Expanding and assessing simulations in POGIL activities: Using smart-phones, tablets, and laptops to aid student learning of Physical Chemistry

Sean Garrett-Roe
Demographics
25 students
almost all chemistry majors
almost all 4th year
Spring and Fall 2016

Participation
23 attend except “excused” absences
1 occasional (50%)
1 only shows for exam

Grading
25% Exercises (HW) 0-1-2 scale
25% MT1
25% MT2
25% Final exam
Students and faculty share highest order goals for college education.

What should a person with a degree from Pitt be able to do?

- Think critically (evaluate evidence)
- Solve problems (be creative)
- Communicate effectively
- Contribute to society
- Get a job (in field)
- Work in a team (demonstrate leadership)
What should a Pitt grad be able to do?

Feel (somewhat) prepared for life
Use studies to develop new ideas
Be professional
Collaborate
Think critically

Solve problems
Apply concepts to the "real world"

Communicate scientific ideas to specialist and general audiences
Work independently (self-motivated)
Play well with others
Deal with disappointment/criticism
Don't sound dumb
Demonstrate leadership

Manage $
Process Oriented

- Students work in self-managed teams.
- Activities use discipline content to facilitate the development of higher-level thinking and the ability to learn and to apply knowledge in new contexts.
- Interpersonal skills are developed.
- Communication is important.
- Reflection is important (meta-cognition)
- Students develop problem solving skills

Guided Inquiry Learning

- The Eureka effect
- Activities guide students to construct their own understanding
- Evidence-based learning for large and small classes

www.pogil.org
1. **Model**: an information rich data display

2. **Prompts**: a series of questions that guide students to develop their observations and understand the consequences
POGIL activities are based on a learning cycle of exploration, concept invention, and application.

Exploration

1. An “Exploration” phase in which a pattern of regularity in the environment or data (collected by the students, or presented to them directly) is sought. Students generate hypotheses and test them in an attempt to explain or understand this information.

Concept invention

2. A “Concept Invention” or “Term Introduction” phase in which a concept is developed from patterns in the data and a new term is introduced to refer to these newly-identified trends or patterns. By having the “Term Introduction” phase follow the “Exploration” phase, new terms are introduced at a point when the student has already constructed her own understanding of the concept to which the term is then attached. This is in contrast to a typical textbook (or lecture) presentation in which terms are frequently presented or defined before examples of their use are given.

Application

3. An “Application” phase in which the just-developed concept is applied in new situations. This phase is intended to generalize the concept’s meaning and applicability, frequently requiring deductive reasoning skills.

Moog and Spencer “POGIL: An overview” doi:10.1021/bk-2008-0994.ch001
What do learners do in a POGIL activity?

- Answer questions where you don’t know the answer.
- Questions are connected —> trail of thinking.
- Checkpoints at important points in thought process.
- Exploring, making predictions and making own understanding.
- Communicating with groups.
- Dependent on each other.
- Might disengage —> strategies?
- Nice to discuss how we got to answers.
- Verbalize.
- Come to consensus.
- Formed and tested models, test hypotheses, collaborative discussions.
Compare the learning tasks in a POGIL activity to the learning tasks in a lecture.

- More discussion of fewer topics.
- Active learning rather than passive listening.
- Each student had a role.
- More active and engaging. Student centered. Requires TIME for each topic.
- Different perspectives on an idea rather than only the professor’s.
- As a student, in both lectures and POGIL activity, students look for cues of what is important vs unimportant. (What is on exam?)
Vs. Lecture

- Self taught
- Problem solving in class vs. listen and at home work
- Easier to keep up
  - Communicate with peers if miss something
  - Start easy → hard
- Interactive/engaging
- More collaboration
- More application
- Sense of discovery
- Churning mental machinery in class
ADV
Learn multiple approaches
More engaging
Develop working relationship with class leader
Material more easily learned (forced to explain to others)
Forced interaction w/ students (peers)
Pace is slower

DIS
Pace is slower
Requires certain class size
Harder to study from notes
Depends on peers/group dynamics

Don't feel ashamed to ask questions / not know
Prof knows each student (not just tests)
Easier to ask Qs
Relationships w/ peers
not/less competition/hostility
What is the role of the teacher in a POGIL activity?

- Keeps students out of holes. Gets students unstuck.
- Facilitates discussion. Offers structure and guidance.
- Predicts trouble and student responses (right and wrong).
- Visit groups —> keeps students on track.
- Provide context for what we work on.
- Kept us on time —> moving forward.
Innovations

- Visual summaries (course roadmaps)
- Integrated computer activities that run on smart-phones, tablets, and laptops linked with QR-codes.
  - simulations
  - videos
  - interactive mathematics
Thermodynamics Statistical Mechanics

Fundamental questions
• When substances are mixed, will they react?
• If a reaction occurs, how much energy will be released?
• If a reaction begins, when will it stop and equilibrium be reached?
• If a reaction can occur, how fast will it happen?

Energy

Enthalpy H
Free energies G and A

Internal energy U
Entropy S

verified facts and theoretical understanding generate solutions to hard problems

The eyes of a thermodynamicist:
• Separation of system and bath
• Work on system vs. on surroundings
• Reversible and irreversible processes
• Adiabatic vs. isothermal (heat flow)
• Closed vs. open (mass flow)
• How does energy flow, change, and degrade?

Eyes of a statistical mechanic:
• Ensembles – microcanonical, canonical, grand canonical
• Molecular descriptions to calculate Q
• From Q calculate thermodynamics
• From individual particles to collective behavior

Eyes of a dynamicist:
• How fast does a transformation occur?
• Interplay of rate and mechanism
• Kinetic vs thermodynamic products
• Activation energy and transition state

Laws of Thermodynamics

0. Thermal equilibrium
1. Conservation of Energy
\[ \Delta U = q + w \]
2. Entropy increases
\[ \Delta S_{\text{sys}} \geq 0 \]
\[ dS = \frac{dq_{\text{sys}}}{T} \]
3. Absolute entropy
\[ S = 0 \text{ when } T = 0 \]

Entropy — Probability
\[ S = k \ln W \]

Approach to equilibrium

Predict the direction of flow of
• Heat (thermal equilibrium)
• Work (mechanical equilibrium)
• Particles (chemical equilibrium)

Potential energy
Chemical energy

Maxwell-Boltzmann distribution

\[ \text{Maxwell relations} \]
\[ U = U - TS \]
\[ A = -\frac{\partial U}{\partial T} \]
\[ G = U + PV - TS \]

Legendre transformations
\[ U \]
\[ H = U + PV \]
\[ A = U - TS \]

Cyclic rule
\[ \frac{\partial f(x, y)}{\partial y} x + \frac{\partial f(x, y)}{\partial x} y - \frac{\partial f(x, y)}{\partial y} x = \frac{\partial f(x, y)}{\partial x} y \]

Partial derivatives of state functions
\[ \left( \frac{\partial f(x, y)}{\partial y} \right)_x \]
\[ \left( \frac{\partial f(x, y)}{\partial x} \right)_y \]

Thermodynamics Statistical Mechanics and Kinetics

Empirical rules from macroscopic observations

Molecular descriptions to macroscopic properties

Approach to equilibrium

\[ \text{Rates of change!} \]
\[ \frac{\partial Q}{\partial T} = \frac{\partial P}{\partial S} \]

Molecular descriptions

\[ S = S_A + S_B \]
\[ dS = dS_A + dS_B \]
\[ N_A + N_B = \text{const} \]
\[ dN = dN_A + dN_B \]

Species A
Species B

Species A
Species B

\[ \Delta G = \Delta H - T \Delta S \]

\[ \Delta G^\ddagger = \Delta G_{\text{sys}} \]
\[ k = A e^{-\Delta G^\ddagger / k_B T} \]

\[ k_{\text{eq}} = \frac{k_f}{k_r} \]

\[ \text{Arrhenius expression} \]

Dynamic equilibrium

kinetic schemes

\[ A = k_B T \ln Q \]

\[ A = 0 \]

\[ k_B T \ln \frac{Q}{N_A N_B} \]

\[ k_B T \ln Q \]

\[ k_B T \ln \frac{Q}{N_A N_B} \]

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Entropy of mixing part 3

The models we were just working with are extreme simplifications. One thing that they neglect is the empty space around the particles. Let's calculate the effect a more detailed model has on the change in entropy for the mixing process.

If you have a box of 4 black balls and 4 white balls as before, but now you also have 100 slots on the left and right sides of the box:

A) If the black and white start separated, and then you mix them up, what do you expect the most probable state to look like?

b)

Brownian motion
Heat transport
Structure of liquids
New types of models based on interactive mathematics platforms (MathStudio / Mathematica / Geogebra)

```plaintext
1 Slider(m,1,53,1,5)
2 maxy=Binomial(m,m/2);
3 Plot(Binomial(m,m*n),n=[0,1],y=[-0.2*maxy,1.2*maxy],max=1)
```

http://mathstud.io/gCbmF3
New types of models based on interactive mathematics platforms (MathStudio / Mathematica / Geogebra)

In[3]:= Manipulate[
    Block[{},
    y = Table[Binomial[n, k], {k, 0, n} ];
    ListPlot[y]
    ],
    {n, 1, 53, 1}
]
I employed multiple assessment strategies in parallel.

- Qualitative impressions
- Attitude survey (ASCI v2)
- Student Assessment of Learning Gains (SALG)
- Focus Groups
- OMETs
Pre-post ASCI v2 survey showed no effect.

ASCI (V2) Attitude assessment

Refinement of a Chemistry Attitude Measure for College Students

Xiaoying Xu and Jennifer E. Lewis

Department of Chemistry, University of South Florida, Tampa, Florida 33620, United States


DOI: 10.1021/ed900071q

Publication Date (Web): March 18, 2011
### Class Activities

6. **HOW MUCH** did each of the following aspects of the class **HELP YOUR LEARNING?**

<table>
<thead>
<tr>
<th>Activity</th>
<th>No Help</th>
<th>A Little Help</th>
<th>Moderate Help</th>
<th>Much Help</th>
<th>Great Help</th>
<th>Not Applicable</th>
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<td>6.1 Daily topic introductions and recaps</td>
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<td>6.2 Participating in discussions during class</td>
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<td>6.3 Listening to discussions during class</td>
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<td>6.4 Participating in group work during class</td>
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<td>6.5 Doing hands-on classroom activities</td>
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<td>6.6 Specific Class Activities</td>
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<td>6.6.1 Rubberband activity</td>
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<td>6.6.2 Relationship of kinetic energy and temperature simulation</td>
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<td>6.6.3 Heat flow activity</td>
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6.7 Please comment on how the **CLASS ACTIVITIES** helped your learning.

6.8 Please comment on **HOW OFTEN YOU PARTICIPATED** in class discussions and **HOW THE ATMOSPHERE IN THE CLASSROOM ENCOURAGED OR DISCOURAGED** your participation.
## Assignments, graded activities and tests

7. **HOW MUCH** did each of the following aspects of the class HELP YOUR LEARNING?

### 7.1 Graded assignments (overall) in this class

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<tr>
<th>No help</th>
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### 7.2 Opportunities for in-class review

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### 7.3 The fit between class content and tests

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### 7.4 The mental stretch required by tests

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### 7.5 The way the grading system helped me understand what I needed to work on

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### 7.6 The feedback or my work received after tests or assignments

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### 7.7 Please comment on how the GRADED ACTIVITIES AND TESTS helped your learning.

[Blank]

## Class Resources

8. **HOW MUCH** did each of the following aspects of the class HELP YOUR LEARNING?

### 8.1 The primary textbook

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<th>No help</th>
<th>A little help</th>
<th>Moderate help</th>
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### 8.2 The worksheets

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### 8.3 Please comment on how the RESOURCES in this class helped your learning.

[Blank]
### Class impact on your attitudes

3. As a result of your work in this class, what GAINS DID YOU MAKE in the following?

<table>
<thead>
<tr>
<th>3.1 Enthusiasm for chemistry in general</th>
<th>no gains</th>
<th>a little gain</th>
<th>moderate gain</th>
<th>good gain</th>
<th>great gain</th>
<th>not applicable</th>
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<tr>
<td>3.2 Enthusiasm for physical chemistry</td>
<td>no gains</td>
<td>a little gain</td>
<td>moderate gain</td>
<td>good gain</td>
<td>great gain</td>
<td>not applicable</td>
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<td>3.3 Interest in discussing the subject area with friends or family</td>
<td>no gains</td>
<td>a little gain</td>
<td>moderate gain</td>
<td>good gain</td>
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<td>3.4 Interest in taking or planning to take additional classes in this subject</td>
<td>no gains</td>
<td>a little gain</td>
<td>moderate gain</td>
<td>good gain</td>
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<td>3.5 Confidence that you understand the material</td>
<td>no gains</td>
<td>a little gain</td>
<td>moderate gain</td>
<td>good gain</td>
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<td>3.6 Confidence that you can do this subject area</td>
<td>no gains</td>
<td>a little gain</td>
<td>moderate gain</td>
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<td>not applicable</td>
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<td>3.7 Your comfort level in working with complex ideas</td>
<td>no gains</td>
<td>a little gain</td>
<td>moderate gain</td>
<td>good gain</td>
<td>great gain</td>
<td>not applicable</td>
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<td>3.8 Willingness to seek help from others (teacher, peers, TA) when working on academic problems</td>
<td>no gains</td>
<td>a little gain</td>
<td>moderate gain</td>
<td>good gain</td>
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<td>3.9 Please comment on how has this class CHANGED YOUR ATTITUDES toward this subject</td>
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Add sub question

Your understanding of class content

1. As a result of your work in this class, what GAINS DID YOU MAKE in your UNDERSTANDING of each of the following?

1.1 The main concepts explored in this class

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1.2 The relationships between the main concepts

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1.3 The following concepts that have been explored in this class

1.3.1 Multiplicities, entropy, and the approach to equilibrium

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1.3.2 The second law of thermodynamics

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1.3.3 The dynamical basis of equilibrium

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1.4 How ideas from this class relate to ideas encountered in other classes within this subject area

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1.5 How studying this subject area helps people address real world issues

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1.6 Please comment on HOW YOUR UNDERSTANDING OF THE SUBJECT HAS CHANGED as a result of this class.

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1.7 Please comment on how THE WAY THIS CLASS WAS TAUGHT helps you REMEMBER key ideas.

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### The information you were given

9. **How much** did each of the following aspects of the class help your learning?

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<th>great help</th>
<th>not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1 Explanation of how the class activities, reading and assignments related to each other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.2 Explanation given by instructor of how to learn or study the materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.3 Explanation of why the class focused on the topics presented</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9.4 Please comment on **how** the information you received about the class helped your learning.

### Support for you as an individual learner

10. **How much** did each of the following aspects of the class help your learning?

<table>
<thead>
<tr>
<th></th>
<th>no help</th>
<th>a little help</th>
<th>moderate help</th>
<th>much help</th>
<th>great help</th>
<th>not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1 Interacting with the instructor during class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.2 Interacting with the instructor during office hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.3 Working with teaching assistants outside of class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.4 Working with peers during class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.5 Working with peers outside of class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10.5 Please comment on **how** the support you received from others helped your learning in this class.
### Integration of your learning

4. As a result of your work in this class, what GAINS DID YOU MAKE in INTEGRATING the following?

<table>
<thead>
<tr>
<th>4.1 Connecting key class ideas with other knowledge</th>
<th>no gains</th>
<th>a little gain</th>
<th>moderate gain</th>
<th>good gain</th>
<th>great gain</th>
<th>not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>4.2 Applying what I learned in this class in other situations</th>
<th>no gains</th>
<th>a little gain</th>
<th>moderate gain</th>
<th>good gain</th>
<th>great gain</th>
<th>not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>4.3 Using systematic reasoning in my approach to problems</th>
<th>no gains</th>
<th>a little gain</th>
<th>moderate gain</th>
<th>good gain</th>
<th>great gain</th>
<th>not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>4.4 Using a critical approach in analyzing data and arguments in my daily life</th>
<th>no gains</th>
<th>a little gain</th>
<th>moderate gain</th>
<th>good gain</th>
<th>great gain</th>
<th>not applicable</th>
</tr>
</thead>
</table>

| 4.5 What will you CARRY WITH YOU into other classes or other aspects of your life? | input box |

### The Class Overall

5. HOW MUCH did the following aspects of the class HELP YOUR LEARNING?

<table>
<thead>
<tr>
<th>5.1 The instructional approach taken in this class</th>
<th>no help</th>
<th>a little help</th>
<th>moderate help</th>
<th>much help</th>
<th>great help</th>
<th>not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>5.2 How the class topics, activities, reading and assignments fit together</th>
<th>no help</th>
<th>a little help</th>
<th>moderate help</th>
<th>much help</th>
<th>great help</th>
<th>not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>5.3 The pace of the class</th>
<th>no help</th>
<th>a little help</th>
<th>moderate help</th>
<th>much help</th>
<th>great help</th>
<th>not applicable</th>
</tr>
</thead>
</table>

| 5.4 Please comment on how the INSTRUCTIONAL APPROACH to this class helped your learning. | input box |

| 5.5 How has this class CHANGED THE WAYS YOU LEARN/STUDY? | input box |
## Increases in your skills

2. As a result of your work in this class, what GAINS DID YOU MAKE in the following SKILLS?

### 2.1 Performing a mathematical proof
- no gains
- a little gain
- moderate gain
- good gain
- great gain
- not applicable

### 2.2 Developing a logical argument
- no gains
- a little gain
- moderate gain
- good gain
- great gain
- not applicable

### 2.3 Working effectively with others
- no gains
- a little gain
- moderate gain
- good gain
- great gain
- not applicable

### 2.4 Explaining the meaning of temperature
- no gains
- a little gain
- moderate gain
- good gain
- great gain
- not applicable

### 2.5 Explain the relationship of dynamics, probabilities, and thermodynamic quantities
- no gains
- a little gain
- moderate gain
- good gain
- great gain
- not applicable

2.6 Please comment on what SKILLS you have gained as a result of this class.
<table>
<thead>
<tr>
<th>1. What GAINS DID YOU MAKE in your UNDERSTANDING of each of the following?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The main concepts explored in this class</td>
</tr>
<tr>
<td>The following concepts that have been explored in this class</td>
</tr>
<tr>
<td>Multiplicities, entropy, and the approach to equilibrium</td>
</tr>
<tr>
<td>The second law of thermodynamics</td>
</tr>
<tr>
<td>The dynamical basis of equilibrium</td>
</tr>
<tr>
<td>The meaning of temperature</td>
</tr>
<tr>
<td>The origin of macroscopic laws from microscopic properties</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. What GAINS DID YOU MAKE in the following SKILLS?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derive the fundamental equations of physical chemistry</td>
</tr>
<tr>
<td>Work effectively with others</td>
</tr>
<tr>
<td>Solve problems independently</td>
</tr>
<tr>
<td>3. What GAINS DID YOU MAKE in the following?</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Build a hypothesis (or premise), investigate it, and reach your own conclusions</td>
</tr>
<tr>
<td>Connect representations of physical chemistry: molecular, macroscopic, and mathematical</td>
</tr>
<tr>
<td>Seeing connections between mathematical reasoning and fundamental concepts in chemistry</td>
</tr>
<tr>
<td>Seeing that there can be multiple valid approaches to solve a complex problem</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. HOW MUCH did the following aspects of the class HELP YOUR LEARNING?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The instructional approach taken in this class</td>
</tr>
<tr>
<td>How the class topics, activities, reading and assignments fit together</td>
</tr>
<tr>
<td>The pace of the class</td>
</tr>
</tbody>
</table>
### 6. HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily topic introductions and recaps by the instructor</td>
<td>4.5</td>
</tr>
<tr>
<td>Doing hands-on classroom activities</td>
<td>4.9</td>
</tr>
<tr>
<td>Participating in small group discussions during class</td>
<td>4.8</td>
</tr>
<tr>
<td>Participating in whole class discussions during class</td>
<td>5.0</td>
</tr>
<tr>
<td>Listening to whole class discussions during class</td>
<td>5.0</td>
</tr>
</tbody>
</table>

### 7. HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graded assignments (overall) in this class</td>
<td>3.9</td>
</tr>
<tr>
<td>The feedback on my work received after tests or assignments</td>
<td>4.0</td>
</tr>
</tbody>
</table>
8. HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Help Your Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>The in-class activities (worksheets / packets)</td>
<td>4.9</td>
</tr>
<tr>
<td>The primary textbook</td>
<td>3.1</td>
</tr>
<tr>
<td>The homework</td>
<td>4.3</td>
</tr>
</tbody>
</table>

10. HOW MUCH did each of the following aspects of the class HELP YOUR LEARNING?

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Help Your Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interacting with the instructor during class</td>
<td>4.9</td>
</tr>
<tr>
<td>Interacting with the instructor outside of class</td>
<td>5.0</td>
</tr>
<tr>
<td>Working with teaching assistants outside of class (n=1)</td>
<td>5.0</td>
</tr>
<tr>
<td>Working with peers during class</td>
<td>4.7</td>
</tr>
<tr>
<td>Working with peers outside of class</td>
<td>4.3</td>
</tr>
</tbody>
</table>
Problem-solving gains

2.4 The way the class was presented at first seemed to be very difficult but in the end it helped me greatly in the way I looked at a problem at hand or the way I looked at a system as a whole. I learned to apply ideas that may not seem to be connected together to generate the correct solutions.

This class really helped **to improve my ability to think through the material on my own** and with classmates as opposed to feeling the need to wait to be taught by a lecturer.

4.2 I think I **approach complex problems more confidently**, am more patient in the process of solving problems. I am not as hesitant to express my thoughts. I think about things more critically and **constantly look for connections**.

Not just looking at a problem that I might come across as having one solution or one approach. This class opened up the way that looked at the problems at hand and I was really able to explore the huge amount of variation in the "out of the box" thinking method. Seeing things from a very different viewpoint really helped me truly understand and breakdown tough and or weird problems.

I think I will be **better prepared to analyze a situation and logically determine the best course of action or propose a good solution to a problem**.

The open discussion in the classroom definitely **opened me up to others ideas** and made me for accepting and interested in others opinions and thought processes.
Critical thinking gains

4.2 What will you CARRY WITH YOU into other classes or other aspects of your life?

Being able to admit that I don't know what's going on; being quick to ask for someone to explain something to me; being quick to help others when they need a nudge.

I think I approach complex problems more confidently, am more patient in the process of solving problems. I am not as hesitant to express my thoughts. I think about things more critically and constantly look for connections.

Not just looking at a problem that I might come across as having one solution or one approach. This class opened up the way that looked at the problems at hand and I was really able to explore the huge amount of variation in the "out of the box" thinking method. Seeing things from a very different viewpoint really helped me truly understand and breakdown tough and or weird problems.

I think I will be better prepared to analyze a situation and logically determine the best course of action or propose a good solution to a problem.

The open discussion in the classroom definitely opened me up to others ideas and made me for accepting and interested in others opinions and thought processes.
Teamwork gains

2.4 Please comment on what SKILLS you have gained as a result of this class.

This class really helped to improve my ability to think through the material on my own and with classmates as opposed to feeling the need to wait to be taught by a lecturer.

I am better prepared to work with colleagues and to think on my feet/work in an interactive setting.

6.7 Please comment on HOW OFTEN YOU PARTICIPATED in class discussions and HOW THE ATMOSPHERE IN THE CLASSROOM ENCOURAGED OR DISCOURAGED your participation.

Everyday most of the class was presenting idea to the entire class and as we worked in small groups everyday we were able to talk and brainstorm idea/ information for almost the entire class period. Very helpful in building skills of team work and sharing of information with different sized groups of people.
10.6 Please comment on how the SUPPORT YOU RECEIVED FROM OTHERS helped your learning in this class.

Being able to talk and bounce ideas off other people from class was one of the most helpful parts of the class. The material presented in the class is difficult and hard to get a hold of but once you or someone else does get it, it forces you to become the teacher or learn in a different fashion. Because the class was based around the idea of group learning, asking questions to others in the class was easy and this pushed the environment of learning forward like no other class I have taken. This class formed very close connections with the people in the class and this was a huge factor in the way information was taken in and understood. Having that great deal of support from others within the class allowed for people to not fall behind like they might in another class that wasn't was closely formed and connected. I think that having the class designed in this fashion pushes the people taking it to become closer and this just reinforces the environment of learning that is taking place.
Communication gains

2.4 I think it helped me contribute to discussion more, be more social with classmates, apply math to chemistry better, communicate science better,

4.2 Being able to admit that I don't know what's going on; being quick to ask for someone to explain something to me; being quick to help others when they need a nudge

6.7 I think the most noteworthy part of the class activities is that there was always a lively combination of having problems explained to me by a group member or Sean, explaining problems myself to other group members or to the whole class, and working together with group members to solve problems at the same time.

Taught me how to learn from other people and admit to needing help. On the flip side it helped me be more open to helping others and improved my teaching abilities.

Everyday most of the class was presenting idea to the entire class and as we worked in small groups everyday we were able to talk and brainstorm idea/ information for almost the entire class period. Very helpful in building skills of team work and sharing of information with different sized groups of people.
Focus groups highlight some positives:

- Weak students like the approach
- Strong students like the approach
- I like the approach
- Room is effective for supporting group interactions
- Students engage the material
- Pacing of material is not too fast or too slow
- Book supports in-class material
Focus groups were extremely informative and helpful.

- Students have strong opinions about “form factor”. They prefer rooms to lecture halls, prefer tables to desks, prefer chairs to stools.

- Students prefer 75 min sessions. “The 50 minutes goes by so fast.”

- Students always comment on how much the group-work is helpful. Most students prefer stable groups for the semester (but not unanimously).

- Students suggest even more effort on summary sections.

- Students like computer activities but these are secondary to the overall format of the class.
We are using the newly renovated “active learning” classroom in David Lawrence Hall and a lecture hall.

Groups of 3-4 work at tables
Wrap around white boards
Projector sharing technology

Recitation is in a traditional lecture hall (seats 150)
Room is effective in aiding student learning

1. Tables allow easy discussion
2. White boards allow parallel reporting

Lesson: Renovate a room in Chemistry Department?
The projector sharing technology is not effective for this use scenario.
Areas to improve

• Peer learning makes students uncomfortable with their own authority.

• End of section summaries. Need to focus on higher level thinking and analysis.

• Efficiency.
Focus group problem: “Not sure what to focus on”

At the end of a series of POGIL activities, students sometimes felt “lost” in the ideas. They were not sure what the most important idea was.

Solution: Summary quiz

The Laws of Thermodynamics Spring 2016

10. Summary

(a) The total differential of the internal energy, in terms of occupation numbers and energy levels, is
   A. \( \sum E_i \, da_i + (a_i + da_i) \, dE_i \)   B. \( \sum E_i \, da_i + a_i \, dE_i \)   C. \( \sum da_i \, dE_i \)

(b) The term \( \sum a_i \, dE_i \) in the total differential of \( U \) corresponds to
   A. work   B. heat   C. power

(c) The term \( \sum E_i \, da_i \) in the total differential of \( U \) corresponds to
   A. work   B. heat   C. power

(d) Restate the first law of thermodynamics in your own words.
Students still want the “correct” answers to the activities...

- It would be great if there would be summary handout with sort of answers to activity package after it finishes.

- I think that uploading the packets with answers after we have finished them would be helpful just because sometimes we don't go over every single little things and I would have one of those wrong and not understand how to solve the problem in the end.
Future

• Developing new material for Physical Chemistry 1 Introduction to Quantum Mechanics

• Participating in the POGIL Project working group “Framework for New Materials”

• Activities contributed to a new POGIL Physical Chemistry textbook with Shepherd (St. Edwards) and Grushow (Rider)
Advice
Thanks
Assessment strategy

- **Assessment of learning**
  - Self assessment
    - Questionnaire based on “Student assessment of learning gains” ([www.salgsite.org](http://www.salgsite.org)). (Understanding, Activities, Integration of learning, increases in skills, etc)
  - Performance data
    - 1 Minute papers to express understanding of topics. For example: “Explain in your own words, figures, and equations, the approach to equilibrium and the changes in the relevant thermodynamic variables.”
    - Tentative Exam questions for parallel content in two sections.

- **Assessment of attitudes**
  - Pre/post course attitude survey ASCI (V2)
  - SALG questionnaire (attitude section)
  - Focus groups (based on David Nero’s model)