Educational Philosophy

David Holmes

Modern society has a fondness for simple answers to complex questions. But, as is often the case, there is no simple nor complete answer to the question of what makes good physics pedagogy. Physics education research has taken some of the guesswork out of figuring out what works by validating or refuting alternative approaches.

One particular approach that has received much attention in the last decade is called modeling-based instruction. The basic idea is to have students construct and apply conceptual models. Students are first primed with a problem or puzzle, consistent with Popper's “theory-driven” basis for scientific investigation. With the educator working in a selective guiding role, the students work together to construct and refine their models. This development phase is highly inclusive and collaborative and usually involves white-boarding of ideas and culminates in group discussion, reflection, and idea improvement akin to the scientific peer review process. This development phase is followed by a deployment phase in which concepts and formulas elucidated are applied to solve other problems. Some researchers have proposed that the coupling of spatial and language representations in the brain, exercised to different extents during the development and deployment phases, may be responsible for better retention. While the neuroscience of education is still in its infancy, what does seem to be demonstrated by physics education research is that this approach is more successful, on the average, in producing students with cognitive attitudes that correlate with those of experts. Modeling-based instruction has evidently dramatically improved the conceptual and problem-solving skills of young students. Is there something similar that we can do for mathematical physics skills?

Computer programming, integrated with a physics course and suitably organized, would provide a similar hands-on, inquiry-based experience that would simultaneously increase mathematical understanding and provide more realistic problem-solving. For example, many students initially struggle with variables and their numeric and symbolic representations. With programming, an understanding of variables and the value of symbolic representations quickly becomes second-nature. Programming kinematic and dynamical models virtually invites you to explore calculus, difference equations, multiple variables, and vectors in 3 dimensions. The unreasonable effectiveness of mathematics and its necessity in describing physics becomes obvious. Raising the level of mathematical maturity in tandem with the physical intuition through modeling would make the “Physics-First” movement more viable and would lengthen the runway leading up to college.

Beyond conceptual skills, mathematical and problem-solving skills, is there anything else that we should attend to? I believe that there are a number of things less tangible than understanding and mastering physics but equally important. We should help students to understand how physics relates to the other sciences and how the topics that they are studying are relevant in the world and universe around us. We should take time to reflect on the nature of science and make connections with events and scientists from the past and present. Above all, we should do our utmost to inspire our students with a grand vision that speaks to the health and welfare of the planet and the potential for the human race.

David Holmes, 2014.