Measuring Transfer and Conceptual Learning
Using Online Procedural Tools
or
Data-Mining an Online Homework System

Andrew Bennett
Dept. of Mathematics
Kansas State University
bennett@math.ksu.edu

Why Use Online Homework?

- For the student
  - Multiple attempts
  - Immediate feedback

- For the teacher
  - Automatic grading
  - No shuffling papers

Our Online Homework

1. Amazon.com found a way to order and ship lots of different books more easily.
2. We have ways to provide problems and solutions to our students more easily.
3. Amazon.com then studied how people used the site to do a better job selling books online.
4. We need to do similar work to do a better job teaching math.

What Are They Learning?

- Procedural Knowledge
  - Rote memorization of procedures for solving specific problem types
- Conceptual Knowledge
  - Trying to understand why things work
  - Building different models of ideas

Recognizing Conceptual Learning

- Traditionally measured with clinical interviews
  - Provides rich data
  - Time consuming
- Can we recognize conceptual learning from online results?
  - Data is less rich
  - But there is a lot more of it
Recognizing Conceptual Learning

- Recognize when class grapples with new concepts
  - Criterion: Divergence between % of A's and average score.
- Recognize whether students are learning conceptually
  - Criterion: Acceleration through related assignments

Performance on Trig Assignments

Transfer of Learning

- How can we tell if students are transferring concepts to later work?
- Criterion: Assessments in different courses (taught in different semesters) that are more closely correlated than assessments in the same course demonstrate transfer.
- This criterion is hard to satisfy.

Trig and Calculus 2

Transfer to Other Disciplines

- Best measure of transfer is speed of learning new material.
- Compare work of electrical engineering students in differential equations to the speed with which they mastered online assignments 2-4 semesters later in linear systems.
- Use stepwise linear regression to build a predictive model

Final Model
Testing The Model

- The model is statistically significant (p-value less than $4 \times 10^{-6}$)
- The model appears suitable for predicting future success
  - Explains over 65% of variation
  - $F$-statistic exceeds critical value (95% conf. level) by a factor of over 5.
- Key variable is acceleration of learning in differential equations

Summary

- Can detect conceptual learning from procedural work given sufficient data
- Conceptual learning as measured can be correlated to successful transfer.

Future Research

- Can we develop accepted measures of transfer?
- Can we develop accepted measures of conceptual knowledge that can be readily evaluated?
- Can we get real time feedback on how well the class is learning?

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