

A lifetime of everyday experiences builds an often-misleading physical intuition that I call the “inner Aristotle.” These misconceptions must be confronted and reassessed in introductory classes that deal with everyday phenomena as well as in upper-level classes where classical physics is extended in counter-intuitive ways. To help students do this, I use interactive in-class discussions, computational simulations, and feedback designed to improve understanding on repeated assessment.

To make students aware of what their “inner Aristotle” is telling them, I have them discuss conceptual questions designed to reveal common misconceptions in a “think-pair-share” setting. I use a polling app to collect responses before leading a class discussion. Taking advantage of small class sizes, I assign context-rich group problems that have real-world relevance and require decisions about appropriate assumptions and concepts. As groups progress independently, I circulate and have each group explain their assumptions and problem-solving strategy, asking leading questions to guide them to a solution. Research shows discussion and group work to be particularly beneficial to students with backgrounds underrepresented in physics. I have also taught exploratory labs, where students make predictions and discuss the best way to use the equipment to test their hypothesis before taking data.

I implement numerical calculation in classes of all levels to develop transferable skills and to explore real-world problems. With simple VPython tutorials I developed, introductory students create animations to determine for themselves when the small-angle approximation for a pendulum is appropriate and the effect of drag on projectile motion. Comparing computational predictions to lab measurements makes abstract mathematical models concrete. To engage biology-focused students, I have them adjust parameters in a simulation of bipedal motion and use their conclusions to win a walking race. I also developed an advanced lab where students compare their numerical solutions to Laplace’s equation for the potential of a capacitor to their lab measurements.

Since I began encouraging students to correct and re-submit homework, I have seen increased engagement from both introductory and advanced students. Rather than making a single attempt to solve a problem, students use feedback to fill gaps in their understanding and re-submit corrected work. Small upper-level classes allow me to perform oral exams to determine if the student has understood the concepts underlying the calculation they performed. Both my assessment and student feedback have shown this examination procedure improves conceptual understanding.

In sum, I adopt pedagogical techniques with a commitment to engaging students with realistic problems to motivate them to absorb physical concepts in place of incorrect previous assumptions. I am increasing interactive in-class activities for upper-level classes, expanding my success in introductory classes. This progress will be increasingly important as both education research and needs of student populations trend away from traditional lectures and toward interactive engagement and use of technology in the classroom.