Arkansas State University (ASU) General Chemistry Assessment
Arkansas State University  
Department of Chemistry and Physics  
Current Budgeted Personnel

<table>
<thead>
<tr>
<th>Title</th>
<th>Number of Positions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>16 (^a)</td>
<td>10 chemistry, 5 physics, 1 science education</td>
</tr>
<tr>
<td>Instructor</td>
<td>2</td>
<td>chemistry, physical science</td>
</tr>
</tbody>
</table>

\(^a\) A tenure track chemistry faculty search has successfully concluded during spring 2013, and thus an additional faculty will join the department in August 2013.
• After a long period of water-cooler assessment.... initiate the assessment of the Arkansas State University (ASU) General Chemistry course sequence:

**CHEM 1013.** General Chemistry I Study of chemical reactions and equations, periodic relationships, the gaseous state, and the fundamentals of atomic theory, quantum theory, electronic structure, chemical bonding, stoichiometry and thermochemistry. Special course fees may apply. Corequisite or prerequisite, MATH 0013 or MATH 1023. Prior completion of CHEM 1003 or high school chemistry strongly recommended. Fall, Spring, Summer.

**CHEM 1023.** General Chemistry II Study of liquids, solids, solutions and the fundamentals of chemical kinetics, chemical equilibria, acids and bases, thermodynamics, and electrochemistry. Special course fees may apply. Prerequisites, CHEM 1011 and CHEM 1013. Fall, Spring, Summer.
2006 Initial Questions

- Are students “learning” concepts presented in general chemistry?
  - What are we doing right/wrong?

- How well prepared are incoming freshman for general chemistry?
  - What chemistry content is being covered in high school?

What would we get?...

- Centralized, systematic collection of non-anecdotal data.
- Non-punitive feedback for tenure track/tenured general chemistry faculty
Components of Assessment

- Multiple choice, pre-post format (Spring 2007-Spring 2010 25 questions; Fall 2010-present 30 questions)
  - Developed in-house
  - Pre given in corresponding lab sections
  - Post embedded in individual faculty final exams
- Demographic data collection
<table>
<thead>
<tr>
<th>Question #</th>
<th>Description</th>
<th>Requires math manipulation</th>
<th>Assumed Material</th>
<th>chapter (Burdge 2nd ed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>metric-metric conversion</td>
<td>x</td>
<td>x</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>scientific notation</td>
<td>x</td>
<td>x</td>
<td>appendix</td>
</tr>
<tr>
<td>3</td>
<td>nomenclature</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>element symbol</td>
<td></td>
<td>x</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>molar mass</td>
<td></td>
<td>x</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>balance chemical equation</td>
<td></td>
<td>x</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>limiting reactant</td>
<td></td>
<td>x</td>
<td>3</td>
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<tr>
<td>8</td>
<td>molarity</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>identify oxidized material</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>type of reaction</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>definition of calorimetry</td>
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<tr>
<td>12</td>
<td>ΔH and endothermic/exothermic</td>
<td>x</td>
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<td>5</td>
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<tr>
<td>13</td>
<td>Hess's law</td>
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<td>14</td>
<td>energy and regions of electromagnetic spectrum</td>
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<td>6</td>
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<tr>
<td>15</td>
<td>subatomic particles</td>
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<td>x</td>
<td>2</td>
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<tr>
<td>16</td>
<td>quantum number description</td>
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<tr>
<td>17</td>
<td>significance of line spectrum</td>
<td></td>
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<td>6</td>
</tr>
<tr>
<td>18</td>
<td>electron configuration periodic trend</td>
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<td>identify isoelectronic species</td>
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<td>electron configuration periodic table</td>
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<td>22</td>
<td>identify types of bonding</td>
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<td>23</td>
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<td>molecular geometry</td>
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<td>sigma and pi bonds</td>
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<td>27</td>
<td>molecule polarity</td>
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<td></td>
<td>9</td>
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<tr>
<td>28</td>
<td>p-v relationship</td>
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<td>11</td>
</tr>
<tr>
<td>29</td>
<td>density of gas</td>
<td></td>
<td>x</td>
<td>11</td>
</tr>
<tr>
<td>30</td>
<td>ideal gas behavior</td>
<td></td>
<td></td>
<td>11</td>
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</table>

Assessment Instrument
- 3 questions per chapter
- 8 questions on assumed material
Pre/Post Assessment Score Distributions

30 questions, Fall 2010 – Spring 2013

<table>
<thead>
<tr>
<th></th>
<th>Pre Assessment</th>
<th>Post Assessment</th>
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<tbody>
<tr>
<td>n</td>
<td>1429</td>
<td>1181</td>
</tr>
<tr>
<td>average</td>
<td>10.1</td>
<td>18.2</td>
</tr>
<tr>
<td>median</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>standard deviation</td>
<td>3.26</td>
<td>4.62</td>
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<tr>
<td>max</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>min</td>
<td>2</td>
<td>5</td>
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</tbody>
</table>
Requested Demographic Data

- Student ID
- Race
- Gender
- Major
- Classification
- Lecture Section
- State/country of last high school attended

- Highest level math course completed with a grade of C or better
- When last math course was completed
- Math course currently taking at ASU
- Highest level chemistry course completed with a grade of C or better
- When last chemistry course was completed
• Average fall/spring enrollment: 560 students
<table>
<thead>
<tr>
<th>ACS Meeting</th>
<th>Sample size</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2008</td>
<td>763</td>
<td>Average pre-assessment score highest for students completing calculus</td>
</tr>
<tr>
<td>August 2010</td>
<td>710</td>
<td>Pre-Assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Students completing High School, PreAP, or AP chemistry scored significantly higher on than those completing Advanced Chemistry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-Assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Freshman score significantly higher than sophomores</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Students completing High School Chemistry scored significantly higher on the posttest than those completing Advanced or AP Chemistry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Students completing PreAP scored significantly higher than those completing Advanced, High School, or AP Chemistry.</td>
</tr>
</tbody>
</table>
Over 5 years worth of pre/post-assessment and demographic data.

- **Drowning in data** (data collection is easy)….
- Essentially no experience with assessment design and analysis (data analysis requires statistics experience)….

### Assessment Director Intervention

- Class project for one group of students enrolled in PSY 4173 (Introduction to Psychological Tests and Measurements):
  
  - **Is the assessment instrument reliable** Crohnbach’s alpha)?
    - Post test reliability = 0.706 (0.80 good reliability)
  
  - **Item analysis: difficulty and discrimination**
    - Identified several difficult questions with low discrimination (low number of high scoring students answering correct)
Spring 2013

• ~ 35% DFW rate….general chemistry is a “gatekeeper” course for several degree programs.
  • Received internal grant to study the impact recitation would have on general chemistry lecture final course grades.

Assessment Director Intervention

• Class project for one group of students enrolled in PSY 4173 (Introduction to Psychological Tests and Measurements):
  • Focus Group: 28 recitation participants to investigate students’ perceptions of both lecture class and recitation.
    • Expand recitation program.
  • ANOVA analyses: performance as a function of recitation participation.

• Ezra Rodgers
• Devin Harper
• Kasha Shannon
• Brett Shirley
Recitation participants perform better in general chemistry than non-participants ($\alpha = 0.05$).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Average % points earned</th>
<th>Average Post Assessment Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied &amp; participated in Recitation (attend &gt; 60% of recitation sessions)</td>
<td>70.73 (n = 19)</td>
<td>19.9 (n = 18)</td>
</tr>
<tr>
<td>Applied &amp; did not participated in Recitation, Applied but not accepted in recitation, Did not apply to recitation</td>
<td>49.29 (n = 225)</td>
<td>17.3 (n = 157)</td>
</tr>
</tbody>
</table>
Scientific Method

Ask a question

State a hypothesis

Conduct an experiment

Analyze the results

Make a conclusion

Idealized linear process
The Reality of the Scientific Method

1. Ask a question
2. State a hypothesis
3. Conduct an experiment
4. Analyze the results
5. Make a conclusion

Ask a new question
Ask a question

State a hypothesis

Conduct an experiment

Analyze the results

Make a conclusion

2006: What are we doing right/wrong?
How well prepared are incoming freshman for general chemistry?

Assessment is Research

Is the test reliable?

Will recitation help student performance?

???????
Promoting the Development of the Data Driven Culture of Learning (Assessment) in STEM Fields

• Culture of Learning
  • Assessment is a tool providing input necessary to make the data driven decisions to develop and grow the desired culture of learning.
Promoting the Development of the Data Driven Culture of Learning in STEM Fields

• **Infrastructure**

  • Conduct an Experiment and Analyze the Data.....take different forms depending on the 1) discipline, 2) course level, and 3) course enrollment.

  • Design of appropriate assessment instruments and analysis of the resulting collected data require specialized training and skills which not all faculty have.

    • What data should be collected/requested?
    • Should it be collected as continuous or discrete data?
    • IRB related issues?
    • What statistical method(s) are appropriate?
    • How are the tests performed?
    • Interpretation of test results?

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Knowledge/Skills and Attitudes/Beliefs, “provide individualized just-in-time support”
Susan Donat & Jennifer Fisler, Taming Lions Without a Whip: The Power of Strategic Influence
Promoting the Development of the Data Driven Culture of Learning in STEM Fields

• Acknowledge and promote assessment as meaningful research.

• Upper administrative support
  • Clear, on-going commitment to assessment must exist despite administrative turnover, “new initiatives,” or realignment of resources.
  • Q: Who is successful at developing a culture of learning?
  • A: Institutions that have a well defined focus….baccalaureate or Ph.D. education.

The Scholarship of Teaching and Learning (SoTL)
Jonathan Keiser, Conversations with Assessment Experts

Clear and meaningful purpose and direction
Linda Suskie, Why are we Assessing?
Promoting the Development of the Data Driven Culture of Learning in STEM Fields

• **Additional Resources**

  • Nothing is free!!
  • Ongoing efforts that will be an addition to existing workload, and thus growth of assessment efforts will require additional people and time.

  • Available resources will be limited and thus appropriate prioritization of institutional initiatives will be necessary.......the pie is not getting bigger....how do you cut it?
Promoting the Development of the Data Driven Culture of Learning in STEM Fields

- Director of Assessment: The “Right” Mix of Flexibility and Focus

  - “Research advisor” and Colleague

  - What makes someone a Colleague?

<table>
<thead>
<tr>
<th>Step</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ask a question</td>
</tr>
<tr>
<td>2</td>
<td>State a hypothesis</td>
</tr>
<tr>
<td>3</td>
<td>Conduct an experiment</td>
</tr>
<tr>
<td>4</td>
<td>Analyze the results</td>
</tr>
<tr>
<td>5</td>
<td>Make a conclusion</td>
</tr>
<tr>
<td>Is the data reliable?</td>
<td></td>
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</tbody>
</table>
Promoting the Development of the Data Driven Culture of Learning in STEM Fields

• **Flexibility in Faculty Involvement**

  • Ongoing, focused effort to recruit new blood……if you want the club to grow their must be a recruitment plan.
  • It may be necessary to “compensate” those willing and best suited to participate in assessment.

  • Accept there may be only a handful of faculty interested/suited for assessment,
  • No reason to expect all faculty should participate in assessment in the same way (or at all). Accept there will be faculty that are not interested in participating in assessment.
  • Do not “force” assessment efforts on entire campus. This approach may result in short term progress, but it is not the way to create widespread support and enthusiasm for any initiative.

Feed the one cow
Janice Dickenson, Connecting Scholarly Teaching and Assessment of Student Learning: reframing the Assessment Conversation
2006: What are we doing right/wrong? How well prepared are incoming freshman for general chemistry?

- Ask a question
- State a hypothesis
- Conduct an experiment
- Analyze the results
- Make a conclusion

Will recitation help student performance?

Is the test reliable?
• Huge amount of Pre/Post and Demographic data....
  • How well prepared are incoming freshman?
  • What are we doing right/wrong?

Close the Loop
“Rethink what we thought”

- Is 18/30 average post test score okay?
  - General Chemistry is a broad, abstract, math intensive course….maybe kids are right where they should be.
  - Develop longitudinal assessment: will students understand concepts better as sophomores or juniors?

- Change assessment instrument?
  - More in-depth analysis of tested concepts (a longer exam)
  - Other factors:
    - Angela Duckworth and the Research on 'Grit'