Why don’t your students learn the material? Methodologies for discovering student difficulties

Rachel Pepper, Steve Goldhaber, Steven Pollock, Kathy Perkins
Overview:

• Methods to learn what yours students are thinking/how they are reasoning
  – Find where students are having difficulties
  – Address common conceptual errors

• Some ideas discussed in this poster for discovering student learning difficulties:
  – Homework help sessions
  – Clicker questions
  – Exams
  – Student interviews
  – Classroom observations
  – Concept inventories
Technique: Homework Help Sessions

- Replace/supplement office hours with scheduled homework help session in a class room
- Students work in small groups
- Eavesdrop on groups’ homework discussion
- Note questions asked to instructor
- Can have help of LA, TA or Noyce Fellow

Example: Sophomore Classical Mechanics

- Noticed in HW help session that students don’t recognize immediately that $\dot{y}$ is the same as $\frac{\partial y}{\partial t}$ (common physics notation – automatic for experts)
- Need to be careful in class when using this notation since students will need extra time to think
Technique: Student Interviews

• Interview students to find difficulties with course concepts

• Examples of interview questions:
  – Ask think-aloud questions from past exams or homework where class scores were low
  – Ask conceptual questions (e.g., unused clicker questions)
  – Ask students to build a concept map

Example: Concept Map

“On these cards are terms and formulas from quantum mechanics. Use them to tell a story about what quantum mechanics means to you.”
Technique: Clicker Questions

- Provide quick feedback on student learning difficulties
- At the beginning of class, gets students thinking about the topic of the day
- During class, find out what students are thinking about important concepts
- Learn more at http://stemvideos.colorado.edu

Example: Junior Quantum Mechanics

- In Classical Mechanics, can this equation be derived? $\vec{F}_{net} = \frac{d\vec{p}}{dt}$
- Class split 50 / 50 (instructor expected 100% correct).
- Important concept to review and also leads into discussion of postulates in physics.
Technique: Classroom Observations

- Listen to and note down questions in lecture, lab or tutorial
- Ask for student answers *and reasoning* for your questions and questions from their peers
- Can have help of LA, TA or Noyce Fellow

Example: Junior Electricity and Magnetism

- In-class discussion of divergence of a point charge electric field
- Student reasoning: “I think there is divergence everywhere because the lines are spreading out, but I’m not sure what happens at the origin”
- Reveals common misconception connecting the visual idea of diverging lines with divergence
Technique: Exams

• Ask paired questions on exams. Follow a traditional computational question with a conceptual one on the same subject.

• A common pattern is a high score on the computational question and a much lower one on the conceptual question. This concept is unclear to the students.

Example: Junior Quantum Mechanics Exam

Consider a system in the state $Y_2^{-2}$ (i.e., $\ell = 2; m = -2$). Evaluate $\hat{L}_- Y_2^{-2}$ and give a physical interpretation of your result.

• While 96.7% of the students were able to compute the correct result, only 30% were able to give any sort of physical reasoning.
Technique: Concept Inventories

• Research-based conceptual test (often multiple choice) with common student misconceptions as distractors
• Measure student understanding of key concepts quantitatively and can compare with other semesters, other institutions, and with published results
• Many already written, researched, and easy to find with Google

Example: Junior Electricity and Magnetism

• After Junior E&M:
  • 31% of CU students apply Gauss’s law incorrectly
  • 40% have trouble recognizing when to use a magnetic dipole approximation
Conclusion

• Learning about the difficulties students are having learning the material in your course can help you improve your teaching

• There are a varieties of methods which you can use to find student learning difficulties.

• LAs and TAs can help!

• This work was funded in part by The National Science Foundation (NSF-CCLI Grant # 0737118)