantage of the narrative nature of biology when introducing students to its subject matter, this paper argues that students in biology courses could benefit from being asked to write narratives and that this activity could fit into either a fairly traditional curriculum or a more innovative, process-oriented approach. The paper suggests encouraging students to first write a creative narrative (for example, on photosynthesis) and discusses how creative narratives could be used in either a content-driven biology classroom or a classroom dominated by the learning-cycle approach. Contains 11 references. (NKA)

The Biology Classroom: A Natural Place for Narrative

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Biology is full of stories. Organisms live and die. Species evolve. Cellular processes transform one substance into another. Many elements of narrative—physical settings, temporal sequences of events, causative agents (or characters)—exist, but unfortunately, traditional approaches to biology education do not take full advantage of the narrative nature of biology when introducing students to its subject matter. In this paper I will argue that students in biology courses could benefit from being asked to write narratives and that this activity could fit into either a fairly traditional curriculum or a more innovative, process-oriented approach.

The Creative Narrative

The first type of narrative students could be encouraged to write would be a creative narrative. Through such story-telling students would develop their own analogies for how a biological phenomenon occurs. For instance, before being exposed to the details of a complex process like photosynthesis, students could first be exposed to a few critical events of the process: the conversion of the energy in sunlight into a form usable by both plants and animals through two steps, the capture of light energy and the transformation of that energy into a stable, transportable sugar.

After this minimal introduction to photosynthesis, students could be invited to write their creative narratives. Their task would be to write a story that describes one way light could be turned into sugar and they could do it however they wanted. Personified, fanciful characters could be encouraged; if students want to write a story in

which men and women with butterfly nets catch chunks of sunlight in order to capture their energy, so be it. If the students want to make up fancy tools or pieces of machinery to be used in the process, so be it. The only restriction on their creativity would be that the basic events of the story—the capture of energy in sunlight and eventual production of sugar—be maintained.

These narratives could fairly informal; students would be writing for themselves, perhaps in the form of a learning log or journal entry, or even an in-class free-write. The point of these initial stories would be for students to develop a basic framework to help them process and organize the additional details of photosynthesis they would be exposed to later. Only after students had written these stories would they be introduced to additional details of the light reactions and the Calvin Cycle. After exposure to these details, students could be invited to compare them with their stories to see how they well they matched, and ultimately, the students could even be encouraged to return to their stories and revise them to make them match the additional details they have learned.

Rationale for Narratives in Content-heavy Classrooms

Writing such creative narratives could be an effective learning tool in a traditional biology classroom (where students are expected to master large amounts of biological information) for at least two reasons. They may help to develop student motivation and interest, and they could help students to understand a complex process like photosynthesis by activating cognitive schemata.

Motivating Students. When reviewing techniques to help students become more interested in and motivated to learn in science courses, Sandoval (1995) identifies several characteristics of effective activities and topics, four of which seem to apply to the creative narratives:

- characters,
- goal-directed activities,
- novelty, and
- incongruity.

The first one requires little explanation; the creative narratives would invite students to develop characters—personified representations of abstract phenomena and microscopic/molecular objects—which may help to engage their attention.

To consider Sandoval's second characteristic, we can think of the narratives as relating to goal-directed activities in two different contexts. First, the students would be engaged in a goal-directed activity, not just writing any story they want, but a story that describes a very specific process. In addition, the narratives could force students to view photosynthesis as a goal-directed activity. While this teleological vocabulary may be uncomfortable for some, the perspective it describes could still have some merit. If the narratives help students to focus on the functional significance of a process like photosynthesis, perhaps they will be less likely to get lost in a sea of detail. Some biology instructors complain that students, who may be able to name some of the intermediate steps in the process, sometimes emerge from such a unit with no understanding of the process as a whole; such students are unable to answer questions about what the importance of the photosynthesis is, or how it relates to cellular respiration. The creative narrative's preliminary focus on such functional significance could help students maintain this important perspective.

The final two traits, novelty and incongruity, may overlap somewhat in the effects of the creative narratives. For many students, the invitation to engage in creative writing in a biology course might be novel or incongruous with their previous experiences; either way it could serve to grab their attention. Further, if the students are asked to revise their creative narratives after exposure to additional details of the biological

process, they will encounter additional incongruity. To the extent that their preliminary stories do not match the subsequent information, they will need to recognize and reduce the incongruities.

Cognitive Processing. In addition to promoting student interest and motivation, the creative narratives may help students to process the details of complex scientific phenomenon by activating cognitive schemata. In order to consider the cognitive function of these narratives, we need to recognize that they are more than just stories; they are metaphors or analogies for what is actually going on in photosynthesis. From this cognitive perspective, the creative narratives could be beneficial at two distinct levels.

At the most basic level, the creative narratives might function by stimulating a generic-level metaphor. Such metaphors, as described by Mark Turner in *Reading Minds*, are essentially archetypal thinking patterns we regularly use to process information we encounter. Turner lists several different generic-level metaphor which can operate; the one that seems most pertinent to the creative narratives is the EVENTS ARE ACTIONS metaphor (1991, p.162). Via this metaphor, events are processed not as static things which simply occur at a given place and time, but as things which happen for a reason; the cognitive processing of such actions requires the identification of causative agents and resulting effects. If the creative narratives help to turn on this metaphor as students begin to study a complex process like photosynthesis, hopefully they will not be as likely to approach it as a static diagram on a page which has to be memorized; instead they might be encouraged to process it as a series of cause-and-effect relationships in which functions and interactions would be emphasized.

The intended audience for Turner's description of the cognitive importance of metaphors is largely composition instructors in English departments; nevertheless, metaphor and analogy are not strangers to biology classrooms. Analogy is widely recognized as a powerful tool in science education. For instance, analogy figures

prominently in Sandoval's 1995 review article of cognitive psychology-informed pedagogical practices in the sciences, and the *Journal of Research in Science Teaching* devoted an entire special issue (volume 30, issue 10) to "The Role of Analogy in Science and Science Teaching" (1993). As a result of this recognition, both textbooks and teachers often supply students with analogies to help them grasp abstract concepts of science.

However, E.D. Wong (1993) has done research suggesting that student-generated analogies might be more effective than teacher or textbook-supplied ones. There are at least two reasons for this. The first is that there is no guarantee that students know enough about the analogy for it to work; for instance, if you tell students that something works like an internal combustion engine, but they don't have any idea how such an engine works, then they are not going to get much out of the analogy. Student-generated analogies on the other hand, necessarily draw on experience and knowledge the student already has.

Additionally, Wong's depiction of the process of analogy-generation by students illustrates how learning could occur. Essentially he presents it as a trial-and-error process. If students are given the task to come up with an analogy for scientific phenomenon x, they first come up with an idea and then start comparing it to x. Typically they reach a point where they realize their analogy isn't going to work—the two things are too dissimilar. So they abandon the first idea, come up with a new candidate, and start trying to match it; it may take them several tries to find an adequate analogy. It's during this repeated sequence of trying out potential analogies that students often develop a better conceptual understanding of the scientific process they're trying to match. Similarly, if students were encouraged to revisit their preliminary creative narratives and to revise them after they had been exposed to more details about photosynthesis, they might develop a better understanding for the process.

Creative and Historical Narratives in a Learning Cycle

The cognitive rationale described above might be most pertinent to a content-driven biology classroom in which students are expected to process many biological details. However, the creative narratives could also be used in a classroom dominated by a different pedagogy, the learning-cycle approach. In such a classroom (as described by Lawson 1988, and Lawson, Rissing and Faeth 1990), some of the details of traditional biology curricula are sacrificed in order to allow the process of doing science to be emphasized; the goal is that students will emerge with a thorough understanding of how the scientific method works, how scientists reason, and how new scientific information is developed. This "inquiry approach" assumes that students will learn both biological principles and the scientific method by attempting to answer questions about biological phenomena for themselves (Lawson, Rissing and Faeth 1990).

A learning cycle consists of three stages (Lawson 1988 and Lawson, Rissing and Faeth 1990). The first stage is exploration. Students are given a question about a biological system to answer, and then try to answer it for themselves. Typically, the exploration takes place in the laboratory, where as a class, they create and experimentally evaluate a set of alternative hypotheses or explanations for the question they were given; however sometimes the exploration is based more on information acquired through readings, lecture and discussion. Only after students have worked through the experiments or information and come up with their own "best answer" for the original question are the technical terms and definitions of biology introduced. This is the second phase of a learning cycle, "term introduction" (Lawson 1988, and Lawson, Rissing and Faeth 1990).

Creative narratives, as described previously, could represent an alternative form of exploration for students in learning cycle classrooms. In the photosynthesis example, each student would write his or her own explanation for how the energy in sunlight

could be transformed into sugar; these stories could be shared and compared with each other as well as the additional biological details provided during term introduction.

After term introduction, the third and final step of a learning cycle is concept application (Lawson 1988, and Lawson, Rissing and Faeth 1990). What is striking about concept application is that quite often, the target concept students are asked to apply after the unit is not a nugget of biological information; it is instead a concept related to the scientific method. For instance, Lawson, Rissing, and Faeth (1990) describe 2 cycles associated with the topic of photosynthesis, neither one of which has photosynthesis, or even a more general notion of energy-transforming reactions as the ultimate concept. In one, laboratory exploration of the role of light in photosynthesis, which certainly does teach the students something about the details of the process, ultimately results in the concept of experimental controls and how important they are to the scientific method. In the other photosynthesis cycle, students explore, via lecture and discussion, a series of classic experiments from the 16th, 17th, and 18th centuries in order to answer the question "where do plants acquire the energy to grow?" Again, although students learn about photosynthesis by doing this exploration, the concept that is emphasized during the application stage is hypothesis-testing (Lawson, Rissing, and Faeth 1990).

In a learning cycle that included creative narratives during the exploration phase, students could be made aware of the power of analogy, not just as a tool for their own learning, but also as a heuristic device in science. A large body of research points to the importance of metaphors and analogies in developing new hypotheses, experiments, and theories (reviewed by Hoffman 1980 and Leary 1995, see also Gibbs and Lawson 1992 for a discussion of the importance of analogy in hypothesis formation); for instance, perhaps the most famous example from biology is Darwin's use of artificial selection (the "breeder analogy") in developing and describing his theory of natural selection (Richards 1997). Ultimately, in such a learning cycle, during the concept application

phase, students could be exposed to the role of analogies in the development of new scientific knowledge. In fact, after writing their own creative narratives for themselves during exploration, later, during concept application, students could be invited to write a more formal narrative for an external audience: a historical narrative based on library (or even ethnographic) research, in which they describe how a particular analogy was used by a practicing scientist.

Making the Most of the Biology Classroom

According to Ost and Yager, "An underlying goal of biology instruction must be to prepare the students to be active citizens who have the correct values, appropriate knowledge and necessary skills to make decisions that would benefit both man and environment" (1993, p. 284). Their goal of providing students with knowledge and skills to a large extent summarizes the rationales provided in the preceding sections; narrative writing in either a traditional or learning-cycle classroom could help students to learn biology, learn about the process of biological research, and learn how to critically evaluate and respond to information as they develop their own analogies.

In addition, the narratives could represent a subtle way to approach the "correct values" that Ost and Yager advocate. For instance, writing creative narratives could influence a student's values by validating each individual's approach to thinking about a complex process like photosynthesis; the textbook diagram isn't the only way to conceive of the process, and if students are allowed to explore their own notions about how to understand biological phenomena, then they may learn to accept alternative ways of thinking more easily.

In addition, the very act of engaging in creative writing in a science classroom may help to integrate the students' educational experiences across multiple disciplines. For instance, Penick (1995) suggests that students should learn to recognize that creativity is an important part of science, not just something they need in English

classes. Ultimately, such interdisciplinary links may help to change the way students value and reflect upon their education. If they can see the ties between the different classes they take in school, then perhaps they'll be able to take the next step and see ties to their life outside school.

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