- Activity-based physics course for non-science majors
  - 20 worksheet-based activities utilizing hands-on experiments and computer simulations, 9 laboratory activities, two group projects with presentations
  - activities, labs, and projects completed by groups of 4 students
  - Goals: understanding fundamental concepts and *the nature of science*

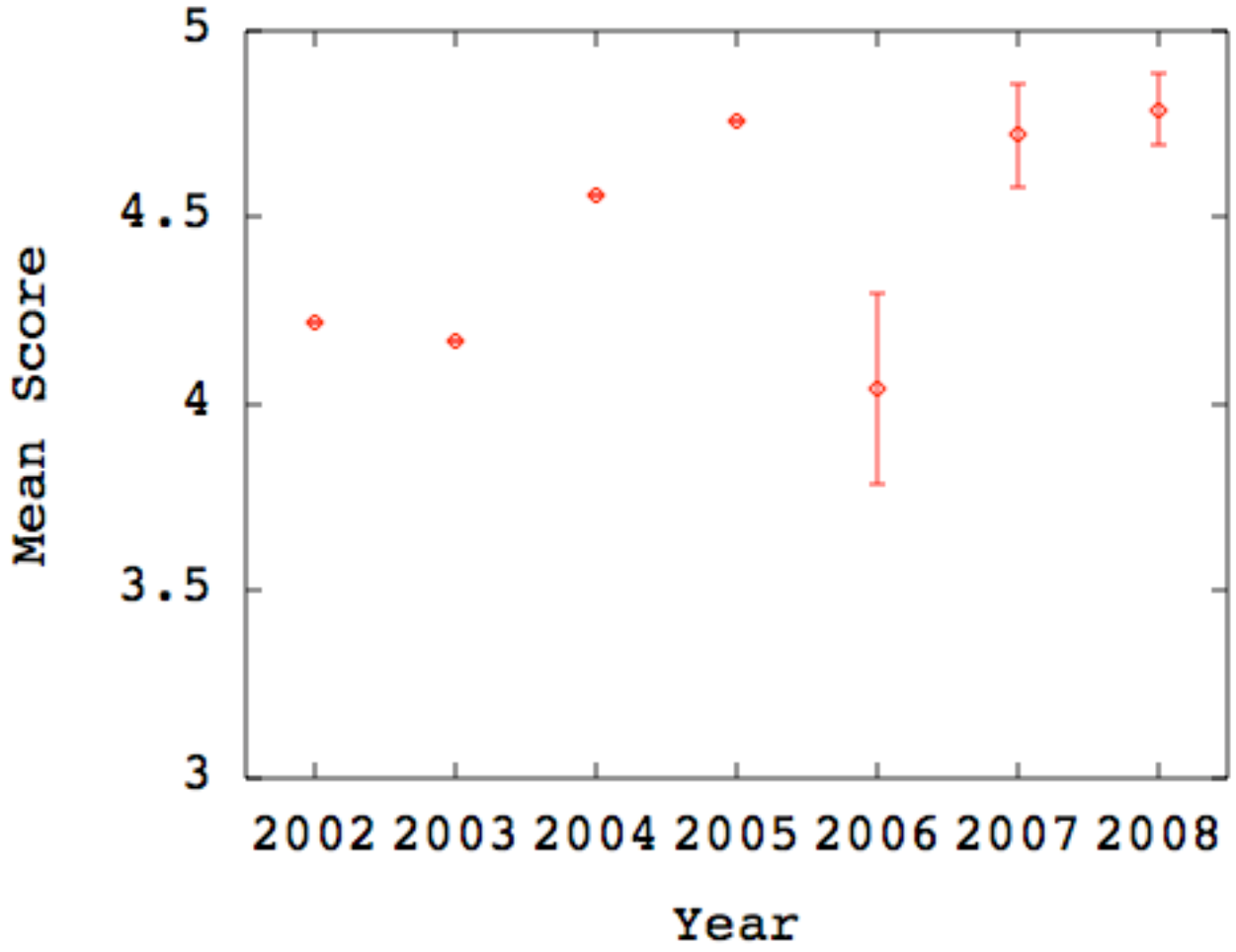
- Example of an activity (on entropy):
  - Worksheet on microstates vs. macrostates. Coin example (microstate: HHTTHTH, macrostate: 4H, 3T).
  - Multiplicity: number of microstates in a given macrostate.
  - Hands-on experiment: start with row of 20 heads, roll 20-sided die and flip over resulting coin, record number of heads, repeat.
  - Computer simulations used to extend this example and connect it to the behavior of gases (expansion, mixing of hot and cold gases, etc.).

- Three versions of the course:
  - 2002-2005: Mostly traditional lecture with a few group activities.
  - 2006: Activity-based, but with no explicit instruction in the nature of science.
  - 2007: Two lectures on philosophy of science and numerous questions about the nature of science in the activities (and tests).
  - 2008: relatively minor modifications.

- Used Epistemological Beliefs About Physical Science (EBAPS) survey to measure student understanding of the nature of science (`http://www2.physics.umd.edu/~elby/EBAPS/home.htm`). Measures student belief in five categories:
  - Structure of Scientific Knowledge
  - Nature of Knowing and Learning
  - Real-life Applicability
  - Evolving Knowledge
  - Source of Ability to Learn

- EBAPS results:
  - Activity-based approach led to small but statistically significant gains in Nature of Knowing and Learning and Source of Ability to Learn.
  - Activity approach alone did not improve other categories.
  - Saw small gains in Structure of Knowledge and large gains in Evolving Knowledge after incorporating explicit instruction in nature of science.
  - Real-life Applicability: small gain in 2006, large gain in 2007, small gain in 2008.

- Numerical course evaluations



- Student Comments
  - 2006
    * Good: The activities were great. They had information on them and they allowed us to have a hands-on learning environment. I got to work with group members - so we got to feed off of each other.
    * Bad: I am strongly opposed to students learning on their own. . . . Physics is a discipline that is quite difficult and it is necessary that the professor explains the material. If this class serves as a model for the way all science classes are conducted, then I pray to God that no one takes their sciences here at Berry. . . .

- 2008
  - Good: A definite strength of this course is that the activities were hands-on and interesting. This is one class, I knew I would not fall asleep in because the activities were interactive. The simulations were very helpful and the physical objects we used, such as a spectrometer.
  - Bad: While the activities were very good at communicating the subject matter, I think I would rather have a lecture-based class time and then maybe have group activities for the labs to cover other new experiments or experiments we have learned about in lecture.

- Lessons Learned
  - Think carefully about what you *really* want to teach. In some classes, content knowledge may not be the only (or even the most) important thing.
  - Include explicit (inquiry-based) instruction on what is important to you. Don't expect students to "pick it up."
  - Figure out if students are learning what you want them to learn. Tests or surveys administered before and after class can be useful. USE the results.
  - Active learning strategies can be effective *and* well-received by students, but expect a negative reaction at first. Stick with it!