A Hybrid Classroom Model for Chemistry 103 and the Achievement Gap

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Drivers for Reform at UW

- Address apparent achievement gaps
- Increase fraction of students successfully completing the course
- Increase fraction of students choosing to take second semester of two semester Chemistry sequence
- Increase mastery of all aspects of Chemistry proficiency
- Make teaching exciting
Some history

- UW-Madison and other institutions engage in “New Traditions” Chemistry reform effort in 1996-2001, Clark Landis, John Wright, and John Moore, PIs

- UW-Oshkosh achievement gap data presented in 2006-2007

- UW-Madison compiles similar data in 2008 (next slide)

- Aaron Brower invites Chemistry Faculty to consider reforms to Chem 103 to address achievement gap in 2009
Students across the range of ACT scores show the gap in adverse outcome rates.

For math courses, students are enrolling in courses according to the placement test recommendations.
Courses Enrolling At Least 100 Targeted Minority Undergraduates in Fall 2005, 2006 and 2007 Combined (N=43 courses)

Equality of Targeted and Non-Targeted Rates

Average for these courses

Math 221
• Chemistry Achievement Gap
General Chemistry Enrollment at Wisconsin is Growing
<table>
<thead>
<tr>
<th>Key Findings</th>
<th>Brower Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>• “Targeted” minority students twice as likely to have D’s, F’s or drops</td>
<td>• We started experiments in 7 courses in 5 departments</td>
</tr>
<tr>
<td>than other students (same ACTs)</td>
<td>• <strong>Comprehensive</strong> course reform using best teaching practices (“rising tide lifts all boats”)</td>
</tr>
<tr>
<td>• Especially true in quantitatively oriented intro/gateway courses</td>
<td></td>
</tr>
<tr>
<td>(Chemistry, Calculus, Psychology, Physics, etc.)</td>
<td></td>
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</tbody>
</table>
Comprehensive course reform using “best practices” to increase engagement & active learning

- **Elements that make a difference:**
  - Engaging students in Big Questions
  - Experiences that integrate learning in and out of classroom
  - High challenge coupled with high support
  - Frequent interaction among student, faculty/staff, curricular material

- **5 best practices of teaching:**
  - Learning in context
  - Group-based learning
  - Increased time on task
  - Increased frequency of feedback
  - Positive classroom climate

Many Instructional Degrees of Freedom Exist

- Clickers/Concept Tests (eric-mazur-confessions-of-a-converted-lecturer)
- Traditional Lectures (Passive Learning?)
- On-line homework
- Tutorials
- Video and Simulators (PHET)
- Demonstrations
- Group learning
- PLTL (Peer lead – teaching learning, David Gosser, Jack Kampmeier, etc.)
- Peer review (grading written assignments)
- Thematic learning (Angie Stacy, Jim Anderson)
- Spiral Curricula
- Inquiry based cooperative learning (Rick Moog and Jim Spencer)
- Flipping the classroom
Chemistry 103 at UW-Madison

- 6 Lecture Sections in Fall each with 300-350 students, 6 Lecturers, 48 TAs
- Three lectures/week, 2 discussion sections, laboratory averages 2 hours per week.
- All lecture sections use same book but exams are not common and pace varies some. Coverage is similar.
- Most sections use Learn@UW as main portal
Design of Reform Chemistry 103

- Promote active learning in large lecture section through ConcepTests, Clickers, Group Discussion
- “Inquiry-based” cooperative learning activities used in discussion sections (ca. 30 minutes/week)
- Required On-line homework & Tutorials (Smartworks & Mastering Chemistry)
- Regular Group-oriented Challenge Problems
- Evening workshop sessions (voluntary, students must work in groups)
- Experiment with Social-Psychological Interventions
## Scope of Study

<table>
<thead>
<tr>
<th></th>
<th>Fall 2009</th>
<th>Spring 2010</th>
<th>Fall 2010</th>
<th>Spring 2011</th>
<th>Number of students included to date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Course-Reform Sections</strong></td>
<td>1 section team taught</td>
<td>1 section team taught</td>
<td>3 sections (1 section partially implemented)</td>
<td>1 section</td>
<td>Targeted 189, Non-targeted 1680</td>
</tr>
<tr>
<td><strong>Traditional sections for comparison</strong></td>
<td>1 section</td>
<td>1 section</td>
<td>3 sections</td>
<td>1 section</td>
<td>170, 1333</td>
</tr>
</tbody>
</table>
Assessment Elements

- Grades, retention in Reform and Traditional sections
- Six common questions in final exam
- One common essay question
- Student surveys of hours spent outside of class, course perceptions, etc. (Colorado Learning Attitudes about Science Survey (CLASS; www.colorado.edu/sei/class/) and one we developed based on the Student Assessment of Learning Gains project (http://www.salgsite.org/))
- Achievement gap (gender-based and targeted groups)

Seymour, Wiese, Hunter, & Daffinrud, 2000
Reform Did NOT affect:

- The achievement gap for targeted students
- The fraction of adverse outcomes (D/F/drop)
- Performance on final exam common questions
- Performance on common essay question
Common Exam Questions Reveal No Differences (Reform vs. Traditional)

<table>
<thead>
<tr>
<th></th>
<th>Conceptual common questions (out of 3)</th>
<th>Algorithmic common questions (out of 3)</th>
<th>Atomic-molecular perspective (means of three questions; out of 5; 1=strongly disagree with expert, 5=strongly agree with expert)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reform</td>
<td>1.64* (0.8), N=1012</td>
<td>1.71* (0.8), N=1012</td>
<td>“I think about how the atoms are arranged in a molecule to help my understanding of its behavior in chemical reactions.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- “When I see a chemical formula, I try to picture how the atoms are arranged and connected.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- “To understand a chemical reaction, I think about the interactions between atoms and molecules.”</td>
</tr>
<tr>
<td>Traditional</td>
<td>1.71 (0.9), N=806</td>
<td>1.64 (1.2), N=806</td>
<td>3.29*** (.8), N=977</td>
</tr>
</tbody>
</table>

Results of t-test:*p<0.2, ***p<0.01. SD shown in parenthesis
## Outcomes and Assessment

<table>
<thead>
<tr>
<th>Lecture Section</th>
<th>Reform-oriented instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture 1 (Landis)</td>
<td>Yes</td>
</tr>
<tr>
<td>Lecture 2 (Landis)</td>
<td>Yes</td>
</tr>
<tr>
<td>Lecture 5 (Sibert)</td>
<td>Yes</td>
</tr>
<tr>
<td>Lecture 3 (Martin)</td>
<td>No</td>
</tr>
<tr>
<td>Lecture 4 (Hutchison)</td>
<td>No</td>
</tr>
<tr>
<td>Lecture 6 (Nutbrown)</td>
<td>No</td>
</tr>
</tbody>
</table>

- Embedded final exam questions.
- Short questions
- Surveys
Students in Reform Sections Perceive Greater Emphasis on Collaborative and Conceptual Learning

<table>
<thead>
<tr>
<th></th>
<th>Perceived emphasis on collaborative learning (out of 7; 1=completely disagree, 7=completely agree)</th>
<th>Perceived emphasis on conceptual learning (out of 7; 1=completely disagree, 7=completely agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reform</td>
<td>6.1*** (1.0), N=879</td>
<td>5.8*** (1.0), N=879</td>
</tr>
<tr>
<td>Traditional</td>
<td>4.9 (1.4), N=707</td>
<td>5.6 (1.1), N=707</td>
</tr>
</tbody>
</table>

Results of t-test: ***p<0.01. SD shown in parenthesis.
Reform Students Worked and Discussed More Outside of Class

**Worked with classmates outside of class to prepare class assignments or to study for quizzes/exams**

- Reform: 198 always, 319 very often, 212 often, 159 sometimes, 61 never
- Non-Reform: 47 always, 234 very often, 385 often, 214 sometimes, 214 never

**Discussed ideas from the course material with others outside of class (students, family members, co-workers, etc.)**

- Reform: 119 always, 208 very often, 240 often, 276 sometimes, 100 never
- Non-Reform: 66 always, 214 very often, 310 often, 403 sometimes, 107 never
Students Relate Chemistry More to Daily Life and Are More Confident in Problem Solving

<table>
<thead>
<tr>
<th>Communication skills based on essay question (out of 10)</th>
<th>Personal meaning making (means of 4 questions; out of 5; 1=strongly disagree with expert, 5=strongly agree with expert)</th>
<th>Problem-solving approach (means of three questions; out of 5; 1=strongly disagree with expert, 5=strongly agree with expert)</th>
<th>Hours studied outside of class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref.</td>
<td>I think about the chemistry I experience in everyday life.</td>
<td>When I’m solving chemistry problems, I often don’t really understand what I am doing.</td>
<td>6.93** (4.2), N=970</td>
</tr>
<tr>
<td></td>
<td>Learning chemistry changes my ideas about how the world works.</td>
<td>In learning chemistry, I usually memorize reactions rather than make sense of the underlying physical concepts.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To understand chemistry, I sometimes think about my personal experiences and relate them to the topic being analyzed.</td>
<td>A significant problem in learning chemistry is being able to memorize all the information I need to know.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I study chemistry to learn knowledge that will be useful in my life outside of school.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.78 (1.5), N=917</td>
<td>2.37* (0.9), N=977</td>
<td></td>
</tr>
<tr>
<td>Trad.</td>
<td>8.79 (1.5), N=739</td>
<td>2.43 (0.9), N=765</td>
<td>6.52 (4.3), N=760</td>
</tr>
<tr>
<td></td>
<td>3.09 (0.8), N=765</td>
<td>3.22*** (0.8), N=977</td>
<td></td>
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</tbody>
</table>

Results of t-test:*p<0.2, **p<0.5, ***p<0.01. SD shown in parenthesis
Conceptual Question

A student observes a temperature increase of $\Delta T_1$ when she mixes 100 mL of a 1.0 M solution of HCl with 100 mL of a 1.0 M solution of NaOH in a calorimeter. She then conducts a second experiment by mixing 100 mL of 1.0 M HCl with 300 mL of 1.0 M NaOH and observes a temperature change of $\Delta T_2$. Which choice below best describes the relationship between $\Delta T_1$ and $\Delta T_2$?

a) $\Delta T_2$ is the same as $\Delta T_1$

b) $\Delta T_2$ is greater than $\Delta T_1$

c) $\Delta T_2$ is less than $\Delta T_1$

d) Not enough information is given to determine the relationship.

Algorithmic Question

NH$_4$NO$_3$ absorbs 25.69 kJ of heat per mole when dissolved in water. In a coffee-cup calorimeter, 3.40 g NH$_4$NO$_3$ is dissolved in 100.0 g of water at 21.0 °C. What is the final temperature of the solution? Assume that the solution has a specific heat capacity of 4.18 J/g·K.

a) 0.0 °C  b) 18.5 °C  c) 20.2 °C  d) 21.0 °C  e) 23.5 °C
Reform Did NOT affect:

- The achievement gap for targeted students
- The fraction of adverse outcomes (D/F/drop)
- Performance on final exam common questions
- Performance on common essay question
Should we evaluate performance differently?

A Novel Strategy for Assessing the Effects of Curriculum Reform on Student Competence

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Active Learning: Wright Study

- 2 Lecture sections of Chem 110: one Structured Active Learning (SAL) and one Responsive Lecture (RL)
- Similar class sizes, grade distributions, instructor ratings, etc.
- 25 assessors gave 30 minute oral exams to groups of about 8 students, 4 from each section, paired by similar course grade
- Assessors force-ranked students in evaluation group
Figure 1. The bars show the difference in student ranks, for each assessor, between SAL and RL students. The letters above the bars indicate the octile of students that the assessor interviewed, A being the lowest and H the highest octile. The numbers below the bars indicate the classification of the criterion used by the assessor according to the code indicated in the figure.
Additional Studies

Psychological Interventions

- UV
- VA
Psychological Interventions
Value Added (VA) vs Utility Value (UV)

It is often hard for students to see value or the connection between course material and their lives outside of the classroom, especially in subjects such as mathematics ... Tasks that benefit everyday activities or have relevance for a learner’s future are high in utility value. Research has shown that perceptions of value are associated with a wide range of positive motivational outcomes such as performance, interest, and course enrollment decisions. Harackiewicz et al. [PERS. AND SOC. PSYC. BULL. 37, 303 (2011)].

Values affirmation, in which people reflect on self-defining values, can buffer people against such psychological threat. When they affirm their core values in a threatening environment, people reestablish a perception of personal integrity and worth, which in turn can provide them with the internal resources needed for coping effectively. Indeed, lab studies show that such affirmations lessen evaluative stress and improve the performance of stereotype threatened individuals. Miyaki et al. [Science 330, 1234 (2010)]
<table>
<thead>
<tr>
<th>Lecture Section</th>
<th>Reform-oriented instruction</th>
<th>Values Affirmation Exercise (VA)</th>
<th>Utility Value Exercise (UV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture 1 (Landis)</td>
<td>Yes</td>
<td></td>
<td>Randomly assigned to treatment-treatment, treatment-control, or control-control groups</td>
</tr>
<tr>
<td>Lecture 2 (Landis)</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture 5 (Sibert)</td>
<td>Yes</td>
<td>Randomly assigned to treatment-treatment or control-control groups</td>
<td></td>
</tr>
<tr>
<td>Lecture 3 (Martin)</td>
<td>No</td>
<td></td>
<td>No UV exercise</td>
</tr>
<tr>
<td>Lecture 4 (Hutchison)</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture 6 (Nutbrown)</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## UV and VA Results

<table>
<thead>
<tr>
<th>No VA</th>
<th>No UV</th>
<th>UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>3.22</td>
<td>3.20</td>
</tr>
<tr>
<td>Female</td>
<td>3.01</td>
<td>3.11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VA</th>
<th>No UV</th>
<th>UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>3.19</td>
<td>3.16</td>
</tr>
<tr>
<td>Female</td>
<td>2.73</td>
<td>3.03</td>
</tr>
</tbody>
</table>
Summary

Adapting classes to better incorporate five best practices

• Does not show significant influence on achievement gaps or frequency of adverse outcomes

• Does influence time spent on class material, student attendance, perceptions of chemistry

Is value-added that we don’t capture in standard exams?

Thanks to Ned Sibert, Aaron Brower, and Shusaku Horibe.


General Chemistry at Wisconsin

There are 4 flavors of general chemistry.

- **Chem 109** - one semester fast track (900 students)
- **Chem 115** - superstar course (35 students)
- **Chem 103/104** - two semester course (6 lectures of 350)
- **Chem 108** - one semester terminal course (250)
Consider heating a tube that contains water only (no air). The dark and light blue colors correspond to $\text{H}_2\text{O}(\text{l})$ and $\text{H}_2\text{O}(\text{g})$, respectively. The dark grey lid slides up and down so that the pressure is constant at 1.0 atm and no water escapes. Assume equilibrium is maintained. Which of the two pictures is correct?
The bubbles that form in water when it boils are gas. The main components of this gas are.

A. $\text{H}_2$ and $\text{O}_2$
B. $\text{H}_2\text{O}$
C. $\text{CO}_2$
D. $\text{CO}_2$ and $\text{O}_2$
The bubbles that form in water when it boils are gas. The main components of this gas are.

A. $H_2$ and $O_2$
B. $H_2O$
C. $CO_2$
D. $CO_2$ and $O_2$

Boiling occurs when the vapor pressure equals the atmospheric pressure. If a little bubble of vapor appears, its pressure is equal to the atmospheric pressure so it can continue to grow.
Cooperative Learning & Guided Inquiries

- Generally follow the Moog and Spencer lectureless teaching format.

- All activities structured with presentation of data or set of definitions. Students are guided to discover fundamental concepts.

- TAs act as guide.
Cooperative Learning & Guided Inquiries

Guided Inquiry - Basic Atomic Properties

Shell Structure of Atoms
Charged particles are either attracted to, or repelled from, one another. The potential energy of the attraction (repulsion) is given by Coulomb’s law:

\[ V = \frac{k \times q_1 \times q_2}{d} \]

where
- \( d \) = distance between particles
- \( k \) = proportionality constant
- \( q_1 \) = charge on particle one
- \( q_2 \) = charge on particle two

An electron has a charge of -1 and a proton has charge +1. The sign of the proportionality constant, \( k \), is positive.

1. Two interacting particles with the same charge sign (e.g., proton-proton, electron-electron) repel one another. Is the potential energy between repelling particles positive or negative? Explain.

What is the sign of the potential energy between two particles that are attracted to one another?

What is the sign and magnitude for the potential energy of a neutron interacting with an electron?

As the distance between two particles increases, what happens to the absolute value of the potential energy?

Some first ionization energies for gas phase elements are provided in the table below. Note that all of the energies are per mole of atom and use the units of MJ/mole.

<table>
<thead>
<tr>
<th>Element</th>
<th>Z</th>
<th>IE(MJ/mole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>1</td>
<td>1.31</td>
</tr>
<tr>
<td>He</td>
<td>2</td>
<td>2.37</td>
</tr>
<tr>
<td>Li</td>
<td>3</td>
<td>5.22</td>
</tr>
<tr>
<td>Be</td>
<td>4</td>
<td>1.80</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>1.09</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>1.40</td>
</tr>
<tr>
<td>O</td>
<td>8</td>
<td>1.31</td>
</tr>
<tr>
<td>F</td>
<td>9</td>
<td>1.68</td>
</tr>
<tr>
<td>Ne</td>
<td>10</td>
<td>2.08</td>
</tr>
<tr>
<td>Na</td>
<td>11</td>
<td>0.50</td>
</tr>
<tr>
<td>Mg</td>
<td>12</td>
<td>0.74</td>
</tr>
<tr>
<td>Al</td>
<td>13</td>
<td>0.58</td>
</tr>
<tr>
<td>Si</td>
<td>14</td>
<td>0.79</td>
</tr>
<tr>
<td>P</td>
<td>15</td>
<td>1.01</td>
</tr>
<tr>
<td>S</td>
<td>16</td>
<td>1.00</td>
</tr>
<tr>
<td>Cl</td>
<td>17</td>
<td>1.25</td>
</tr>
<tr>
<td>Ar</td>
<td>18</td>
<td>1.52</td>
</tr>
<tr>
<td>K</td>
<td>19</td>
<td>0.42</td>
</tr>
<tr>
<td>Ca</td>
<td>20</td>
<td>0.59</td>
</tr>
</tbody>
</table>

4. Consider the elements H, Li, Na, and K which are all members of the first group or column of the periodic table. Do the first ionization energies change with \( Z \) in the way that you predicted in part 3? If not, how is it different?

Now consider the general trend for elements across the second period, or row, of the periodic table: Li, Be, B, C, N, O, F, Ne. Do the first ionization energies change with \( Z \) in the way that you predicted in part 3? If not, how is it different?

The Shell Model of the Atom

The atoms H and He follow the expected trend: as \( Z \) increases the first IE increases. Overall this reflects the greater attraction of the electrons to the nucleus with higher charge. This is mitigated somewhat by e-e
On-Line Homework

MOTIVATION
- Provides incentive to work problems and stay up-to-date.
- Gives instant feedback on problems.
- Provides TA’s data about who is keeping up in the course.

SYSTEM REQUIREMENTS
- Inexpensive.
- Not tied too closely to a particular book.
- Instructor can edit and create questions.
- One can enter chemical formulas, Lewis dot structures, …
- System is robust.
Evening Workshop Sessions

- Four nights per week, both Chemistry and dormitory settings, attendance not required
- Work on homework in groups or work on Challenge Problems
- TAs act as guide
Challenge Problems

Discuss the following with your study group(s) and then prepare your own solution sheet. Although we encourage group discussion, all answers must be written in your own words. Plagiarism is not tolerated. Show all of your work and write in complete sentences. Identify your study partners on your sheet. Turn in this assignment at the beginning of Lecture on Oct 20.

1. A 1.0 M solution of HCl exhibits a pH of 0.
   (a) Describe how much water (to the nearest order of magnitude that) is needed to raise the pH to 2.0. Explain.
   (b) How much water must be added to get to pH 4?
   (c) Is it possible to continue this process to get a pH of 9? Why or why not?
   (d) Calculate the number of moles of HCl in 10 mL of 10 M HCl vs. 10,000 L of 0.00001 M HCl. If you had to choose one of these two solutions to pour on your hands, which would you choose and why?
2. The following information deals with fullerenes, $C_{60}$ and $C_{70}$, which are allotropes of carbon.
(a) Combustion of one mole of carbon atoms in the form of $C_{60}$ with excess $O_2$ yields $CO_2$ and 435 kJ of energy are released. The combustion of one mole of carbon atoms in the form of $C_{70}$ yields $CO_2$ and 432 kJ of energy are released. Write a balanced chemical equation for the combustion of one mole of carbon atoms of each $C_{60}$ and $C_{70}$.

*Your equations should include heat as a reactant or product as appropriate.*

(b) Use an energy diagram to illustrate the combustion reactions of $C_{60}$ and $C_{70}$ according to the equations written in part 2(a). From the energy diagram show the conversion of one mole of carbon atoms in the form of $C_{70}$ to one mole of carbon atoms in the form of $C_{60}$. Write a chemical equation showing the conversion of one mole of carbon atoms in the form of $C_{70}$ to one mole of carbon atoms in the form of $C_{60}$. *Your equation should include the calculated value of heat as either a reactant or product.*

(c) Based on your answer to part 2(b) and Le Châtelier’s Principle, would the conversion of $C_{70}$ into $C_{60}$ be favored by high temperature or low temperature? Explain using complete sentences.

(d) In both $C_{70}$ and $C_{60}$, each carbon atom is bonded to three other carbon atoms. Is the average C-C bond stronger in $C_{70}$ or $C_{60}$? Explain.

Hint: There are 89 C-C bonds in $C_{60}$ and 104 C-C bonds in $C_{70}$.

(e) Make sketches for (i) the Hard-Ionization mass spectra expected for $C_{70}$ and $C_{60}$ and (ii) the Soft-Ionization mass spectrum expected for $C_{60}$ and $C_{70}$. (You can ignore minor isotopes such as $^{13}C$ in your sketched spectra).
3. Solid solutions are very important in the semiconductor industry. CdS and CdSe can be blended to make solid solutions with the general formula Cd$_x$Se$_{1-x}$. These solid solutions react with strong acids, such as nitric acid, to form aqueous solutions of Cd(NO$_3$)$_2$ and H$_2$S and H$_2$Se gases. Consider a solid solution with the formula Cd$_x$Se$_{1-x}$, where $x$ is not known.

(a) Write a balanced equation for the reaction of Cd$_x$Se$_{1-x}$ with HNO$_3$.

(b) Use the descriptors redox, gas-forming, acid-base, and precipitation, as appropriate, to characterize these reactions. Justify your descriptors and use complete sentences.
The values-affirmation intervention involved writing about personally important values (such as friends and family).

Students in the affirmation group selected their most important values from a list (such as relationships with friends and family or learning or gaining knowledge) and, in response to structured prompts, wrote about why these values were important to them.

Students in the control group selected their least important values from the same list and wrote why these values might be important to other people.

Both groups wrote about values and their importance, but the exercise was self-relevant only for the affirmation group.

The 15-min writing exercise was integrated into the class and given in the first recitation and in an online homework assignment (week 4) shortly before the first midterm exam. Each student was assigned to the same condition at both administrations.
Students are given a selection of topics and asked to write a 300-700 word summary of one of them of their choosing.

The control group are given the following instructions. You should attempt to organize the material in a meaningful way, rather than simply listing the main facts or research findings. Remember to summarize the material in your own words.

The treatment group are given the following instructions. You should discuss the relevance of the concept or issue to your own life. Be sure to include some concrete information that was covered in this unit, explaining why this specific information is relevant to your life.
Reducing the Gender Achievement Gap in College Science: A Classroom Study of Values Affirmation

Akira Miyake, Lauren E. Kost-Smith, Noah D. Finkelstein, Steven J. Pollock, Geoffrey L. Cohen, Tiffany A. Ito.
Gender Gap in WI General Chemistry

Bar chart showing the distribution of grades for men and women in WI General Chemistry. The x-axis represents grades (A, AB, B, BC, C, D, F), and the y-axis represents the number of students.
### Gender Gap

<table>
<thead>
<tr>
<th>Gender</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Exam 4</th>
<th>Final Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>No.</td>
<td>523</td>
<td>523</td>
<td>521</td>
<td>521</td>
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<tr>
<td></td>
<td>Mean</td>
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<td>0.11</td>
<td>0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>Female</td>
<td>No.</td>
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<td>504</td>
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<tr>
<td></td>
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<td>0.77</td>
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<tr>
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<td>Std. Dev.</td>
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<td>0.11</td>
<td>0.10</td>
<td>0.11</td>
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</tbody>
</table>
## Average Scores on Multiple Choice Exams

<table>
<thead>
<tr>
<th>Gender</th>
<th>EX1</th>
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<th>EX3</th>
<th>EX4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>0.85</td>
<td>0.76</td>
<td>0.60</td>
<td>0.72</td>
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<tr>
<td>Female</td>
<td>0.84</td>
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</table>

## Average Scores on Written Exams

<table>
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<tr>
<th>Gender</th>
<th>EX1</th>
<th>EX2</th>
<th>EX3</th>
<th>EX4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>0.88</td>
<td>0.86</td>
<td>0.90</td>
<td>0.89</td>
</tr>
<tr>
<td>Female</td>
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<td>0.86</td>
<td>0.90</td>
<td>0.90</td>
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</tbody>
</table>