# Inside Out:
# A Computer Science Course
# Gets a Makeover

*Brought to you by . . .*

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# Overview

- The instructional challenge
  - Software testing is cognitively complex, requires critical thinking, effective communication, and rapid self-directed learning

- The course
  - Pulled lecture out of the classroom (put it onto the web) to make time/space for coached activities
  - Students join a well-known open source project, apply the course lessons and create portfolio-quality artifacts
  - Study guide drives exams, fosters strategic preparation of high-quality exam answers

- Creative Commons license facilitates transfer of instructional materials back to industry
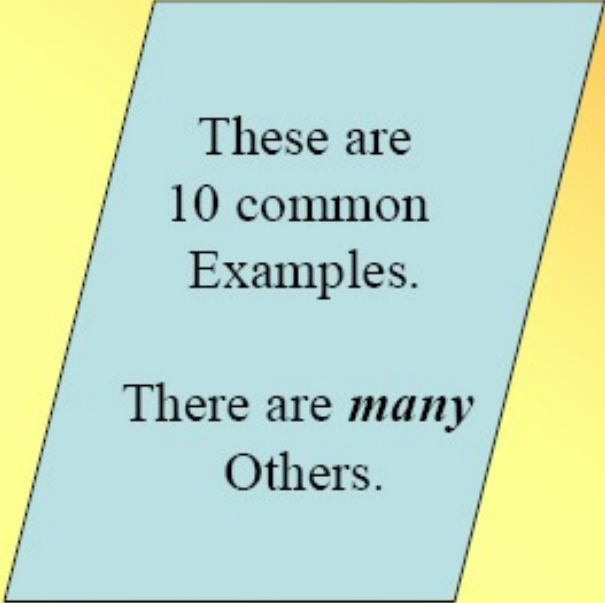
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# What's this course about?

*Software testing is a process of technical investigation of the product under test conducted to provide stakeholders with quality-related information.*

# What's a test technique?
# Ten dominating techniques

- Function testing
- Specification-based testing
- Domain testing
- Risk-based testing
- Scenario testing
- Regression testing
- Stress testing
- User testing
- State-model based testing
- High volume automated testing

These are 10 common Examples.

There are *many* Others.

http://www.testingeducation.org/BBST/BBST--IntroductiontoTestDesign.html

# Test attributes

**To different degrees, good tests have these attributes:**

- **Power**. When a problem exists, the test will reveal it.
- **Valid**. When the test reveals a problem, it is a genuine problem.
- **Value**. It reveals things your clients want to know about the product or project.
- **Credible**. Your client will believe that people will do the things that are done in this test.
- **Representative** of events most likely to be encountered by the user. (xref. Musa's *Software Reliability Engineering*).
- **Non-redundant.** This test represents a larger group that address the same risk.
- **Motivating**. Your client will want to fix the problem exposed by this test.
- **Performable**. It can be performed as designed.
- **Maintainable**. Easy to revise in the face of product changes.
- **Repeatable**. It is easy and inexpensive to reuse the test.
- **Pop**. (*short for Karl Popper*) It reveal things about our basic or critical assumptions.
- **Coverage**. It exercises the product in a way that isn't already taken care of by other tests.
- **Easy to evaluate**.
- **Supports troubleshooting.** Provides useful information for the debugging programmer.
- **Appropriately complex.** As the program gets more stable, you can hit it with more complex tests and more closely simulate use by experienced users.
- **Accountable**. You can explain, justify, and prove you ran it.
- **Cost**. This includes time and effort, as well as direct costs.
- **Opportunity Cost**. Developing and performing this test prevents you from doing other work

Black Box Software Testing    Copyright © 2003    *Cem Kaner & James Bach*    25

http://www.testingeducation.org/BBST/BBST--IntroductiontoTestDesign.html

# It's kind of like CSI



MANY tools, procedures, sources of evidence.

- Tools and procedures don't define an investigation or its goals.
- There is too much evidence to test, tools are often expensive, so investigators must exercise judgment.
- The investigator must pick what to study, and how, in order to reveal the most needed information.

# Commercial Teaching Style

- **Primary communication style was lecture**

  - Real-life examples

    - Motivating

    - Memorable

    - Illustrate applications

    - Illustrate complexity

- **Lectures can be excellent for conveying basic knowledge, but they are weak for developing higher order cognitive skills**

First U.S. Edition of the Classic Work on Lecturing

WHAT'S THE USE OF Lectures?

Donald A. Bligh
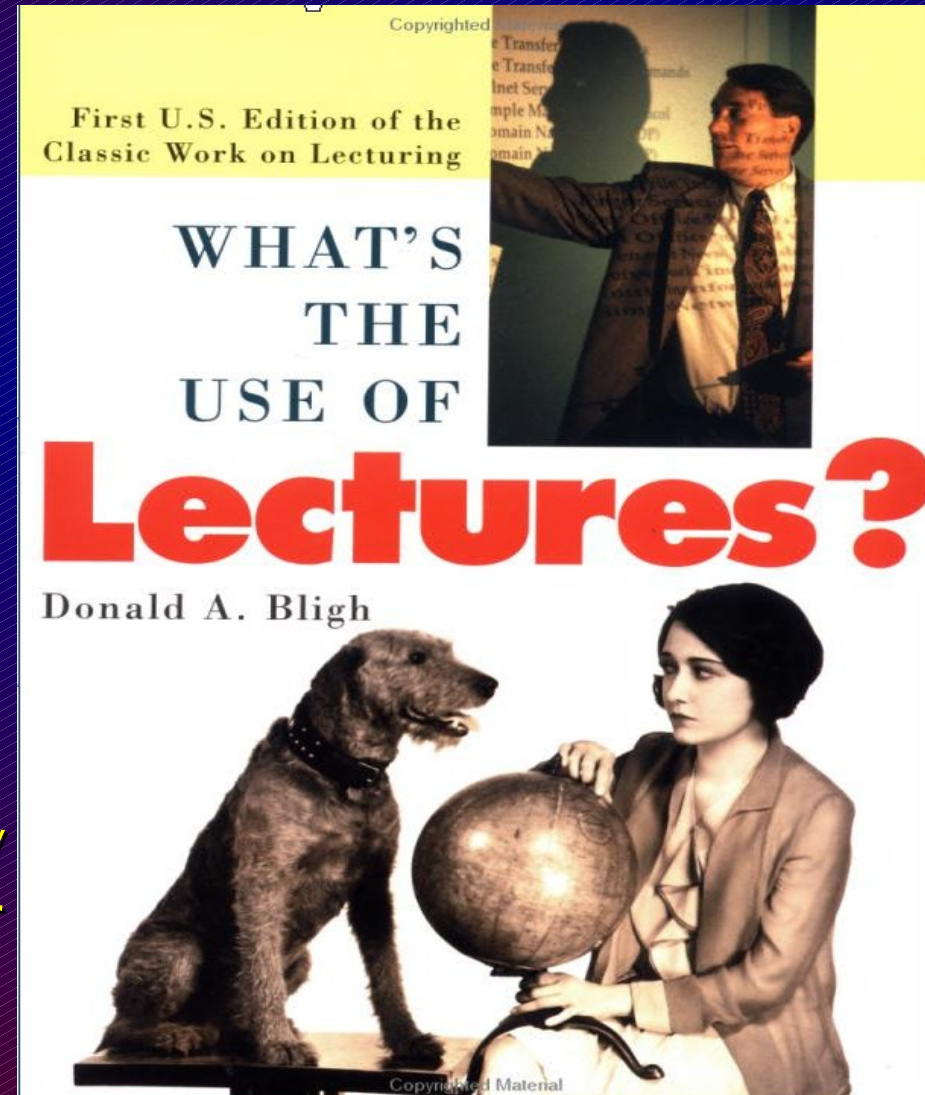
# Example Problem: Domain Testing

- Most widely taught testing technique
  - For details, see http://www.testingeducation.org/BBST/Domain.html
  - Easy to explain the basic concepts
  - Classic examples widely taught
  - Students quickly signal that they understand it
  - But when you give them exercises under slightly new circumstances
    - They blow it
      - And then they blow the next one
        - And the next one . . .

# Brilliant (?) idea

- Lots of practice exercises
- Like we used to do as math students

# I Tried This With Commercial Students

- Many (often, most) of them needed a lot of practice under changing circumstances

- But the perceived slow pace of the course made them anxious

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- After 16 years of sending my staff to training, training my own staff, and training strangers . . .

  . . . I realized two things:

  1. This wasn't working (not for me, not for the field)

  2. In terms of commercial training, I didn't know how to make it work

# So I Became a University Instructor

- Big pay cut, but a clear goal:

*Improve the state of the practice in software testing by improving the test-related education of software testers*

- This responds to my belief that the most significant cause of the slow pace of change in testing, compared to programming, is the weak educational support for theory, practice, and experimentation in testing.

# Commercial    vs.    Academic

- Drive-by teaching
  - 2-5 days, rapid-fire ideas, visiting instructor

- Bias for breadth over activities

- No time for homework
- No tests
- Work experience helps to bring home concepts
- Objective: one applicable new idea per day

- Local teaching
  - Several months, a few hours per week, students get to know instructor

- Bias for depth, activities welcome

- Extensive homework
- Assessment expected
- Students have no work experience, need context
- Expect mastery of several concepts and skills

This course is academic,

but the goal of the work

is to provide an alternative model

for commercial (in-house) training

and professional self-study

# Back to that Brilliant (?) idea

- Lots of practice exercises

- Like we used to do as math students

- It was impractical in commercial training

- Now, at last, we can try it on university students.

# Padmanabhan's Thesis:
# Practice on Domain Testing

- 15 classroom hours of lecture plus examples plus practice, practice, practice. Lots of procedural instruction and drill

- Students mastered every procedure

- Final exam

  - Applied what they knew to similar questions (near transfer)

    - **They aced them**

  - Applied what they knew to a problem that was beyond their practice (not beyond the lecture) (a little bit farther transfer)

    - **They all failed miserably**

- Successful transfer of learning requires more than procedural training and practice **(Of course, YOU already know that ...)**

# Dealing With the Transfer Problem

Edited by
Richard Lesh
Helen M. Doerr

## Beyond Constructivism

Models and Modeling Perspectives on Mathematics Problem Solving, Learning, and Teaching

**Expanded Edition**

## How People Learn

Brain,

Mind,

Experience,

and

School

NATIONAL RESEARCH COUNCIL
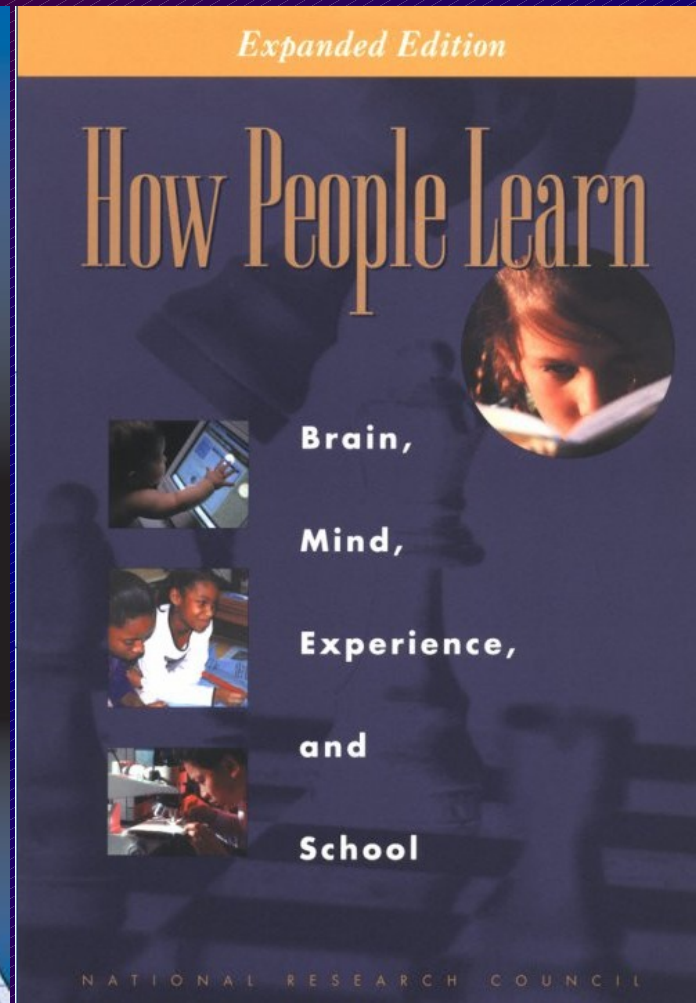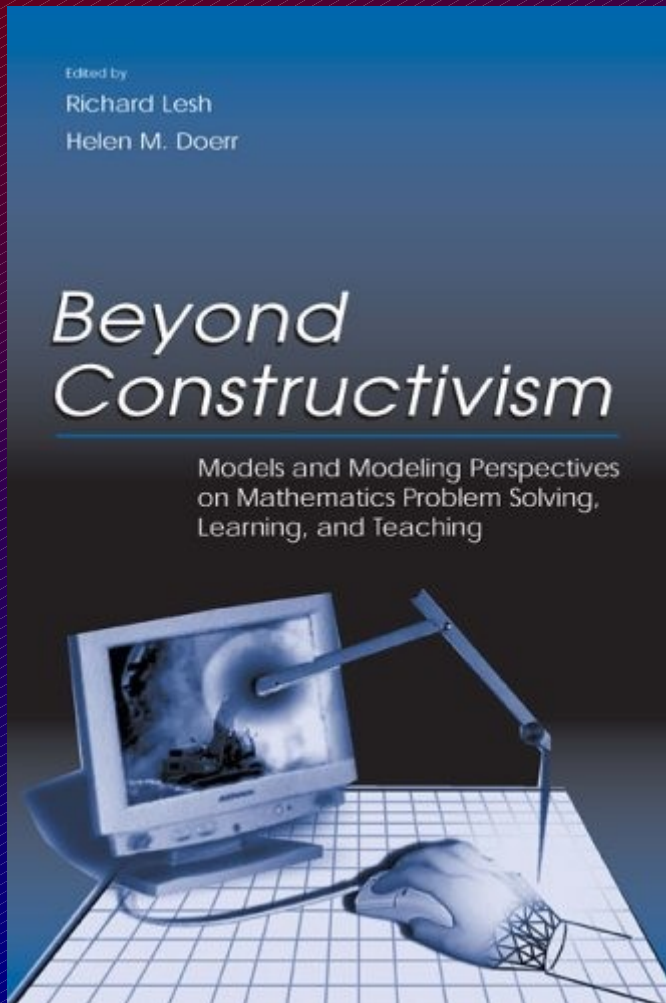
- In science / math education, the transfer problem is driving fundamental change in the classroom

- Students learn (and transfer) better when they discover concepts, rather than by being told them

# Andragogy

- Pedagogy: study of teaching / learning of children

- Andragogy: study of teaching / learning of adults

- University undergrads are in a middle ground between the teacher-directed child and the fully-self-directed adult

- Both groups, but especially adults, benefit from activity-based and discovery-based styles

ELSEVIER
BUTTERWORTH
HEINEMANN

Malcolm S. Knowles
Elwood F. Holton III
Richard A. Swanson

Sixth Edition 6

The Adult Learner

The Definitive Classic in Adult Education
and Human Resource Development

# Characterizing Cognitive Complexity
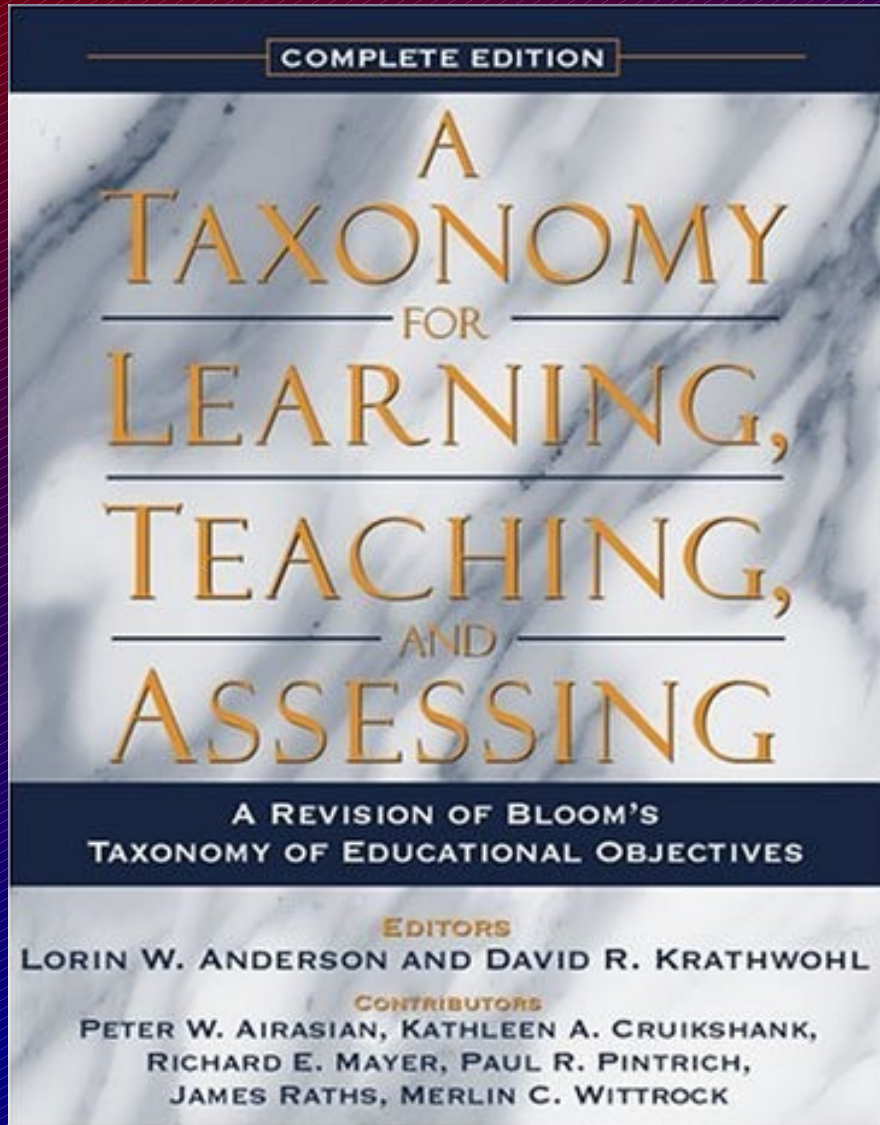


- Anderson & Krathwohl (2001) provide a modern update to Bloom's (1956) taxonomy

# Characterizing Cognitive Complexity

|  | Cognitive Process Dimension | | | | | |
|---|---|---|---|---|---|---|
|  | Remember | Understand | Apply | Analyze | Evaluate | Create |
| Factual | **lecture** | **lecture** |  |  |  |  |
| Conceptual | **lecture** | **lecture** |  |  |  |  |
| Procedural | **lecture** | **lecture** |  |  |  |  |
| Meta-Cognitive |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Knowledge Dimension

## Anderson & Krathwohl, 2001

# We Start Over

- Cognitively complex material

- We need to develop skill, judgment, and attitudes, not just knowledge of facts and definitions

- We face the usual (for science education) transfer problems

- Set **a few** explicit learning objectives

- And assess against them

THOMAS A. ANGELO
K. PATRICIA CROSS

# CLASSROOM ASSESSMENT TECHNIQUES

*A Handbook for College Teachers*

SECOND EDITION

# Learning Objectives

- Do context-driven testing: Select the technique(s) that satisfy:
  - Practical under the circumstances
  - Likely to provide the right types of information
- They must be able to **apply** and **evaluate** the techniques
- They also need to **know how to find out** (such things as) how the product should behave, why, who thinks so and who thinks not
- They have to **communicate plans, status and results effectively,** often to people who wish the facts were different.
- I also wanted them to **create artifacts that could demonstrate their sophistication to potential employers.**

# Here's Where We Are Now

- We created a variety of out-of-classroom activities, such as homework (with application to real products) and group study sessions

- Students praised the (by now, well polished) lectures

- But they often told us that they learned the most from the out-of-class activities

- In many cases, the most effective (our subjective assessment) student-and-instructor interactions happened out of class, such as discussions at the local cafe.

- So we turned the class inside out

  - **Lectures out** of the classroom

  - **Activities** (including discussion) **in** the classroom

# Tour de Course

- The BBST main page

- The first instructional segment (later ones are similarly structured):

  – Video lecture

  – Lecture slides

  – Worked examples such as <u>this one</u>

  – Review quizzes

  – Activities

    - Soon to be applied to a product under test

  – A set of study guide questions

    - From a much larger pool

# Lectures On-Line

- http://www.testingeducation.org/BBST

- Video lectures

  – Students watch them before class

  – Take simple quiz that checks that they watched the video and paid attention

  – Then we do in-class activities

- The results seem good. I'm still evaluating (grad) student performance from last term compared to prior years, but my informal assessment at this point is that students did well

- Undergrads are struggling with this, but at a higher level than before (I think)

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# Application Under Test

- Like service learning, but not as heavy a commitment for the students or for me

  – Facilitates student learning (application level and above)

  – Facilitates student transfer of skills / knowledge to the workplace

  – We pick a well-known product

  – Students apply what they learn to that product

  – Typically, I use an open source product because it avoids NDA problems, students can show their work at interviews

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  - Activities
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# Study Guides

- http://www.testingeducation.org/k04/BBSTreviewfall2005.htm

- 100 questions, include all candidates for mid-term and final exam

- Students prepare answers together, assess each other's work

- I can require well-organized, thoughtful answers

- Fosters strategic preparation

- Reduces disadvantage of students whose native language is not English

- Creates cooperative learning tasks that should help limited-English-proficiency students improve language skills

# Study Guides

- Study guide results
  - Students inexperienced with these, often blow the first test
  - Make-up mid-terms
    - Replace grade, not average, not best 1 of 2 results
    - Students who take it improve more (1$^{st}$ test compared to final exam) than students who did not take it
      - Practice effect, motivation confound
  - Writing is better, answers are better, I have greater freedom to grade less forgivingly
  - Many students told me this was the most valuable learning experience in the course, and the most time-consuming

# Nuts and Bolts

- I tape the videos myself and edit them myself

- Adobe Premiere (Final Cut Pro had too many bugs)

- 2-10 hours of tape for an hour of edited lecture

- Several hours of slide formatting / preparation for integration with video

- Several hours of preparation of lecture notes (tradeoff from scripted versus unscripted: spontaneous and active but hours more tape)

- Several hours editing, for a total of about 35 hours work per hour of taped class

- Significant potential for intellectual property issues, because many schools are asserting IP rights to course materials.