

Strategies for Assessing Course-Specific Outcomes

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Outline

- Introduction
- Outcome Assessment Trials (and Errors)
 - What's Wrong With These Pictures?
 - "Wheel of Fortune" Anomaly
 - To "E" or Not to "E"?
 - Why Not "I" Instead of "E"?
 - Incorporation of Dynamic Thresholds
 - Further Refinements
- Lessons Learned
- Summary and Conclusions

Basic Questions Addressed

- Formulation of content-specific learning outcomes that can be consistently and quantitatively assessed
- Formulation of effective outcome assessment instruments along with mechanisms to determine outcome demonstration thresholds

Basic Questions Addressed

- Formulation of grading strategies that incorporate outcome demonstration thresholds yet produce results consistent with prior (accepted) grading practices (i.e., course GPA in range of approximately 2.5 – 2.8)
- Formulation of outcome remediation strategies that are both fair and efficient

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)

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

...were ultimately compacted to the following six:

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 ability to analyze, design, and implement sequential circuits and use a hardware description language to specify them
6. an ability to design and implement a simple computer based on combinational and sequential building blocks

The Outcomes

Four specific outcomes originally 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

...were refined as follows:

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

The Outcomes

...and will most likely be compacted to the following **three**:

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

Edict from the Visitors

"We want to see evidence of failing grades assigned for cases in which students [who 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 "course passing threshold", that he/she has successfully demonstrated all the course outcomes. Also, application of outcome assessment should produce some form of **meaningful/measurable** difference.

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/semester

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?)
 - consistent with grading cutoff (A-B-C-D) thresholds

Major Issues

- Assigning course grades **consistent with proven prior practice**, yet reflecting **meaningful application of outcome assessment** thresholds
- Achieving consistency
 - semester-to-semester
 - professor-to-professor
 - course-to-course
 - school-to-school
 - institution-to-institution

Outcome Assessment Trials (and Errors)

- Four prior (discarded) 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" (**conditional failure**) grade for those who were otherwise 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 prove to be effective
 - 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)

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

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**

Primary Assessment Statistics Trial 4 - ECE 270, S'03

Outcome	Avg. Score	Passed	Failed
1	71.5%	75.2%	24.8%
2	63.4%	57.7%	42.3%
3	75.8%	84.3%	15.7%
4	65.0%	68.6%	31.4%
5	61.7%	55.8%	44.2%
6	62.0%	55.8%	44.2%
7	80.5%	89.4%	10.6%
8	65.1%	65.0%	35.0%
9	54.7%	46.4%	53.6%
10	54.5%	41.6%	58.4%

Number of students who demonstrated ALL outcomes based on primary assessments: 53 / 274 = 20%

Final Assessment Statistics Trial 4 - ECE 270, S'03

Outcome	Successful
1	98.5%
2	99.3%
3	99.6%
4	99.6%
5	97.8%
6	94.5%
7	98.2%
8	93.8%
9	85.4%
10	91.2%
ALL	82%
GPA	3.44

Final Assessment Statistics Trial 4 - ECE 270, S'03

Outcome	Successful
1	98.5%
2	99.3%
3	99.6%
4	99.6%
5	97.8%
6	94.5%
7	98.2%
8	93.8%
9	85.4%
10	91.2%
ALL	82%

↑ increasing "soak time" effect

Final Assessment Statistics Trial 4 - ECE 270, S'03

Distribution of "E-student" Remediation Requirements

Students needing 1 remediation exams(s):	25/274 = 9.12%
Students needing 2 remediation exams(s):	5/274 = 1.82%
Students needing 3 remediation exams(s):	7/274 = 2.55%
Students needing 4 remediation exams(s):	9/274 = 3.28%
Students needing 5 remediation exams(s):	1/274 = 0.36%
Students needing 6 remediation exams(s):	3/274 = 1.09%
Students needing 7 remediation exams(s):	0/274 = 0.00%
Students needing 8 remediation exams(s):	0/274 = 0.00%
Students needing 9 remediation exams(s):	0/274 = 0.00%
Students needing 10 remediation exams(s):	0/274 = 0.00%

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
Prior to final, course GPA was approximately 1 point lower!

- If Bilbo (*Lord of the Rings*) 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"*

Primary Assessment Statistics Trial 4 - ECE 362, S'03

Outcome	Avg. Score	Passed	Failed
1	66.1%	70.2%	29.8%
2	58.8%	55.3%	44.7%
3	59.6%	60.6%	39.4%

Number of students who demonstrated ALL outcomes based on primary assessments: 31 / 94 = 33%

Final Assessment Statistics Trial 4 - ECE 362, S'03

Outcome	Successful
1	84.0%
2	81.9%
3	83.0%
ALL	77%
GPA	3.11

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" ("incomplete") 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-epidemic"

Incorporation of Dynamic Thresholds

- Strategy Number Five (Fall 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!!

Sample Exam Distribution (362, F'03)

DISTRIBUTION FOR PRIMARY ASSESSMENT OF ECE 362 COURSE OUTCOME 2

100%	(0)
90-99%	(6)
80-89%	(13)
70-79%	(31)
60-69%	(35)
50-59%	(35)
40-49%	(17)
30-39%	(9)
20-29%	(6)
10-19%	(2)
1-9%	(0)
NOT TAKEN	(2)

Number of students = 152/154
 Range of scores was from 13% to 99%
 Average score = 61.2%
 Standard deviation = 16.3
 Outcome Demonstration Threshold = 45.0%

Primary Assessment Statistics Trial 5 - ECE 270, F'03

Outcome	Avg. Score	Thresh	Passed	Failed
1	68.4%	54.1%	86.3%	13.7%
2	81.0%	60.0%	92.4%	7.6%
3	72.2%	56.4%	86.0%	14.0%
4	60.6%	40.0%	79.0%	21.0%
5	81.8%	60.0%	91.9%	8.1%
6	57.8%	40.0%	75.5%	24.5%

Number of students who demonstrated ALL outcomes based on the primary assessments: 149 / 277 @ 54%

Final Assessment Statistics Trial 5 - ECE 270, F'03

Outcome	Successful
1	95.7%
2	94.9%
3	92.4%
4	90.3%
5	90.6%
6	88.8%
ALL	87%
GPA	3.07

Primary Assessment Statistics Trial 5 - ECE 362, F'03

Outcome	Avg. Score	Thresh	Passed	Failed
1	62.1%	45.0%	88.7%	11.3%
2	65.5%	48.5%	85.0%	15.0%
3	69.9%	54.1%	86.0%	14.0%

Number of students who demonstrated ALL outcomes based on the primary assessments: 101 / 152 @ 66%

Final Assessment Statistics Trial 5 - ECE 362, F'03

Outcome	Successful
1	94.1%
2	94.1%
3	92.8%
ALL	93%
GPA	3.17

Further Refinements

- Trial Six (Fall 2004 & Spring 2005)
 - dynamic thresholds on each primary and final assessment (mean – standard deviation, with bounded range of 40% to 60%)
 - final assessment used for remediation only ("Wheel of Fortune" eliminated, overhead reduced!) – automatic exemption from final for students who demonstrate all outcomes on the primary assessments
 - must have a passing grade to qualify for the final assessment (no restriction on number of outcomes re-taken on final, but "passing grade" restriction will provide practical limit)

Final Assessment Statistics Trial 6 - ECE 270

Outcome	Successful (Fall 2004)	Successful (Spring 2005)
1	94.4%	92.9%
2	93.0%	94.0%
3	93.0%	92.4%
4	90.8%	91.3%
5	90.8%	92.4%
6	87.3%	87.0%
ALL	85.2%	82.6%
GPA	2.56	2.51

Final Assessment Statistics Trial 6 - ECE 362

Outcome	Successful (Fall 2004)	Successful (Spring 2005)
1	97.7%	94.1%
2	95.9%	94.1%
3	95.3%	95.6%
ALL	94.7%	94.1%
GPA	2.81	2.79

Current Trial

- Trial **Seven** (Fall 2005 & Spring 2006)
 - added **limited** opportunity for **grade improvement** on final assessment
 - effective outcome score = **weighted average** of primary and final assessments
 - number of outcomes re-taken limited to **half**
 - must have passing grade to qualify for final
 - workload associated with final greater than Trial 6, but still significantly less than prior trials
 - grade inflation associated with grade improvement on final about **an order of magnitude less** than Trial 5

Final Assessment Statistics Trial 7 - ECE 270

Outcome	Successful (Fall 2005)	Successful (Spring 2006)
1	87.2%	TBD
2	88.7%	TBD
3	85.7%	TBD
4	85.7%	TBD
5	85.7%	TBD
6	81.2%	TBD
ALL*	78.2%	TBD
GPA	2.41	TBD

*anomaly? (about 5% lower than expected)

Final Assessment Statistics Trial 7 - ECE 362

Outcome	Successful (Fall 2005)	Successful (Spring 2006)
1	98.8%	TBD
2	95.2%	TBD
3	94.0%	TBD
ALL	94.0%	TBD
GPA	2.82	TBD

Lessons Learned – A “Delicate Balance”

- Assigning course grades consistent with proven prior practice
- Providing incentives for students to successfully demonstrate outcomes, yet not causing grade inflation
- Establishing reasonable, meaningful thresholds for outcome demonstration success that are decoupled from the “exam difficulty”
- Determining a fair level of pass/fail “filtering” based on outcome demonstration success

Some Remaining Questions

- What is an appropriate amount of outcome-based “filtering” for various kinds of courses?
 - currently averaging about **5-6%** in ECE 362 and about **15-20%** in ECE 270
 - is this too much, too little, or about right?
- What is an appropriate balance between number of attempts allowed to demonstrate an outcome, and the incremental workload associated with managing this effort
 - currently offer **two** attempts
 - is this too much, too little, or about right?

Summary and Conclusions

- Different kinds of courses (e.g., “content-intensive” vs. “design-intensive”) require different outcome assessment strategies
- Finding an “optimal” strategy is non-trivial
- Concern over the non-uniformity of effort applied across the curriculum to outcome assessment

Summary and Conclusions

- Have the “basic questions” been answered?
 - Formulation of content-specific learning outcomes that can be consistently and quantitatively assessed **YES**
 - Formulation of effective outcome assessment instruments along with mechanisms to determine outcome demonstration thresholds **YES**
 - Formulation of grading strategies that incorporate outcome demonstration thresholds yet produce results consistent with prior (accepted) grading practices (i.e., course GPA in range of approximately 2.5 – 2.8) **YES**
 - Formulation of outcome remediation strategies that are both fair and efficient **YES (on balance)**

More Information

Detailed information about the courses discussed in this presentation can be found at
<http://shay.ecn.purdue.edu/~dsml>