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Evolving: Using Science Fiction to Engage Students in Evolutionary Theory

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ABSTRACT

Evolutionary biology is not well-understood by a majority of the population. Many misperceptions and misconceptions exist as well as outright resistance to the theory. Various teaching and learning strategies have been tried in an attempt to involve students in exploring the theory, with mixed results. The use of science fiction to engage students in this area has been sparse, and virtually no quantitative assessment of learning with the method has been done. Using Origins, an anthology based on evolution, we created an interdisciplinary teacher's resource manual that will be offered free to teachers. This paper examines some of the difficulties biology teachers face in the classroom. It also explores the importance and benefit of interdisciplinary thinking and the significance of stories on student thinking. Future research opportunities are considered.

KEYWORDS

Evolutionary Biology, Evolution, Science Fiction, Interdisciplinary Teaching, Teaching and Learning, Curriculum

Imagine a group of humans who, some years ago, merely drew on walls to communicate their understanding of the world. As they developed, they learned to speak and to operate machinery. However, as their understanding of the world increased, so did their recognition that there was much they did not comprehend. For simplicity's sake, they just wanted to push it all aside.

Those humans are real. They are here today, and are sitting in your non-major biology courses. Imagine their consternation regarding not only the content, but also the concepts that may even challenge some of their personal beliefs. The difficulty is how to get students comfortable with the material and, ideally, make them more open to science and scientific concepts. One answer: Stories.

Delving into science and scientific concepts through various art forms is nothing new (Asimov, 1968; Finch, 2000; Bixler, 2007; Kilby-Goodwin, 2010; Pierce, 2001; Raham, 2004). Professors have long used art in their classes to explicate, illustrate, and question theories; however, much of the work seems to be done in

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physics. The intersection of evolution and art is one area that could be more fully explored. Not only would this allow for more in-depth, thoughtful discussions concerning evolution; it might also engage students to interact and appreciate science in more profound and complicated ways.

Anyone familiar with teaching evolution understands the difficulty inherent in communicating the theory. First, many students just don't care enough about the subject. Besterman and Baggott la Velle (2007) state that students find evolution "boring" (p. 76). Further, research (Alters and Nelson 2002; Evans 2006) notes that a large swathe of the population has little to no understanding of evolutionary theory. Hoffmaster (1986) showed there is a belief in a variety of pseudoscience among college students. Even more disturbing, Smith (2010b) highlighted a great deal of research showing public high school teachers and university undergraduates not only resist abandoning these misunderstandings and misperceptions, but continue to resist even after completing courses in evolution that take advantage of the current research.

Many challenges to address those preconceived notions exist due to teacher and student trepidation. Sundberg and Dini (1993) documented that teaching and learning about evolution can be conceptually difficult, stressful, and even fear inducing for many learners. Brem, Ranney, and Schindel (2003) underscored the fear for teachers, specifically, highlighting their lack of content and pedagogical knowledge, lack of resources, pressure or potential conflict from students, parents, or the public, and their own view that teaching only one view is wrong.

One way to address these significant barriers to teaching and learning evolution is by thinking about the topic in new ways. McKeachie, Lin, and Strayer (2002) call upon instructors to make learning interesting and to stimulate student curiosity. Dr. Randall Hayes, an Assistant Professor of biology, and I, an Assistant Professor of English, decided to explore the use of fiction to teach evolution based on the anthology, *Origins: Tales of Human Evolution* (Reynolds, 2009).

In our free two-pronged resource manual, *Origins: The Science Behind the Story* (Rohrbacher & Hayes, in press), for teachers in high school and undergraduate biology courses, we attempt to be as comprehensive as possible to alleviate biologists' fears of teaching literature. The manual offers a brief synopsis of each story, a breakdown of characters, and even a list of vocabulary. It further offers ideas on how to use literature in story, suggests some assessment tools, shares a number of other resources, and suggests possibilities to connect the story to the biology presented in the story. While loosely based on Mike Brotherton's anthology *Diamonds in the Sky* that explicitly compiled stories with "ample and accurate astronomy" ("mikebrotherton", n.d.), we believe this is the first time a complete anthology was used to study and teach evolutionary theory. More significantly, we recognize that teaching fiction, like any other skill, must be developed. This free resource manual developed by professionals in their respective fields to accompany the anthology seems to be the first of its kind. We hope it will spark many partnerships between private publishers and the public sector with the ultimate goal of aiding biology teachers in using fiction in the classroom to teach sound theory.

First, I will offer the rationale for using fiction to teach evolution, including the importance of interdisciplinary thinking. Next, I will share the process by which we

identified a viable anthology based on evolution. The teacher's resource manual and suggestions of implementation are followed by our future planned assessments and goals.

INTERDISCIPLINARY THINKING

Interdisciplinary thinking is integral to students today. The National Council for Teachers of English (NCTE, 1995) stated, "educational experiences are more authentic and of greater value to students when the curricula reflects real life, which is multi-faceted rather than being compartmentalized into neat subject-matter packages" (para. 2). Joseph Piro (White, n.d) claimed that in order to truly cultivate the 21st century skills students need to be successful, educators need to bring STEM closer to the arts. After a great deal of research, Astin (1993) concluded that the "true-core" interdisciplinary approach was the only general education curriculum that appeared to have a significant and positive effect on student development outcomes and student satisfaction (p. 425). For students not merely to survive, but to thrive in today's complex world they need to learn about its complexities in unique, integrative ways.

Merely relying on one's specific discipline without engaging the intellectual imagination inherent in all students is missing the opportunity to make a lasting impression on the student. As educators, we want students to have significant learning experiences rather than forget the material five minutes after the final. Fink (2003) explained that significant learning takes place when meaningful and lasting classroom experiences occur. Researchers (Kavaloski, 1979; Newell, 2001) have identified a number of distinct educational benefits of interdisciplinary learning including: Recognize bias; think critically; tolerate ambiguity; and acknowledge and appreciate ethical concerns. Bransford (2000) underlines the significance of how interdisciplinary thinking helps students overcome a tendency to maintain preconceived notions (as cited in "Starting Point: Teaching and Learning Economics," n.d.). This is especially pertinent when one considers teaching evolution - a topic that comes with layers of social and political baggage.

Many biologists may have a difficult time justifying the use of art in in their class. They may think that injecting interdisciplinary material may take time away from their discipline knowledge. However, as Fransella and Thomas (1988) point out, teaching and learning are constructions "invented by humankind" (qtd. in Jorg, 2009, p. 2); therefore, there is opportunity for reinvention. Indeed, reinvention may be a necessity. Alan Brinkley argued the false choice between science and humanities should be addressed by highlighting how both science and arts are "essential underpinnings in a complex and diverse and turbulent world" (2009, para. 5). Further, by including interdisciplinary material, educators may be moving students beyond the lower-order learning skills like memorization and towards higher-order concerns like analyzing, synthesizing, and making judgments. For example, a student may have to analyze a story, judge its applicability to science, and synthesize it with evolutionary theory.

Arts in the sciences serve multiple purposes, not the least of which is improving the student overall. The Neuroeducation Study done in 2009 led by Johns

Hopkins University and the Dana Foundation, showed that arts education improves student cognition, memory and attention skills in the classroom as well as a range of life and academic skills (Mehta, 2009). Chairman Landesman of the National Endowment for the Arts (NEA) said, "The arts provide us with new ways of thinking, new ways to draw connections…and they help maintain our competitive edge by engendering innovation and creativity" (White, n.d., para. 52). The classroom experience needs to be as creative and diverse as the students are. As Rocca (2010) noted, straight lecture is generally being replaced by other, more participatory methods like discussions, dyadic work, and peer review. Rocca (2010) continued that today's students demand more interaction from their classroom experience. Thus, for this type of student a large lecture hall will not suffice, especially for something like evolution that comes to the table with a host of misperceptions and misconceptions. Ultimately, when students are challenged and find the material new and engaging, they will have a significant learning experience concerning the material.

SCIENCE FICTION

Stories give us meaning. They shape the world into manageable, understandable bits. The complexity of evolution may intimidate some students; and for the science teacher, finding ways to demystify and reclaim the science from the other more egregious non-scientific narratives is to replace them with new, interesting stories. Narrative allows students to imagine the possible, and if they can imagine it in fairly "realistic terms" and combine it with the actual scientific record, it might be the first step toward accepting evolution.

Stories may ultimately help instructors facilitate discussion and exploration, and act as a point of departure for further research on evolution. One difficulty biology teachers face is when students remain unconvinced of the scientific evidence. In cases such as this, fiction may be a new tool for teachers that will allow students to reimagine and reengage evolution without challenging their sensibilities. Rocca (2010) notes a great deal of research concerning students' class participation. Students may feel inadequate or intimidated by other students and/or professors, and therefore not get involved; however, we believe fiction may alleviate some of those issues. Fiction's human element automatically eases student's concerns about being challenged and they are more likely to participate in class.

Importantly, fiction does not require students to "believe," but rather to question. As previously discussed, students often come to class with very personal reasons against evolution. No matter the amount of rational evidence that is presented, these students may feel like they are personally being attacked. However, Finch (2000) explains science fiction's purpose is not to accept a position, but to consider possibilities. Dr. Hayes and I believe professors can take advantage of fiction and use it as a doorway to imagination so students can consider possibilities. Czerneda (2006) describes how science fiction digs into concepts with imagination, creativity, and a thorough appreciation of consequences. Once students are willing to discuss the fiction, they may be more likely to engage the scientific material (Bixler, 2012). Bonwell and Eisen (1991) developed this idea

saying that the positive effect of science fiction was its ability to spur true scientific thinking, such as application, analysis, synthesis, and evaluation.

While students consider possibilities investigated in the stories, they are also influenced. Gottschall explains that psychological research repeatedly shows people's "attitudes, fears, hopes, and values are strongly influenced by story" (n.d., para. 4). Gottschall continues saying fiction seems more adept at influencing beliefs than academic writing. Green and Brock's (2002) studies shows that the more absorbed readers are in a story, the more the story changes them. Ideally, stories on evolution will get students to question their preconceived notions concerning evolution and trigger a willingness to openly examine the theory.

Using science fiction to explore scientific concepts has been proven effective by other scientists. Dubek et al. (1990) completed an extensive experiment involving close to 1000 students in a controlled study. They found 80 percent of students improved in at least one of the variables: Improved attitudes toward science, knowledge of the scientific discovery process, and cognitive development. Further, 68 percent of teachers found the strategy so worthwhile they trained another teacher in the process.

ANTHOLOGY CHOICE

Every class begins with learning goals that direct the pedagogy and coursework. Smith and Siegal (2004) offered two goals for any evolutionary biology course: One is for students to get a meaningful understanding of evolutionary principles; and two, they should gain an acceptance of evolution as the best explanation of the origin of new species from existence of a preexisting species. These learning objectives are clear and concise and helped direct our search for a good anthology.

The first practical criteria that guided our anthology search was looking for a book that contained many illustrations of evolution with engaging characters and good stories. The anthology we settled on, *Origins: Tales of human evolution*, has seven stories by authors like Gerri Leen, Jenny Blackford, and Mike Resnick. The stories begin at 3,000,000 years ago and move forward in time, ending with Resnick's story that touches on multiple time periods of human existence including a possible future.

Origins follows a principle that Asimov (1968) pointed out: The short stories should be well adapted for illustrating some scientific point or initiating discussion. Each of the stories offers multiple opportunities to examine a particular claim or different perspectives. Consider the story "Dawn of Reason" that follows The Hunter and his tribe/clan as they flee from two formidable antagonists: a blizzard that brings starvation and the "Others" who took their homes and land. One could examine the effect that environment or cultural factors had on human evolution. Further, we wanted stories that would be as close to the science as possible. As Czerneda (2006) stated, good science fiction stories rely on scientific principles to direct thinking through possible consequences. "Arrows of Apollo" alludes to the scientific principles underpinning bacterial warfare and the significant effects it has on human beings in their environment.

Catley (2006) argues that teaching evolution has become synonymous with natural selection. In 2009, Catley and Novick further this idea, arguing that students need to understand that over vast periods of time "seemingly insignificant changes do accumulate, often with major impacts" (p. 13). The anthology highlights multiple small changes in physical and mental attributes, as in the story "The Ugly Ones," that depicts the time period where humanoids started to evolve in different ways including body hair, tool usage, and mythmaking.

MANUAL

As previously mentioned, for many reasons some biologists find it difficult to cover evolution. One way they address that problem is by framing evolution in terms of lower animals and plants, or resort to indirectness instead of directness by expecting students to discover evolution (Oliveira, Cook, & Buck, 2011). Oliveira et al. (2011) continue that indirect discussion is not a good way to teach or learn and instead one should conduct the class as an intellectual discussion that focuses on exchanges of ideas and information. The manual specifically involves students in the process of learning in a non-threatening environment where discussions of science require students to actively integrate evolutionary theory with the text, analyze, evaluate, and finally participate in directed discussions.

Our top priority for the manual was to make it practical and easy to use. At 50 plus pages, the manual covers topics such as: reading for understanding and meaning, how to annotate a text, questions to help identify both literary and scientific connections, a checklist for creating writing assignments, sample evaluation rubrics, in-class assignments, and other resources. Most importantly, each story is presented with a synopsis, key terms, main characters, discussion questions, and connections to science.

ASSESSMENTS & FUTURE RESEARCH

With the integration of science fiction and evolutionary biology, there is a great deal of opportunity for future research. We believe there are opportunities to measure student engagement with the material, student perceptions before and after the course, and students' actual learning of complex concepts. Ideally, this examination would not only look at their knowledge of basic concepts, but also their ability to perform higher order thinking skills as identified by Bloom's taxonomy. We would also like to examine instructor's perceptions of the manual, its effectiveness, and the use of science fiction in the classroom as a whole.

CONCLUSION

Teaching evolutionary theory to high school and undergraduate non-major biology students has been rife with difficulties. Teachers face the standard difficulties of engaging students and helping them learn the content, while also contending with a host of ingrained misperceptions and irrational thought. Using

science fiction to teach evolutionary biology in the classroom may alleviate and address many of those concerns for teachers and allow students an opportunity to engage without feeling that their personal values are being attacked. We believe the discussion and learning that can occur will make a significant impact on the students and their perceptions of evolution. The public and private partnership with the publisher increases the likelihood of cross-promotion, thus increasing the utilization of materials. Ideally, this partnership ultimately educates students concerning evolutionary biology.

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