Deliberate Instruction:
Applying Principles of Learning to Enhance Teaching – with or without technology

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The Big Idea That Can Revolutionize Higher Education: 'MOOCs'

Massive open online courses combine the best of education -- online instruction -- with the best of technology -- online interaction. What does it mean for higher education?

Laura McKen

May 11, 2012

Online education is not new. The University of Phoenix started its degree program in 1989. Four million college students took at least one online class during the fall of 2007.

But, over the past few months, something has changed. The elite, pace-setting universities have embraced the Internet. Not long ago, online courses were interesting experiments. Now online activity is at the core of how these schools envision their futures.

David Brooks

May 9, 2012

The Campus Tsunami
We’ve been here before

Technology will...

**Radio**
“allow students access to the finest teachers, the best authorities in every field, and the world’s leaders.”

**Motion pictures**
“revolutionize our education system… and in a few years it will supplant largely, if not entirely, the use of textbooks.”

**CD-ROM**
“transform educational content into an engaging world of stories, facts, ideas, pictures, and sounds that students can actively explore.”
SAMR Model for Technology Use

- **Substitution**: Tech acts as a direct tool substitute, with no functional change
- **Augmentation**: Tech acts as a direct tool substitute, with functional improvement
- **Modification**: Tech allows for significant task redesign
- **Redefinition**: Tech allows for the creation of new tasks, previously inconceivable
Technology’s “Revolution”

The overwhelming majority of teachers employ technology to sustain existing patterns of teaching, rather than to innovate.

“Only a tiny percentage of high school and university teachers used new technologies to accelerate student-centered and project-based teaching practices.” (Cuban, p. 134)
SAMR Model for Technology Use

**Substitution**
*Tech acts as a direct tool substitute, with no functional change*

**Augmentation**
*Tech acts as a direct tool substitute, with functional improvement*
Unintended consequences...

...for the teacher:

promotes stand & deliver
discourages Q&A
requires staying in box
Unintended consequences…

…for the student:

laptops distract
(self & others)
tempted to multitask
poorer note-taking

These consequences induce costs to teaching & learning
SAMR Model for Technology Use

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Redefinition
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Plan for Talk

Describe two fundamental, but surprising, findings from learning science:

- Learning is skill-specific
- Practice need *not* make perfect

Define a new approach to teaching and faculty development:
- Deliberate Instruction

Illustrate how Deliberate Instruction can enhance teaching with and without technology
Key insight: Learning is skill specific

Old view: Mind is a muscle, so strengthen it in general

Research shows: By practicing skill/concept X, you learn (and get better at) skill/concept X only

*not related skill/concept Y*
As students practice a given skill, their performance at that skill improves; Other skills are not affected.
“Blips” in the learning curve

Data do not always show the predicted learning curve

(cf., Lovett & Chang, 2007)
Further investigation reveals why

Interpret histogram
Interpret boxplot
Interpret table
Power Law Learning holds

If you’re not paying attention to the skills students are supposed to learn, you’re missing something fundamental.

Data averaged by skill practice
The key to understanding student performance is **identifying the skills** they are practicing.

The key to setting a learning goal is **specifying the skills** required to achieve it.

The key to designing instruction is **providing practice on those skills**.

The key to assessing student learning is **measuring their performance on those skills**.
Expert: “Back out of this parking space and head south to exit.”

You’re the novice driver:
Would you know what to do?
What is the expert presuming?
Expert Blind Spot

Occurs when expert instructors have so automatized their performance that they are blind to the skills students need to practice

- Over-estimating what novices know and can do
- Under-estimating how long novices will take
- Mis-predicting where novices will have difficulty
- Presuming that novices do things the way we do

Hinds (1999); Nathan & Koedinger (2000); Nickerson (1999)
Key insight: Practice need not make perfect!

**Deliberate practice** involves

- Focusing on an explicit goal, such as improving a specific aspect of performance
- Feedback that compares actual to desired task performance
- Appropriate level of challenge, so the learner stays motivated
- Ample opportunities for repetition, so the desired level of performance can be achieved.

Ericsson & Tesch-Romer, 1993
Being deliberate about practice
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Deliberate Instruction

**Deliberate instruction** involves:

- Creating for yourself an explicit goal, such as improving a specific aspect of teaching
- Finding ways to get targeted feedback
- Once achieved, shifting your goal to stay motivated
- Applying deliberate practice to design instruction
Epistemology of Teaching

Great teachers (just like great students) are not born; they are made.
Epistemology of Teaching

% US Ph.D.’s who are female Belief in field-specific ability

Leslie et al., 2015

Carnegie Mellon University
Steps of Deliberate Instruction

Applying deliberate practice to design instruction

1. Identify target performance tasks
2. Analyze skills required for those tasks
3. Align practice with those skills
4. Provide targeted feedback
5. Collect data – at the skill level

Also: Explicit goals, appropriate challenge, motivation
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Deliberate Instruction (DI) Case Studies

Applying DI with educational technology:
  Instructional videos
  Online course design

Applying DI without educational technology:
  Problem sets
  Papers
Case Study: Instructional Videos
Steps 1 & 2: Identify task & analyze skills

What should students be able to do or say after watching?

Are these videos *aligned* with those learning objectives?

What specific concepts and/or skills are required for those learning objectives? Are they addressed in the videos?
Steps 3 & 4: Align Practice & Provide Feedback

Tendency to disengage while watching video
Known value of testing for promoting learning

(Szpunar, 2013)
Steps 3 & 4: Align Practice & Provide Feedback

Testing promotes retrieval & learning (over study)
less mind wandering, more note taking

(Spzunar, 2013)
Step 5: Collect data at skill level

Typical measures reflect what/how much students watched, clicked, or “completed”

What we want to know is how well students learned the key skills
Case Study: Online Course Design

Open Learning Initiative (OLI) Statistics course

Introduction

Before we move on to the third measure of spread (standard deviation), we'll summarize what we've learned so far about measuring spread and use it to introduce another graphical display of the distribution of a quantitative variable, the **boxplot**.

The Five Number Summary

Carnegie Mellon University
Step 1: Identify target tasks   OR
*How I learned to leave objectives behind*…

What should students be able to do or say?

What target tasks should students be able to perform well?
Backward design

- Learning Objectives
- Assessments
- Instructional Strategies

adapted from Wiggins and McTighe (2005)
Step 2: Analyze skills

What specific concepts and/or skills are required for performing target tasks?

(Remember: Expert blind spot!)

Examples from statistics course

– Distinguishing quantitative/categorical variable
– Which graphic to display 2 quantitative variables
– How & when to compute correlation
Q1. Is there a relationship between students’ college GPAs and their high school GPAs?

Q2. Are there differences between males and females with respect to body image?

Q3. Is students’ academic performance in college related to their typical seating location in class?

Plan Analyses (Question One)

Before choosing the appropriate analyses, it is helpful to:

Identify the relevant variables:
Which variable(s) among those listed below is/are particularly relevant to the current question?

- Gender
- Height
- GPA
- HS_GPA
- Seat
- WtFeel
- Cheat

Classify the relevant variables:
The variable ______ is the [select one] variable, and is [select one]
Mapping Skills to Practice

Just like aligning learning objectives with instructional activities & assessments, but more detailed, explicit.

Two approaches work well together:

– For each skill or learning objective, identify which specific instructional activities, resources & assessments support it.
– For each instructional activity, resource, & assessment item, identify which skill or learning objective it supports.
## Skill Mapping: Example

<table>
<thead>
<tr>
<th>Instr’l Object</th>
<th>Skill 1</th>
<th>Skill 2</th>
<th>Skill 3</th>
<th>Skill 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 1</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity 2</td>
<td></td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiz #3</td>
<td></td>
<td></td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Video #4</td>
<td></td>
<td>✔️</td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Steps 3 & 4: Align Practice & Provide Feedback

Practice activities are easily embedded with content; tailored feedback is provided.

Learn by Doing

Now you complete the table by computing the conditional percentages for the males.
What is the correct number for the cell indicated by the question mark?

<table>
<thead>
<tr>
<th>Gender</th>
<th>Total</th>
<th>Underweight</th>
<th>Overweight</th>
<th>About Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>560/760=73.7%</td>
<td>163/760=21.5%</td>
<td>37/760=4.9%</td>
<td>760/760=100%</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td>?</td>
</tr>
</tbody>
</table>

- 295/580=52.7%
- 295/855=34.5%
- 295/440=67%
- 295/1200=24.6%

Page 1 of 4
Steps 5: Collect data tied to skills

Feedback to Student

Feedback to Instructor
Testing Effectiveness...

Traditional College Course
> 100 hours
~3% learning gain

Blended, Data-Driven OLI Course
< 50 hours
~18% learning gain

Replicated 3 times at CMU External report by ITHAKA

See jime.open.ac.uk/jime/article/view/2008-14
Deliberate Instruction (DI) Case Studies

Applying DI with educational technology:
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Case Study: Problem sets

Introductory Physics course: Students should be able to apply physical laws to solve problems describe limitations of a solution, assumptions made

Assumptions:
• Weekly problem sets (~5-10 problems)
• Problems may vary in difficulty but always solved from start to finish
• Focus on physical law introduced the previous week

Carnegie Mellon University
Case Study: Problem sets

Step 1: Identify target task

Step 2: Analyze skills
    Setting up the problem involves hidden skills: drawing a diagram, selecting frame of reference)
    Identifying which physical law should apply is tricky

Steps 3 & 4: Provide practice & feedback
    Assign problems where the endpoint is set-up!

Step 5: Collect data
    Have TAs enter scores by problem, not overall
Grades as a measure of learning

+ Based on performance of target tasks
+ Motivate students to demonstrate their ability
- Do not account for prior knowledge of particular skills
- Do not distinguish partial credit vs. mastery
- Tend to be coarse, not measuring skills/concepts
Case Study: Paper Assignment

Step 1: Identify target task

Step 2: Analyze skills
   Tip: *Do the assignment yourself!*

Steps 3&4: Provide practice & feedback
   Consider milestones/checkpoints to highlight key skills

Step 5: Collect data at the skill level
   Rubrics can help
A **rubric** is an assessment tool that explicitly lays out your performance expectations for an assignment.

Organized as a table with rows & columns
Rows represent each dimension (map to skill)
Columns represent different levels of quality
## Layout of a Rubric

<table>
<thead>
<tr>
<th></th>
<th>Excellent</th>
<th>Competent</th>
<th>Needs Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of key concepts (30 pts)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinking/inquiry (30 pts)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication (20 pts)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of visual aids (20 pts)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each cell contains a description of that level of quality for that dimension/skill
Take-Home Points

Be your own coach:
- Set appropriately challenging goals & analyze how you’re achieving them
- Don’t let teaching become overly automatic (like the mindless driver)

Technology can be a great asset when we use it deliberately
- Make current effective practices more efficient
- Address teaching/learning problems, enable new opportunities
- But beware unintended consequences

Apply Deliberate Instruction in designing instruction
- Analyze key skills required for target performance
- Provide practice & feedback, collected data with those skills in mind