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Promoting Critical Thinking in General Biology Courses: The Case of the White Widow Spider

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Abstract

It is generally accepted that critical thinking is an important, and likely essential, component of success in college and beyond. Despite the nearly universal acceptance of the importance of critical thinking, only a low percentage of students in the U.S. can demonstrate critical thinking proficiency on standardized exams. This phenomenon may result from instructors using a reductionist view of critical thinking and focusing on learning processes rather than on evaluation of intellectual resources. In general biology courses, I use non-threatening, active-learning, group activities to promote critical thinking. For example, students are presented with an email from a member of the community and asked to formulate a response using the internet as their resource. I have found that using this non-threatening activity near the start of the semester promotes students' acquisition of critical thinking skills and allows me to present assignments focusing on more controversial topics that require critical thinking later in the semester.

Introduction

The past 30 years have initiated a renaissance of sorts in the concept of critical thinking in U.S. education. This new focus on developing critical thinking, particularly in science courses, has come about partially through the efforts of various national science organizations (e.g., American Association for the Advancement of Science, 1989; National Research Council, 1995; National Science Foundation, 1996), and has resulted in a dramatic increase in published literature about critical thinking in science education. For example, a Google Scholar search of papers that include the phrase "critical thinking" and "biology" in the text found 1,240 papers published from 1980-1985, 7,450 from 1990-1995, and 15,800 from 2000-2005.

In addition to policymakers and science organizations, college professors also consider critical thinking to be one of the most important indicators of student learning. In fact, an Association of American Colleges and Universities (AACU) report found that 93% of higher education faculty members considered critical thinking to be essential, and 87% of undergraduate students felt that their college experience helped them develop the ability to think creatively and analytically (AACU, 2005). Unfortunately, despite the nearly universal acceptance of the importance of critical thinking, the same AACU report found that only 6% of undergraduate seniors were able to demonstrate critical thinking proficiency based on standardized assessments (AACU, 2005).

While there are numerous definitions of what critical thinking is (Quitadomo and Kurtz, 2007), most center around the idea that critical thinkers are able to solve problems and make decisions based on reasoning and logic in a self-regulated way. The disconnect between recognizing the importance of critical thinking and actually seeing the development of critical thinking skills in our students could be the result of problems with the conceptions of how to teach critical thinking (Bailin, 2002). Critical thinking is often taught in terms of processes or skills, so that if students follow a specific process, they will have critically analyzed a problem (Bailin, 2002). An example of this can be found in the reductionist way we often teach the scientific method, which generally follows a flowchart from observations and questions, to hypothesis, then prediction, followed by experiment, analysis of data, and conclusion. The problem with this is, if we simply focus on the process, it is possible that students can participate in the process but fail to be critical in their thinking (Bailin, 2002; Van Gelder, 2005). Rather than focus on teaching the process and skills, critical thinking can be taught by focusing on understanding and analyzing intellectual resources (Bailin et al., 1999; Bailin, 2002).

Critical Thinking in Science Courses

Critical thinking can and should be taught in every discipline and at all education levels, but there is a growing concern over the performance of U.S. students in their performance in science, technology, engineering, and math (STEM) fields, relative to other industrialized countries (Freeman et al., 2014b). At many institutions, STEM courses can have among the largest class sizes and are taught primarily through lecture-based instruction, yet recent research shows that active-learning can dramatically increase student performance over lecture-based instruction (Freeman et al., 2014a).

Most college majors require their students to take a life sciences class as part of their general education, and many students fulfill this requirement by taking a general biology course. While memorizing facts, figures, and processes is a necessary part of learning general biology, on its own, memorizing does not promote critical thinking.

Today, many of the facts that educated people once carried around in their heads are now accessible on the smartphones that nearly all incoming freshman carries in their pockets. With the increased accessibility of facts, why have our students' critical thinking abilities remained relatively low? Perhaps it is because the ability to wade through the overwhelming abundance of facts available to students with the click of a button takes a more analytical way of thinking; it requires readers to be hyper-vigilant about what information they accept as fact and demands that they question the logic behind the answers to their internet searches.

We can tell students that they need to become critical thinkers until we are blue in the face, but until they experience actual critical thinking, the concept will likely not stick. Studies have shown that community-based inquiry methods that incorporate aspects of research can increase students' abilities to think critically (e.g., Quitadomo et al., 2008). In this paper, I will discuss how we can teach critical thinking in general biology classes through the implementation of simple, active-learning, group-based research activities that focus on answering the types of questions college professors regularly get in their inboxes.

Background

As a biologist, I get asked a variety of science-based questions, ranging from what critter my students found in their basement to what the difference is between fast and slow twitch muscles. Many times, I do not know the answer off the top of my head, yet I am generally able to use the internet to find the answers to the questions I receive. So, why are professors often able to answer people's questions by searching the internet, when the questioners themselves are not? Do professors have access to different information than non-scientists? Of course, the answer is no. The information is the same, but the ability to critically evaluate that information might be different.

It may be true that one major difference between a scientist and a college freshman is that the scientist has memorized more facts, figures, and processes than the student. But knowing these facts and figures alone is not generally what gives scientists the answers we seek. Instead, scientists have learned to critically navigate the internet to find answers in which we can be confident. As instructors, then, how can we help students learn these skills through guided experiences?

Many instructors successfully promote critical thinking by giving their students what they consider critical challenges, in which students are assigned a problem to solve or are asked to evaluate an idea (Bailin, 2002). In college classes, these critical challenges are often based on current hot-button ideas or arguments (i.e., ways to combat global warming, or is nuclear power a desirable energy source?). While these topics can provide lively classroom discussions and can promote critical thinking, many students come to class with preconceived notions about the controversial topic, which can cloud their judgment and hinder their critical-thinking exercise.

Below, I describe some activities I use to teach students to critically evaluate the information they find on the internet, by having them answer questions that biologists are regularly asked. Generally, I begin the semester with non-threatening exercises, such as the case of the white widow spider. As the semester progresses and students become more comfortable with critically evaluating information, I move on to more controversial topics; for example: "Are fats healthy?" "Is nuclear energy safe?" or "Is climate change real?"

The Case of the White Widow Spider

Near the beginning of the semester in my general biology class, I have a discussion with my students about the different types of scientific inquiry and how we have more resources available to us than all previous generations of scientists. To illustrate this point, I often ask someone to look up a particular scientific fact, something like, "What are the stages of the cell cycle?" or, "What organelle makes proteins?" I then point out that when I was a freshman, I had to look up this information in my biology book rather than simply on my phone. I then discuss with my students that in our class we will be memorizing facts and learning about biological processes, but I want them to be able to think critically about the subjects we are learning, and I want them to be able to apply this material to their lives.

At this point, I split the students into groups (depending on the class size, generally groups of three to six students) and present them with the following email:

> *Dear biology department,*
>
> *My name is [Jane Doe] and I have a question about a spider I recently found at my house near my kitchen window. I wasn't sure exactly who to contact so I'm sending this email to the biology department contact email address I found online in hopes it will reach someone that can help me.*
>
> *As I mentioned I recently found a spider in my kitchen that matches the description I found online of the white widow spider. I have small children and I am really concerned since I have never seen a spider like this before. I was hoping you could give me some information.*
>
> *Thank you.*

I tell the students that this is a real email I received while working at the University of Nevada, Reno and that it was sent by someone living in the Reno area. I then let the students know that their assignment is to write a response to this person. I encourage students to use any resources they have, including their textbook, online resources, and past experience.

As the groups are researching and formulating their responses, I walk among the groups, ask questions, and provide some guidance. I generally give my students 10 to 15 minutes to research and develop an answer. Once students are finished, we go over some of their responses as a class and discuss how they found their information. In large classes you can simply select a few groups to discuss their results. I then walk them through the process I went through in order to respond to this email.

Generally, the first thing students do to answer the question is to search "white widow spider" on the internet. The first website to come up using this search is a Wikipedia page about white widow spiders (*Latrodectus pallidus*). This short Wikipedia page tells about the range of the spider (it is found in North Africa, the Middle East, and Central Asia), the description of the spider, and its medical significance. It is toxic, and a bite can be fatal to children or the weak ("*Latrodectus pallidus*", n.d.). At this point in their search, students need to think critically about this information: What is the likelihood that the white widow spider, which is native to the Middle East, was in a homeowner's kitchen in Nevada?

From here, students often go in a variety of directions, sometimes looking up spiders found in Nevada and sometimes focusing on the dangerous aspects of white widow spider bites. Sometimes student groups decide that while it is unlikely this is a white widow spider, the best thing to recommend is to kill it, just in case.

In my own quest to answer this question, I did the same thing my students did: I searched "white widow spider" on the internet, which led me to the Wikipedia page. Realizing it is very unlikely that the spider in Reno was the white widow spider, I assumed the home owner thought the spider looked similar to a black widow but with lighter coloration. I then used Wikipedia to find the taxonomic family to which the white widow belongs (Theridiidae). Next, assuming that most of the spiders in that family look similar to the widow spiders, I did an image search for Theridiidae and looked for light-colored species. Through this process, I concluded that the homeowner from Reno likely had a common cobweb spider or a tangleweb spider, both of which are harmless.

Are Fats Healthy?

Finding answers to questions on the internet can be challenging, as suggested websites might differ, depending on how you phrase your question. Another activity I use to teach my students to be critical consumers of information requires students to visit various websites that offer different points of view and asks them to critically evaluate the information they find.

After discussing organic compounds, including carbohydrates, oils and fats, and proteins, I split my students into groups and assign each group a topic to research on the internet. Research topics include: "Are fats healthy?" "Are carbohydrates healthy?" and, "Is a high-protein diet healthy?" I then direct student groups to use the internet to answer their assigned question. I specifically tell each group to find at least two websites that suggest their organic compound (fats, carbohydrates, or proteins) is healthy, and at least two websites that suggest it is not healthy.

As student groups research their topics (for about 15 min), I walk among groups asking questions and providing feedback. Groups are then asked to present their findings to the class (as well as turn in a sheet of paper with their findings). In addition to presenting their view of whether or not their particular organic compound is healthy, I ask groups to share their source websites and tell us if they trust the site or not, and why.

Follow Up

Because critical thinking can be difficult (Gelder, 2005), students will likely not get the hang of it after a single activity, or even after multiple activities. I suggest regularly incorporating activities like those mentioned above throughout the semester. Like any skill, critical thinking takes practice, and students often need to be guided through the process (Gelder, 2005). I have found that by presenting students with a non-threating critical challenge near the beginning of the semester, like the ones described above, they become used to the process of critically assessing internet-based information. This enables me to delve into more controversial topics later in the semester with less resistance from the students than I have experienced in the past.

In order to help coach students as they practice critical thinking, it is important to let them discuss some of the challenges and successes they had during the activities. Rather than discuss these directly after the activity, I suggest waiting until the following class period to find out what the students liked and disliked about the activity. I have found it is useful to ask two questions: 1) What was something you liked about [the activity]? and 2) What is one way [the activity] could be improved? I often include these questions at the end of quizzes or exams, or even ask them as online surveys. Asking what they like and how it could be improved allows students to meditate on their successes and failures and often results in beneficial suggestions that improve future implementations of similar activities.

Conclusion

Active-learning activities such as "the case of the white widow spider" or "are fats healthy?" can help students learn to critically evaluate information (Zohar et al., 1994), particularly information they read online. I find that presenting students with non-threatening case studies at the beginning of the semester can train them to critically evaluate ideas. It also allows me to introduce more controversial topics later in the semester with less student resistance. Activities like those presented here, or variations of them, can be used in small or large classes and can positively influence students' critical thinking abilities.

References

American Association for the Advancement of Science (1989). Science for All Americans. A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology, Washington, DC.

Association of American Colleges and Universities (2005). Liberal Education Outcomes: A Preliminary Report on Student Achievement in College, Washington, DC.

Bailin, S., Case, R., Coombs, J. R., & Daniels, L. B. (1999). Conceptualizing critical thinking. *Journal of Curriculum Studies, 31*(3), 285–302.

Bailin, S. (2002). Critical thinking and science education. *Science & Education, 11*(4), 361–375.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014a). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410-8415.

Freeman, B., Marginson, S. and Tytler, R. eds., (2014). *The age of STEM: educational policy and practice across the world in science, technology, engineering and mathematics.* Routledge.

Gelder, T. V. (2005). Teaching critical thinking: Some lessons from cognitive science. *College Teaching, 53*(1), 41-48.

Latrodectus pallidus. (n.d.). In Wikipedia. Retrieved August 27, 2017, from https://en.wikipedia.org/wiki/Latrodectus_pallidus

National Research Council (1995). *National Science Education Standards*. Washington, DC: National Academy Press.

National Science Foundation (1996). *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology.* Washington, DC: Directorate for Education and Human Resources.

Quitadamo, I. J., & Kurtz, M. J. (2007). Learning to improve: using writing to increase critical thinking performance in general education biology. *CBE-Life Sciences Education, 6*(2), 140-154.

Quitadamo, I. J., Faiola, C. L., Johnson, J. E., & Kurtz, M. J. (2008). Community-based inquiry improves critical thinking in general education biology. *CBE-Life Sciences Education, 7*(3), 327-337.

Van Gelder, T. (2005). Teaching critical thinking: Some lessons from cognitive science. *College Teaching, 53*(1), 41–48.

Zohar, A., Weinberger, Y., & Tamir, P. (1994). The effect of the biology critical thinking project on the development of critical thinking. *Journal of Research in Science Teaching, 31*(2), 183-196.