Tracking Students' Knowledge of Electricity and Magnetism from 1st to 3rd Year

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- First year curricula in physics generally include a mastery of the basic concepts of electricity and magnetism as a goal.

- Upper year courses generally assume that the first year conceptual background is retained and focus on a mathematical treatment of the subject.

Two obvious questions:

1. Do students retain their conceptual knowledge over time? e.g. during 2nd year when they have no formal courses in the subject?

2. Does their conceptual understanding change during the upper year mathematical treatment of the subject?

Retention between 1st and 3rd year

- In April 2009 we gave a diagnostic (described below) to all the first physics classes teaching electricity and magnetism (approximately 1500 students took the test). The average score was 50%.
- In September 2010 we administered the same test to 128 students in PHYS 301 at the beginning of this 3rd year course. The students had no formal E&M in the interim.

1st and 3rd year comparison

- To make a valid comparison we need to select only those students who wrote both tests.
- Of the 128 3rd year students who wrote in Sept 2010 we had 1st year data on 56.
- 26 came from P153, the engineering course
- 12 came from P102, the general course
- 11 came from P108, the enriched course
- 7 came from Science One

Paired student data

- 56 students April ‘09 vs Sept ‘10
- Electricity and Magnetism Diagnostic

- End of first yr - April ‘09 62.5% +/- 2%
- Beginning of third yr 60.5% +/- 2%

- Conclusion: Conceptual knowledge retained

Comments on the retention data

- This data is similar to Pollock's data from Colorado which showed a slight loss <5%. In both cases one is dealing with students committed to further physics study.
- Older data (Kohlmeyer et al) showed a marked decrease in retention for students who generally did not continue in physics after first year.

Conceptual change during upper years

- Upper year electricity and magnetism courses focus on applying mathematics and assume students have a conceptual understanding.
- We compared student performance on the conceptual diagnostic at the beginning and end of an upper year 2 course sequence in electricity and magnetism

Conceptual gain in upper year

- 27 3rd year Engineering Physics students
- Electricity and magnetism diagnostic

- Beginning of P354 (9/2008) 62% +/- 3%
- End of P454 (4/2009) 73% +/- 3%

- Conclusion: Increased conceptual understanding

Comments on 3rd yr gain

- Pollock at Colorado has reported no gain for a similar group of students. The conclusion was that since conceptual understanding wasn't addressed, it was not surprising that there was no gain.
- Conclusion: More data and analysis are needed to determine if there is real conceptual learning in these very mathematical courses.

The measuring tool

Assessing student understanding of the concepts in electricity and magnetism across course and institutional boundaries is challenging. The Brief Electricity and Magnetism Assessment (BEMA) was developed in 1997 by Chabay and Sherwood and a validation of it was published by the authors in 2006 [L. Ding et al]. It is a 31 question, ~30 min diagnostic for student understanding of the conceptual ideas of electricity and magnetism.

References

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