Letter from the Editor-in-Chief: What is Critical Thinking?

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“... if you're doing an experiment, you should report everything that you think might make it invalid — not only what you think is right about it; other causes that could possibly explain your results; and things you thought of that you've eliminated by some other experiment, and how they worked — to make sure the other fellow can tell they have been eliminated.” – Richard Feynman, 1974

In this age of assessment, rethinking general education, accreditation, and self-reflection as educators, one idea keeps entering our discussions – critical thinking. It is a buzz word capable of rising up to become an educational goal for all disciplines. But how do we define it? Is it really new? Does it apply in every discipline? Looking over the papers published in the last three years, only one paper actually mentioned critical thinking in the title (McDougall & LaMonica, 2007). As important as this topic seems to be on our campuses, why have more papers not addressed it? Maybe we will see more in the future. For now, I will just convey my thoughts on how critical thinking plays a role in what I teach – physics.

My first thought about what critical thinking is – it is the questioning with an open mind of any belief, coming to an unbiased conclusion supported by evidence and scrutinized assumptions. However, this is next to impossible. Bertrand Russell and Alfred Whitehead set off a century ago to derive all of mathematics from first principles (Whitehead & Russell, 1910). I recall reading that after about twenty years Russell had to move on to other endeavors so as not to go mad. If that is what can happen in a logical field such as mathematics, imagine what difficulty there may be in applying critical thinking to every decision one faces throughout life!

Do I teach critical thinking? I certainly aim to teach my students to view the world differently. But I do not ask them to start from scratch, but to see how we have gotten to where we are. It took two thousand years to go from Aristotelian thinking to Newtonian thinking. It then took a couple hundred years before the revolutions of relativity and quantum mechanics took over. What would it take for our students to really apply critical thinking and end up anywhere near what is commonly accepted today? Richard Feynman, noted Nobel laureate and ultimate critical thinker on the Rogers Commission investigating the Challenger space shuttle accident, hinted at an answer as noted from two notes still on his blackboard at the time of his death in 1988 (Hawking, 2001):

1 Author's email: hermanr@uncw.edu
2 “Cargo Cult Science”, commencement address given at Caltech (Feynman, 1974)
What I cannot create I cannot understand.
Know how to solve every problem that has been solved

As a result, our teaching of physics does not train students in critical thinking until we have lead students through the quagmire of the last several hundred years to understand the current views of physics. Only then can they ask the new questions and make their contributions, using the language and results of years of experiment and scrutiny by others. Students should at least appreciate the idea that critical thinking is an important goal, but can I expect them to acquire such skills in only four years? Do we even teach this in our science classes? Perhaps once they have mastered some of the tools in a narrow area, they can go off and experiment or theorize on their own. But generally, this is only accomplished by the brightest, who have an opportunity to do honors theses or capstone courses. Even then, it is of limited extent. But still, there are those who think it can be done.

The notion of critical thinking as an important goal is not new, though the term seems to have gained acceptance in 1940s and 1950s (Hare, 1998). For example, Paul J. Burke writes about teaching critical thinking in physics in a 1949 paper in the American Journal of Physics, quoting even earlier articles. While proponents of the idea can go back to Socrates, or Kant, it is probably sufficient to note that we are still grappling with the notion. In Burke’s paper he makes the case that the scientific method is a creative endeavor and that training in physics is more about critical thinking, as expressed by Dewey in 1945.

“The end of science teaching is to make us aware of what constitutes the more effective use of mind, of intelligence; to give us a working sense of the real nature of knowledge, of sound knowledge as distinct from mere guesswork, opinion, dogmatic belief, or whatever.”

Before trying to teach critical thinking, one needs to define it. Burke lays out fifteen behaviors constituting critical thinking, carefully pointing out that each behavior needs to be something testable. Thinking like the formulation of hypotheses and devising experiments are not delegated to critical thinking but to creative thinking. What Burke does list for these behaviors can be paraphrased as

Differentiation between authoritative and non-authoritative sources of information; Criticism of faulty deductive reasoning; Differentiation between statements describing observations and those introducing new terminology; Drawing appropriate inferences, recognizing assumptions; Selecting and criticizing pertinent data and inferences drawn from the data; and, Recognizing and evaluation of errors of measurement.

The main point being that critical thinking in physics will be hard to teach except at a low level, would take a lot of effort on the part of a busy teacher to design appropriate tests of critical thinking. In spite of the work in physics education research, there has been slow progress in incorporating critical thinking into our curriculum. This has been born out as the way we teach has not generally changed since Burke’s article was published.
What is Critical Thinking?

There are many definitions of critical thinking. A web search provides a few of these:

- Critical thinking involves determining the meaning and significance of what is observed or expressed, or, concerning a given inference or argument, determining whether there is adequate justification to accept the conclusion as true. [en.wikipedia.org/wiki/Critical_thinking](en.wikipedia.org/wiki/Critical_thinking)
- The application of logical principles, rigorous standards of evidence, and careful reasoning to the analysis and discussion of claims, beliefs, and issues [en.wiktionary.org/wiki/critical_thinking](en.wiktionary.org/wiki/critical_thinking)
- An essential tool of inquiry; purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based. [www.netnet.org/students/student%20glossary.htm](www.netnet.org/students/student%20glossary.htm)
- Exploring questions about and solutions for issues which are not clearly defined and for which there are no clear-cut answers. [aaahq.org/aecc/intent/glossary.htm](aaahq.org/aecc/intent/glossary.htm)

The incorporation of critical thinking across disciplines has a long way to go. It would be nice to hear of successes that others have had in the form of articles for this journal. In the mean time, there are numerous discussions of critical thinking. In particular, Hare’s 1998 essay summarizing Bertrand Russell’s ideas on education is interesting in that it not only describes the needed abilities of forming opinions, finding impartial solutions, and identifying and questioning assumptions, but also that the thinker needs do develop the appropriate habits leading the thinker to wish to learn and aim for the truth.

“A habit of basing convictions upon evidence, and of giving to them only that degree of certainty which the evidence warrants, would, if it became general, cure most of the ills from which this world is suffering.” – Bertrand Russell

References


3 From Russell, B. Why I am Not a Christian, Lecture on March 6, 1927 to the National Secular Society, South London Branch, at Battersea Town Hall.