Outcome Assessment 234

Conversations on Teaching

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A saga of outcome assessment strategies encompassing two cities, three courses, and four prior attempts…

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Outline

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Introduction

- The Catalyst: ABET 2000
- The resulting "Outcome Assessment Mandate" (OAM) in the Schools of Engineering
- The "Do Your Own Thing (and We'll Tell You Whether or Not We Like It) Accreditation Dilemma" (DYOTAD)
- The plethora of outcome assessment strategies devised, deployed, and ultimately discarded as a consequence of OAM and DYOTAD

The Presenter

- Initially skeptical, but now fully committed to the idea of outcome assessment
- Interested in developing and promoting "best practices" for outcome assessment
- No claim for having all the answers…
- …but not afraid to try any new strategy (at least once)!

The Cities

- West Lafayette, home of the "better results so far than the Cubs" Purdue Boilermakers
- Grove City, Pennsylvania, home of Grove City College (small, private, predominately liberal arts institution)

The Courses

- ECE 270 – *Intro to Digital System Design* (a sophomore lecture/lab course on digital logic and system design)
- ECE 362 – *Microprocessor System Design and Interfacing* (a junior lecture/lab course on embedded microcontrollers)
- ECE 477 – *Digital Systems Design Project* (a senior course that involves a semester-long, team-oriented, multidisciplinary design project)

The Outcomes

Ten specific outcomes originally defined for ECE 270…

1. an ability to analyze static and dynamic behavior of digital circuits
2. an ability to map and minimize Boolean functions as well as represent them in various standard forms
3. an ability to design and implement combinational logic circuits
4. an ability to use a hardware description language to specify a digital circuit
5. an understanding of various combinational "building blocks" (e.g., decoders, multiplexers, encoders)
6. an ability to design and implement arithmetic logic circuits
7. an understanding of the behavior exhibited by latches and flip-flops
8. an ability to design and implement sequential circuits
9. an understanding of various sequential "building blocks" (e.g., counters, shift registers)
10. an ability to design and implement a simple computer

The Outcomes

…have been reduced to the following eight:

1. an ability to analyze static and dynamic behavior of digital circuits
2. an ability to represent Boolean functions in standard forms, to map and minimize them, and to implement them as combinational logic circuits
3. an ability to use a hardware description language to specify combinational logic circuits, including various "building blocks" such as decoders, multiplexers, encoders, and tri-state buffers
4. an ability to design and implement arithmetic logic circuits
5. an understanding of the behavior exhibited by latches and flip-flops
6. an ability to analyze, design, and implement sequential circuits
7. an ability to use a hardware description language to specify sequential circuits, including various "building blocks" such as counters and shift registers
8. an ability to design and implement a simple computer

The Outcomes

Four specific outcomes defined for ECE 362:

1. an ability to design and implement a simple computer
2. an ability to write programs for a computer in assembly language
3. an ability to interface a microprocessor to various devices
4. an ability to effectively utilize the wide variety of peripherals integrated into a contemporary microcontroller

The Outcomes

Five specific outcomes defined for ECE 477:

1. an ability to apply knowledge obtained in earlier coursework and to obtain new knowledge necessary to design and test a microcontroller-based digital system
2. an understanding of the engineering design process
3. an ability to function on a multidisciplinary team
4. an awareness of professional and ethical responsibility
5. an ability to communicate effectively, in both oral and written form

The Visitors

"We want to see evidence of failing grades assigned for cases in which students [would otherwise be passing but] failed to successfully demonstrate one or more course outcomes."

Interpretation: We can't just *say* that, because a student earned a total score above the "passing threshold", that he/she has successfully demonstrated all the course outcomes.

Major Issues

- Balance
  - fairness to students
    - providing students with a sufficient number of opportunities to demonstrate course outcomes
    - ensuring that students' own work is used as the basis for outcome demonstration success
  - overhead for instructor
    - keeping the incremental workload associated with outcome assessment and tracking to a minimum
    - keeping the outcome assessment process "contained" within a given term

Major Issues

- Evaluation Instruments
  - exams (whole or question subsets)
  - quizzes (written/oral)
  - homework assignments
  - labs
  - papers/projects/presentations
- Passing Thresholds
  - static (what absolute value?)
  - dynamic (what algorithm?)

Major Issues

- Consistency
  - semester-to-semester
  - professor-to-professor
  - course-to-course
  - school-to-school
  - institution-to-institution
- We're not there yet…
- …but "culture shift" is slowly occurring

The Sophomore/Junior Saga

- Four prior attempts
  - fixed passing threshold (60%) on weighted sum of (selected) lab, homework, and exam scores
  - fixed passing threshold (60%) on primary assessment, remediation homework, and final assessment
  - fixed passing threshold (60%) on primary assessment, final assessment, and remediation homework
  - fixed passing threshold (60%) on primary and final assessments; use of "E" grade for those who would otherwise be passing, with opportunity to take remediation assessment the following semester

What's Wrong With These Pictures?

- fixed threshold (60%) on weighted sum of (selected) lab, homework, and exam scores
  - basically everyone "passed" – strategy did not provide an effective "filter"
  - impossible to ensure that students' own work was being evaluated on labs and homework
  - remediation strategy was ill-defined (had to be done on a one-on-one basis)

Commercial Break

- There is obviously something "wrong" with the rest of these pictures, too (otherwise, they would not be called "prior attempts"!)
- Before delving into the reasons, it may be instructive to see how the next strategy played out at two significantly different academic institutions

A Tale of Two Cities

- Study involves an introductory computer engineering course taught at two different academic institutions
  - Purdue University, West Lafayette, Indiana
  - Grove City College, Grove City, Pennsylvania
- Goal was to discover the effectiveness of a particular approach to outcome assessment
- Each institution was preparing for their ABET accreditation visit when the course was taught

A Tale of Two Cities

- "Standard" sophomore-level digital system design course
  - ECE 270 at Purdue University
  - ELEE 204 at Grove City College
- Same: Lecture-Workbook for class notes, textbook, presentation style/format, homework exercises, on-line homework solution videos, lab experiments (and equipment), course outcomes, outcome assessment instruments

A Tale of Two Cities

- Student pool
  - similar average SAT scores (approx. 1250)
  - order of magnitude difference in class size (295 at Purdue vs. 26 at Grove City)
  - attendance sample average significantly different (68% at Purdue vs. 90% at Grove City)

Outcome Assessment

- Students were given a total of three opportunities to demonstrate each outcome
  - primary assessment (3 outcomes packaged into an hourly exam X 3, 10th outcome tested separately)
  - remediation homework
  - final assessment (all 10 outcomes packaged into two-hour final exam)
- To successfully demonstrate a given outcome, students had to have a score of at least 60% on any of the three evaluation instruments (fixed threshold)
- All ten outcomes had to be demonstrated in order to receive a passing grade

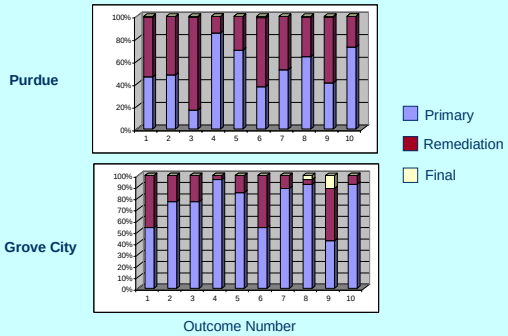
A Tale of Two Cities

- Several students who were otherwise passing (8 at Purdue, 0 at Grove City) received a failing grade because they did not demonstrate all ten course outcomes
- Course grades were differentiated primarily based on exam scores
- Average GPA for course at each institution virtually identical:
  - 2.91 (out of 4.0) at Purdue
  - 2.92 (out of 4.0) at Grove City

A Tale of Two Cities

- Cumulative success rate for the "three-try" outcome assessment strategy used:
  - overall minimum = 95.3%
  - overall average = 98.8%
  - overall maximum = 100%
- Average cumulative success rate obtained at each institution was similar:
  - 97.5% at Purdue
  - 100% at Grove City

Cumulative Success Rate (%) for Course Outcome Demonstration



A Tale of Two Cities

- Primary concerns with this attempt at outcome assessment strategy
  - reliability of using "remediation homework" to demonstrate course outcomes (*who is actually doing the work?*)
  - amount of overhead required to evaluate, process, and track the remediation homework (large volume due to relatively low primary assessment pass rate)
  - limited amount of "filtering" (was all this work really *accomplishing* anything??)

A Tale of Two Cities

- Revised strategy proposed based on results of this trial
  - "invert" the role of the final exam and the remediation homework (essentially convert to a "two-and-one-half-try" strategy)
  - remediation homework only completed by students who fail to demonstrate outcomes on both the initial quiz and the final exam ("conditional failure")

Now, Back to the Saga…

- Four prior attempts
  - fixed passing threshold (60%) on weighted sum of (selected) lab, homework, and exam scores
  - fixed passing threshold (60%) on primary assessment, remediation homework, and final assessment
  - fixed passing threshold (60%) on primary assessment, final assessment, and remediation homework
  - fixed passing threshold (60%) on primary and final assessments; use of "E" grade for those who would otherwise be passing, with opportunity to take remediation assessment the following semester

What's Wrong With These Pictures?

- fixed threshold (60%) on primary assessment, final assessment, and remediation homework
  - remediation homework delayed until after the final assessment (theory: there should be less of it, given the opportunity to demonstrate a previously failed outcome on the final)
  - major limitation: only works if final (happens to be) scheduled early during finals week; also, requires students to stay in town after final to do remediation
  - excessive finals week overhead in grading exams and processing remediation homework
  - impossible to ensure that students' own work was being evaluated on remediation homework

Back to the Saga…

- Four prior attempts
  - fixed passing threshold (60%) on weighted sum of (selected) lab, homework, and exam scores
  - fixed passing threshold (60%) on primary assessment, remediation homework, and final assessment
  - fixed passing threshold (60%) on primary assessment, final assessment, and remediation homework
  - fixed passing threshold (60%) on primary and final assessments; use of "E" grade for those who would otherwise be passing, with opportunity to take remediation assessment the following semester

What's Wrong With These Pictures?

- fixed threshold (60%) on primary and final assessments; use of "E" grade for those who would otherwise be passing, with opportunity to take failed outcome remediation assessment the following semester
  - reduced the outcome demonstration attempts to controlled exam situations – eliminated ambiguity on whose work was being evaluated…big plus
  - fixed threshold for passing became a significant factor – hard ("impossible") to write exams that produce a predictable mean/distribution (too many factors "beyond the instructor's control")…big minus

How It Played Out (ECE 270, S'03)

PRIMARY ASSESSMENT

```
Outcome # 1 Avg Score:   71.5%    Passed: 206/274 =  75.18%    Failed:  68/274 =  24.82%
Outcome # 2 Avg Score:   63.4%    Passed: 158/274 =  57.66%    Failed: 116/274 =  42.34%
Outcome # 3 Avg Score:   75.8%    Passed: 231/274 =  84.31%    Failed:  43/274 =  15.69%
Outcome # 4 Avg Score:   65.0%    Passed: 188/274 =  68.61%    Failed:  86/274 =  31.39%
Outcome # 5 Avg Score:   61.7%    Passed: 153/274 =  55.84%    Failed: 121/274 =  44.16%
Outcome # 6 Avg Score:   62.0%    Passed: 153/274 =  55.84%    Failed: 121/274 =  44.16%
Outcome # 7 Avg Score:   80.5%    Passed: 245/274 =  89.42%    Failed:  29/274 =  10.58%
Outcome # 8 Avg Score:   65.1%    Passed: 178/274 =  64.96%    Failed:  96/274 =  35.04%
Outcome # 9 Avg Score:   54.7%    Passed: 127/274 =  46.35%    Failed: 147/274 =  53.65%
Outcome #10 Avg Score:   54.5%    Passed: 114/274 =  41.61%    Failed: 160/274 =  58.39%

Summary of Outcome Demonstration:
Number of students who demonstrated  0 outcome(s) on the primary assessments:   4
Number of students who demonstrated  1 outcome(s) on the primary assessments:   8
Number of students who demonstrated  2 outcome(s) on the primary assessments:  16
Number of students who demonstrated  3 outcome(s) on the primary assessments:  20
Number of students who demonstrated  4 outcome(s) on the primary assessments:  24
Number of students who demonstrated  5 outcome(s) on the primary assessments:  35
Number of students who demonstrated  6 outcome(s) on the primary assessments:  31
Number of students who demonstrated  7 outcome(s) on the primary assessments:  28
Number of students who demonstrated  8 outcome(s) on the primary assessments:  25
Number of students who demonstrated  9 outcome(s) on the primary assessments:  30
Number of students who demonstrated 10 outcome(s) on the primary assessments:  53
```

How It Played Out (ECE 270, S'03)

FINAL ASSESSMENT

```
Outcome:  1     Passed = 270     Failed =   4     Successful =  98.5%
Outcome:  2     Passed = 272     Failed =   2     Successful =  99.3%
Outcome:  3     Passed = 273     Failed =   1     Successful =  99.6%
Outcome:  4     Passed = 273     Failed =   1     Successful =  99.6%
Outcome:  5     Passed = 268     Failed =   6     Successful =  97.8%
Outcome:  6     Passed = 259     Failed =  15     Successful =  94.5%
Outcome:  7     Passed = 269     Failed =   5     Successful =  98.2%
Outcome:  8     Passed = 257     Failed =  17     Successful =  93.8%
Outcome:  9     Passed = 234     Failed =  40     Successful =  85.4%
Outcome: 10     Passed = 250     Failed =  24     Successful =  91.2%

Demonstrated all ten outcomes based on final assessement: 224/274 =  81.75%

Distribution of Remediation Requirements
Number of students needing to complete  1 remediation exams(s):  25/274 =   9.12%
Number of students needing to complete  2 remediation exams(s):   5/274 =   1.82%
Number of students needing to complete  3 remediation exams(s):   7/274 =   2.55%
Number of students needing to complete  4 remediation exams(s):   9/274 =   3.28%
Number of students needing to complete  5 remediation exams(s):   1/274 =   0.36%
Number of students needing to complete  6 remediation exams(s):   3/274 =   1.09%
Number of students needing to complete  7 remediation exams(s):   0/274 =   0.00%
Number of students needing to complete  8 remediation exams(s):   0/274 =   0.00%
Number of students needing to complete  9 remediation exams(s):   0/274 =   0.00%
Number of students needing to complete 10 remediation exams(s):   0/274 =   0.00%
```

How It Played Out (ECE 270, S'03)

FINAL ASSESSMENT

```
Outcome:  1     Passed = 270     Failed =   4     Successful =  98.5%
Outcome:  2     Passed = 272     Failed =   2     Successful =  99.3%
Outcome:  3     Passed = 273     Failed =   1     Successful =  99.6%
Outcome:  4     Passed = 273     Failed =   1     Successful =  99.6%
Outcome:  5     Passed = 268     Failed =   6     Successful =  97.8%
Outcome:  6     Passed = 259     Failed =  15     Successful =  94.5%
Outcome:  7     Passed = 269     Failed =   5     Successful =  98.2%
Outcome:  8     Passed = 257     Failed =  17     Successful =  93.8%
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Number of students needing to complete  7 remediation exams(s):   0/274 =   0.00%
Number of students needing to complete  8 remediation exams(s):   0/274 =   0.00%
Number of students needing to complete  9 remediation exams(s):   0/274 =   0.00%
Number of students needing to complete 10 remediation exams(s):   0/274 =   0.00%
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increasing "soak time" effect

Wheel of Fortune Anomaly

- As part of this trial, the Final Assessment could not only be used for remediation of all ten course outcomes, but could *also* be used to improve score on any/all ten outcomes
- Many students took advantage of this and improved their course grades dramatically
- Too many others, however, did not, and despite the "generous offer" still managed somehow not to demonstrate all ten course outcomes

Wheel of Fortune Anomaly


```
GRADE CUTOFFS: A > 88.00 > B > 76.00 > C > 64.00 > D > 52.00 > F

 DISTRIBUTION:   (A)   (B)   (C)   (D)   (E)   (F)
                 129    91     5     0    42     7

 COURSE GRADE POINT AVERAGE BASED ON LETTER GRADES: 3.44/4.00
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Prior to final, course GPA was approximately 1 point lower!

- If Bilbo had been the instructor, he might have expressed the following sentiment:
  "I helped the students in the top half of the class more than I anticipated, and helped the students in the bottom half of the class less than I had hoped"

To "E" or Not to "E"?

- Re: use of "E" grade for those who would otherwise be passing, with opportunity to take remediation assessment the following semester
  - no one (i.e., most students and faculty) know what the "E" grade is and/or how it is to be used and/or what restrictions are associated with "improving" it
  - while (thankfully) many students elected to simply re-take the course to clear the "E" they received, significant overhead was incurred providing remediation exams for the few "happy to get a D"
  - major problem: lack of containment within the term ("overhead leakage")

Why Not Use "I" Instead of "E"?

- Some faculty have elected to use a grade of "I" (instead of "E") for cases in which a student is "otherwise passing" but who has failed to demonstrate one or more outcomes…so, why not use "I" instead of "E"?
  - appears to violate the "intended spirit" of the "I" grade
  - incurs the same amount of overhead as "E" (requires same remediation assessment and paperwork)
  - associates smaller consequence with failure to demonstrate outcomes (getting an "E" is much more significant than getting an "I")…could induce an "I-pidemic"

The Saga Continues

- Strategy Number Five (Spring 2003)
  - dynamic thresholds on each primary and final assessment (mean – standard deviation, with bounded range of 40% to 60%)
  - must pass at least 50% of N (total) outcomes on the primary assessments to qualify for a passing grade
  - final assessment can be used for remediation and/or improvement of score on up to N/2 outcomes
  - self-contained – no "E" grades or "I" grades!!

ECE 362 Course Outcome Assessment

- Students must demonstrate basic competency in ***all*** course outcomes to receive a passing grade
- TWO opportunities will be provided:
  - Primary Outcome Assessments
  - Final Outcome Assessments (used for remediation or grade improvement of up to TWO outcomes)
- A minimum score of EXAM MEAN – STD DEV (limited to 40-60%) on ***either*** evaluation instrument will be sufficient to establish basic competency, but students must demonstrate ***at least two*** (of the four) course outcomes on the Primary Assessments to receive a passing grade
- NOTE: Students who demonstrate ***all*** course outcomes on the Primary Assessments (and are "happy" with their projected grade) will be ***exempt*** from the Final Exam!

Preliminary Results (ECE 270 – F'03)

```
ECE 270 PRIMARY OUTCOME ASSESSMENT REPORT

Outcome  1 -- Avg Score:  73.6%   Threshold:  52.0%   Took: 161/164 =  98.2%
              Passed: 135/161 =  83.9%

Outcome  2 -- Avg Score:  62.9%   Threshold:  43.5%   Took: 160/164 =  97.6%
              Passed: 136/160 =  85.0%

Summary of Outcome Demonstration:
Number of students who demonstrated  0 outcome(s) on the primary assessments:  15
Number of students who demonstrated  1 outcome(s) on the primary assessments:  27
Number of students who demonstrated  2 outcome(s) on the primary assessments: 122
```

Preliminary Results (ECE 362 – F'03)

```
ECE 362 PRIMARY OUTCOME ASSESSMENT REPORT

Outcome  1 -- Avg Score:  76.4%   Threshold:  58.1%   Took: 154/154 = 100.0%
              Passed: 135/154 =  87.7%

Outcome  2 -- Avg Score:  61.3%   Threshold:  45.0%   Took: 152/154 =  98.7%
              Passed: 133/152 =  87.5%

Summary of Outcome Demonstration:
Number of students who demonstrated  0 outcome(s) on the primary assessments:  11
Number of students who demonstrated  1 outcome(s) on the primary assessments:  18
Number of students who demonstrated  2 outcome(s) on the primary assessments: 125
```

The Senior Saga

- Senior Design – kind of outcomes (teamwork, design, communication, and professional skills) totally different than "content" courses
- Major challenge is attempting to quantify the assessment of these inherently qualitative outcomes and apply appropriate thresholds
- Another challenge is equitable distribution of workload and grade determination based on individual and corporate contributions

Senior Design Outcomes

Five specific outcomes defined for ECE 477:

1. an ability to apply knowledge obtained in earlier coursework and to obtain new knowledge necessary to design and test a microcontroller-based digital system
2. an understanding of the engineering design process
3. an ability to function on a multidisciplinary team
4. an awareness of professional and ethical responsibility
5. an ability to communicate effectively, in both oral and written form

Evaluation Instruments

1. Design Component Homework (individual)
2. Lab Notebook (individual)
3. Project Success Criteria (team)
4. Professional Component Homework (individual)
5. Formal Design Review, Final Video Presentation, Final Report (team)

A fixed threshold of 60% is applied to 1, 2, 4, and 5; a fixed threshold of 80% is applied to 3 (i.e., finished projects must be at least 80% functional)

Senior Design Remediation

- Challenge: Need to provide students who initially fail to demonstrate an outcome the opportunity for prompt remediation
- Examples of senior design project remediation
  - rewriting a section of the final report to improve the technical writing style score
  - revising the reliability/safety analysis to correct errors
  - augmenting the hyperlinks in the on-line lab notebook
  - correcting errors on the printed circuit layout and/or errors in the software so that more of the project-specific success criteria are met

How It Is Playing Out (S'03 Results)

```
Outcome # 1 Avg Score:   85.5%    Passed:  48/ 48 = 100.00%
Outcome # 2 Avg Score:   72.0%    Passed:  48/ 48 = 100.00%
Outcome # 3 Avg Score:   93.3%    Passed:  48/ 48 = 100.00%
Outcome # 4 Avg Score:   82.1%    Passed:  48/ 48 = 100.00%
Outcome # 5 Avg Score:   85.7%    Passed:  48/ 48 = 100.00%

Demonstrated all five outcomes based on primary assessement:  48/ 48 = 100.00%
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Note: Some outcome remediation was required for several students (had to revise sections of report) – data is based on results achieved after remediation was completed

Summary and Conclusions

- A plethora of outcome assessment strategies have been devised, deployed, and discarded as a consequence of OAM and DYOTAD
- Different kinds of courses require different outcome assessment strategies – finding the "best ones" for each case is non-trivial
- Quantitative comparison of "best practices" is an instructive exercise
- Despite all the challenges and overhead, "Outcome assessment is a good thing"

More Information

Detailed information about the courses discussed in this presentation along with a copy of the presentation slides can be found at

http://shay.ecn.purdue.edu/~dsml