

**Research and development
of enhanced assessment
tools in chemistry**

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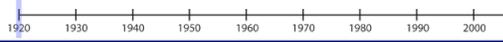
 ACS DivCHED Examinations Institute

Exams Institute?

- How is it that chemistry has an Exams Institute?

A Short History

- 1921 - Division of Chemical Education
- 1930 - Committee on Examinations and Tests
- 1934 - First cooperative exam released
- 1946 - Ted Ashford appointed as Chair of the Committee
- 1984
 - Committee on Examinations and Tests renamed to Examinations Institute
 - Board of Trustees appointed to oversee operation of the Institute
- 1986 - Ted Ashford retires
- 1987 - Dwaine Eubanks becomes Director
- 2002 - Tom Holme becomes director



Example exam offerings: General Chemistry Exams

- Full Year Exam (2007, 2009)
- First Term Exam (2005, 2009)
- Second Term Exam (2002, 2010)
- 1st Term Paired Questions (2005)
- 2nd Term Paired Questions (2007)
- Conceptual (1st term, 2nd term, full year)
- Full year - brief exam (2002, 2006)

Exam development

- Chair is named
- Committee is recruited
- First meeting - sets content coverage
- Items are written and collated
- Second meeting - editing items, setting trials
- Trial testing in classes - provides item stats
 - Recently includes "more"
- Third meeting - look at stats and set exam
- Exam is RELEASED (not published).

Norms and reporting

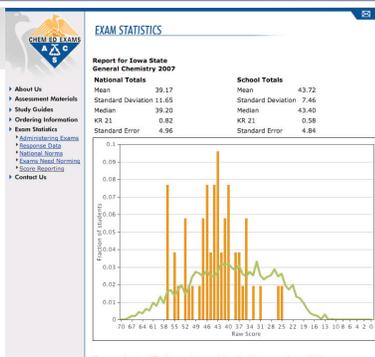
- Norms are calculated on voluntary return of student performance data
- We have an interactive web site for score reporting for exams that do not yet have enough data to report a norm.
- People often use norm (percentile) to help students who transfer to other programs.

Facilitating data return

- Build interactive, on-line tool
- Scores are entered
- Entered scores are compared to current national sample
- Institute staff verifies scores are legitimate before they are added to the national sample.
 - Begs faculty to send in student response data for item statistics

Input

Output



Sampling issues

- Voluntary sampling likely over estimates national proficiency on these exams.
- Lake Wobegon effect observed

Moving past norm-referenced exams

- A key advantage to the Exams Institute is that the community of practitioners in chemistry education trust the exams.
 - Essentially a brand trust
- Means that change to a venerable product must be made carefully.

Adding criterion referencing

- Requires criteria
- At the college level, they don't exist.
- Build a consensus content map.
- Similar to using backward design¹.

1: *Understanding by Design*, Grant P. Wiggins, Jay McTighe

Anchoring Concept

- Use "big ideas" or anchoring concepts to organize content across disciplines.
- Build levels with finer grain size down to the point where exam items are generally written.

Levels of criteria map

- | | |
|----------------|---------------------------------|
| Level 1 | • Anchoring Concept |
| Level 2 | • Enduring Understanding |
| Level 3 | • Sub-disciplinary articulation |
| Level 4 | • Content details |

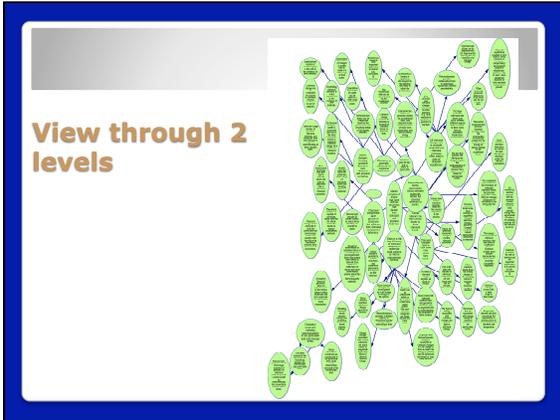
Starting Point

A conference by the Society Committee on Chemical Education of the ACS held a conference in 2003 that enumerated some possible big idea starting points.

Society Committee on Education
Exploring the Molecular Vision
Conference Report
June 27-29, 2003

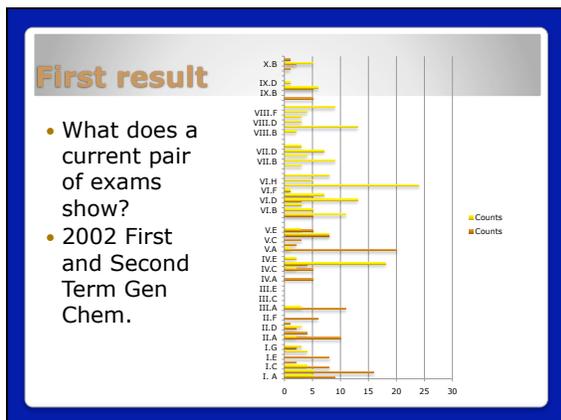
American Chemical Society

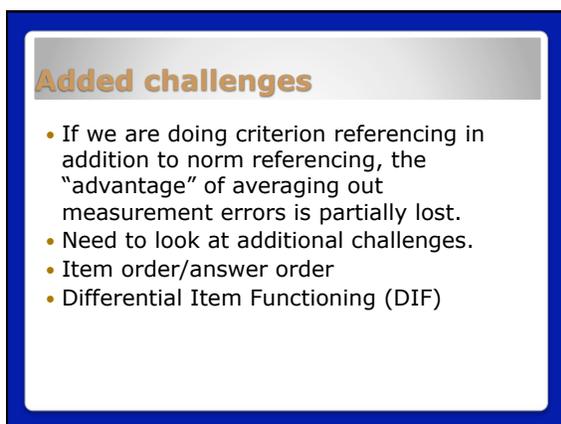


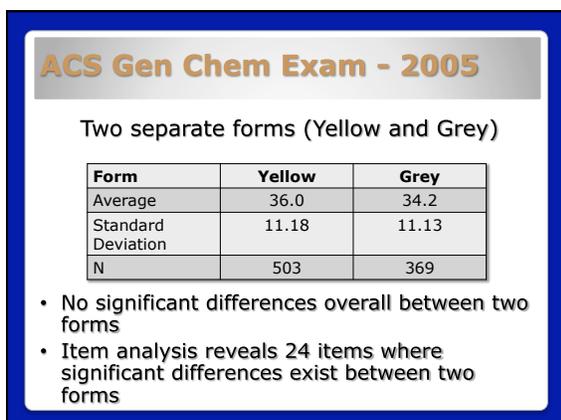


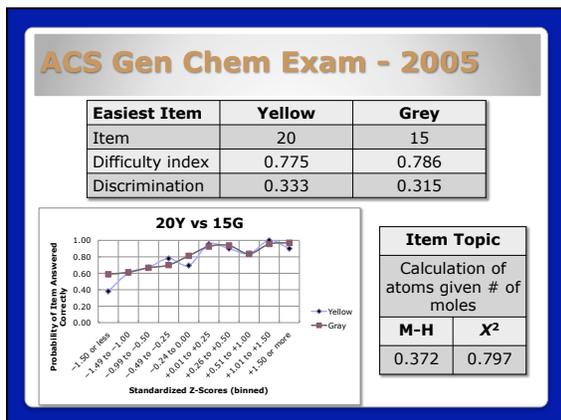
- Process for setting map (so far)**
- Begin from EMV conference ideas
 - Focus Group (Mar08): Level 1 + Level 2
 - Workshop (Jul08): Level 2 + Level 3 (General)
 - Focus Group (Aug08): Level 2 + Level 3 (Organic)
 - Workshop (Mar09): Level 3 + Level 4 (General)
 - Focus Group (Aug09): Level 2 + Level 3 (Organic)
 - Workshop (Mar10): Alignment (General)
 - Focus Group (Mar 10): Level 2 + Level 3 (Physical)

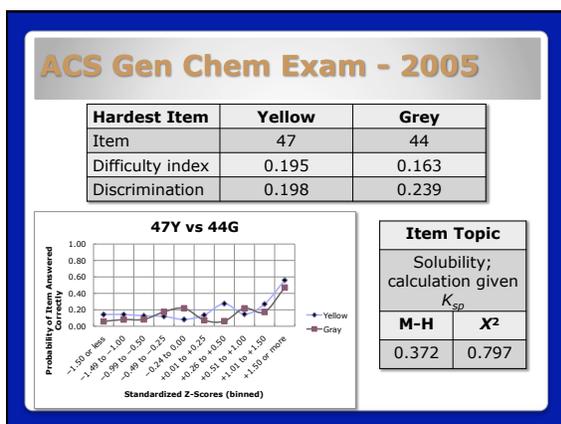
- Step 2: Alignment**
- Look at current items from ACS Exams and align them to Level 3/4
 - Process guided by psychometric experts.
 - Can include both skills and content
 - Ultimately can help define specifications for future ACS Exams.

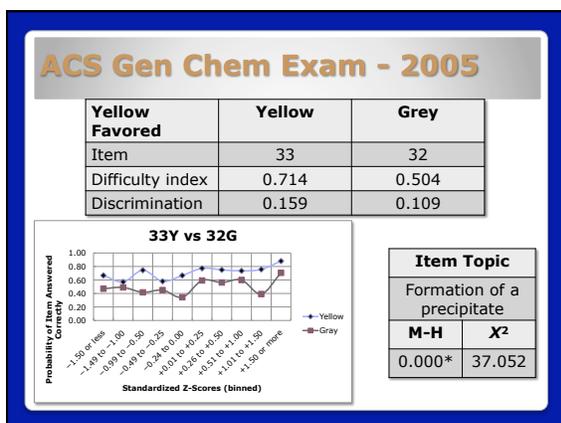










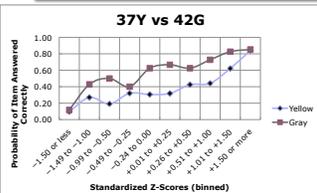


ACS Gen Chem Exam - 2005

Preceding Items	Item Topic	Difficulty Index
Yellow		
32	Physical properties; states of matter	0.590
31	Stoichiometry calculation (moles)	0.489
30	Physical processes; states of matter	0.614
Grey		
31	Solutions; boiling point and structure	0.233
30	States of matter; intramolecular forces	0.347
29	Energetics; ΔG° calculation	0.328

ACS Gen Chem Exam - 2005

Grey Favored	Yellow	Grey
Item	37	42
Difficulty index	0.378	0.583
Discrimination	0.460	0.435



Item Topic	
Dynamics; collision theory	
M-H	χ^2
0.000*	47.985

ACS Gen Chem Exam - 2005

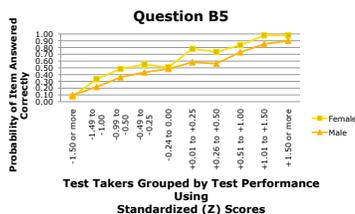
Preceding Items	Item Topic	Difficulty Index
Yellow		
36	Solutions; boiling point and structure	0.316
35	Pressure calculation at increased temp.	0.384
34	States of matter; intramolecular forces	0.284
Grey		
41	Reaction rates and temperature	0.556
40	Mass calculation given isotope half life	0.591
39	Rate law from a reaction mechanism	0.537

DIF

- Calculate DIF for trial tests.
- Items that have significant DIF are not included on the released exam.
 - Even though we cannot determine at that point if the DIF is a fluctuation
- Take items and study them further

Establishing DIF

- Use ICC's
- What is the formula of copper (II) phosphate?
 (A) Cu_2PO_4 (B) $\text{Cu}(\text{PO}_4)_2$
 (C) $\text{Cu}_2(\text{PO}_4)_3$ (D) $\text{Cu}_3(\text{PO}_4)_2$



Investigating DIF

- Consider construct versus content
- (Build a matrix with variations along each vector)
- Establish proficiency both internally and externally
- Establish the role of the stakes for the student.

Look at our example

- Women perform better
- At all stakes, low, medium, high
- Independent of internal or external referencing
- Limited to the 3:2 ratio case.
- No clues from wrong answers

What is the formula of copper (II) phosphate?

- (A) Cu_2PO_4 (B) $\text{Cu}(\text{PO}_4)_2$
 (C) $\text{Cu}_3(\text{PO}_4)_2$ (D) $\text{Cu}_3(\text{PO}_4)_3$

Summary

- Exams Institute has strong buy-in from the community of practitioners
- Norm-referencing from consensus built content coverage
- Content map that spans UG chemistry is in process
- Criterion referencing will allow new analysis
 - Will also require greater care to new questions about the measurements.

Acknowledgements (phase 2)

- Kristen Murphy (UWM)
- Many exam writing committee volunteers
- April Zenisky (UMass)
- Jacob Schroeder (ISU)
- Heather Caruthers (ISU)
- National Science Foundation
 - DUE-0618600
 - DUE-0717769
 - DUE-0817409
 - DUE-0920266