Learning Assistant Model for Teacher Preparation in Science and Technology (LA-TEST)

Project Annual Report to the National Science Foundation

Academic Year 2008-2009

Project Activities & Findings

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Background

The STEM Colorado Learning Assistant Model at the University of Colorado Boulder is a multidisciplinary experiential learning program. Students who participate as Learning Assistants (LAs) show much higher learning gains in their majors than their peers and show very high shifts in attitudes about learning science (their peers, on average show small to large negative shifts on the same measure). Currently, 75 LAs are hired each semester in 9 departments (Applied Mathematics; Astrophysical and Planetary Science (APS); Chemistry and Biochemistry; Geological Sciences; Molecular, Cellular, and Developmental Biology (MCDB); Mathematics; and Physics. The program is currently funded by grants, department chairs, and temporary funds provided by the Provost and the Deans of the School of Education and the College of Arts and Sciences.

The LA program was initially developed at CU Boulder in 2003 as an effort to recruit more talented math and science majors into careers in teaching. Forty-eight students have been recruited to careers in teaching, which represents approximately 15% of the students who serve as LAs. This number is very large nationally, especially because the program focuses on departments traditionally underrepresented in the Secondary Science Certification program including MCDB, Physics, Chemistry and Biochemistry, APS, and Applied Math. The STEM Colorado LA Program has become a national model for course transformation, teacher recruitment, and teacher preparation. Over 8 institutions including Cornell University, University of Minnesota, and Florida International University have received significant funding to replicate the STEM Colorado LA program and we continue to provide conceptual support and materials for this replication.

Courses using Learning Assistants in the 2008-2009 Academic Year

<table>
<thead>
<tr>
<th>2008-2009</th>
<th># of LAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPM1340</td>
<td>Calculus I with Algebra (semester 1) 5</td>
</tr>
<tr>
<td>APPM1345</td>
<td>Calculus I with Algebra (semester 2) 5</td>
</tr>
<tr>
<td>APPM3310</td>
<td>Matrix Methods 3</td>
</tr>
<tr>
<td>APPM3570</td>
<td>Applied Probability 1</td>
</tr>
<tr>
<td>APPM4350</td>
<td>Methods: Fourier Series and Boundary Value Problems 2</td>
</tr>
<tr>
<td>APPM4360</td>
<td>Methods: Complex Variables and Applications 1</td>
</tr>
<tr>
<td>ASEN</td>
<td>Aero Space Engineering (to prepare for upcoming term) 1</td>
</tr>
<tr>
<td>ASTR1010</td>
<td>Introductory Astronomy 6</td>
</tr>
<tr>
<td>ASTR1020</td>
<td>General Astronomy – Stars and Galaxies 8</td>
</tr>
<tr>
<td>ASTR1110</td>
<td>General Astronomy – Solar System 4</td>
</tr>
<tr>
<td>ASTR2000</td>
<td>Ancient Astronomy 2</td>
</tr>
<tr>
<td>CHEM1111</td>
<td>General Chemistry I 13</td>
</tr>
<tr>
<td>CHEM1131</td>
<td>General Chemistry II 12</td>
</tr>
<tr>
<td>GEEN1350</td>
<td>Calculus I Workshop-small group problem solving 5</td>
</tr>
<tr>
<td>GEEN1360</td>
<td>Calculus II Workshop-small group problem solving 8</td>
</tr>
<tr>
<td>GEOL1100</td>
<td>Introduction to Geology - Laboratory 5</td>
</tr>
<tr>
<td>MATH1300</td>
<td>Analytic Geometry and Calculus I 12</td>
</tr>
<tr>
<td>MCDB1041</td>
<td>Fundamentals of Human Genetics 3</td>
</tr>
</tbody>
</table>
Distribution of Majors of Students Serving as LAs

Most of the students not majoring in math or science have a math or science minor.
Recruitment of LAs to certification programs since 2005 is shown in the graph below according to the students’ majors.
Impact of the Learning Assistant Program in the Physics & Chemistry Departments

The Learning Assistant (LA) program (http://stem.colorado.edu/la-program) has considerably increased the enrollments of Chemistry and Physics majors in teacher certification programs. The data below show enrollment data from 2000 through 2009.

Note that the Physics department began using LAs in 2003 and the Chemistry department did not begin using LAs until 2006. The Chemistry department currently does not have a chemistry education research program. Therefore, the use of LAs was not possible in Chemistry until Carl Wieman’s project hired Post-Doctoral Science Teaching Fellows (Laurie Langon and Tom Pentecost) to run the LA program in the Chemistry department.

The two graphs below compare average enrollments per year in teacher certification programs before and after the LA program was officially launched in the physics (2003) and chemistry (2006) departments.
Expansion of the LA Program

The PhysTEC program (http://www.phystec.org/) has provided generous funding to institutions around the nation to replicate the STEM Colorado Learning Assistant Program in physics departments. PhysTEC funding was awarded to over 8 institutions including Cornell University, University of Minnesota, and Florida International University.
LATEST Research Project

The Learning Assistant model for Teacher Education in Science and Technology (LA-Test) research project was designed to test the effectiveness of the LA model specifically in terms of LAs’ development of content knowledge, pedagogical knowledge, and their practice in K-12 schools. Faculty members from education, mathematics, and science, K-12 teachers, graduate students, and Noyce Fellows comprise three interacting research teams: the Discipline-Based Educational Research (DBER) team, the Conceptions of Teaching and Learning (CTL) team, and the K-12 team. These interacting research teams investigate teacher recruitment rates as well as the research questions shown in table 2 and synthesize results on an ongoing basis.

Each research team focuses on a specific set of questions (shown below). Answers to these questions will be synthesized by the end of the project in order to make inferences about the impact of the Learning Assistant (LA) Model on teachers’ pedagogical content knowledge.

The DBER team consists of and graduate students from five departments: Physics, Chemistry, Applied Mathematics, Astrophysical and Planetary Sciences, and Molecular, Cellular, and Developmental Biology. The CTL team consists of faculty members from the School of Education in Research and Evaluation Methodology and from the Physics department, and graduate students in Science Education and in Physics Education Research. The K12 team consists of faculty members and graduate students in Science and Mathematics Education.

Research Questions

DBER Team:
(a) How do LAs compare to other STEM majors in terms of their content understanding, beliefs about the discipline, and beliefs about learning in the discipline?
(b) What effects can be observed on student achievement in courses that are supported by LAs?

CTL Team:
(a) What is the effect of the LA model on the sophistication of LA pedagogical understanding?
(b) Does sophistication of pedagogical understanding vary by length of exposure to the LA model?
(c) How is the pedagogical sophistication of STEM LAs different from the sophistication of STEM non-LAs who become teachers?

K-12 Team:
How do teachers and teacher candidates who participated as LAs compare to those who did not in terms of:
(a) Practicum-based coursework
(b) Their teaching practices
(c) K-12 student attitudes and beliefs about mathematics and science
(d) Retention and attrition rate

Current results for each of these research teams are found in the pages that follow.
Dissemination of LA Program and LATEST Research

Publications


http://www.sciencemag.org/cgi/content/full/323/5910/122

http://www.lifescied.org/cgi/content/full/7/4/422


Workshops and Conference Presentations


We also submitted a session proposal for the 2010 AERA conference and will produce related manuscripts this year.


C. Turpen* and N.D. Finkelstein, “Institutionalizing Change: Case Studies & Institutional Analysis of
S. Chasteen, S. Pollock, "Assessing Student Understanding in Upper Division Undergraduate E&M l", *Physics Education Research Conference proceedings, Edmonton, Ont Canada, Aug 08
C. Turpen* and N.D. Finkelstein “Case Studies and Institutional Analysis of the Implementation
Of a Pedagogical Reform in Introductory Physics,” Facilitating Change in STEM Education, Western MI, Jun 17, 2008 [invited]
S. Pollock, L. Kost*, N. Finkelstein, "Does PER-based instruction help underrepresented groups succeed, and how can it do so better?", Invited session, Physics Education Research Conference, Edmonton, Ontario Canada, Aug 2008
L. Kost*, S. Pollock, N. Finkelstein, "Examining the Gender Gap in Introductory Physics", APS April meeting, Denver.

V. Otero and S. Pollock, "Transforming your Undergraduate Physics Course using Learning Assistants", Workshop for NASULG Leadership Collaborative, pre-PTEC 09 meeting, Pennsylvania.
V. Otero and S. Pollock, "Running weekly planning sessions for LAs: A workshop for physics faculty", Workshop for PTEC 09 meeting, Pennsylvania
V. Otero, N. Finkelstein, S. Pollock, "Transforming your Undergraduate Physics course using LAs", Workshop for the bridging session to the APS meeting, PTEC 09 meeting, Pennsylvania
S. Pollock, "A comparison of two research-based conceptual surveys: CSEM and BEMA", poster, American Association of Physics Teachers' Summer meeting, July 19-23 2008, Edmonton, Alberta Canada
S. Chasteen, S. Pollock, "Assessing Student Understanding in Upper Division undergraduate E&M", poster, Physics Education Research Conference (PERC) meeting, July 24, 2008, Edmonton, Alberta Canada
S. Chasteen, S. Pollock, Darren Tarshis, Ward Handley, Paul Beale, "Transforming Upper-Division Undergraduate Electricity & Magnetism", talk, American Association of Physics Teachers' Summer meeting, July 19-23 2008, Edmonton, Alberta Canada Session
S. Chasteen, S. Pollock, "Assessing Student Understanding in Upper Division undergraduate E&M"", poster, American Association of Physics Teachers' Summer meeting, July 19-23 2008, Edmonton, Alberta Canada
S. Chasteen, S. Pollock, Darren Tarshis, Ward Handley, Paul Beale, "Reforming Upper-Division Undergraduate Electricity & Magnetism", poster, American Association of Physics Teachers' Summer meeting, July 19-23 2008, Edmonton, Alberta Canada


N.D. Finkelstein, " Reconsidering Tools in STEM Education: The Use of Analogy and Representation," Department of Mathematics and Science Education, School of Engineering and Sciences, Clemson University, April 24, 2009. [invited]

N.D. Finkelstein, "Scholarly Education: Implications of Physics Education Research" GAANN Retreat, School of Engineering, University of Colorado, Apr 16, 2009. [invited]


S. Pollock, Colloquium, Colorado School of Mines, Fall 2008, "A research-based approach to transforming upper-division Electricity & Magnetism I"

S. Pollock, Seminar to Physics Education Research Group, Colorado School of Mines, Fall 2008, "Gender issues in introdutory physics"


“STEM Colorado Learning Assistant Model for Recruiting and Preparing STEM Teachers” – Talk (Otero & Hornstein) on LA program at 2009 NMSI-UTeach Institute Conference on May 27-29th in Austin, Texas

Shi, J., Knight, JK, Wood, WB, Guild, NA, Martin, JM, Small-group sessions enhance student learning in a large, lecture-based, introductory cell and molecular biology course.

Nelson (2009, April). Oral assessments to improve calculus understanding. Presented at the Colorado Mathematical Assosciation of Two-Year Colleges (Colomatyc)


Nelson (2009, Spring). The cooperative nature of oral assessments and the nature of team work in understanding problems and how these skills are related to a work environment. Presentation at the Lead Graduate Teaching Assistants for Engineering and Mathematics.


Nelson (2008, Fall). Common student misconceptions and how oral assessments can help students overcome those misconceptions. Presentation at Discipline Based Educatinal Research Community (DBER).


Nelson (2008, December). *How and why to implement oral assessments in order to improve grades and retention*. Presentation given at Colorado State University Mathematics department Colloquium in Fort Collins


**Professional Press**


b. We have created a Website that has orals questions for APPM, and will have questions from MechE, Aerospace and high school algebra. We are in the process of linking it to our APPM Website.


Articles written about the project:

1) **Article in CU’s Campus newsletter**


This article was published after the official notice of receiving the grant in 2008. The article describes the departments involved, as well as what an oral assessment is. The history of passing rates in calculus were included as the rationale for the study. The article can be found at [http://www.colorado.edu/news/r/40c92d874183314e002226645b96db37.html](http://www.colorado.edu/news/r/40c92d874183314e002226645b96db37.html).

2) **News article in the Boulder Daily Camera (local newspaper)**

Oral pre-tests equals more students passing calculus at CU by Brittany Anas, Tuesday, November 25, 2008

This article was written shortly after the official notice of receiving the grant in November, 2008. It summarizes what CU, Boulder and Colorado Springs, Applied Math departments, as well as the local high school, Fairview, would be doing with oral assessments during the grant. The article can be found at [http://www.dailycamera.com/news/2008/nov/25/oral‐pre‐tests‐equals‐more‐CU‐students‐passing/](http://www.dailycamera.com/news/2008/nov/25/oral‐pre‐tests‐equals‐more‐CU‐students‐passing/).

3) **Article in CUEngineering**: A Publication of the College of Engineering and Applied Science

Applied Mathematics: Oral Assessments Help Freshman Understand and Pass Calculus 2009 This article gives the background on the Applied Mathematics department’s work with oral assessments in calculus. It includes a photo of Dr. Nelson working with calculus students. The article discusses the importance of learning calculus, as calculus is a gateway course to engineering majors. It reports that Mechanical Engineering also participated in Spring 2009 and Aerospace engineering will join the effort in Fall 2009. The article can be found at [http://engineering.colorado.edu/news/CUE/2009/programs/am.htm](http://engineering.colorado.edu/news/CUE/2009/programs/am.htm).

4) **Article in the Colorado Arts & Sciences Magazine**

Pre-test assessments in math to be studied
by Annie Scott, April 6, 2009
In this article, Scott gives a brief historical background on the Applied Mathematics department and their work with oral assessments along with news of the NSF grant and the current work with other departments and Fairview High School. Scott interviewed both Anne Dougherty (whose picture is included) and Mary Nelson. The article can be found at http://artsandsciences.colorado.edu/magazine/2009/04/pre-test-assessments-in-math-to-be-studied/.
K-12 Research Team: Activities and Findings
Conduct of Classroom Research and Analysis

David Webb, Kara Gray, Erin Allaman, Kim Geil, May Lee, Michael Matassa, Deb Morrison, Michael Ross, & Robert (Bud) Talbot

Activities

The overarching goal of the LA-Test K-12 research team is to conduct a quasi-experimental study comparing the beliefs and practices of Learning Assistants (LA) who become secondary teachers with teachers of comparable experience who completed a CU-Boulder licensure program with no experience as an LA. Under the purview of the LA-Test research project, our approach and method is designed in particular to study the effects of the LA program among practicing K-12 teachers and their students. As a post-undergraduate follow-up study, our research involves interview, observation of practice in situ, survey of student attitudes towards math and science, and collection of classroom artifacts across various school contexts to provide objective portraits of teacher beliefs and practice.

The LA-Test K-12 research team is led by Dr. Webb and currently includes five doctoral students (Gray, Lee, Matassa, Morrison and Ross). During the 2008-09 school year, three additional doctoral students also worked on the research team (Allaman, Geil & Talbot). The subject background of the research team includes mathematics education (Webb & Matassa), with the rest of the doctoral students involved having disciplinary emphases in research methodology (Allaman & Geil) or science education (Gray, Lee, Morrison, Ross, & Talbot).

Data Collected

Research conducted during the 2008-09 school year involved the continuation of data collection of the teacher cohort recruited in Spring 2007 and the recruitment of additional participants identified as LA teacher candidates who had found teaching positions in math and science. Due to the low number of non-LA (control) teachers we were able to recruit and retain from the previous year, we also tried to over-subscribe the number of control teachers who would agree to participate. For Year 2, we were able to secure participation from 8 former LA students and 12 non-LA students, with 9 math and 11 science teachers (see Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Science</th>
<th>Math</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Non-LA (control)</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 1. Year 2 K-12 cohort experience and content area

Of the 15 former LA students who we contacted for participation in Year 2, three were not teaching, two decided to pursue graduate studies, one we were not able to contact, and one declined to participate a second year because he was moving out-of-state to teach at a new school and was over-committed with additional professional responsibilities (7 out of 15 LAs declined). Of the 31 non-LA students we contacted, nine did not respond to multiple invitations to
participate, three said they were too busy, three were not teaching, one decided to pursue
graduate studies, and two moved out of state and are now in difficult to reach locations (20 out of
31 non-LAs declined). One control teacher who agreed to participate, later dropped out of the
study, and we were not able to contact her after the first interview. District approval for current
and future teacher participation was secured for each participant in addition to permission from
school principals to conduct research at the school site.

Since participation in this study was voluntary, we assume that the greater difficulty in recruiting
or eliciting replies from potential control teachers might have been due to a lesser commitment to
research in teaching and learning among non-LAs. This is in contrast to the LA students who
were immersed in such studies during their undergraduate experience and had ongoing contact
with math, science and education faculty over several years.

Given the complexity of classroom-based research and the many variables that could be
examined, we developed a coding scheme in Spring 2007 that included a set of primary variables
that could be examined across all data sources. These LA Test K-12 Constructs of Interest (LAT-
CoI) are:

1. Assessment practices (methods and conceptions)
2. School Context (perception of support from colleagues and administrators)
3. Construction of knowledge (i.e., teachers conceptions of how students learn math/science)
4. Teacher background (including LA and teacher education experiences)
5. Teacher self-efficacy (i.e., perceptions of and responses to problems of practice)
6. Views of students (how they regard student diversity, readiness to learn, students’ struggles)
7. Lesson Design/Planning (regard for student prior knowledge, inquiry, content)

Secondary and tertiary codes were also developed to elaborate different aspects of these
constructs of interest, exemplified in the various data sources. Since the research questions and
related coding scheme call for an examination of teachers’ conceptions and practices, the data
sources selected drew from a blend of interview protocols, survey instruments, classroom
observation protocols and sampling of classroom artifacts. The data sources used in this study
include:

<table>
<thead>
<tr>
<th>Teacher Conceptions</th>
<th>Teacher baseline interview</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observation interview</td>
</tr>
<tr>
<td></td>
<td>Reformed Teaching Observation Protocol</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teacher Practice</th>
<th>Scoop notebook</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reformed Teaching Observation Protocol</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Students’ Conceptions</th>
<th>Colorado Learning Attitudes Science Survey (adapted for secondary school use)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scoop notebook</td>
</tr>
</tbody>
</table>

Baseline interviews were administered to all teachers upon their entry into the study. The
majority of interviews were conducted in person, at the school site. Three classroom
observations were conducted for 19 participants (we did not conduct observations for the one out-of-state participant), which included use of Reformed Teaching Observation Protocol (RTOP) and the observation interview. To document any change in teacher conceptions over the school year, we extended the third observation interview to include prompts that referenced back to the constructs of interest targeted in the baseline interview. All interviews were recorded on digital audio records, transcribed, and have since been coded using qualitative analysis software.

The Scoop notebook materials and procedure were used to collect classroom artifacts, including teacher lesson plans, assessments, assignments, and reflections about lessons over a period of one week. Teachers selected the week that they “scooped.” Scoop notebooks were collected from all participating teachers. The Scoop materials will be analyzed during in the late summer using LA-TEST constructs of interest (LAT-CoI) reflected in lesson plans, reflections, and classroom artifacts.

Last year we reformatted and adapted the Colorado Learning Attitudes Science Survey (CLASS) so that it could be administered to middle and high school students. Due to the increase in the number of participating teachers and a need to administer the CLASS to multiple classes per teacher (to ensure sufficient student sample sizes per teacher), we produced machine scoreable versions of the CLASS for secondary math and science students. We also administered the CLASS to a panel of mathematics experts (faculty and grad students in mathematics and math education) to refine the scoring scheme for the mathematics version of the CLASS (the science version already had an expert-novice scoring scheme). Spanish translations of the math and science CLASS were also developed. All participating teachers administered the CLASS to at least three classes of students.

Status of data collected and findings

*Teacher Interviews.* The coding of transcripts for all baseline and observation interviews is complete. To document and ensure sufficient inter-rater reliability (IRR), all members of the research team coded the baseline and observation interviews for one teacher. The codes used by different raters were compared using functions of the qualitative software. Any secondary code that was found to have less than 85% IRR was discussed among the research team to develop a shared meaning and definition of the code. Multiple interviews were then coded by at least two raters and checked for IRR; in each instance, the IRR was greater than 85% with the majority of secondary codes showing an IRR of greater than 92%. We are currently analyzing the secondary codes across all teachers for patterns of conceptions and practice, and relative differences (if any) between LA and non-LA participants. A paper written by Kara Gray (noted in the publications section) indicated some preliminary findings from the interview analysis showing that science LAs have different reasons for having their students participate in group activities, compared to non-LA science teachers. The rationale for LAs included socio-cultural perspectives of learning whereas the rationale for non-LAs was to distribute scarce resources such as lab equipment.

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1 Two math participants (one LA, one non-LA) had teaching assignments in South Dakota and Vermont. The agreed to participate in all phases of the data collection with the exception of classroom observation.
Classroom Observations. All Reformed Teaching Observation Protocol (RTOP) data from classroom observations has been translated into an Excel file and summarized as descriptive statistical data for the LA and non-LA groups. Table 3 below includes all RTOP data collected since Spring 2007, according to the observation year and the number of teachers of experience at the time the observation was completed. Table 4 summarizes the RTOP data, organized by LA and non-LA groups.

Table 3. RTOP data collected Spring 2007 – Spring 2009*

<table>
<thead>
<tr>
<th></th>
<th>LA</th>
<th>NonLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>48</td>
<td>44</td>
</tr>
<tr>
<td>Obs Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sp07</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Sp08</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>Sp09</td>
<td>23</td>
<td>30</td>
</tr>
<tr>
<td>Tchr Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yr1</td>
<td>24</td>
<td>35</td>
</tr>
<tr>
<td>Yr2</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>Yr3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

*The percentages for each observation category are for LA and non-LA, not total.

The differences in the mean between the LA and non-LA groups in Table 4 favor LAs for Overall, Lesson Design, Content, and Classroom Culture, with the differences in means for the overall score (t[90] = 2.679, p < 0.009), content (t[90] = 2.297, p < 0.024), and classroom culture (t[90] = 3.034, p < 0.003) statistically significant. Figures 1 through 3 offer visual representation of these differences in means along with error bars for standard error of the means.

Table 4. Summary of all RTOP data collected

<table>
<thead>
<tr>
<th></th>
<th>LA</th>
<th>Non LA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>56.6</td>
<td>45.93</td>
</tr>
<tr>
<td>Std Dev.</td>
<td>18.79</td>
<td>19.40</td>
</tr>
<tr>
<td>Minimum</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>Maximum</td>
<td>93</td>
<td>84</td>
</tr>
<tr>
<td>Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.88</td>
<td>1.48</td>
</tr>
<tr>
<td>Std Dev.</td>
<td>1.03</td>
<td>0.91</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.6</td>
<td>3.8</td>
</tr>
<tr>
<td>Content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.30</td>
<td>1.97</td>
</tr>
<tr>
<td>Std Dev.</td>
<td>0.68</td>
<td>0.72</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Maximum</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Culture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.42</td>
<td>1.89</td>
</tr>
<tr>
<td>Std Dev.</td>
<td>0.81</td>
<td>0.87</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.6</td>
<td>3.7</td>
</tr>
</tbody>
</table>
These differences favoring LAs also hold for the math and science groups. This result is an improvement over last year’s RTOP results which indicated that although there were differences favoring LAs in each of these categories, they were not statistically significant comparisons.

*Figures 1 & 2. RTOP: Lesson Design/Implementation and Content, means and standard error of means*

![Graphs showing mean and standard error of means for Lesson Design/Implementation and Content](image1)

*Figure 3. RTOP: Classroom Culture, means and standard error of means*

![Graph showing mean and standard error of means for Classroom Culture](image2)

When comparing RTOP data for participants in their first year of teaching, the difference in overall mean is even more pronounced. The 1st year LA group (N[obs]=27, mean = 58.18, SD = 21.743) is more likely to engage in inquiry-oriented classroom practices than the 1st year control group (N[obs] = 35, mean = 44.69, std dev = 21.086). The difference in these means is also statistically significant (t[90] = 2.466, p < 0.017).
Scoop notebooks. With respect to the Scoop notebooks, we will complete the analysis of classroom artifacts after we have completed the analysis and reporting of interview results. The Scoop notebook data will support the triangulation of findings from the RTOP and interviews and will be cross-referenced to the constructs of interest. Some Scoop notebooks have been analyzed and we expect to complete the analysis of all Scoop notebooks by late fall 2009.

Student surveys. To date, all CLASS data have been sorted and machine scored. Since the CLASS was administered by teachers to three of their classes, the sample sizes were much larger than the previous year which allowed us to make comparisons between students of former LAs and nonLAs. Therefore, our adaptation to the Year 2 administration of the CLASS was a methodological improvement that we will continue in Year 3 along with two administrations of the CLASS to capture growth or declines in students’ attitudes towards or conceptions of math and science.

Due to our ability to have the CLASS machine scored, we are now able to report the summary and findings from this data source. In all cases, the CLASS was administered to math and science of participating teachers in Spring 2009. Teachers distributed the assent forms to students and consent forms to the students’ parents, allowing a sufficient window of time to collect the completed forms from parents. Teachers administered the CLASS to three classes of students during one semester. Student names were not included on any of the CLASS forms.

As a check for student authentic engagement in completing the survey, one of the questions on asks students to mark #4 as their answer. After receiving the CLASS packets from teachers, the research team removed any forms for which students did not complete this prompt correctly. Any other indication of random selection of survey responses (a pattern of responses, the same response for all prompts) were also removed from the stack of scoreable surveys. Even though this reduced the yield, this process ensured that the scored surveys were a more authentic representation of students’ attitudes and conceptions. Table 6 includes the summary of CLASS scores for science students, disaggregated by students who had teachers who were former LAs and those who were not. Table 7 includes the same summary table for students of math teachers.

Table 6. Spring 2009 CLASS summary results, science teachers

<table>
<thead>
<tr>
<th>Categories</th>
<th>non-LA group</th>
<th>LA group</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>average</td>
<td>std error</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for min # of</td>
<td>of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>questions</td>
<td>mean</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>128</td>
<td>42.33</td>
<td>1.51</td>
<td>190</td>
</tr>
<tr>
<td>Personal Interest</td>
<td>130</td>
<td>35.69</td>
<td>2.66</td>
<td>196</td>
</tr>
<tr>
<td>Real World Connection</td>
<td>130</td>
<td>40.52</td>
<td>2.89</td>
<td>197</td>
</tr>
<tr>
<td>PS General</td>
<td>130</td>
<td>46.28</td>
<td>2.30</td>
<td>193</td>
</tr>
<tr>
<td>PS Confidence</td>
<td>130</td>
<td>51.67</td>
<td>2.71</td>
<td>196</td>
</tr>
<tr>
<td>PS Sophistication</td>
<td>129</td>
<td>42.49</td>
<td>2.41</td>
<td>196</td>
</tr>
<tr>
<td>Sense Making/Effort</td>
<td>130</td>
<td>53.04</td>
<td>2.34</td>
<td>196</td>
</tr>
<tr>
<td>Conceptual understanding</td>
<td>130</td>
<td>41.74</td>
<td>2.35</td>
<td>194</td>
</tr>
<tr>
<td>Applied Conceptual understanding</td>
<td>129</td>
<td>35.54</td>
<td>1.93</td>
<td>195</td>
</tr>
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</table>
For the students of science teachers, their aggregate responses seem to favor the group of students with teachers who were former LAs. This is true for all categories with the exception of Conceptual Understanding. Two of these categories showed statistically significant differences for science having Real World Connections ($p < 0.029$) and Problem Solving Confidence ($p < 0.048$).

For the students of math teachers, their aggregate responses favor the group of students with teachers who were former LAs in five of eight categories. Similar to the science group, the Real World Connections category showed a statistically significant difference in favor of the LA group ($p < 0.028$).

Table 7. Spring 2009 CLASS summary results, math teachers

<table>
<thead>
<tr>
<th>Categories</th>
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<td>average for</td>
<td>N</td>
<td>average for</td>
</tr>
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<td></td>
<td></td>
<td>min # of questions</td>
<td></td>
<td>min # of questions</td>
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<tr>
<td></td>
<td></td>
<td>std error of mean</td>
<td></td>
<td>std error of mean</td>
</tr>
<tr>
<td>Overall</td>
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<td>45.54</td>
<td>75</td>
<td>47.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.40</td>
<td></td>
<td>2.04</td>
</tr>
<tr>
<td>Personal Interest</td>
<td>154</td>
<td>41.54</td>
<td>76</td>
<td>48.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.27</td>
<td></td>
<td>3.39</td>
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<td>Real World Connection</td>
<td>154</td>
<td>34.47</td>
<td>77</td>
<td>43.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.19</td>
<td></td>
<td>3.40</td>
</tr>
<tr>
<td>PS General</td>
<td>154</td>
<td>50.18</td>
<td>75</td>
<td>52.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.03</td>
<td></td>
<td>2.81</td>
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<tr>
<td>PS Confidence</td>
<td>154</td>
<td>59.09</td>
<td>75</td>
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<td>2.59</td>
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<td>PS Sophistication</td>
<td>154</td>
<td>42.71</td>
<td>76</td>
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<td>3.04</td>
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<td>57.54</td>
<td>77</td>
<td>55.21</td>
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<tr>
<td></td>
<td></td>
<td>2.03</td>
<td></td>
<td>3.31</td>
</tr>
<tr>
<td>Conceptual understanding</td>
<td>154</td>
<td>45.91</td>
<td>76</td>
<td>43.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.38</td>
<td></td>
<td>3.20</td>
</tr>
<tr>
<td>Applied Conceptual</td>
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<td>44.35</td>
<td>75</td>
<td>43.96</td>
</tr>
<tr>
<td>understanding</td>
<td></td>
<td>2.17</td>
<td></td>
<td>2.91</td>
</tr>
</tbody>
</table>

Since these results were recently made available to the research team, we have not had sufficient time to conjecture why these CLASS results might favor students of LAs in the Real World Connections and, for science, the Problem Solving Confidence categories. We are not sure why the undergraduate experiences of LA students might have produced this result. It is worth noting that this data is a snapshot of students’ attitudes and conceptions in spring 2009. These data do not show students’ incoming conceptions/attitudes or the degree to which learning experiences with a specific teacher might impact their conceptions/attitudes over time. However, since LAs tended to teach in schools serving higher proportions of low-income students we posit that it is likely that differences in student attitudes in fall 2008 may have favored students of non-LAs. In Year 3, we will administer the CLASS in the fall and spring so that we might ascertain teacher specific influences on students’ conceptions and attitudes towards math and science.
Future directions

In reviewing the results from the final interview with participating teachers in spring 2009, we are expecting to lose up to six teachers from the Year 2 group (5 science, 1 math). The reasons given for non-participation include pursuit of graduate studies, maternity leave, and district layoffs. Three of the six are former LAs in science. Therefore, in addition to including the spring 2009 LA graduates in the year 3 pool, we will need to recruit some additional control teachers to maintain adequate comparison groups.

Next year we will continue the same approach to data collection, conducting on site observations and interviews of teachers and monitoring the impact of teacher practice on student attitudes towards math and science over the 2009-10 school year. We plan to increase the use of the CLASS instrument to include two administrations, in fall 2009 and spring 2010 to determine relative gains or declines in the CLASS constructs over the school year. Next year we will also examine the longitudinal effects of the LA program on teacher induction and classroom practice.
CTL Research Team: Activities and Findings
The Flexible Application of Student-Centered Instruction Instrument and Research

Robert (Bud) Talbot and Derek Briggs

Overview of Project Activities

Research Team Information

The Conceptions of Teaching and Learning (CTL) Research Team is working on the development and validation of the Flexible Application of Student-Centered Instruction (FASCI) survey instrument. The research team consists of Professor Derek Briggs, doctoral candidate Robert Talbot, and Professor Valerie Otero. Team members met weekly throughout the year to work on the FASCI instrument, data analysis, and dissemination of findings.

Description of Research Activities

During the academic year 2008-2009, the FASCI survey was further developed and pilot tested, and additional validation studies are currently being undertaken. Prior to this year, one pilot test had been administered (Pilot Test 1, during 2007-2008). In Pilot Test 1, five scenario-based items were administered to 65 respondents (see 2007-2008 LA-TEST/CTL annual report). Pilot Tests 2 and 3 were conducted during 2008-2009 and will be described below. All administrations are completed online using QuestionPro (http://questionpro.com). Also described below are our current validation studies, which involve cognitive interviews with survey respondents, observations of teaching practice, and the development and administration of a subject-specific version of the FASCI.

Pilot Test 2 Development and Administration

Version 2.3 of the FASCI (see Appendix A) was developed for Pilot Test 2. This version of the survey included background and demographic questions, and six open-ended scenario-based items, two of which were common with version 2.1 (used in Pilot Test 1). Pilot Test 2 was conducted between 09-04-2008 and 03-29-2009. Scores from 98 respondents (described in the next section) were analyzed and compared to the data from Pilot Test. Analysis of Pilot Test 2 data is ongoing.

Pilot Test 3 Development and Administration

Version 2.4 of the FASCI (see Appendix B) was developed for Pilot Test 3. This version of the survey consists of items that are either fully or partially constrained, rather than completely open-ended as in the previous versions. We developed this more constrained version of the FASCI in order to afford more economical scoring and administration on a larger scale. This version was administered pre- and post-semesters’ instruction to students in the Learning Assistant class at CU Boulder during the Spring semester 2009. Approximately 40 students took this version pre and post. We are currently in the process of scoring and analyzing the results from Pilot Test 3.

New and Ongoing Validity Studies

Cognitive interviewing of FASCI respondents is an ongoing validity activity. From each pilot test, we interviewed 3-6 respondents to see how they interpreted survey questions and how they reacted to taking the survey. The protocol for these interviews is given in Appendix C. Analysis of these interview transcripts is currently being undertaken.
Observations of teaching practice were conducted using the FASCI observation protocol (see Appendix D). Results from these observations are currently being analyzed together with scores from FASCI Pilot Test 2 and with scores from the Reformed Teaching Observation Protocol (RTOP, see Appendix E; Piburn, et al., 2000) which was used in observing the same class sessions. Participants for these observations are involved in the LA-TEST K-12 research project ($n = 19$).

Our third validity study which is being conducted involves the development of another version of the FASCI with is specific to the domain of physics. This version is modeled after v2.1 (from Pilot Test 1) and uses the same background and demographic questions, and a similar set of five open-ended, scenario-based items. The original FASCI is intended to be content-neutral within the sciences. Whether or not this domain neutrality is a threat to the validity of FASCI score interpretations is the subject of this particular validity study. The physics-specific FASCI (see Appendix F) places the respondent within the context of physics, rather than science generally. We then administered the FASCI v2.1 (content-neutral) or the physics-FASCI at random to a population of pre-service teachers, both pre and post-semesters’ instruction. Each version also contained physics content questions (see physics-FASCI in Appendix F) as a proxy for respondents’ physics content knowledge. Analysis of this responses data is currently being undertaken.

**Participants**

Pilot Test 2: As mentioned above, 98 respondents participated in Pilot Test 2. Characteristics of these respondents are summarized in Table 1.

Pilot Test 3: Descriptive statistics for the 80 sets of responses (40 students, pre and post-semesters’ instruction) to Pilot Test 3 are not yet available.

Cognitive Interviews: In the past year, 11 individuals have been interviewed after having taken one of the versions of the FASCI. These respondents are primarily pre-service teachers ($n = 10$, the remaining individual is a practicing K-12 teacher). Four of these respondents are Learning Assistants.

Observations of Practice: Together with the K-12 research team, we observed the teaching practice of 18 teachers at least two times; some teachers were observed three times. All took v2.3 of the FASCI (in Pilot Test 2).

Physics-FASCI Validity Study: In our physics-FASCI/neutral-FASCI validity study, 60 individuals responded to the pre-test. Characteristics and statistical comparisons of these groups are given in Table 2. Based on the $p$-values from t-tests and chi-squared tests, there are no statistically significant differences between each group on all available covariates except number of physics courses taken. We are currently in the process of compiling the post-semester responses, therefore that data is not displayed here.
Table 1.

Descriptive Characteristics of the v2.3 Pilot Test Sample

<table>
<thead>
<tr>
<th></th>
<th>LA (1) (n = 54)</th>
<th>Noyce (2) (n = 7)</th>
<th>Tchr Ed (3) (n = 3)</th>
<th>STEM Faculty (4) (n = 1)</th>
<th>STEM Grad Students (6) (n = 6)</th>
<th>SOE Grad Students (7) (n = 1)</th>
<th>K-12 (8) (n = 22)</th>
<th>Group? (n = 5)</th>
<th>Entire Sample (N = 98)</th>
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</thead>
<tbody>
<tr>
<td>Mean Age (SD)</td>
<td>20.33 (2.45)</td>
<td>20.71 (1.11)</td>
<td>30.0 (12.12)</td>
<td>44 (1.67)</td>
<td>22 (4.91)</td>
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<tr>
<td></td>
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<td>4</td>
<td>1</td>
<td>1</td>
<td>13</td>
<td>1</td>
<td>53</td>
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<tr>
<td>Mean Years Teaching Experience (SD)</td>
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<td>2.29 (1.25)</td>
<td>1.00 (0.0)</td>
<td>4 (3.40)</td>
<td>1 (1.20)</td>
<td>1.78 (1.52)</td>
<td>2.40</td>
<td>2.06 (1.91)*</td>
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<td>1</td>
<td>8</td>
<td>4</td>
<td>11</td>
<td>12</td>
<td></td>
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<tr>
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<td>10</td>
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<td>24</td>
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</table>

*15 missing values
Table 2.

*Comparison of respondent characteristics (frequency counts or mean/SD) by survey version, physics-FASCI/neutral-FASCI validity study*

<table>
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<tr>
<th>Variable</th>
<th>neutral-FASCI</th>
<th>physics-FASCI</th>
<th>( p ) values from ( t )-test</th>
<th>( p ) values from chi-square test</th>
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<tr>
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<tr>
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Project Findings

Pilot Test 2

Average completion time for responding to v2.3 of the FASCI was 35.8 minutes. This was about four minutes longer than the time required in Pilot Test 1 (which had one fewer scenario-based item). Responses to this version have been scored by one rater at this point in time. We are currently conducting a scoring reliability check in which a random sample of these responses will be scored by another trained rater (data not yet available).

Classical item statistics were computed for all FASCI items. In addition, FASCI item responses were scaled using Item Response Theory (IRT; Lord, 1980). Each dimension of the FASCI (Flexible Application “FA”, and Student-Centered Instruction, “SCI”) was scaled independently. Latent regressions were run to compare the FASCI performance as a function of group status (e.g. Learning Assistant, K-12 teacher, etc).

Below are reliability estimates (given as Cronbach’s alpha), overall mean scores (and SD’s), percent missing data, standard error of measurement (SEM) and classical item statistics for the FA and SCI dimensions of the FASCI from Pilot Test 2.

Pilot Test 2 (v2.3) FA Dimension Item Statistics

Cronbach’s Alpha = 0.67

Overall Mean score (SD) out of 12 = 4.72 (1.70)

Missing data = 2.38%

SEM = 1.24
### Table 3.
Classical Item Statistics: FA dimension

<table>
<thead>
<tr>
<th>Item 1</th>
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<th>% of Total</th>
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<td></td>
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<table>
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<th>Point Biserial</th>
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<table>
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<th>Point Biserial</th>
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<td>35.11</td>
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<td></td>
<td>1</td>
<td>61</td>
<td>64.89</td>
<td>0.41</td>
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Pilot Test 2 (v2.3) SCI Dimension Item Statistics

Cronbach’s Alpha = 0.76

Overall Mean score (SD) out of 6 = 2.41 (1.30)

Missing data = 1.70%

SEM = 1.01

Table 5.

Classical Item Statistics: SCI Dimension

<table>
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<tr>
<th>Item 1</th>
<th>Score</th>
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<th>% of Total</th>
<th>Point Biserial</th>
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<td></td>
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<th>Point Biserial</th>
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<table>
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<th>Point Biserial</th>
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<table>
<thead>
<tr>
<th>Item 4</th>
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<th>Point Biserial</th>
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<table>
<thead>
<tr>
<th>Item 5</th>
<th>Score</th>
<th>Count</th>
<th>% of Total</th>
<th>Point Biserial</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>79</td>
<td>82.29</td>
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<tr>
<td></td>
<td>1</td>
<td>17</td>
<td>17.71</td>
<td>0.58</td>
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<table>
<thead>
<tr>
<th>Item 6</th>
<th>Score</th>
<th>Count</th>
<th>% of Total</th>
<th>Point Biserial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>59</td>
<td>62.11</td>
<td>-0.59</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>36</td>
<td>37.89</td>
<td>0.59</td>
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</table>

Note that the reliability for the FA dimension was about the same for Pilot Test 1 (2007-2008) and Pilot Test 2 (0.71 for Pilot 1 and 0.67 for Pilot 2), and the SCI reliability increased markedly (from 0.47 for Pilot 1 to 0.76 for Pilot 2). There are two possible areas to examine when seeking to explain the increase in SCI reliability relative to the stable FA reliability: the items used on each version, and the scoring of item responses.

With respect to the items themselves, version 2.3 (Pilot Test 2) had one more item relative to version 2.1 (Pilot Test 1), and the two versions had two common items (see Table 7). These two common items performed similarly on each version (e.g. similar IRT difficulty estimates and correlations with total score). Of particular note, no single SCI item in Pilot Test 2 was nearly as difficult as item 3 on Pilot Test 1 (IRT difficulty estimate of 2.583, 53 responses scored as 0 and 8 responses scored as 1). The common...
item 1 was by far the easiest on each version. In summary then, it could be that the replacement of three items in Pilot Test 1 by four items in Pilot Test 2, slightly better item fits, and no single very difficult SCI item on Pilot 2 contributed to increased SCI reliability on this version.

With respect to the item scoring, there were differences in scoring between each version as mentioned above. Although the same sets of scoring rules were used for each, scores from Pilot Test 1 are the result of three rater’s moderated scores. Those from Pilot Test 2 are the result of one rater’s scores. Until we our scoring reliability check by another trained rater, this possibility will remain in question.

Table 7.

A comparison of the common items between v2.1 (Pilot Test 1) and v2.3 (Pilot Test 2)

<table>
<thead>
<tr>
<th>Item 1</th>
<th>Item 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Test 1</td>
<td>Pilot Test 2</td>
</tr>
<tr>
<td>FA IRT Difficulty</td>
<td>-0.932</td>
</tr>
<tr>
<td>Correlation with total score</td>
<td>0.39</td>
</tr>
<tr>
<td>SCI IRT Difficulty</td>
<td>-3.504</td>
</tr>
<tr>
<td>Correlation with total score</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Other item-level analyses are currently in process.

Table 8 shows a comparison of group ability estimates between Learning Assistants (LAs) and Noyce Fellows, and LAs and K12 teachers (refer to Table 1 for group numbers and descriptions) from both Pilot Test 1 (2007-2008) and Pilot Test 2. These group comparisons are based on the latent regression coefficients and are expressed in effect size units, which are calculated as the difference between the groups’ regression coefficients divided by the population SD for each dimension.

Table 8.

Group Comparisons on each dimension of the FASCI, Pilot Tests 1 and 2

<table>
<thead>
<tr>
<th>Groups Compared</th>
<th>FA Effect Size</th>
<th>SCI Effect Size</th>
<th>FA Effect Size</th>
<th>SCI Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noyce-LA</td>
<td>2.12</td>
<td>-0.08</td>
<td>1.93</td>
<td>0.97</td>
</tr>
<tr>
<td>K-12-LA</td>
<td>0.42</td>
<td>-1.14</td>
<td>1.69</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Based on the data in Table 8, it seems that the comparison of LAs to Noyce Fellows on the FA dimension is fairly consistent from Pilot Test 1 to Pilot Test 2. On both tests, the difference is about two effect size units showing that the Noyce Fellows have a larger strategic repertoire than the more novice LAs. This is what we would expect to find. The SCI comparison is not so straightforward. On Pilot Test
1, there is essentially no difference (less than 0.1 effect size units) and on Pilot Test 2, Noyce Fellows are more sophisticated by about one effect size unit. Further analyses of this difference are in process.

With respect to the K-12 teacher-LA comparisons, direct interpretation is confounded by the fact that the K-12 sample changed from Pilot Test 1 to Pilot Test 2. In Pilot Test 1, the K-12 teacher sample consisted of local K-12 teachers who had not been affiliated with the LA program at CU Boulder. In Pilot Test 2, the K-12 teacher sample is a combination of teachers who had been either LAs or Noyce Fellows at CU Boulder and teachers who had not been a part of the LA program (the “control” teachers in the LA-TEST K-12 research team sample). We are currently in the process of separating the K-12 group from Pilot Test 2 into two distinct groups (former LAs/Noyce Fellows, and control K-12 teachers) and analyzing the data based on these groupings. It should also be noted that the teacher sample discussed below in the Observations of Practice section is the same sample discussed here: a combination of former LAs/Noyce Fellows and control teachers.

Pilot Test 3

No findings are ready to be reported from Pilot Test 3 (version 2.4 of the FASCI, the partially constrained version) as we are still in the process of organizing response data from this administration. However, we can report that the process of developing this new version of the survey helped us to re-conceptualize potential scoring of the SCI dimension based on previous work by Otero and Nathan (2008) dealing with formative assessment.

Validity Studies

Cognitive Interviews

We have conducted 17 cognitive interviews to date, and have three more scheduled for the near future. All interviews are transcribed and are currently being coded using a framework shown in Appendix G. As coding is completed, we will use the evidence gathered to support our validity argument for the FASCI, and to investigate possible alternative explanations or interpretations that arise from the respondents’ comments.

Observations of Practice

Eighteen teachers that are part of the LA-TEST K-12 project make up the sample for this particular validity study. These teachers were already being observed using the RTOP (Piburn, et al., 2000) and interviewed as part of the LA-TEST K-12 research team efforts. We also employed the FASCI Observation Protocol (Appendix D) in these observations, and administered the Pilot Test 2 FASCI to these teachers. We are in the process of analyzing their raw FASCI scores (not IRT-scaled), FASCI observation protocol scores, and RTOP scores for multiple observations (total number of observations = 37). Preliminary analyses show moderate to strong correlations between FASCI scores and RTOP scores, both in the aggregate and by dimension for the FASCI and RTOP. Note that these correlations are higher for SCI than they are for the FA dimension. Figure 1 shows FA raw score vs. RTOP total score (correlation = 0.30) for the observation sample and Figure 2 shows SCI raw score vs. RTOP total score (correlation = 0.54) for the sample.
Figure 1. *FA raw score vs. RTOP total score for Observation sample. Correlation = 0.30*
Domain-Specificity of the FASCI Construct

Analysis of response data from the physics-FASCI/content-neutral FASCI is ongoing. We are currently finishing scoring the response data and analyzing the associated cognitive interviews.

Appendix A: FASCI v2.3

Thank you for agreeing to respond to the FASCI. Your participation should take about 45-60 minutes of your time.

The first set of questions pertains to your personal information

1) Which statement best describes you?
   a) I am a Learning Assistant
   b) I am a Noyce Fellow
   c) I am a student in the teacher education program, but not in the LA program
   d) I am STEM Faculty
   e) I am School of Education Faculty
   f) I am a STEM graduate student
   g) I am a School of Education graduate student
   h) I am a Practicing K-12 teacher

2) What is your age?

3) What is your gender?
   a) Female
   b) Male

4) What is your race?
   a) American Indian or Alaska Native
   b) Asian
   c) Black or African American
   d) Hispanic or Latino
   e) Native Hawaiian or Other Pacific Islander
   f) White

Figure 1. SCI raw score vs. RTOP total score for Observation sample. Correlation = 0.54
The next set of questions pertains to your most recent teaching experience

5) What was the setting of your most recent teaching experience
   a) Elementary School (K-5)
   b) Middle School (6-8)
   c) High School (9-12)
   d) Instructor for an undergraduate course
   e) Learning Assistant for an undergraduate course
   f) Teaching Assistant for an undergraduate course
   g) Instructor for a graduate course
   h) Teaching Assistant for a graduate course
   i) Other (Please specify): ___________________________

6) In what content area were you teaching?
   a) Astronomy
   b) Biology or Life Science
   c) Chemistry
   d) Engineering
   e) Geology or Earth Science
   f) Physics
   g) Mathematics
   h) Statistics
   i) Other (Please specify)

7) What was the approximate number of students in your class(es)?
   a) Less than 10
   b) 11-20
   c) 21-30
   d) 31-50
   e) 51+

8) What was the gender distribution of your class(es)?
   a) More females than males
   b) About equal distribution of females and males
   c) More males than females

9) What was the racial/ethnic composition of your class(es)?
   a) Primarily African-American
   b) Primarily Asian
   c) Primarily Hispanic
   d) Primarily white/Caucasian
   e) Other (Please specify):

10) How many years of experience have you had in the role of a teacher, in any setting?
    Please specify: _____
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

11) Students are working in groups of four to discuss a conceptual question you provided them at the beginning of class.

a) How might this activity facilitate student learning?

As the activity proceeds, one group gets frustrated and approaches you—they’ve come up with two solutions but can’t agree on which one is correct. You see that one solution is right, while the other is not.

b) Describe both what you would do and what you would expect to happen as a result.

c) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?

12) You are working out an example problem up on the board.

a) How might this activity facilitate student learning?

You accidentally make a mistake in solving the problem but don’t realize this until you get to the end of your solution and realize that the answer doesn’t make sense. No one in the class has said anything, so you’re not sure if they caught the mistake or not.

b) Describe both what you would do and what you would expect to happen as a result.

c) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?
You are using a computer simulation to demonstrate some abstract natural phenomenon to your class.

a.) How might this activity facilitate student learning?

As you are presenting this simulation, the students enjoy and discuss it, but it seems clear to you that they are not connecting the demonstration to the phenomenon of interest. They appear to be more interested in the simulation itself rather than the topic.

d) Describe both what you would do and what you would expect to happen as a result.

e) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?

13) You are teaching a lesson in which the students generate their own questions about the topic under study and their own methods for investigating those questions.

a.) How might this activity facilitate student learning?

As the activity begins, many students become frustrated by the lack of explicit direction given to them. They don’t know how to proceed.

a) Describe both what you would do and what you would expect to happen as a result.

b) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?

14) Students are writing up lab reports for an experiment that they did in class.

a.) How might this activity facilitate student learning?

As you are helping them with their write-ups, you notice that their written interpretation of the data is inconsistent with their graphical representation of the data. This is true for a majority of the reports you’ve seen.

a) Describe both what you would do and what you would expect to happen as a result.

b) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?

15) Before doing a demonstration for the class, you ask the students to make a prediction about what they might observe.

b.) How might this activity facilitate student learning?

While walking around, you notice that many of the students have the same incorrect prediction.

a) Describe both what you would do and what you would expect to happen as a result.

b) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?
Appendix B: FASCI v2.4

Thank you for agreeing to respond to the FASCI. Your participation should take about 45-60 minutes of your time.

The first set of questions pertains to your personal information

16) Which statement best describes you?
   a) I am a Learning Assistant
   b) I am a Noyce Fellow
   c) I am a student in the teacher education program, but not in the LA program
   d) I am STEM Faculty
   e) I am School of Education Faculty
   f) I am a STEM graduate student
   g) I am a School of Education graduate student
   h) I am a Practicing K-12 teacher

17) What is your age?

18) What is your gender?
   a) Female
   b) Male

19) What is your race?
   a) American Indian or Alaska Native
   b) Asian
   c) Black or African American
   d) Hispanic or Latino
   e) Native Hawaiian or Other Pacific Islander
   f) White

The next set of questions pertains to your most recent teaching experience

20) What was the setting of your most recent teaching experience
   a) Elementary School (K-5)
   b) Middle School (6-8)
   c) High School (9-12)
   d) Instructor for an undergraduate course
   e) Learning Assistant for an undergraduate course
   f) Teaching Assistant for an undergraduate course
   g) Instructor for a graduate course
   h) Teaching Assistant for a graduate course
   i) Other (Please specify): ___________________________

21) In what content area were you teaching?
   a) Astronomy
   b) Biology or Life Science
   c) Chemistry
   d) Engineering
22) What was the approximate number of students in your class(es)?
   a) Less than 10
   b) 11-20
   c) 21-30
   d) 31-50
   e) 51+

23) What was the gender distribution of your class(es)?
   a) More females than males
   b) About equal distribution of females and males
   c) More males than females

24) What was the racial/ethnic composition of your class(es)?
   a) Primarily African-American
   b) Primarily Asian
   c) Primarily Hispanic
   d) Primarily white/Caucasian
   e) Other (Please specify):

25) How many years of experience have you had in the role of a teacher, in any setting?
   Please specify: _____

For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

Students are working in groups of four to discuss a conceptual question you provided them at the beginning of class. How might this activity facilitate student learning? Choose the most important.

   a. The stronger students can teach the weaker students
   b. The students can construct their own understanding
   c. It can help students overcome misconceptions
   d. The students can argue for their ideas and try to convince their peers
   e. The students can learn the material if they want to learn
   f. The less motivated students can depend on the more motivated students

As the activity proceeds, one group gets frustrated and approaches you—they’ve come up with two solutions but can’t agree on which one is correct. You see that one solution is right, while the other is not. What would you do? Choose one action.

   a. I would explain the topic to the students
   b. I would have the students explain the topic to each other
   c. I would have the students explain the topic to me
d. I would ask the students conceptual questions in order to determine what they know

e. I would ask the students “leading” questions such as in a Socratic dialog

f. I would facilitate a whole-class discussion

g. Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?

a. I would explain the topic to the students in a different way

b. I would have the students explain the topic to each other

c. I would have the students explain the topic to me

d. I would ask the students conceptual questions in order to determine what they know

e. I would ask the students “leading” questions such as in a Socratic dialog

f. I would facilitate a whole-class discussion

g. It depends

h. Other

(If choice g. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

What would your choice of action depend on?

Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?

1. not confident

2. neutral

3. confident

What would make you more or less confident?
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

You are working out an example problem up on the board. How might this activity facilitate student learning? Choose the most important.
   a. The weaker students can learn from watching me
   b. The students can construct their own understanding
   c. It can help students see their misconceptions
   d. The students can ask me about the problem and articulate their ideas
   e. The students can learn the material if they want to
   f. The less motivated students can depend on me to work the problem

You accidentally make a mistake in solving the problem but don’t realize this until you get to the end of your solution and realize that the answer doesn’t make sense. No one in the class has said anything, so you’re not sure if they caught the mistake or not. What would you do? Choose one action.
   a. I would explain my mistake and the problem to the students
   b. I would ask the student conceptual questions in order to see if they could find the mistake
   c. I would ask the student “leading” questions such as in a Socratic dialog
   d. I would facilitate a whole-class discussion about the problem
   e. I would have the students solve the problem in groups
   f. Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?
   a. I would explain my mistake and the problem to the students
   b. I would ask the student conceptual questions in order to see if they could find the mistake
   c. I would ask the student “leading” questions such as in a Socratic dialog
   d. I would facilitate a whole-class discussion about the problem
   e. I would have the students solve the problem in groups
   f. It depends
   g. Other

(If choice f. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

What would your choice of action depend on?

Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?
   1. not confident
   2. neutral
   3. confident

What would make you more or less confident?
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

You have just finished giving a presentation on a complicated topic. How might this activity facilitate student learning? Choose the most important.

a. The weaker students can learn from watching and listening to me
b. The students can construct their own understanding
c. It can help students see their misconceptions
d. The students can ask me about the topic and articulate their ideas
e. The students can learn the material if they want to learn
f. The less motivated students can depend on me to explain the topic

You notice that many of the students in the class have very confused expressions on their faces. What would you do? Choose one action.

a. I would explain the topic to the students again
b. I would ask the students conceptual questions in order to see what their problems were
c. I would ask the student “leading” questions such as in a Socratic dialog
d. I would encourage the students to ask me questions
e. I would facilitate a whole-class discussion about the topic
f. Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?

a. I would explain the topic to the students again in a different way
b. I would ask the students conceptual questions in order to see what their problems were
c. I would ask the student “leading” questions such as in a Socratic dialog
d. I would encourage the students to ask me questions
e. I would facilitate a whole-class discussion about the topic
f. It depends
g. Other

(If choice f. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

What would your choice of action depend on?

Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?

1. not confident
2. neutral
3. confident

What would make you more or less confident?
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

You have given your students a quiz to assess their understanding of a difficult topic. How might this activity facilitate student learning? Choose the most important.
   a. The students can learn what they don’t know
   b. The students can construct their own understanding
   c. It can help students and me identify what they know
   d. The students can work through the quiz and articulate their ideas
   e. The students can show me what they know

Many of your students are discouraged after performing poorly on the quiz. What would you do? Choose one action.
   a. I would go over the quiz answers with the students
   b. I would ask the student conceptual questions about the quiz in order to find out what their problems were
   c. I would encourage the students to ask me questions
   d. I would facilitate a whole-class discussion about the quiz questions
   e. I would have the students solve the quiz problems in groups
   f. Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?
   a. I would go over the quiz answers with the students again
   b. I would ask the student conceptual questions about the quiz in order to find out what their problems were
   c. I would encourage the students to ask me questions
   d. I would facilitate a whole-class discussion about the quiz questions
   e. I would have the students solve the quiz problems in groups
   f. It depends
   g. Other

(If choice f. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

What would your choice of action depend on?

Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?
   1. not confident
   2. neutral
   3. confident

What would make you more or less confident?
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

In talking with one of your students you discover that they have a misconception about a central topic presented in that week’s class. You attempt to address the misconception by having a one-on-one conversation with the student. How might this activity facilitate student learning? Choose the most important.

- The student can learn what they don’t know
- The student can construct their own understanding
- It can help the student and me to identify what they know
- The student and I can work through the concept together
- The students can show me what they know

Despite your conversation, the student maintains the same misconception. What would you do? Choose one action.

- I would explain the topic to the student
- I would have the student explain the topic to me
- I would ask the student conceptual questions in order to see what their ideas were
- I would ask the student “leading” questions such as in a Socratic dialog
- I would have the student work with another student who understood the topic
- Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?

- I would again explain the topic to the student
- I would have the student explain the topic to me
- I would ask the student conceptual questions in order to see what their ideas were
- I would ask the student “leading” questions such as in a Socratic dialog
- I would have the student work with another student who understood the topic
- It depends
- Other

(If choice f. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

What would your choice of action depend on?

Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?

1. not confident
2. neutral
3. confident

What would make you more or less confident?
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

You are using a computer simulation to demonstrate some abstract natural phenomenon to your class. How might this activity facilitate student learning? Choose the most important.

a. The weaker students can learn from watching the simulation
b. The students can construct their own understanding
c. It can help students see their misconceptions
d. The students can ask me about the simulation and articulate their ideas
e. The students can learn from the simulation if they want to learn
f. The less motivated students can play with the simulation

As you are presenting this simulation, the students enjoy and discuss it, but it seems clear to you that they are not connecting the demonstration to the phenomenon of interest. They appear to be more interested in the simulation itself rather than the topic. What would you do? Choose one action.

a. I would explain the simulation and the concept to the students
b. I would ask the students conceptual questions in order to help them link the simulation and concept
c. I would ask the students “leading” questions such as in a Socratic dialog
d. I would facilitate a whole-class discussion about the simulation and concept
e. I would have the students continue to work with the simulation
f. Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?

a. I would again explain the simulation and the concept to the students
b. I would ask the students conceptual questions in order to help them link the simulation and concept
c. I would ask the students “leading” questions such as in a Socratic dialog
d. I would facilitate a whole-class discussion about the simulation and concept
e. I would have the students continue to work with the simulation
f. It depends
g. Other

(If choice f. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

What would your choice of action depend on?

Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?

1. not confident
2. neutral
3. confident

What would make you more or less confident?
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

You are teaching a lesson in which the students generate their own questions about the topic under study and their own methods for investigating those questions. How might this activity facilitate student learning? Choose the most important.

a. The weaker students can learn from asking me what to investigate  
b. The students can construct their own understanding  
c. It can help students to discover their misconceptions  
d. The students can ask me about the investigation  
e. The students can learn the material if they want to engage in the activity  
f. The less motivated students can depend on the more motivated ones to generate the questions

As the activity begins, many students become frustrated by the lack of explicit direction given to them. They don’t know how to proceed. What would you do? Choose one action.

a. I would explain the topic to them and suggest some questions to investigate  
b. I would ask the students conceptual questions in order to see if they could develop their own questions  
c. I would ask the students “leading” questions about the topic, such as in a Socratic dialog  
d. I would facilitate a whole-class discussion about the topic and questions to investigate  
e. I would have the students work in groups to develop questions to investigate  
f. Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?

a. I would explain the topic to them and suggest some questions to investigate  
b. I would ask the students conceptual questions in order to see if they could develop their own questions  
c. I would ask the students “leading” questions about the topic, such as in a Socratic dialog  
d. I would facilitate a whole-class discussion about the topic and questions to investigate  
e. I would have the students work in groups to develop questions to investigate  
f. It depends  
g. Other

(If choice f. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

What would your choice of action depend on?

Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?

1. not confident  
2. neutral  
3. confident

What would make you more or less confident?
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

Students are writing up lab reports for an experiment that they did in class. How might this activity facilitate student learning? Choose the most important.
   a. The weaker students can learn from writing the report
   b. The students can construct their own understanding as they write
   c. It can help students identify their misconceptions
   d. The students can ask me about the lab report and articulate their ideas
   e. The students can learn from writing the report if they want to learn
   f. The less motivated students can depend on me to tell them how to write the report

As you are helping them with their write-ups, you notice that their written interpretation of the data is inconsistent with their graphical representation of the data. This is true for a majority of the reports you’ve seen. What would you do? Choose one action.
   a. I would explain how to write about the graphical representation of the data
   b. I would ask the students conceptual questions in order to see if they could identify the inconsistencies
   c. I would ask the student “leading” questions such as in a Socratic dialog
   d. I would facilitate a whole-class discussion about the written and graphical representations
   e. I would have the students work on the lab report in groups
   f. Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?
   a. I would explain how to write about the graphical representation of the data
   b. I would ask the students conceptual questions in order to see if they could identify the inconsistencies
   c. I would ask the student “leading” questions such as in a Socratic dialog
   d. I would facilitate a whole-class discussion about the written and graphical representations
   e. I would have the students work on the lab report in groups
   f. It depends
   g. Other

(If choice f. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

   What would your choice of action depend on?

   Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?
   1. not confident
   2. neutral
   3. confident

What would make you more or less confident?
For the scenarios that follow, please assume (unless it is otherwise specified) that you are teaching a high school course in physics, chemistry, biology, earth science or math to a class of 25-30 students.

Before doing a demonstration for the class, you ask the students to make a prediction about what they might observe. How might this activity facilitate student learning? Choose the most important.

a. The weaker students can learn from watching me do the demonstration
b. The students can construct their own understanding
c. It can help students see their misconceptions
d. The students can ask me about the demonstration and articulate their ideas
e. The students can learn from watching the demonstration if they want to learn
f. The less motivated students can depend on me to explain the demonstration and topic

While walking around, you notice that many of the students have the same incorrect prediction. What would you do? Choose one action.

a. I would tell the students to re-think their predictions
b. I would ask the student conceptual questions in order to prompt them to think further about their predictions
c. I would ask the student “leading” questions such as in a Socratic dialog
d. I would facilitate a whole-class discussion about the predictions
e. I would have the students make their predictions in groups
f. Other

The approach you chose in the previous question did not produce the desired results. What would you do in the next class session?

a. I would tell the students to re-think their predictions
b. I would ask the student conceptual questions in order to prompt them to think further about their predictions
c. I would ask the student “leading” questions such as in a Socratic dialog
d. I would facilitate a whole-class discussion about the predictions
e. I would have the students make their predictions in groups
f. It depends
g. Other

(If choice f. selected above, then respondent prompted to answer the following, otherwise skip to confidence question)

What would your choice of action depend on?

Based on your response to the previous question, what would you do next?

How confident are you that your choice of strategy in the previous question would produce the desired results?

1. not confident
2. neutral
3. confident

What would make you more or less confident?

Please use the space below to provide us with any feedback about the survey and your experience in participating. We welcome any suggestions on specific items.
Appendix C: Cognitive Interview Protocol

Prompts to ask in guiding the cognitive interview:

- What did you think of the survey overall?
- What do you think was the most difficult part of the survey to respond to?
- What do you think the easiest part of the survey was?
- Did anything about the survey frustrate you?
  - Did the frustration have an impact on how you responded to anything?
- What do you think this survey is trying to get at?
- Do you think it is designed in a way that does this well?
- Can you talk me through your thought process as you were formulating some of your (or this particular) responses?
- Do you have any suggestions?
Appendix D: FASCI Observation Protocol

Date: ___________________  Teacher:______________________ Location:______________
Observer:______________ Grade Level/Subject:____________ Start/End Times:______________

<table>
<thead>
<tr>
<th>Does the teacher elicit students’ ideas or current conceptions about the topic?</th>
<th>Once</th>
<th>&gt; Once</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

Which of the following teaching strategies did the teacher employ and how often?

<table>
<thead>
<tr>
<th>Demos</th>
<th>Once</th>
<th>&gt; Once</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducts a demonstration for the students</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Has the students conduct a demonstration for each other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Explanations</th>
<th>Once</th>
<th>&gt; Once</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explains the concept or procedure to the students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has students explain the concept or procedure to each other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has students explain their reasoning</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questioning</th>
<th>Once</th>
<th>&gt; Once</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asks closed-ended questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asks open-ended questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encourages students to ask them questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilitates a class discussion</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Representations</th>
<th>Once</th>
<th>&gt; Once</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete materials representation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal representation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematical representation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual representation (pictures, graphs, etc)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Once</th>
<th>&gt; Once</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair-share or use peer tutoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jigsaw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teams or teams/games</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group problem solving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group presentation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Did anything happen during the class that appeared to be unexpected by the teacher? For example, anything that posed a potential obstacle to learning and may have caused the teacher to improvise? If so, please describe:

**During the follow-up interview, ask:** “During class today, did anything happen that you did not expect to happen? Probe: “What was it? What did you do?”
Appendix E: Reformed Teaching Observation Protocol

Reformed Teaching Observation Protocol (RTOP)

Daya Szwada
External Evaluator

Michael Pihurn
Internal Evaluator

and

Kathleen Falconer, Jeff Turley, Russell Benford and Irene Bloom
Evaluation Facilitation Group (EFG)

Technical Report No. IN00-1
Arizona Collaborative for Excellence in the Preparation of Teachers
Arizona State University

I. BACKGROUND INFORMATION

Name of teacher _____________________________
Announced Observation? (yes, no, or explain)

Location of class ____________________________
(district, school, room)

Years of Teaching __________________________
Teaching Certification (K-8 or 7-12)

Subject observed ____________________________
Grade level _________________________________

Observer ________________________________
Date of observation _________________________

Start time ________________________________
End time _________________________________

II. CONTEXTUAL BACKGROUND AND ACTIVITIES

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc.), and any relevant details about the students (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate.
Record here events which may help in documenting the ratings.

<table>
<thead>
<tr>
<th>Time</th>
<th>Description of Events</th>
</tr>
</thead>
</table>

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p 2 of 2
### III. LESSON DESIGN AND IMPLEMENTATION

<table>
<thead>
<tr>
<th></th>
<th>Never Occurred</th>
<th>Very Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The instructional strategies and activities respected students’ prior knowledge and the preconceptions inherent therein.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>2</td>
<td>The lesson was designed to engage students as members of a learning community.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>3</td>
<td>In this lesson, student exploration preceded formal presentation.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>4</td>
<td>This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>5</td>
<td>The focus and direction of the lesson was often determined by ideas originating with students.</td>
<td>0 1 2 3 4</td>
</tr>
</tbody>
</table>

### IV. CONTENT

**Propositional Knowledge**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>6</td>
<td>The lesson involved fundamental concepts of the subject.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>The lesson promoted strongly coherent conceptual understanding.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>The teacher had a solid grasp of the subject matter content inherent in the lesson.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Connections with other content disciplines and/or real world phenomena were explored and valued.</td>
<td>0 1 2 3 4</td>
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</tbody>
</table>

**Procedural Knowledge**

<p>| | | | | |</p>
<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Students made predictions, estimations and/or hypotheses and devised means for testing them.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Students were reflective about their learning.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Intellectual rigor, constructive criticism, and the challenging of ideas were valued.</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Continue recording salient events here.

<table>
<thead>
<tr>
<th>Time</th>
<th>Description of Events</th>
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<tbody>
<tr>
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</tbody>
</table>

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## V. CLASSROOM CULTURE

<table>
<thead>
<tr>
<th>Communicative Interactions</th>
<th>Never Occurred</th>
<th>Very Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>16) Students were involved in the communication of their ideas to others using a variety of means and media.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>17) The teacher’s questions triggered divergent modes of thinking.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>18) There was a high proportion of student talk and a significant amount of it occurred between and among students.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>19) Student questions and comments often determined the focus and direction of classroom discourse.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>20) There was a climate of respect for what others had to say.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>

### Student/Teacher Relationships

<table>
<thead>
<tr>
<th></th>
<th>Never Occurred</th>
<th>Very Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>21) Active participation of students was encouraged and valued.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>22) Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>23) In general the teacher was patient with students.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>24) The teacher acted as a resource person, working to support and enhance student investigations.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>25) The metaphor “teacher as listener” was very characteristic of this classroom.</td>
<td>0 1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>

Additional comments you may wish to make about this lesson.
The first set of questions pertains to your personal information

1) Which statement best describes you?
   a) I am a Learning Assistant
   b) I am a student in the teacher education program, but not in the LA program
   c) I am a Practicing K-12 teacher
   d) Other (Please specify)

2) What university do you attend?
   a) Florida International University
   b) Rutgers
   c) Seattle Pacific University
   d) University of Colorado at Boulder
   e) University of Iowa
   f) Other (Please specify)

3) What is your age?

4) What is your gender?
   a) Female
   b) Male

5) What is your race? Choose all that apply.
   a) American Indian or Alaska Native
   b) Asian
   c) Black or African American
   d) Hispanic or Latino
   e) Native Hawaiian or Other Pacific Islander
   f) White
   g) Other (Please specify)

6) What is your subject area specialty that you plan on teaching in the near future (when you complete teacher education, or in your next year of teaching practice)?
   a) Astronomy
   b) Biology
   c) Chemistry
   d) Geology/Earth Sciences
   e) Math
   f) Physics
   g) Other (Please specify)
The next set of questions pertains to your most recent teaching experience

7) What was the setting of your most recent teaching experience
   a) Elementary School (K-5)
   b) Middle School (6-8)
   c) High School (9-12)
   d) Instructor for an undergraduate course
   e) Learning Assistant or Teaching Assistant for an undergraduate course
   f) Instructor for a graduate course
   g) Learning Assistant or Teaching Assistant for a graduate course
   h) I have never taught before
   i) Other (Please specify)

8) In what content area were you teaching? Choose all that apply.
   a) Astronomy
   b) Biology or Life Science
   c) Chemistry
   d) Engineering
   e) Geology or Earth Science
   f) Physics
   g) Mathematics
   h) Statistics
   i) I have not taught before
   j) Other (Please specify)

9) What was the approximate number of students in your class(es)?
   a) Less than 10
   b) 11-20
   c) 21-30
   d) 31-50
   e) 51+
   f) I have not taught before

10) What was the gender distribution of your class(es)?
    a) More females than males
    b) About equal distribution of females and males
    c) More males than females
    d) I have not taught before
11) What was the racial/ethnic composition of your class(es)?
   a) Primarily African-American
   b) Primarily Asian
   c) Primarily Hispanic
   d) Primarily white/Caucasian
   e) I have not taught before
   f) Other (Please specify)

12) How many years of experience have you had in the role of a teacher, in any setting?

   Topic 1: Newton’s 3rd Law

   For the questions and scenarios that follow, please assume that you are teaching a high school course in physics to a class of 25-30 students. You have defined the following learning objectives for this class:

   o Students should understand Newton’s Third Law so that, for a given system, they can identify the force pairs and the objects on which the forces are exerted, and specify the magnitude and direction of each force.

   o Students should be able to apply Newton’s Third Law in analyzing the forces that two objects in contact exert on each other when they accelerate together along a horizontal or vertical line, or the forces that two surfaces that slide across one another exert on each other.

   To assess your students’ understanding of this content, you have given them the following conceptual questions:

13) Two students sit in identical office chairs facing each other. Bob has a mass of 95 kg, while Jim has a mass of 77 kg. Bob places his bare feet on Jim’s knees, as shown to the right. Bob then suddenly pushes outward with his feet, causing both chairs to move. In this situation, while Bob’s feet are in contact with Jim’s knees,
   a) Neither exerts a force on the other
   b) Bob exerts a force on Jim, but Jim doesn’t exert any force on Bob
   c) Each student exerts a force on the other, but Jim exerts the larger force
   d) Each student exerts a force on the other, but Bob exerts the larger force
   e) Each student exerts the same amount of force on the other
   f) None of these answers is correct
The next set of questions refer to a large truck which breaks down out on the road and receives a push back to town by a small compact car, as in the picture below.

Pick one of the choices a) through f) which correctly describes the forces between the car and the truck for each of the descriptions in questions 2 through 5 below.

14) The car is pushing on the truck, but not hard enough to make the truck move.
   a) The force of the car pushing against the truck is equal to that of the truck pushing back against the car.
   b) The force of the car pushing against the truck is less than that of the truck pushing back against the car.
   c) The force of the car pushing against the truck is greater than that of the truck pushing back against the car.
   d) The car's engine is running so it applies a force as it pushes against the truck, but the truck's engine isn't running so it can't push back with a force against the car.
   e) Neither the car nor the truck exert any force on each other. The truck is pushed forward simply because it is in the way of the car.
   f) None of these descriptions is correct.

15) The car, still pushing the truck, is speeding up to get to cruising speed.
   a) The force of the car pushing against the truck is equal to that of the truck pushing back against the car.
   b) The force of the car pushing against the truck is less than that of the truck pushing back against the car.
   c) The force of the car pushing against the truck is greater than that of the truck pushing back against the car.
   d) The car's engine is running so it applies a force as it pushes against the truck, but the truck's engine isn't running so it can't push back with a force against the car.
   e) Neither the car nor the truck exert any force on each other. The truck is pushed forward simply because it is in the way of the car.
   f) None of these descriptions is correct.
16) The car, still pushing the truck, is at cruising speed and continues to travel at the same speed.
   a) The force of the car pushing against the truck is equal to that of the truck pushing back against the car.
   b) The force of the car pushing against the truck is less than that of the truck pushing back against the car.
   c) The force of the car pushing against the truck is greater than that of the truck pushing back against the car.
   d) The car's engine is running so it applies a force as it pushes against the truck, but the truck's engine isn't running so it can't push back with a force against the car.
   e) Neither the car nor the truck exert any force on each other. The truck is pushed forward simply because it is in the way of the car.
   f) None of these descriptions is correct.

17) The car, still pushing the truck, is at cruising speed when the truck puts on its brakes and causes the car to slow down.
   a) The force of the car pushing against the truck is equal to that of the truck pushing back against the car.
   b) The force of the car pushing against the truck is less than that of the truck pushing back against the car.
   c) The force of the car pushing against the truck is greater than that of the truck pushing back against the car.
   d) The car's engine is running so it applies a force as it pushes against the truck, but the truck's engine isn't running so it can't push back with a force against the car.
   e) Neither the car nor the truck exert any force on each other. The truck is pushed forward simply because it is in the way of the car.
   f) None of these descriptions is correct.
Please respond to the following questions about your teaching:

18) Students are working in groups of four to discuss the conceptual questions about the car pushing the truck.
   a) How might this activity facilitate student learning?

   As the activity proceeds, one group gets frustrated and approaches you—they cannot agree on the answers regarding the forces exerted by the car and truck on each other.

   b) Describe both what would you do and what you would expect to happen as a result.

   c) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?

19) On the board, you are drawing free-body diagrams of the car and the truck.
   a) How might this activity facilitate student learning?

   You accidentally make a mistake in drawing these diagrams but don’t realize this until after you complete the diagrams and realize that they don’t make sense. No one in the class has said anything, so you’re not sure if they caught the mistake or not.

   b) Describe both what would you do and what you would expect to happen as a result.

   c) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?

20) You have just finished giving a presentation on Newton’s Third Law.
   a) How might this activity facilitate student learning?

   You notice that many of the students in the class have very confused expressions on their faces.

   b) Describe both what would you do and what you would expect to happen as a result.

   c) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?
**Topic 2: Newton’s 2nd Law**

For the questions and scenarios that follow, please assume that you are teaching a high school course in physics to a class of 25-30 students. You have defined the following learning objectives for this class:

- Students should understand the relation between the net force that is exerted on an object and the resulting change in the object’s velocity, so they can:
  - Calculate, for an object moving in one dimension, the velocity change that results when one constant force is exerted on the object over a specified time interval.
  - Determine, for a constantly accelerating object, the average net force that was exerted on the object.
  - Understand how Newton’s Second Law applies to an object that interacts with the Earth, and be able to draw a well-labeled free-body diagram of that object.
  - Analyze situations in which an object moves with specified acceleration when one or more forces are exerted on it, and determine the magnitude and direction of the net force.

To assess your students’ understanding of this content, you have given them the following conceptual questions:

You throw a coin vertically downward. Please indicate whether each of the following statements is true or false. Ignore air resistance and note that more than one of the statements could be true.

21) After the coin leaves your hand, the net force on the coin is increasing
22) After the coin leaves your hand, the acceleration of the coin is increasing
23) After the coin leaves your hand, the speed of the coin is increasing
24) After the coin leaves your hand, the net force on the coin is zero
25) After the coin leaves your hand, the speed of the coin is constant
26) After the coin leaves your hand, the acceleration of the coin is constant
27) A ball is rolled up a ramp and has reached its highest point as indicated in the figure below. Which vector represents the net force on the ball when it is at its highest point and is just beginning to roll back down the ramp? Consider friction and air resistance to be negligible.
Please respond to the following questions about your teaching:

28) You have given your students a quiz about the above questions to assess their understanding of Newton’s 2nd Law.

   a) How might this activity facilitate student learning?

      Many of your students are discouraged after performing poorly on the quiz.

   b) Describe both what would you do and what you would expect to happen as a result.

   c) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?

29) In talking with one of your students you discover that they think that there is still a force exerted by your hand on the coin after it leaves your hand. You attempt to address this difficulty by having a one-on-one conversation with the student.

   a) How might this activity facilitate student learning?

      Despite your conversation, the student stills holds his/her prior idea.

   b) Describe both what would you do and what you would expect to happen as a result.

   c) If the approach you described above in (b) didn’t produce the result(s) you anticipated by the end of that class session, what would you do in the next class session?

30) Approximately how many Physics course have you taken at the post-secondary level?

   a) 0
   b) 1
   c) 2
   d) 3
   e) 4
   f) 5
   g) more than 5
Appendix G: Cognitive Interview Coding Framework

Cognitive Interview Codes:

- Respondent background (including teacher experience, motivation for teaching, group status (e.g. LA, non-LA))
- General reactions
- Difficult
- Easy
- Frustrating
- Formulating responses/thought processes
- FASCI construct/purpose of survey

Suggestions/comments on survey

References


DBER Team: Department of Physics
Activities and Findings

2008-2009

Steve Pollock, Noah Finkelstein, and Ben Spike

Activities

Department Info

Transformed course details:

**PHYS 1110** (Physics I, Mechanics)
Enrollment typically 500-600 each semester. There are three 50 minute lectures a week (using Peer Instruction) and one 50-minute Tutorial section for ~24 students, led by a grad physics TA and 1-2 LAs.
Principal role of LA is to facilitate UW-style Tutorials, (four per week), along with office hours in the Physics help room.

**PHYS 1120** (Physics II, E&M)
Enrollment typically 350-500 each semester. There are three 50 minute lectures a week (using Peer Instruction) and one 50-minute Tutorial section for ~24 students, led by a grad physics TA and 1-2 LAs
Principal role of LA is to facilitate UW-style Tutorials, (four per week), along with office hours in the Physics help room.

**PHYS 1010/1020** (Physics of Everyday Life)
Enrollment typically 200 each fall for 1010, and 50 each spring for 1020. There are three 50 minute lectures a week (using Peer Instruction). **Principal role of LA is to facilitate student conversations during lecture periods, along with running optional study/homework sessions**

**PHYS 2130/2170** (Modern Physics)
Enrollment 70-200 in 2130 (aimed at Engineers), 40-80 in 2170 (aimed at Physics majors) There are three 50 minute lectures a week (using Peer Instruction) **Principal role of LA is to facilitate student conversations during lecture periods, along with running optional study/homework sessions**

**PHYS 4810/7810** (Teaching and Learning Physics)
Enrollment typically 12-24, mixed graduate and advanced undergraduate. Meets twice a week for 75 minutes. Enrolled students work in roles parallel to those of LAs.
**PHYS 3310** (Junior level Electricity and Magnetism)
As part of a project to transform an upper-division physics course building on principles of education research, a former physics LA worked with a lead faculty member, implementing Tutorial activities.

**PHYS 3220** (Junior level Quantum Mechanics)
New addition this term - also a part of a project to transform an upper-division physics course building on principles of education research, a physics LA works with a lead faculty member, implementing Tutorial activities.

Current course syllabi can be found at
http://www.colorado/edu/physics/phys[1110, or 1120, etc]  
For earlier semesters, the naming convention is e.g.  
http://www.colorado/edu/physics/phys1110/phys1110_fa04

**The Physics department is a member of the Physics Teachers Education Coalition**  
(PhysTEC, http://www.ptec.org/)

**Faculty** for AY 2008-2009 in courses involving LAs:

**Fall 2008:**
- Phys 1010 (Everyday life): Margaret Murnane. 1 returning LA
- Phys 1110 (Mechanics, calc-based): Kevin Stenson (lead) and Kathy Perkins (in charge of LAs). 7 LAs, of whom 1 was returning
- Phys 1120 (E&M I, calc-based): Victor Gurarie (lead) and Shijie Zhong (in charge of LAs). 7 LAs, of whom 4 were returning
- Phys 3310 (Electricity and Magnetism): Michael Dubson and Ed Kinney. No LA this term.

**Spring 2009:**
- Phys 1020 (Everyday life): Noah Finkelstein. 3 LAs, of whom 1 was returning
- Phys 1110 (Mechanics, calc-based): Michael Dubson (lead) and Thomas Schibli (in charge of LAs). 7 LAs
- Phys 1120 (E&M I, calc-based): Murray Holland (lead) and Dana Anderson (in charge of LAs). 7 LAs, of whom 2 were returning
- Phys 3310 (Electricity and Magnetism): Ed Kinney, and, Phys 3220 (Quantum Mechanics): Oliver DeWolfe. 1 LA was shared for both these courses.

**Applications** for Fall 2008: 50 new and 9 returning (of the 59 total, 19 had another departmental interest as well) Females: 9, plus 4 returning.

**Applications** for Spring 2009: 40 new and 5 returning (of the 45 total, 12 had another departmental interest as well) Females: 2, plus 3 returning.
Accepted, Fall 2008: 15 LAs (5 female) (6 returning, 4M, 2F)
Accepted, Spring 2009: 18 LAs (4 female) (3 returning, 1M, 2F)

Longer term brief summary of LAs in Physics:
We have hired a total of 165 undergraduate LAs since Fall 2003.
Of these, 39 were female = 24%
39 of these total LAs have served two or more semesters. (15 of these were female)

The rough total number of applicants for physics LA positions over 10 semesters is 521.
Of the 521 total, approximately 112 were female. (21%)
Findings

LAs

❖ Content expertise

Physics I: FMCE (Force and Motion Concept Evaluation) a research-based, published assessment tool, given pre and post in Phys 1110 (introductory, calculus based physics): 

*Conceptual Learning: Learning Assistant data* (not all matched - typically missing ~1 or 2 for pre and/or post)

<table>
<thead>
<tr>
<th>Semester</th>
<th>N</th>
<th>Pre ave</th>
<th>Post ave</th>
<th>Gain of ave</th>
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<td>100</td>
<td>1.00</td>
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<tr>
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<td>5</td>
<td>90.8</td>
<td>98.2</td>
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</tbody>
</table>

*Notes:* We did not take FMCE data for LAs in earlier semesters. Given the consistently very high pretests, and essentially "pegged" posttests, for all the previous semesters, we have decided it is not necessary to regularly measure LA learning in this environment with the FMCE instrument.

Physics II: BEMA(Brief Electricity and Magnetism Survey)

<table>
<thead>
<tr>
<th>Semester</th>
<th>N</th>
<th>Pre ave</th>
<th>Post ave</th>
<th>Gain of ave</th>
</tr>
</thead>
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<td>.76</td>
<td>.31</td>
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<td>.31</td>
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<td>.70</td>
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LA posttest results fluctuate considerably, and with the small numbers of LAs, it is not clear what "error bar" to associate with these numbers. We consider scores above .80 on the BEMA or CSEM posttest to be quite respectable; these are much harder tests than the FMCE (where we would like to see high 90's)

❖ Beliefs

67
CLASS data is not available for the LAs.

❖ Other LA activities

1) LAs in physics assist with Tutorials and other transformed classes. They also all work 1-2 hours/week in the Physics Help room. This is essentially "office hours" for any students in any of the lower division introductory courses, in a large space in the basement of Duane Physics.

2) The JILA Molecular, Atomic, and Optical Physics NSF Physics Frontier Center outreach activities include recruiting and training university students to participate in inquiry-based science activities in K12 environments. We are actively considering adding the JILA program to the list of possible required activities for returning LAs in future semesters, several of our LAs volunteered for this program this year.

LA-supported courses

❖ General Introduction: Course development and transformations have been going on since before the LA-TEST grant, with our first Tutorials implemented in 2003, and data collection beginning in 2004. We have observed and documented the following:

- improved student content mastery in:
  o mechanics (Physics 1), electricity and magnetism (Physics 2), physics of everyday life, modern physics, and (when offered) teaching and learning physics (Phys 4810/7810)

- success at supporting favorable attitudes and beliefs:
  o there are some instances of degradation on the CLASS (phys 1), similar to other published work (See Adams, Phys Rev 2, 010101)
  o several of the implementations have seen no degradation on the CLASS, which we consider significant success

- lasting impact on content mastery
  o in upper division physics we observe difference between those students have had Tutorials and those who have not
  o there is differential positive impact for those students who were LAs
  o outcomes apparently depend upon which / how faculty implement these curricula

❖ Content Conceptual Learning: Data for classes as whole:
Physics I: (Phys 1110) (introductory, calculus based physics)
FMCE (Force and Motion Concept Evaluation) given pre and post:

<table>
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<tr>
<th>Semester</th>
<th>Recitation</th>
<th>N (matched)</th>
<th>Ave pre*</th>
<th>Ave post*</th>
<th>Norm. gain**</th>
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</table>

* Average(%) is scored using recommended FMCE rubric, for students with matched pre-post data. (Standard error of the mean is between 1-2% for all terms). F03 used the FC1 exam pre and post, all other terms are FMCE. (Note similar gains for F03 and S04 on these two exams.)

** Normalized gain <<g>> in the last column is computed as the gain of the average pre and post scores for matched students. (Standard error of average gains is roughly ±.02 for all terms.)

FMCE pre-post results: S09 lead faculty was a highly experienced PER group member, backed up by a novice instructor running Tutorial training. F08 lead faculty was a junior faculty member, teaching this course for his second time - backed up by a PER faculty running Tutorial training.
Physics II: (Phys 1120) (introductory, calc-based second semester physics)

BEMA (Brief Electricity and Magnetism Survey) pre and post:

**Summary of BEMA scores**

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<th>posttest score (%)</th>
<th>Normalized gain &lt;g&gt;</th>
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<tbody>
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<td>0.44</td>
</tr>
<tr>
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<td>S09</td>
<td>328 (post)</td>
<td>56</td>
<td>0.40 *</td>
</tr>
</tbody>
</table>

All semesters shown used Tutorials in recitation. Standard errors of the mean are 1-2% on posttest, and roughly ±0.02 for normalized gains. (PER) in parentheses means the lead faculty that term was a member of the Physics Education Research group. (Pretests are very steady at 26±1%)

* No pretest given in S07 or S09, we used the ave pretest (26±1%) to estimate normalized gain.
** In F07 and F08, half the class took BEMA, half CSEM (For the CSEM, the pretest score was 32% in both semesters it was given)

![Histogram of BEMA results for most recent two semesters. F08 was lead by inexperienced faculty, S09 by more experienced team. Both used similar curriculum and materials. Pre data was not collected in S09. Post scores are high compared to a recent publication of results from peer institutions, where traditional classes yield post scores from 35-45%.

70

University of Colorado, Boulder

LATEST Annual Report
Phys 2130/2170 (Modern physics, for engineers/physics majors respectively)

We have administered the QMCS (Quantum Mechanics Concept Survey) pre and post for several semesters in both of these classes. The table shows historical results for both courses, in some cases (reformed, using Learning Assistants) and Trad (more traditional instruction, without LAs) versions of these courses.

<table>
<thead>
<tr>
<th>Course: Phys 2130 (engineers)</th>
<th>Style</th>
<th>Pre</th>
<th>Post</th>
<th>&lt;g&gt;</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp05</td>
<td>Trad</td>
<td>NA</td>
<td>51</td>
<td>NA</td>
<td>68</td>
</tr>
<tr>
<td>Fa05</td>
<td>Reformed</td>
<td>32</td>
<td>69</td>
<td>.54</td>
<td>162</td>
</tr>
<tr>
<td>Sp06</td>
<td>Reformed</td>
<td>30</td>
<td>65</td>
<td>.49</td>
<td>156</td>
</tr>
<tr>
<td>Fa06</td>
<td>Reformed</td>
<td>34</td>
<td>63</td>
<td>.45</td>
<td>73</td>
</tr>
<tr>
<td>Sp07</td>
<td>Reformed</td>
<td>36</td>
<td>62</td>
<td>.41</td>
<td>120</td>
</tr>
<tr>
<td>Fa07</td>
<td>Trad</td>
<td>34</td>
<td>54</td>
<td>.31</td>
<td>40</td>
</tr>
<tr>
<td>Sp08</td>
<td>Trad</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course: Phys 2170 (phys majors)</th>
<th>Style</th>
<th>Pre</th>
<th>Post</th>
<th>&lt;g&gt;</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp05</td>
<td>Trad</td>
<td>NA</td>
<td>63</td>
<td>NA</td>
<td>64</td>
</tr>
<tr>
<td>Fa05</td>
<td>Trad</td>
<td>40</td>
<td>52</td>
<td>.21</td>
<td>54</td>
</tr>
<tr>
<td>Sp06</td>
<td>Trad</td>
<td>44</td>
<td>64</td>
<td>.37</td>
<td>23</td>
</tr>
<tr>
<td>Fa06</td>
<td>Trad</td>
<td>38</td>
<td>52</td>
<td>.22</td>
<td>54</td>
</tr>
<tr>
<td>Sp07</td>
<td>Trad</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Fa07</td>
<td>Reformed</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Sp08</td>
<td>Trad</td>
<td>NA</td>
<td>66</td>
<td>NA</td>
<td>69</td>
</tr>
</tbody>
</table>

Comments: Pre and post scores are %. Standard error of the mean on the gains is typically of order 5%.

Pre is about 7 points higher for the physics majors than the engineers.

Post Trad is on average 12 points lower than Post Reformed in 2130

Post Trad is on average 8 points lower than Post Reformed in 2170 (although this course has only been taught once in the reformed style)

The survey was not given in either class in Sp08 (both traditional), nor in Fa08/Sp09
Phys 3310 (upper division Electricity and Magnetism for majors)

Last year, a Learning Assistant (Darrin Tarshis) helped us develop ten optional weekly Tutorials, using research-based and other reform materials obtained from Bruce Patton (Ohio State) ("Jackson by Inquiry", which he is modifying into "Griffiths by Inquiry") , Oregon State (OSU) Paradigms activities, and materials of Paul Van Campen (Dublin City University). This year, our new LA (Markus Atkinson) ran sessions for Phys 3310 using these already-developed materials, in the context of an optional 1-credit P/F co-seminar (Phys 3311, approved for credit by A&S) He provided detailed observations and feedback, resulting in well-formulated instructor manuals for the tutorials.

**Evaluations:**

1) We developed a new upper-level conceptual post-test for E&M, the CUE (Colorado Upper-division Electrostatics assessment) and graded on a common rubric by two independent graders. See [http://www.colorado.edu/sei/fac-resources/course-archives.htm](http://www.colorado.edu/sei/fac-resources/course-archives.htm). Because the exam changed over time, 14 of the 17 questions were given in common between one semester of the course taught with traditional lecture methods (Trad, Fa07) and three successive iterations of the course taught using a transformed “interactive engagement” (IE) curriculum including clickers and tutorials (IE1-3, running Sp08-Sp09, respectively). Results on CUE questions given in common between these courses is shown in the plot.

![Student performance on Common CUE Questions](image)

Students in all transformed courses perform better on the CUE than those in the lecture-based course. An Anova test shows no significant differences among the three transformed classes (p=0.4), but a highly significant difference between the average of these courses and the traditional semester (p<<.01) Scores were low relative to exam scores because the test was scored more strictly than would an exam. Students in the transformed courses (averaged over all three semesters) performed better on all individual CUE questions than those in the Traditional course, see next plot.
Another comparison was made using more conventional exam questions, but only for the first semester of the transformed course. (Sp08)

Plot shows common exam questions given in Fa07 (traditional) and Sp08 (reformed) Error bars indicate ±1 standard error of the mean. All differences are significant at p<0.05 level except Q5. The transformed class (the course with clicker questions and LA-run Tutorials) generated higher results on all common conventional exam questions, not just on the conceptually focused questions of the CUE evaluation.

Ongoing efforts will pre-post assess the impact of Tutorials individually, but this is work still to be done.
Phys 3220 (upper division Quantum Mechanics for majors)

A Learning Assistant (Markus Atkinson) worked with faculty to inaugurate a new, optional 1-credit co-seminar ((Phys 3221, approved for credit by A&S), consisting of once per week problem-solving session where students work through a Tutorial in small groups. During each hour-long session the course instructor and the learning assistant facilitated the groups. The tutorials were developed last Fall either by adapting tutorials developed at the University of Washington or developed by CU faculty. This Spring, our LA facilitated 14 Quantum sessions using these already-developed materials.

**Evaluations:**

1) The raw scores on the QMAT, divided into ad-hoc subject categories, are shown in the first figure. Without a baseline to compare to traditionally taught semesters, this data is informative to us in terms of topics to work on future development of the course, but does not serve the kind of objective or comparative function of the FMCE or BEMA at the lower division level.

The co-seminar was optional - the distribution of student attendance is shown at right. Overall, 31/47 students had some contact and assistance from the LA.

For the purposes of evaluation, we can divide the class into students who attended the majority of sessions and the students who attended fewer than half of the sessions. We can then compare the student’s final exam scores as well as their score on the conceptual Quantum Mechanics Assessment Tool (QMAT) (not all students took the QMAT). There was a slight difference in final exam scores but not in the QMAT score. However, this analysis suffers from a potentially serious "selection bias" of students who choose to attend the co-seminar (consider e.g. the scenario where students who typically perform worse on exams choose to attend the optional seminar to try to boost their scores)
### Attitudes and Beliefs: *CLASS Data:*

<table>
<thead>
<tr>
<th>Course/Term</th>
<th>N</th>
<th>CLASS overall positive pre</th>
<th>CLASS shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 1110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phys 1110 Sp04 (PER)</td>
<td>398</td>
<td>68.3</td>
<td>+1.5 *</td>
</tr>
<tr>
<td>Phys 1110 Fa04 (No LAs)</td>
<td>389</td>
<td>65.8</td>
<td>-6.5 *</td>
</tr>
<tr>
<td>Phys 1110 Sp05 (No LAs)</td>
<td>349</td>
<td>62.7</td>
<td>-5.2 *</td>
</tr>
<tr>
<td>Phys 1110 Fa05 (No LAs)</td>
<td>277</td>
<td>69.5</td>
<td>-7.0 *</td>
</tr>
<tr>
<td>Phys 1110 Sp06</td>
<td>320</td>
<td>60.4</td>
<td>-3.3 *</td>
</tr>
<tr>
<td>Phys 1110 Fa06</td>
<td>360</td>
<td>68</td>
<td>-11.3 *</td>
</tr>
<tr>
<td>Phys 1110 Sp07</td>
<td>302</td>
<td>62.5</td>
<td>-3.6 *</td>
</tr>
<tr>
<td>Phys 1110 Fa07</td>
<td>346</td>
<td>65.3</td>
<td>-4.4 *</td>
</tr>
<tr>
<td>Phys 1110 Sp08</td>
<td>314</td>
<td>61.5</td>
<td>-6.2 *</td>
</tr>
<tr>
<td>Phys 1110 Fa08</td>
<td>381</td>
<td>64.9</td>
<td>-6.0 *</td>
</tr>
<tr>
<td>Phys 1110 Sp09 (PER)</td>
<td>352</td>
<td>62.9</td>
<td>+0.3</td>
</tr>
<tr>
<td>PHYS 1120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phys 1120 Fa04 (PER)</td>
<td>326</td>
<td>70.0</td>
<td>-2.9 *</td>
</tr>
<tr>
<td>Phys 1120 Sp05 (PER)</td>
<td>219</td>
<td>66.4</td>
<td>-2.2 *</td>
</tr>
<tr>
<td>Phys 1120 Fa05</td>
<td>320</td>
<td>61.2</td>
<td>-3.9 *</td>
</tr>
<tr>
<td>Phys 1120 Sp06</td>
<td>193</td>
<td>63.3</td>
<td>-1.4</td>
</tr>
<tr>
<td>Phys 1120 Fa06</td>
<td>257</td>
<td>62.0</td>
<td>-0.8</td>
</tr>
<tr>
<td>Phys 1120 Sp07</td>
<td>225</td>
<td>63</td>
<td>-1.2</td>
</tr>
<tr>
<td>Phys 1120 Fa07 (PER)</td>
<td>182</td>
<td>62.7</td>
<td>+3.1 *</td>
</tr>
<tr>
<td>Phys 1120 Sp08</td>
<td>195</td>
<td>66.3</td>
<td>-0.9</td>
</tr>
<tr>
<td>Phys 1120 Fa08</td>
<td>290</td>
<td>62.7</td>
<td>-3.8 *</td>
</tr>
<tr>
<td>Phys 1120 Sp09</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>PHYS 1020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phys 1020 Sp08 (PER)</td>
<td>28</td>
<td>62.2</td>
<td>-0.3</td>
</tr>
<tr>
<td>PHYS 2130</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phys 2130 Fa07</td>
<td>42</td>
<td>66.6</td>
<td>-3.2</td>
</tr>
<tr>
<td>PHYS 2170</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phys 2170 Fa07 (PER)</td>
<td>43</td>
<td>81.2</td>
<td>-6.0 *</td>
</tr>
<tr>
<td>Phys 2170 Sp08 (No LAs)</td>
<td>57</td>
<td>71.7</td>
<td>-5.0 *</td>
</tr>
</tbody>
</table>

Typical standard error of mean on these shifts is about +/-1 or 2%.

(PER) in parentheses means the lead faculty that term was a member of the Physics Education Research group.

* means that the shift is statistically significantly different from zero.

Note that many of these classes show overall negative shifts. These results are typical for attitude and belief shifts (as demonstrated e.g. by the MPEX)
Evaluation of department buy-in/challenges

Buy-in

- The physics department has typically been funding 1-2 LAs each term in addition to grant and/or institutional support used for the remaining LAs. The department committed support for 2 LAs/term for the coming academic year.
- The physics department partially supports a lead graduate TA whose primary responsibilities are to support faculty and LAs in the Tutorials. During AY 08-09 the lead TA also assisted in the LA hiring process.
- Starting AY 08-09, the Physics department has secured dedicated classroom space for the Tutorials in introductory physics. This involved a petition to the administration, which included evidence of learning gains in courses using Tutorials. This will allow us to release some of the temporary space in the basement labs we have been using for Tutorials.
- We have developed notebooks for new faculty in Phys 1110 and 1120 Tutorials, with materials, notes, and pretests, to make running this alternative pedagogy as smooth as possible. These notebooks are in the process of being expanded to include extensive information on equipment used in each Tutorial, starting next AY.
- We have collections of concept tests (and other course materials, including online homework banks) which are provided to any interested new physics faculty when they are assigned to teach one of these transformed courses.
- Two postdocs in physics (Stephanie Chasteen and Steven Goldhaber) are working on upper-division course reform in E&M and Quantum Mechanics, respectively.
- A postdoc working jointly between JILA and the physics department studies educational outreach to local high schools.
- As of Spring 2009, over 20 different physics staff/faculty have been directly involved in teaching courses with LAs

Challenges

- LA recruitment and hiring is a large chore, which must be done every term. This process has largely been done by two PER faculty members (SJP and MD), but it is time consuming. In AY 08-09 the Physics lead TA has assisted in coordinating LA interviews making hiring decisions.
- Collection of pre/post data is another large chore, which also must be done every term. This again has been largely spearheaded by one PER faculty member (SJP), but requires cooperation of regular faculty, and is not easy to sustain or support. It is also quite easy to "slip" and miss collecting critical data, just by oversight.
References/sources for the various Posttests used:


National results now available from M. Kohlmeyer et. al., arXiv:0906.0022v1 [physics.ed-ph]

May 29, 2009 (in review)


**CUE**: S. Chasteen and S. Pollock, submitted to PERC 2008. See also [http://www.colorado.edu/sei/fac-resources/course-archives.htm](http://www.colorado.edu/sei/fac-resources/course-archives.htm)


**REVIEWED BOOK CHAPTERS:**


**RELEVANT GRANTS:**

1. NSF DUE-0833258, "STEM Colorado/Noyce Teacher Scholarship Program" $500,000 (2008-2010) (V. Otero PI)
3. NSF ESI TPC -0554616 "Learning Assistant Model of Teacher Education in Science and Technology") $2,493,149 (2006-2009) (V. Otero PI)
4. APS PhysTec grant (~$100,000/yr) (2004-2008) (N. Finkelstein PI)
DBER Team: Astrophysical and Planetary Science
Activities and Findings
2008-2009

Seth Hornstein: APS LA coordinator

Department Info
In the academic year of 2008-2009, 5 faculty from the Department of Astrophysical and Planetary Sciences (Duncan, Stocke, Schneider, Bally, & Hornstein) were involved with the LAs in 7 courses.

LAs employed over the last year: Richard Stelter, Eleanor Johnson, Jennifer (Elin) Leiserson, Catherine Moran, Laura Crow, Sara Murphy, Brennan Andrews, Charles Maier, Joseph Parker, Craig Hoeltgen, Carl Husmann, Justin Searles, Leah Venturoni, Kaylee Keim, Sarah Cretcher, Elias DeQuiroz

Courses using LAs:
Fall 08 - 11 LAs hired (3 returning), 21 applicants (4 returning)
ASTR 1010 – Introductory Solar System Astronomy w/ Lab (Hornstein) – 211 students
ASTR 1020 – Astronomy 2 (Stars & Galaxies) w/ recitation (Duncan) – 159 students
ASTR 2000 – Ancient Astronomies (Stocke) – 161 students
ASTR 1110 – Introductory Solar System Astronomy (Schneider) – 155 students

Spring 09 - 9 LAs hired (4 returning), 25 applicants (5 returning)
ASTR 1010 – Introductory Solar System Astronomy w/ Lab (Hornstein) – 188 students
ASTR 1020 – Astronomy 2 (Stars & Galaxies) w/ recitation (Bally) – 173 students
ASTR 1110 – Introductory Solar System Astronomy (Schneider) – 205 students

I. LAs

a. Content expertise

1010/1110: In Spring 09, for the first time, LAs in 1010 and 1110 (Introductory Solar System courses) the LAs were given the Solar System Concept Inventory at the same time as the students. LAs in 1010 were paired with graduate TAs in the associated small (~20 students) lab sections while LAs in 1110 were used in the large (~200 students) lectures to facilitate discussions during clicker (Think-Pair-Share) questions and small group discussions.

<table>
<thead>
<tr>
<th>Course</th>
<th>N</th>
<th>Pre ave</th>
<th>Post ave</th>
<th>Gain of ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>1010</td>
<td>3</td>
<td>59%</td>
<td>79%</td>
<td>51%</td>
</tr>
<tr>
<td>1110</td>
<td>2</td>
<td>62%</td>
<td>86%</td>
<td>63%</td>
</tr>
</tbody>
</table>
Despite the fact that the LAs came in with roughly average pre-tests (compared to the post-tests of the students, see Section II.a below) they still showed high gains and mastered 50-60% of the remaining unknown material.

1020: LAs reviewed and discussed critical material and difficult concepts in a manner & style different from the approach the instructor followed in class. They also worked examples of problems similar to the ones assigned as homework. They provided additional help and answers to questions that came us as students worked on homework. The LAs were particularly helpful in reviewing basic math concepts that were a frequent stumbling block in doing homework assignments.

b. Beliefs

1010: In addition to their in-class duties, LAs were responsible for organizing optional out-of-class review opportunities. The LAs took this opportunity to engage in several non-traditional techniques. One LA created an AIM (AOL Instant Messaging) account solely for online tutoring. He posted set evening office hours but was also logged on many other times for students to contact him at odd hours. Additionally, this same LA organized review sessions using the Fiske Planetarium in order to use the visualization capabilities of the planetarium.

c. Other LA activities within your department

1010: 2 LAs became very active in our outreach activities involving Sommers-Bausch observatory. One LA went so far as to become trained on operating the telescope so she could run it on her own at our public open house nights. Additionally, she volunteered to help for several hours at our annual Astronomy Day outreach event.

1020: Several of the LAs helped me with the Sommers-Bausch observing sessions. I hosted 6 such sessions and required that each student attend 2. I also required that during these sessions, students observe 6 objects. Several of my LAs were "on-deck" to assist with observations, helped students acquire their targets of observations, and answered questions regarding their observing forms.

The LA program is used extensively in our introductory courses. It has a VERY positive impact on the LAs themselves. By teaching this material, the LAs have learned the key concepts, quantitative reasoning, and elementary mathematical methods used in the course to a much better extend than just by taking the course. This was especially noted for the LAs who were not astronomy majors.
II. **LA-supported courses**

a. **Content**

1010/1110: Student Performance on Solar System Concept Inventory:

<table>
<thead>
<tr>
<th>Course</th>
<th>N</th>
<th>Pre ave</th>
<th>Post ave</th>
<th>Gain of ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>1010</td>
<td>133</td>
<td>28%</td>
<td>65%</td>
<td>51%</td>
</tr>
<tr>
<td>1110 (LA supported)</td>
<td>128</td>
<td>27%</td>
<td>65%</td>
<td>52%</td>
</tr>
<tr>
<td>1110 (no LA support)*</td>
<td>29</td>
<td>27%</td>
<td>42%</td>
<td>20%</td>
</tr>
</tbody>
</table>

*The 1110 section without LA support differs slightly in content and interactivity from the LA-supported section.

Unfortunately, the concept test given to the students and LAs is still under development and changes each semester. Therefore, we do not have historical data to compare from year to year.

1020: Having concepts presented and reviewed multiple times with different perspectives by different individuals assists learning. A number of the 1020 students had very positive comments about their recitation experiences.

2000: I have implemented the self-paced observing projects since I began using LAs. The non-threatening presence of the LAs during observing project help sessions has made these projects much more effective than they would be w/o LAs (although I have only my own personal perspectives to support this assertion...) I know that I would not have attempted the self-paced observing projects w/o LAs.

b. **Other impacts**

1110: This class uses quite a variety of interactive teaching methods to engage the students. In a self-reported survey given to students at the end of the Spring Semester, LAs ranked lowest in terms of effectiveness (Average=3.2 where 1=very ineffective and 5=very effective) compared to Just-In-Time Teaching (average=3.9), instructor questioning (average=3.6), Online Homework (average=3.8), and Clicker/Think-Pair-Share questions (average=4.0). While this may be seen as a negative result, we have concluded that simply having LAs available to enhance discussions and clicker questions is not an effective/efficient use of their time. Perhaps an exceptional LA would make more of a difference (anecdotal evidence from the Fall Semester indicates that the LAs that semester were much more outgoing and engaging to the students), but such an LA would anywhere. In the future, LAs will only be used in this class if small-group activities (tutorials) are included where the LAs would provide an integral role in helping groups work through the material.
1020: In end-of-semester evaluations, there were two major strands of compliments that many students mentioned: 1) “LAs helped my learning” and 2) “LAs made the class more fun.” Both are important and indicate that the LAs are having a positive impact. Both content-knowledge and personality seem to have strong influences on student responses to individual LAs.

III. Evaluation of department buy-in/challenges

The ASTR 1020 course in the APS department has been transformed to include a mandatory 1-hour small-group recitation section led entirely by LAs. Without LAs this small-group learning environment would be unsustainable. However, this has created some challenges as ASTR 1020 is taught on a rotating schedule and has this past semester (for the first time) been taught by a faculty member who has not been very active in the LA program. Overall, the experience was mostly positive although it suggested the need for an organized orientation program for instructors unfamiliar with the LA program who find themselves assigned to a transformed course dependent on LAs.

In order to foster a sense of community amongst the APS LAs, all LAs are given offices in the CASA stadium wing. These offices can be used for help sessions/office hours for the course they are acting as an LA as well as an on-campus home base for the LAs to call their own.

Finally, the APS department was able to fund 2 LAs with department funds for the 2008-2009 school year and has re-committed to the same amount for the 2009-2010 school year.

With various faculty rotating on and off of courses supported by LAs, the creation of an APS LA Coordinator (SH) was crucial in maintaining continuity over semesters. Since this position was established in Fall 2008, APS LA applicant numbers have increased an average of 22% each semester. The Coordinator is responsible for encouraging faculty to advertise the LA program in their classes (and visiting those classes where faculty feel less comfortable describing the program) and coordinating applicant interviews/hiring. This has also resulted in a larger number of APS majors applying to the LA program as they are typically not in the classes supported by LAs and, previously, rarely heard about the program.
Department Information

Transformed course details:

**CHEM 1111** (General Chemistry I).
Largest 5-credit course at CU. Each week, students attend three 50-minute lectures, one 50-minute recitation session, and one 3-hour laboratory session. (Typically, the 20-student recitation and lab occur in the same lab room, in a 4-hour block. Lab follows recitation.)
Enrollment typically 800 – 900 students in Fall; 400 students in Spring. For several years, two faculty members have co-taught the three lecture sections in Fall; one faculty member teaches one lecture section in Spring. Graduate TAs lead lab sections, and co-lead recitation sections with LAs. In Fall 2009, one of the three lecture sections will be replaced by a new course for Chemistry and Biochemistry majors, CHEM 1251, so total enrollment in 1111 will be lower. One faculty member will teach both sections of 1111 in Fall 2009.

<table>
<thead>
<tr>
<th>Semester</th>
<th>LA role(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fa06</td>
<td>Six LAs attended lecture (assisted students during clicker questions) and held help-room hours to assist students with new conceptual homework</td>
</tr>
<tr>
<td>Sp07</td>
<td>No LAs</td>
</tr>
<tr>
<td>Fa07</td>
<td>No LAs</td>
</tr>
<tr>
<td>Sp08</td>
<td>Seven LAs attended lecture and worked with TAs to co-lead recitation sections (3-4 per week). Main role of LA is to facilitate student conversations during lecture and to facilitate small group discussions in recitation. Conceptual homework developed in Fall 2006 was integrated into new recitation materials structured for group work.</td>
</tr>
<tr>
<td>Fa08</td>
<td>Sp08 model scaled up to match Fall enrollment (900+ students, 47-50 total recitation sections, 14 LAs).</td>
</tr>
<tr>
<td>Sp09</td>
<td>No LAs</td>
</tr>
<tr>
<td>Fa09</td>
<td>Plan to repeat Fa08 model. 12 LAs, 36 – 40 recitation sections, ~750 students</td>
</tr>
</tbody>
</table>

**CHEM 1131** (General Chemistry II).
Same course structure as CHEM 1111. Enrollment typically 250 – 300 students in Fall; 500 - 600 students in Spring. One faculty member teaches one lecture section in Fall; one faculty member teaches two lecture sections in Spring. Graduate TAs lead lab sections, and co-lead recitation sections with LAs.

<table>
<thead>
<tr>
<th>Semester</th>
<th>LA role(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fa06</td>
<td>No LAs</td>
</tr>
<tr>
<td>Sp07</td>
<td>Ten LAs attended lecture, led a total of 18 “learning groups”, and hosted a total of 12 help room hours each week. Of 500 students in course, 150 opted to join a learning group. Principle role of LA was to lead student discussions about new conceptual homework.</td>
</tr>
<tr>
<td>Fa07</td>
<td>First small-scale model of TA/LA co-facilitation of recitation. Five LAs attended lecture and worked with TAs to co-lead recitation sections (3-4 per week). Principle role of LA is to facilitate student conversations during lecture and to facilitate small group discussions in recitation. Conceptual homework developed in Spring 2007</td>
</tr>
</tbody>
</table>
was integrated into new recitation materials structured for group work.

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp08</td>
<td>Ten LAs (and one volunteer LA) attended lecture and worked with TAs to co-lead recitation sections (3-4 per week). Similar to Fa07, but scaled-up to 32 total recitation sections.</td>
</tr>
<tr>
<td>Fa08</td>
<td>No LAs; all LA resources directed to CHEM 1111.</td>
</tr>
<tr>
<td>Sp09</td>
<td>11 LAs. Replicated Sp08 model. Progress made on sustainability issues.</td>
</tr>
</tbody>
</table>

**CHEM 1251 (General Chemistry I for Majors).**
Newly created course, enrollment restricted to Chemistry and Biochemistry majors. Overall course structure (lecture, recitation, lab) and content parallels CHEM 1111. Enrollment expected to be 120-160 in Fall 2009. Three LA’s have been assigned to this course, to work along TAs in recitation following the same model used for CHEM 1111 and 1131.

**Faculty for AY 2008-2009 in courses involving LAs:**

**Fall 2008, CHEM 1111 (General Chemistry I):**
Veronica Bierbaum and Susan Hendrickson, Laurie Langdon (Science Education Initiative), 14 LAs (5 Returning)

**Spring 2008, CHEM 1131: (General Chemistry II):**
Matthew Wise, Susan Hendrickson, Robert Parson. 11 LAs (9 New, 2 Returning)

**Applications for AY 2008-09 LA positions:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Applications</th>
<th>Hired</th>
<th>Other Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New</td>
<td>Returning</td>
<td>New</td>
</tr>
<tr>
<td>1111, F08</td>
<td>66</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>1131, S09</td>
<td>38</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

**Longer term brief summary of LAs in Chemistry:**
We have hired a total of 49 undergraduate LAs since Fall 2006. Of these, 28 were female = 57%
16 of these total LAs have served two or more semesters.
The rough total number of applicants for chemistry LA positions over 6 semesters is 240.

**LAs**

**a. Content expertise**

CHEM 1111, General Chemistry I: (Fall 2008) LAs were given the General Chemistry I Concept Survey at the beginning of the semester and again at the end. *(Note: This survey is still in process of revision.)*

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pre ave</th>
<th>Post ave</th>
<th>Gain Ave</th>
<th>Ave Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp08</td>
<td>5</td>
<td>0.71</td>
<td>0.87</td>
<td>0.54</td>
<td>0.70</td>
</tr>
<tr>
<td>Fa08*</td>
<td>13</td>
<td>0.73</td>
<td>0.81</td>
<td>0.32</td>
<td>0.27</td>
</tr>
</tbody>
</table>

*Data from one returning LA is not included. This LA scored 100% on both the “pre” and the “post” surveys.*

CHEM 1131, General Chemistry II: (Spring 2009) LAs were given the General Chemistry II Concept Survey at the beginning of the semester and again at the end. *(Note: This survey is still in process of revision. Its foci are acid/base and solubility equilibria.)* It’s unclear why the LA learning gains were much higher in Spring 2009 compared to previous semesters. However, we are attracting more Chemistry and Biochemistry majors as applicants, and those LAs had considerable learning gains in Spring 2009.

<table>
<thead>
<tr>
<th>Semester</th>
<th>N</th>
<th>Pre ave</th>
<th>Post ave</th>
<th>Gain Ave</th>
<th>Ave of Gains (matched)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fa07</td>
<td>5</td>
<td>0.71</td>
<td>0.85</td>
<td>0.48</td>
<td>0.45</td>
</tr>
<tr>
<td>Sp08</td>
<td>7 (pre)</td>
<td>0.69</td>
<td>0.79</td>
<td>0.30 (0.19 for 5 matched LAs)</td>
<td>0.24</td>
</tr>
<tr>
<td><strong>Sp09</strong></td>
<td>9</td>
<td><strong>0.60</strong></td>
<td><strong>0.81</strong></td>
<td><strong>0.52</strong></td>
<td><strong>0.58</strong></td>
</tr>
</tbody>
</table>
b. Beliefs
We only recently began administering the CLASS survey about attitudes and beliefs of learning chemistry to Chemistry LAs. We have very small sample sizes, so even shifts that appear large are not significant for the most part. However, these data show that we are attracting students who start out with fairly expert views of learning chemistry, and overall their views shift to become even more expert-like. Of course, we also select for these attitudes and beliefs when we are interviewing candidates to be hired as LAs, so this shouldn’t be too surprising.

<table>
<thead>
<tr>
<th>Course and Semester</th>
<th>Personal Interest</th>
<th>Real World Connection</th>
<th>Problem-Solving (General)</th>
<th>Sense-Making / Effort</th>
<th>Conceptual Learning</th>
<th>Atomic-Molecular Perspective of Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Favorable</td>
<td>Favorable</td>
<td>Favorable</td>
<td>Favorable</td>
<td>Favorable</td>
<td>Favorable</td>
</tr>
<tr>
<td>CHEM 1111</td>
<td>Pre</td>
<td>Shift</td>
<td>Pre</td>
<td>Shift</td>
<td>Pre</td>
<td>Shift</td>
</tr>
<tr>
<td>Fa08 (n = 9)</td>
<td>78.0</td>
<td>-0.5</td>
<td>77.8</td>
<td>3.7</td>
<td>83.3</td>
<td>5.6</td>
</tr>
</tbody>
</table>

| CHEM 1131            | Pre       | Shift     | Pre       | Shift     | Pre       | Shift     | Pre       | Shift     |
| Sp08 (n = 5)         | 77.8      | 11.1      | 86.7      | 3.3       | 85.0      | 5.0       | 86.0      | 12.0      | 77.8      | 13.3      | 62.9      | 11.4      | 73.3      | 16.7      |
| Sp09 (n = 5)         | 87.7      | -0.7      | 79.3      | 7.3       | 85.0      | 10.0      | 92.0      | -2.4      | 82.2      | -0.6      | 91.4      | -11.9     | 96.7      | 0.0       |

c. Other LA activities within your department
1) Several experienced LAs contributed to our Fall incoming graduate student TA training in August 2008. They helped incoming TAs plan to lead a practice recitation section, and they also provided feedback to the TAs after the practice session. One reason for this was to introduce the TAs to LAs early on to help TAs and LAs begin to form effective working relationships.

2) We’ve had three Noyce fellows this past year:
   a. One Noyce fellow (biochemistry major) was an LA for a physics course in the Fall. During the Spring, she collected data about student thinking and began to revise a General Chemistry I laboratory experiment.

   b. One Noyce fellow was a CHEM 1111 LA in the Fall (she had previously been an LA for CHEM 1131). In the Spring, she had a reduced LA role in CHEM 1131 because she was also conducting research on LA-TA working
relationships. For this, she observed several recitation sections during the semester and interviewed TAs, LAs, and students. She is analyzing her data and is contributing to a faculty/instructor guide book for facilitating LAs in our current model.

c. One Noyce fellow analyzed data in the Fall related to students’ perceptions of the usefulness of recitation. During the Spring and Summer, he has been working with several General Chemistry personnel (instructors, faculty, lab coordinators) to develop a new laboratory activity for General Chemistry I. The new lab was piloted in the Summer 2009 session and will run in Fall 2009, with revision.

3) We believe that the LA program is having an impact on the number of Chemistry and Biochemistry students deciding to pursue K-12 education as their career. We have had four Noyce fellows work in the department, and in the Fall we will have two more. Below is a graph showing the increase in the number of majors enrolling in certification programs. AY 2006/2007 was the first year that the department participated in the LA program.
LA-supported courses

a. Content

CHEM 1111, General Chemistry I: We have been giving the chem 1111 concept survey as a pre/post assessment of learning since spring 2006. The data are below. The survey has undergone some revision during this time.

<table>
<thead>
<tr>
<th>Semester</th>
<th>N</th>
<th>Pre ave</th>
<th>Post ave</th>
<th>Gain of ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fa06 (limited LAs)</td>
<td>595</td>
<td>0.41</td>
<td>0.55</td>
<td>0.24</td>
</tr>
<tr>
<td>Sp07 (no LAs)</td>
<td>289</td>
<td>0.43</td>
<td>0.52</td>
<td>0.16</td>
</tr>
<tr>
<td>Fa07 (no LAs)</td>
<td>674</td>
<td>0.37</td>
<td>0.50</td>
<td>0.21</td>
</tr>
<tr>
<td>Sp08 (LAs in recitation)</td>
<td>311</td>
<td>0.36</td>
<td>0.47</td>
<td>0.17</td>
</tr>
<tr>
<td>Fa08 (LAs in recitation)</td>
<td>430</td>
<td>0.40</td>
<td>0.57</td>
<td>0.28</td>
</tr>
</tbody>
</table>

LAs were introduced into CHEM 1111 recitations for the first time in Spring 2008, but LA-TA working relationships were not well developed during that term. Fall 08 represents the first full implementation of the TA-LA recitation model in CHEM 1111, including prior TA training and weekly TA-LA meetings before each recitation.

Fall 2007 and Fall 2008 provide the best opportunity to compare effects of use of LAs in CHEM 1111. Both semesters were taught by the same faculty members, the same recitation materials were used (with slight modifications), and TAs went through the same enhanced TA training prior to each semester. The main difference between the two semesters is the use of LAs (which also means that TAs and LAs participated in weekly recitation preparation meetings, which does not occur in semesters when LAs are not used). *The student learning gains show a 33% increase between Fall 2007 and Fall 2008, and the difference is statistically significant (p = .031).*
CHEM 1131, General Chemistry II: We began development of the General Chemistry II Concept Survey in Spring 2007. Since that time, it has been revised to focus mainly on acid-base and solubility equilibria concepts.

- In Spring 2007, only 10 items appeared on both the “pre” and “post” versions. All of those items were related to the topic of acids and bases. That semester, students could choose to join an LA-led learning group. Of the 500 students in the course, about 150 chose to join a group. Thus, only about 30% of students regularly interacted with LAs. Data from the 10 acid/base items are reported below.
- In Fall 2007, the concept survey was revised to only focus on acid/base and solubility equilibria. It is now a 20-item survey. The same version was used “pre” and “post” in subsequent semesters, with some slight modifications. Fall 2007 was the first semester of integrating LAs into recitation, so ALL students were impacted by LAs.
<table>
<thead>
<tr>
<th>Semester</th>
<th>N</th>
<th>Pre ave</th>
<th>Post ave</th>
<th>Gain of ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp07 (10 items; limited use of LAs)</td>
<td>437</td>
<td>0.50</td>
<td>0.61</td>
<td>0.22</td>
</tr>
<tr>
<td>Fa07 (20 items; LAs in recitations)</td>
<td>183</td>
<td>0.34</td>
<td>0.53</td>
<td>0.29</td>
</tr>
<tr>
<td>Sp08 (20 items; LAs in recitation)</td>
<td>276</td>
<td>0.35</td>
<td>0.52</td>
<td>0.27</td>
</tr>
<tr>
<td>Fa09 (20 items; no LAs)</td>
<td>221</td>
<td>0.37</td>
<td>0.54</td>
<td>0.27</td>
</tr>
<tr>
<td>Sp09 (20 items; LAs in recitation)</td>
<td>559</td>
<td>0.37</td>
<td>0.55</td>
<td>0.28</td>
</tr>
</tbody>
</table>

**Attitudes and Beliefs: CLASS-Chemistry Data:**

<table>
<thead>
<tr>
<th>Course and Semester</th>
<th>Selected Categories</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre</td>
<td>Shift</td>
<td>Pre</td>
<td>Shift</td>
<td>Pre</td>
<td>Shift</td>
<td>Pre</td>
<td>Shift</td>
</tr>
<tr>
<td>CHEM 1111</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fa06 (LAs: limited use)</td>
<td>Instructor: 1, 2</td>
<td>59.2</td>
<td>-3.5</td>
<td>57.7</td>
<td>-10.5</td>
<td>62.0</td>
<td>-8.3</td>
<td>62.4</td>
<td>-4.6</td>
</tr>
<tr>
<td>Sp07 (LAs: none)</td>
<td>Instructor: 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fa07 (LAs: none)</td>
<td>Instructor: 2, 3</td>
<td>58.0</td>
<td>-2.0</td>
<td>55.7</td>
<td>-6.1</td>
<td>58.9</td>
<td>-3.8</td>
<td>63.5</td>
<td>-4.3</td>
</tr>
<tr>
<td>Sp08 (LAs: integrated into recitation)</td>
<td>Instructor: 4</td>
<td>55.8</td>
<td>-4.6</td>
<td>53.8</td>
<td>-7.3</td>
<td>58.7</td>
<td>-10.8</td>
<td>60.0</td>
<td>-5.3</td>
</tr>
<tr>
<td>Fa08 (LAs: integrated into recitation)</td>
<td>Instructor: 2, 3</td>
<td>55.9</td>
<td>-1.8</td>
<td>54.6</td>
<td>-5.4</td>
<td>58.8</td>
<td>-6.4</td>
<td>59.5</td>
<td>-2.1</td>
</tr>
<tr>
<td>Sp09 (LAs: none)</td>
<td>Instructor: 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No data for this term</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CHEM 1131**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Selected Categories</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
<th>Favorable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp07 (LAs: limited use)</td>
<td>Instructor: 4</td>
<td>62.0</td>
<td>-2.4</td>
<td>55.7</td>
<td>-1.4</td>
<td>62.9</td>
<td>-5.7</td>
<td>65.7</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

University of Colorado, Boulder LATEST Annual Report
It is difficult to draw conclusions about the use of Learning Assistants and changes in student attitudes / beliefs given these data. The largest overall negative shifts occurred in semesters when an experienced instructor taught either 1111 or 1131 for the first time (same semesters as full implementation of LAs in recitation). Thus, even though students’ attitudes and beliefs improved in CHEM 1131 from Sp07 to Fa07 (same instructor, increased use of LAs in course), Sp08 CHEM 1111 students had large negative shifts with the same instructor and full use of LAs.

c. Other Impacts

We have observed several recitation sections run by TAs and LAs. In general, we find that LAs ask better guiding questions and don’t let students “off the hook.” That is, LAs are more apt than TAs to require students to clarify their language and to justify their reasoning. We video-taped two recitation sections in Spring 2009, which will allow us to make additional systematic observations to characterize LA-student interactions in Chemistry recitations. Perhaps more immediate assessment tools are needed to measure short-term impact of these LA-student interactions.

On end-of-course surveys, we ask students about their experiences in the course. Again, comparing Fall 2007 and Fall 2008 allows us to draw some conclusions about the effects of using LAs in the course. When LAs were used (Fall 2008), students report interacting with other students more during recitation. Students also found recitation more useful for their learning in Fall 2008 ($p = 0.38$).
Evaluation of department buy-in/challenges

- The department became a member of the Science Education Initiative in Fall 2006. The SEI central funds paid for Chemistry LAs that first year (Fall 2006, Spring 2007). Three faculty members participated in hiring LAs that year.
- In Fall 2008 and Spring 2009, Chemistry used some of its departmental SEI funds to pay for several Learning Assistants in CHEM 1111 and 1131.
- The Learning Assistant program has been discussed in several General Chemistry Working Group meetings. The SEI departmental liaison led a presentation and discussion of the LA program at a faculty meeting in Spring 2008.
- The SEI post docs (Laurie Langdon and Tom Pentecost) have been heavily involved in hiring and scheduling LAs, as well as co-leading weekly meetings. In Fa07 and Sp08, faculty members co-led LA and LA/TA meetings, and this continued in Fall 2008.
- Major steps towards sustainability were taken in Spring 2009. Robert Parson, a full faculty member, took over the responsibilities of leading weekly TA/LA recitation meetings. He and Susan Hendrickson (a senior instructor) participated with Laurie Langdon in conducting interviews and hiring LAs for the upcoming Fall 2009 term.
- We are in process of developing course archives for CHEM 1111 and CHEM 1131, including TA/LA/instructor notes for use of recitation materials. One of our Noyce fellows is helping with this effort.
- As of Spring 2009, five different chemistry staff/faculty have been directly involved in teaching courses with LAs. Several others have been involved in working with Noyce fellows who are developing General Chemistry labs.
- Former Chemistry LAs continue to be hired by the department as undergraduate TAs. Several faculty and staff recognized their outstanding performance in this role (especially compared to a few non-LA undergraduates hired in the same capacity). This has helped to spread positive feedback about the LA program.
Challenges

- LA recruitment and hiring is a large chore which must be done every term. This has largely been done by the two SEI post docs, but as mentioned above, two additional faculty have contributed to the decision-making process in recent semesters. We have also found that a larger pool of applicants does not necessarily translate into an overall better pool of applicants, adding time to the prescreening process.

- Baseline data for CHEM 1111 and 1131 (pre Fall 2006) are scarce. In addition, concept survey measurement tools are still in the development/validation stages. So, changes are occurring within the courses at the same time that assessment tools are being developed to measure the effects of those changes. Thus it is difficult to attribute changes in student understanding or attitudes to the use of LAs.

- When the gain scores for chemistry courses are compared to other courses, such as physics 1110, the presence of other reforms beyond LAs must be taken into account. The chemistry courses are reformed in the sense of using clickers and LAs in recitation. Work has only recently begun on making the course exams (largest impact on student grades) less algorithmic and more conceptual.
DBER Team: Molecular, Cellular, and Developmental Biology

Activities and Findings

2008-2009

Transformed course details:

MCDB 1150 Fall 2008: Introduction to Cell and Molecular Biology
- Nancy Guild and Jennifer Martin: instructors; Jia Shi, STF.
- Enrollment: 357 enrolled, 320 completed both pre and post assessments.
- 6 LAs: 2 returning, 4 new.
- LAs were used to run a new class now offered with both introductory courses: this “co-seminar” class (MCDB 1152) is an optional 1 credit pass/fail problem solving session once per week in which students do group activities and work on problem sets.

MCDB 1041 Fall 2008: Fundamentals of Human Genetics (non majors)
- Jennifer Knight, instructor.
- Enrollment: 72 students; 66 completed both pre and post assessments.
- 3 LAs: 1 returning, 2 new.
- On Fridays, LAs lead class in small groups (approximately 20 students per LA). Students worked in small groups to complete hands-on activities or worksheets prepared by instructor.

MCDB 2150 Fall 2008: Genetics
- Tin Tin Su, instructor; Michelle Smith, STF.
- Enrollment: students completed the pre and post assessment
- 3 LAs: 1 returning, 2 new.
- LAs were used to run a new class now offered with both introductory courses: this “co-seminar” class (MCDB 2152) is an optional 1 credit pass/fail problem solving session once per week in which students do group activities.

MCDB 2150 Spring 2009 Genetics
- Mark Winey and Nancy Guild, instructors; Michelle Smith, STF.
- Enrollment: students took the pre and post assessment.
- 6 LAs: 2 returning, 4 new.
- LAs were used to run a new class now offered with both introductory courses: this “co-seminar” class (MCDB 2152) is an optional 1 credit pass/fail problem solving session once per week in which students do group activities.
**LAAs**

a. **Content Expertise**

### Introduction to Molecular and Cellular Biology Assessment (IMCBA)

<table>
<thead>
<tr>
<th>Course</th>
<th>Number</th>
<th>Pre-assessment +/- SE</th>
<th>Post assessment +/- SE</th>
<th>Normalized Learning Gain +/- SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCDB 1150 07</td>
<td>4</td>
<td>67.7 +/- 2.9</td>
<td>80.6 +/- 1.0</td>
<td>37.3 +/- 9.3</td>
</tr>
<tr>
<td>MCDB 1150 08</td>
<td>6</td>
<td>75.4% +/- 5.2</td>
<td>85.5% +/- 3.6</td>
<td>41% +/- 12</td>
</tr>
</tbody>
</table>

Note that the IMCBA has changed slightly since 08 and thus cannot be directly compared.

### Genetics Concept Assessment (GCA) (Smith et al, 2008)

<table>
<thead>
<tr>
<th>Course</th>
<th>Number</th>
<th>Pre-assessment +/- SE</th>
<th>Post assessment +/- SE</th>
<th>Normalized Learning Gain +/- SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCDB 1041 07</td>
<td>3</td>
<td>72 +/- 11.4</td>
<td>86 +/- 7.6</td>
<td>50.8 +/- 11.9</td>
</tr>
<tr>
<td>MCDB 1041 08</td>
<td>3</td>
<td>78.7 +/- 9.9</td>
<td>92 +/- 7.5</td>
<td>74.8 +/- 20</td>
</tr>
</tbody>
</table>

MCDB 2150 LAs did not take the GCA in 08-09.

b. **Beliefs**

We did not administer the Bio CLASS to the LAs, only to the students (see data below).

### LA-supported courses

a. **Content**

### Introduction to Molecular and Cellular Biology Assessment (IMCBA)

<table>
<thead>
<tr>
<th>Course</th>
<th>Number</th>
<th>Pre-assessment (%) +/- SE</th>
<th>Post assessment (%) +/- SE</th>
<th>Normalized Learning Gain (%) +/- SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCDB 1150 07</td>
<td>307</td>
<td>42 +/- 0.8</td>
<td>71.8 +/- 0.8</td>
<td>51.1 +/- 1.3</td>
</tr>
<tr>
<td>MCDB 1150 08</td>
<td>320</td>
<td>42 +/- 0.8</td>
<td>71 +/- 2.3</td>
<td>50 +/- 1.5</td>
</tr>
</tbody>
</table>

We have been in the process of refining the IMCBA over the past few years, so the data from ’08 cannot be compared directly to data from ’07. However, it is interesting to note that the performance and NLG are almost identical in the two years.
Genetics Concept Assessment (GCA) (Smith et al, 2008)

<table>
<thead>
<tr>
<th>Course</th>
<th>Number</th>
<th>Pre-assessment +/- SE</th>
<th>Post assessment +/- SE</th>
<th>Normalized Learning Gain +/- SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCDB 1041</td>
<td>61</td>
<td>33.6 +/- 1.52</td>
<td>69.7 +/- 1.85</td>
<td>53.5 +/- 3.0</td>
</tr>
<tr>
<td>07 F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCDB 1041</td>
<td>66</td>
<td>31.3 +/- 1.3</td>
<td>62.3 +/- 2.2</td>
<td>45.7 +/- 2.9</td>
</tr>
<tr>
<td>08 F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCDB 2150</td>
<td>107</td>
<td>41.8 +/- 1.4</td>
<td>77.8 +/- 1.5</td>
<td>62.3 +/- 2.3</td>
</tr>
<tr>
<td>07 F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCDB 2150</td>
<td>314</td>
<td>37.7 +/- 0.8</td>
<td>75.9 +/- 0.8</td>
<td>61.7 +/- 1.3</td>
</tr>
<tr>
<td>08 SP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCDB 2150</td>
<td>156</td>
<td>40 +/- 1.1</td>
<td>78 +/- 1.2</td>
<td>63.3</td>
</tr>
<tr>
<td>08 F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCDB 2150</td>
<td>335</td>
<td>32 +/- 0.7</td>
<td>71 +/- 0.9</td>
<td>57.4</td>
</tr>
<tr>
<td>09 SP</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

b. Beliefs

We have developed a biology-specific attitude assessment tool called the BioCLASS (manuscript in preparation) which is similar to the PhysicsCLASS. This assessment tool was finalized in time for Fall 2008 data collection (but is slightly different from the 2007 version). By factor analysis, the 36 questions fall into 7 categories: Use/enjoy biology in everyday life, Problem Solving (PS) sophistication, PS effort, PS strategies, Enjoyment, Conceptual Connections/Memorization, and Reasoning.

**CLASS Data, Overall Shift:**

<table>
<thead>
<tr>
<th>Course/Term</th>
<th>N</th>
<th>CLASS overall agreement with experts (pre)</th>
<th>CLASS overall agreement with experts (post)</th>
<th>CLASS shift (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCDB 1150</td>
<td>320</td>
<td>70.6%</td>
<td>60.5%</td>
<td>-10.1 +/-1.5</td>
</tr>
<tr>
<td>2008 F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCDB 2150</td>
<td>156</td>
<td>72.8%</td>
<td>72.9%</td>
<td>-0.1 +/-1.4</td>
</tr>
<tr>
<td>2008 F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCDB 1041</td>
<td>61</td>
<td>58%</td>
<td>56.1%</td>
<td>-1.9 +/-2</td>
</tr>
<tr>
<td>2008 F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Student attitudes in LA-supported classes.**

Overall, students in LA-supported classes are very satisfied with the performance of the LAs and the level to which the LAs help them learn the material. In addition, students are in general satisfied with the structures of the courses, and with the use of interactive techniques.
such as clickers, problem sets and in-class activities. They are especially positive about the addition of the coseminar courses to 1150 and 2150.

Evaluation of department buy-in/challenges

− MCDB has been using LAs since before the inception of the LA-TEST program (first LAs used in 2003). Since then, the number of faculty using LAs has grown from 1 to 9. LAs are now used in the two introductory courses, as well as the non-majors genetics course. Instructors teaching the next sequence of courses (Cell Biology and Molecular Biology) have expressed an interest in using LAs but have not yet transitioned. In addition to the LAs reported above, MCDB and the Science Education Initiative have funded LAs for Developmental Biology 4650. Because this is a junior/senior level capstone course, the LAs for these courses are typically seniors as well. The LAs in these courses help run optional study sessions, as well as being active participants in lecture (discussing clicker questions and guiding in-class activities).

− Because of the success of optional recitation sections this past year in both MCDB 1150 and 2150, the faculty voted to make such an experience available to all students: these coseminar courses were offered for the first time in 08-09, and were very successful.

− We have archived all materials from the three courses described above, including clicker questions, homework questions, in-class activities, and pre/post assessments, so that others who may teach these courses in the future have access to all materials.
DBER Team: Department of Mathematics
Activities and Findings
2008-2009
Eric Stade, Chair

Department Info

Transformed course details:

*MATH 1300* (Calculus with Analytic Geometry I)
Enrollment is typically 500-700 each semester. There are four 50 minute lectures as well as one weekly 50-minute Tutorial section for ~32 students, led by a grad MATH TA and a MATH LA.

The duties of the LA include facilitation of the weekly Tutorials (three different sections per week), tutoring weekly in the Undergraduate Mathematics Resource Center (help lab), and taking the course MATH 3850: Seminar in Guided Mathematics Instruction.

In 2008-2009, Math 1300 was taught in small sections (22 sections in the fall and 15 in the spring), by Math Department TAs, instructors, and lecturers. All sections were coordinated and supervised by Math Department faculty Eric Stade (Chair) and Robert Tubbs (Associate Chair for Undergraduate Studies).

Applications for Fall 2008: 57 LA applicants specified Math as their first choice.

Applications for Spring 2009: 18 LA applicants specified Math as their first choice.

Accepted, Fall 2008: 7 LAs (5 female)
Accepted, Spring 2009: 5 LAs (5 female) (2 returning: 2F)

IV. LAs
   No data available

V. LA-supported courses
   No data available

VI. Evaluation of department buy-in/challenges
Buy-in

- In 2008-2009 the Math Department funded three of its LAs, to supplement the institutional support used for the remaining LAs. The Department has committed support for 2 LAs per term in the 2009-2010 academic year.
- The Math Department supports a graduate student whose primary responsibilities are to support faculty and LAs in the Tutorials, and to serve as Teaching Assistant for the LA course Math 3850: Seminar in Guided Mathematics Instruction.
- The Department has developed its own series of worksheets for use in the weekly Math 1300 Tutorials.
- As of Spring 2009, two tenured Math Department faculty, one instructor, several lecturers, and over 30 graduate students have been directly involved in teaching Math 1300 with LAs. Additional tenured faculty members and other teaching staff will be involved in 2009-2010.
- Several Math Department faculty have expressed interest in using LAs in other courses (e.g. Calculus II; Functions and Modeling).

Challenges

- LA recruitment and hiring is a large chore, which must be done every term. This process has so far been executed by two Math faculty members (Robert Tubbs and Eric Stade). We hope to enlist others into the process in subsequent semesters.
- Assessment is a task for which Math Department faculty are generally unsuited, or in which they are not interested (or for which they just don’t have time). Fortunately, former Math Department and present School of Education graduate students Ryan Grover and Louisa Harris will, this coming year, be assessing various aspects of the Math LA program, under the direction of School of Ed faculty member David Webb.
- The issue of continuing funding is always a concern.
DBER Team: Applied Mathematics
Activities and Findings
2008-2009
Mary Nelson, Anne Dougherty, Harvey Segur, James Curry
Activities

**Department Info**

*Transformed course details:*

**APPM 1340 (Calculus I with Algebra, Semester 1)**

Enrollment is about 100 every fall semester. There are three 50-minute lectures a week and two 90 minute homework study sessions. Students are offered optional oral assessments four times each semester.

*Principal role of the LAs is to facilitate homework study sessions, along with facilitating oral assessments.*

**APPM 1345 (Calculus I with Algebra, Semester 2)**

Enrollment is about 100 every spring semester. There are three 50 minute lectures a week and two 90 minute homework study sessions. Students are offered optional oral assessments four times each semester.

*Principal role of the LAs is to facilitate homework study sessions, along with facilitating oral assessments.*

**GEEN 1350 (Calculus I Workshop)**

Enrollment is about 75 every fall semester and 25 in the Spring. There is one meeting a week. Students meet for 100 minutes. Students work in groups on challenging problems.

*Principal role of the LAs is to help students confront misconceptions and to help the students engage in mathematical discourse with the facilitator and their peers.*

*LAs offer prompts when needed.*

**GEEN 1360 (Calculus II Workshop)**

Enrollment is about 25 every fall semester and 60 in the Spring. There is one meeting a week. Students meet for 100 minutes. Students work in groups on challenging problems.
Principal role of the LAs is to help students confront misconceptions and to help the students engage in mathematical discourse with the facilitator and their peers.

LAs offer prompts when needed.

**APPM 3310 (Matrix Methods)**

Enrollment is about 100 every fall and 80 in the Spring. There are three 50 minute lectures a week and two 90 minute homework study sessions.

*Principal role of the LAs is to help students learn to write logical proofs. They help students develop conceptual understanding of the basic ideas of linear algebra. They also grade homework and exams with the instructors.*

**APPM 3570 (Applied Probability)**

Enrollment is over 60 students every fall. There are three 50 minute lectures a week and two 90 minute homework study sessions.

*Principal role of the LAs is to help students develop conceptual understanding of the basic ideas of Probability. They help the students make important connections. They also grade homework and exams with the instructors.*

**APPM 4350 (Fourier Analysis)**

Enrollment is over 60 students every spring. There are three 50 minute lectures a week and two 90 minute homework study sessions.

*Principal role of the LAs is to help students develop conceptual understanding of the basic ideas of Fourier Analysis. They help the students make important connections. They also grade homework and exams with the instructors.*

**APPM 4360 (Complex Variables)**

Enrollment is over 30 students every spring. There are three 50 minute lectures a week and two 90 minute homework study sessions.

*Principal role of the LAs is to help students develop conceptual understanding of the basic ideas of Complex Analysis. In their homework study groups they help the students make important connections. They also grade homework and exams with the instructors.*


**Faculty** for AY 2008-2009 in courses involving LAs:

**Fall 2008:**

APPM 1340 (Calculus I with Algebra) Ann Scheels, Silva Chang (4 LAs)
GEEN 1350/1360 (Calculus I and II workshop) Mary Nelson (4 LAs)
APPM 1350 (Calculus I) Mary Nelson, Harvey Segur, Sujeet Bhat, Mike Levy (4 LAs)
APPM 3310 (Matrix Methods) Anne Dougherty (3 LAs)
APPM 4350 (Fourier Analysis) Anne Dougherty, Mark Ablowitz (3 LAs)

Spring 2009:

APPM 1345 (Calculus I with Algebra) Ann Scheels, Silva Chang (4 LAs)
GEEN 1350/1360 (Calculus I and II workshop) Mary Nelson (4 LAs)

APPM 1350 (Calculus I) Anca Radelescu

APPM 3310 (Matrix Algebra) Anne Dougherty (4 LAs)
APPM 3570 (Applied Probability) Tejun Tong (3 LAs)
APPM 4360 (Complex Variables) Anne Dougherty (2 LAs)

Findings

LAs

❖ Content expertise

With the help of one of our learning assistants, this summer we developed a concept inventory for Calculus I which will be offered for the first time as a pre/post test in Fall 2009. Our Learning Assistants will also take this CI pre/post.

❖ Beliefs

CLASS data is not available for the LAs. Learning assistants will take the CLASS in the fall.

❖ Other LA activities

1) LAs play an essential role in the Applied Mathematics Department. They contribute to our effort to offer oral assessments to all Fall Calculus I students and Spring Calculus I and II students. They often offer suggestions on how to improve the roles they play. For example, the fall 2008 LAs instituted review sessions for the 1340/45 students before each of the students’ unit exams. LAs contribute to Applied Math students’ belief that the department cares about their success.

LA-supported courses
**General Introduction:** Course development and transformations have been going on since before the LA-TEST grant, with our first oral assessments being offered in APPM 1340/45 in Fall 3003 and our Calculus workshops begun even earlier. We now offer oral assessments to all Fall and Spring Calculus I students, all Spring Calculus II students, and Mechanical Engineering Component Design students.

Learning Assistants helped with the following course transformations:

1) **Instrument Creation** – Learning assistants have helped us create 6 instruments to measure student learning and attitudes. They will used in Fall 2009.
   
   a) a Calculus Concept Inventory (CCI) to measure learning;
   b) the Oral Effectiveness Surveys for Participants (OES-P) to measure students’ perceptions of oral assessments;
   c) the Oral Effectiveness Surveys for Non-Participants (OES-NP) to determine reasons why students do not participate in oral assessments,
   d) the Oral Effectiveness and Teacher Caring Survey for Participants (OETCS-P),
   e) the Oral Effectiveness and Teacher Caring Survey for Non-Participants (OETCS-NP);
   f) the Oral Assessment Fidelity Checklist (OAFC).

The Calculus Concept Inventory (CCI) will be used as a pre- and post-test for Calculus I courses. There are seventeen multiple-choice items. Seven items are related to algebraic and trigonometric functions; four are related to limits; and six are related to the derivative. We are using Survey Monkey to administer the CCI. It will be part of the students’ homework assignments. We will use it for the first time in Calculus I courses in Fall 2009.

The Oral Effectiveness Surveys for Participants (OES-P) is for students who participate in oral assessments. The questions are about student experiences with oral assessments. There are 22 agreement 5-point Likert-scale items where 1 is strongly disagree and 5 is strongly agree. Examples:

   a. “My experience in orals improved my understanding of Calculus I concepts.”
   b. “When I had to explain my answers in orals, it made me clarify my reasoning.”
   c. “Orals not improve my understanding of the Calculus I concepts.”
   d. “I recommend orals to my friends.”

This survey also includes an open-ended question asking for any further information regarding oral assessments. There are a few items related to “teacher caring.”

The Oral Effectiveness Surveys for Non-Participants (OES-NP) contains nine items and is for students who do not participate in oral assessments. We used the same format and scale, but the questions are related to why students do not participate in oral assessments:
Based on the information we gathered from Oral Effectiveness Surveys thus far, we have Teacher Caring Survey for Participants (OETCS-P), and the Oral Effectiveness and Teacher Caring Survey for Non-Participants (OETCS-NP). One of the salient issues that emerged for students this first year was that when teachers demonstrate care, as manifested by learning students’ names and spending time outside of class answering questions, offering students the opportunity to take orals; students tend to work harder, attend class more, and are more engaged in the learning process. To further examine this phenomenon, we will use the OETCS-P and OETCS-NP to address the following research questions:

a. To what extent is it important to students that their teachers are invested in their success?

b. How is “teacher caring” manifested from the students’ perspective?

c. Is there a relationship between teachers offering oral assessments and students perceptions of the teacher’s care?

d. How does student behavior change as a result of orals with respect to motivation and class attendance?

2) **Capacity Building for Training** – Learning assistants have helped us develop our Oral Assessment Training which we offer twice a year. Training workshops include a discussion of our previous success in oral assessments, the most current research, protocol training, watching a video of an actual oral assessment including discussion of that oral assessment, and mock oral assessments with feedback from trainers. Training materials will include: a video of an actual oral assessment, a database of orals questions (for Calculus I), a manual containing protocol, and the Oral Assessment Fidelity Checklist (OAFC).

3) **Orals Facilitation**: Learning assistants have facilitated oral assessments and we have seen the following improvements in students’ learning:

Fall 2008: Exam scores of those students who attended oral assessments in Fall 2008 showed at least a five percent improvement over those who did not participate. In using placement scores as a covariate, analysis determined that orals made a significant ($p < 0.001$) difference in all unit test scores. In addition, there was a significant difference on the final exam between those students took one or fewer orals for the tests and those who took two or three ($p < 0.001$), even though there were no significant differences in placement scores for those who took orals and those who did not; indicating there was no significant difference in the mathematical preparation of the two groups when they began the course. However, in Fall 2008 Calculus I, the students
who took orals earned almost a full letter grade higher than those students who did not attend orals. Between the years 1997 to 2006, the failure rate average (students earning D, F or W) for Calculus I was 31%. Fall 2008 Calculus I failure rate dropped to 20%.

Surveys provided some information about student attitudes towards oral assessments. Typical comments included the following:

“It is important to have the one-on-one attention of the teacher.”

“So I took an oral for the first exam and got my highest test score for the class. The last exam I did not take an oral and ended up getting 57, orals are great for reviews!”

“I credit 5-10% of my grade on exams to orals.”

“Orals were very helpful because they allowed me to understand the concepts, not just how to work specific problems.”

“Please make orals for Calc 3. I never went to office hours but always went to orals.”

Spring 2009: Exam scores of those Calculus II students who attended oral assessments were compared with exam scores of students who did not attend oral assessments prior to the exam. For Exam 1, students who attended orals scored 5% higher than students who did not attend orals, Exam 2, students who attended orals scored a little under 5% higher than students who did not attend orals, and on Exam 3, students who attended orals scored 6% higher than students who did not attend orals. The averages were statistically different for all three exams. Final exam grades and final course grades have not yet been analyzed.

Spring 2009 Calculus I data were analyzed for the first exam. The majority of the students in this section were re-taking Calculus I in the spring due to a low grade in the fall term. For Exam 1, those students who took an oral scored 2.2% higher than those students who did not attend an oral. It was not a significant difference (p = 0.48). The data for the second and third exams has not been analyzed yet.

Our Noyce Fellows (undergraduates who joined the department as learning assistants and intend to be K-12 teachers) have been given the opportunity to lead recitations for one semester before they graduate after successfully facilitating oral assessments. Two of our current Noyce Fellows will student teach in the Fall and intend to use oral assessments in their student teaching experience.

**Buy-in by the Applied Mathematics Department**

a) We had 42 facilitators over the past year including the Department Chair. With the help of the LAs, we have offered mock orals where we demonstrated how to facilitate orals. Each year we add new facilitators to our roster. Full professors have found how much orals have helped their students. One full professor, who was reluctant to facilitate orals for the first exam, eventually provided three orals to students for that exam. Prior to the second exam, he sent an email to his students in which he told them that if they did
nothing else to prepare for the exam, they should take part in an oral because it would really help them.

b) Four of our learning assistants committed to K-12 teaching by accepting Noyce Fellowships in the 2008/09 school year. Two will student-teach in the fall.

c) Learning assistants have helped us to offer over 800 unique students the opportunity to participate in orals during the past year. Approximately 500 of those students were offered orals in two classes. We find that students learn to defend their reasoning and negotiate meaning with others during orals. This skill should be useful in all of their courses. Many students report that they are more likely to work with others to understand the material in their courses after they have had an orals experience.

d) The Applied Mathematics Department has typically been funding 3-7 LAs each term in addition to grant and/or institutional support used for the remaining LAs. The department committed support for 5 LAs/term for the coming academic year. The Department is also supporting 2 Aerospace and 2 Mechanical Engineering LAs.

e) The Applied Mathematics Department supports two graduate TAs who work with the LAs in Calculus I and II workshops.

f) We have developed a training video, conceptual questions, a fidelity checklist and several other handouts to help new orals facilitators. There will be two versions of every set of orals questions. Each set of orals questions is being provided in a second version which is supplemented by additional prompts and comments to help orals facilitators. These supplemented versions should be ready for the Fall semester.

g) We have collections of concept tests (and other course materials, including online homework banks) which are provided to any interested new Applied Mathematics faculty when they are assigned to teach one of these transformed courses.

h) Two Noyce fellows are working on conceptual questions for Calculus III and Matrix Methods. These will become available on our Website as soon as they are completed.

i) Our Learning Assistants and Noyce fellows help us facilitate oral assessments in local high school algebra classes.

j) As of Spring 2009, over 15 different Applied Mathematics and Engineering faculty have been directly involved in teaching courses with orals.

k) This summer one Noyce Fellow has developed a Website which will offer orals questions for numerous courses, information about the research foundation for orals, a training video and information about facilitating orals.

**Challenges**

- LA recruitment and hiring is a large chore, which must be done every term. This process has largely been done by one faculty member (MN), but it is time consuming. In AY 09-10, we hope to employ the Applied Mathematics lead TA to assist in coordinating LA interviews and making hiring decisions (like the Physics model).
- Until this semester we had only the CLASS survey to measure student attitudes. We have now developed and will test a Calculus Concept inventory in Fall 2009. We will
also collect data on the importance of teacher caring in student learning because that appears to be part of the impact of oral assessments.

- Learning assistants need to be convinced that they are an important part of APPM. We have begun an appreciation dinner at the end of each semester which gives the faculty a chance to thank the LAs for their contributions and gives the LAs an opportunity to offer suggestions on how they can contribute to our efforts. This has been a huge success.

- Collection of pre/post data is difficult, since it needs to be done at the busiest times of the year. This again has been largely spearheaded by one APPM faculty member (MN), but requires cooperation of regular faculty, and is not easy to sustain or support. It is also quite easy to "slip" and miss collecting critical data, just by oversight.
LA-TEST Annual Report
Geological Sciences
2008-2009

I. Department Information

A. Involved faculty

1. Dr. Mary Kraus
2. Dr. Lon Abbot
3. Dr. Alexis Templeton
4. Dr. Leilani Arthurs

B. List of LAs

1. Geoffrey Burtner
2. Casey Kidney
3. Graham McClave
4. Trevor Mills
5. Danielle Russell

C. List of courses impacted

1. GEOL 1030: Introduction to Geology Lab 1 (Spring 2009)
   a. # students: ~200 students were enrolled in all lab sections. Of the total number of students enrolled in GEOL 1030, ~100 students were in a lab section with an LA.
   b. GEOL 1030 description: Features field trips to local points of geologic interest. Studies rocks and topographic and geologic maps. Prior or current registration in 1000-level geology recommended. Meets MAPS requirements for natural science lab, if taken with GEOL 1010. Approved for arts and science core curriculum: natural science. The GEOL 1030 lab course is independent of any lecture course. Dr. Lon Abbott is the coordinator for GEOL 1030 and is responsible for conducting scheduling, providing support to the instructors, etc.; however, he does not teach the course. The lab instructors are primarily first-year graduate student teaching assistants. During their second semester of teaching (i.e. Spring), graduate student teaching assistants are voluntarily paired with an undergraduate learning assistant, and they develop a TA-LA teaching team and mentoring relationship. In Spring 2009, the 5 LAs met weekly with Dr. Leilani Arthurs to discuss their experiences and concerns during the week, expand on teaching pedagogy relevant to their immediate experiences, and share ideas for developing lab activities.
   c. # LA applicants: 10
   d. # applicants accepted: 5
   e. # returning LAs: 0
II. LAs

A. Content expertise*  
B. Beliefs*  
C. Other LA activities within department  
   LAs were only involved with GEOL 1030, not with the Tutoring & Study Room or any other departmental activity.

III. LA-supported courses

1. Content*  
2. Beliefs*  
3. Other impacts  
a. Students in all sections with LAs were asked to complete a paper-and-pencil survey. From the 5 LA-supported sections, 70 students completed the survey. A summary of the student responses to Likert-scale items are included here:
   ➢ 100% of the students said that the course/recitation structure allowed for good use of LAs to facilitate learning.  
   ➢ 100% of the students said that they thought their LA spent enough time with them and/or their groups.  
   ➢ 100% of the students said that they thought their LA helped them develop a conceptual understanding of various topics.  
   ➢ 96% of the students said that if they had a choice between taking this class with or without an LA, then they would choose the class with an LA. (The other 4% of the students did not respond to this particular question.)  
b. Dr. Leilani Arthurs observed 1 complete class/lab/field day for each of the 5 sections with LAs and provided each TA-LA team with feedback. Attached are 2 of the reports as examples.

* No pre/post content surveys were administered to collect data on content expertise. No CLASS surveys were administered to collect data on beliefs.

IV. Evaluation of department buy-in/challenges & Extent to which LA Program has become integrated into the department

1. GEOL 1030: Introduction to Geology Lab 1  
a. Dr. Lon Abbott has spear-headed the implementation of LAs in our department by integrating LAs into GEOL 1030.  
b. Based on a combination of formal interviews and informal interactions with graduate student teaching assistants, it was clear that they strongly preferred not to me paired with an LA during the first semester of their first-year graduate student TA-ship. However, all graduate student teaching assistants said that they would be happy to partner with and mentor an undergraduate learning assistant in their second semester of teaching (i.e. Spring) and onward. As such, Dr. Lon Abbott decided on a “Fall off, Spring on” model of LA implementation for GEOL 1030. Spring 2009 was the second semester in which LAs were implemented into this course (with Spring 2008 being the first semester).
c. In Spring 2008, we had 2 students express interest in being LAs and the department funded both of them.

d. In Spring 2009, we had 10 students apply to be LAs and we had slots for 5. The department funded 4 of the 5, and the fifth one was funded through the LA Program.

2. GEOL 2100: Environmental Geology

a. Due to the success of LA implementation in GEOL 1030 (based on LA, TA, and student feedback) and to her design of in-class collaborative activities, Dr. Alexis Templeton has applied for 3 LAs for Fall 2009. If successful, her implementation of LAs into GEOL 2100 will reflect a gradual spread in the incorporation of the LA Program into the department.

b. The department will fund 2 out of the 3 LAs, and the third one will be funded by the LA Program.

3. Challenges faced during implementation

a. Human resources: The GEOL dept is not among the original group of departments to implement LAs, and information about the LA Program was slow to get here (e.g. in Spring 2008, only 1-2 faculty members had even heard about the LA Program). The primary source of information about the LA Program has been Dr. Leilani Arthurs (GEOL-SEI staff). She has also provided the participating faculty, graduate students, and LAs ongoing support in their LA-related efforts. This situation poses a concern in terms of human resources. Acting as a liaison between the GEOL dept and LA Program places a significant load on Dr. Arthurs’ schedule both during the LA application process and during the semester in which LAs are implemented (e.g. attending orientations, completing faculty applications, meeting weekly with LAs, meeting with LAs and TAs individually by appointment, meeting with faculty to discuss LA-related issues). Due to the demand on human resources from the GEOL-SEI, priorities were set such that this kind of support will not be available for GEOL courses implementing LAs in Fall 2009.

b. Buy-in: As mentioned above, information about the LA Program has been slow to reach the department and efforts to educate the faculty have been made by Dr. Arthurs after she learned about undergraduate GEOL majors’ interest in participating in the LA Program. Based on these concentrated efforts with interested faculty members, only 3 faculty members — Drs. Abbott (instructor), Templeton (junior faculty), and Kraus (senior faculty) — have a deep understanding of what the LA Program is about and see value in it. Dr. Mary Kraus was the past Chair and saw great value in the program; however, other senior faculty members have not yet embraced the program to the same degree she did. Nevertheless, there is growing interest among some other senior faculty members in learning more about and incorporating LAs into their courses (e.g. Dr. Greg Tucker and others in the department’s Environmental Geology group).

c. Potential: Given the (a) interest among our undergraduate GEOL majors to be LAs, (b) interest among our graduate student TAs to partner with LAs, (c) growing interest among our faculty members to mentor and work with LAs, and (d) administrative and financial support coming from the past Chair, the GEOL department has great potential for the LA Program to be integrated into several courses. However, this potential cannot be realized without adequate and long-lasting support structures both from the department’s end and the LA Program.

d. Sustainability: Dr. Arthurs’ position within the department is a temporary one and this brings into question the sustainability of the steps made thus far towards integrating the LA Program into the department when she leaves. As she discussed during one of the Discipline-Based

Prepared: 2009-07-21, L. Arthurs
Education Research meetings, it would befove both the GEOL department and the LA Program to institutionalize a departmental liaison for the LA Program (i.e. someone to inform departments about the LA Program, to provide faculty with advice and options for implementing LAs, assist with the application process, and to provide faculty support during the semester of LA implementation). It is worth noting that the success of the LA Program is implicitly connected to the participating faculty member’s ability to teach and model sound pedagogy to the LAs with which they work, and it is important to remember that faculty members outside of EDUC and PER are generally not adequately trained in this arena and, therefore, they would greatly benefit from such support from the LA Program. Incorporating LAs into labs and courses is an extremely different model of education, and successfully and sustainably implementing the LA Program within the GEOL department requires sustainable support structures that do not yet exist.

V. Publications on Education Research and Reforms within Department

A. Journal Publications


Prepared: 2009-07-21, L. Arthurs


B. Conference Posters & Presentations on Education Research and Reforms within Department


9. A. Bair, “Why use clickers and how to know if they are doing any good, Part III: Student perceptions of clickers across disciplines, instructors, and courses.” Colorado Learning and Teaching with Technology Conference, August 2008.

Prepared: 2009-07-21, L. Arthurs


Learning Assistant Program in GEOL Department
Class Observations & Comments

<table>
<thead>
<tr>
<th>Course</th>
<th>GEOL 1030: Introduction to Geology Lab I</th>
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<tbody>
<tr>
<td>Instructor</td>
<td>Alex Dutchak</td>
</tr>
<tr>
<td>Learning Assistant</td>
<td>Casey Kidney</td>
</tr>
<tr>
<td>Observer</td>
<td>Leilani Arthurs</td>
</tr>
<tr>
<td>Location</td>
<td>Benson Earth Sciences Building, room 145</td>
</tr>
<tr>
<td>Date</td>
<td>Monday, March 9th, 2009</td>
</tr>
</tbody>
</table>

Overall Structure of Class Meeting:
I. The class meeting began with students completing the mid‐semester LA evaluations.
II. I tucked myself in the back corner of the room, which was a good vantage point for viewing the entire classroom, and Alex introduced me and let students know that I’d be taking pictures.
III. Alex introduced students to an outdoor pre‐lab activity, to get their minds wrapped around the enormity of geologic time.
IV. After returning to the classroom, Casey gave a brief lecture on radiometric dating and then Alex introduced the in‐class lab work for the day.
V. Students spent the majority of class time discussing and completing the lab worksheets.
VI. As students began completing their lab worksheets, Alex returned the students’ mid‐term exams.

Perceived Overall Learning Goal(s) for Students:
I. Place their life‐time within the context of geologic time, specifically Earth’s history.
II. Apply the principles of relative age dating to interpret a cross‐section and infer the history of rock formation.
III. Apply the concept of absolute age dating to solve a given problem(s).
IV. Use basic math skills to calculate rates and complete unit conversions.

Student Interactions and Student‐Specific Observations:
17 students attended class that day. For the most part, students worked in pairs (or triads); only 1 student worked by himself. The students appeared to be quite engaged in discussing the lab worksheets with each other and with the TA and LA. The triad working together in the front row, in particular, had excellent discussions that suggested that they were actively thinking about the lab exercises instead of just trying to find the correct answers. For example, at one point, one student explained what she thought to the other two students, one of them posed a counter argument, and the first student said, “Yeah, I can see that but...” and proceeded to explain her reasoning. Overall, the students in this class also demonstrated an overall positive attitude towards doing the work.

The students in this class worked in very functional and productive groups, and it would be worthwhile to discuss with the TA and LA what they think they did help foster these working groups.
LA-Specific Observation & Comments:

Casey prepared a very good short lecture and PowerPoint slides to explain absolute age dating. The visual images, in particular, were helpful instructional aides. A few suggestions for how to improve the lecture include:

(1) Slow down the pace at which you cover the material covered on each slide. A number of tricks you can use to do this include: (a) walk away from the computer in between slides so you can’t advance the slides quickly, (b) use the black/white board to write some of the things you are saying, and (c) ask your students questions (and count to 10 in your mind to give them time to think up an answer – it’ll feel like a loooong 10-seconds, but keep your count going).

(2) Engage the students in the material that you are going to present BEFORE you present the material. For example, you can do this by asking them questions about how they think X might be done, have them discuss their ideas with their neighbor for ~1-2 minutes, and then solicit some ideas that they came up with. Now, you know some of the students’ existing ideas about the subject you are about to cover and you can now build connections between their ideas and the material you are going to present. For example, you could say, “Some of you thought Y and that’s partially true. It’s true if you think about it this way; however, that doesn’t cover the full picture. To understand the full picture, we need to also consider ....”

During the time that the students were completing their lab worksheets, Casey circulated around the room with Alex to field questions from the students and assist them in working through the problem set. Casey did well to consult with Alex at one point in time, when he was not positive that he was on the right track with a particular question; Alex was able to confirm with Casey and the students that Casey was moving the students in the right direction. It was evident that students found Casey approachable and helpful because they would call out his name and flag him down for assistance.

TA-LA Team-Specific Observations & Comments:

Alex and Casey did an excellent job of supporting each other and communicating with each other during the class meeting. Three separate instances epitomize the smooth team work these two exhibited. (1) When Casey was giving his short lecture on radiometric dating, none of the slides included the chemical nomenclature for isotopes of the same element. As Casey was discussing the atomic weight of isotopes, Alexis took the initiative to write two examples of carbon isotopes on the white board, to help support what Casey was saying. (2) When Alex was introducing the worksheets that the students would complete during class time and a question on absolute dating in particular. Casey displayed a decay curve (on a PowerPoint slide) and added that this curve might be helpful to them in working out the problem. (3) While the students were working on the lab exercise, Alex and Casey realized that there was an error in one of the directions initially given to the students. To address this error, they discreetly moved to the front of the room, discussed the error, and then Alex addressed the class as a whole to say there was a mistake made in the instructions and clarify the instructions.

In addition to supporting each other as a team, Alex and Casey also were able to assist the students more effectively than only a single instructor. Throughout the class period, both Alex and Casey were usually engaged at the same time with different students. On at least three different occasions, students called for each one of them at the same exact time – either by name or by raising their hand. The TA-student ant and LA-student interactions (that were audible from my location in the room) always centered around students’ questions and questions posed to the students by the TA/LA. The TA and LA assisted the students in working through problems to figure out the solution on their own rather than simply giving them the correct answer.
Observations of and Comments to Partnering TA:

Alex is a seasoned veteran to teaching. He is comfortable with the content knowledge relevant to the course and comfortable with interacting with the students. Moreover, he is able to imbue a sense of comfort and geologic perspective to his students. Observations that support these comments include: (1) Prior to the outdoor pre-lab activity, Alex asked his students whether they had any sense of geologic time beyond ~20 years, and several students answered by saying, “No.” This was a great segue into the outdoor pre-lab activity in which Alex literally walked his students through the geologic timeline, using a measuring tape as a reference. At the end of the activity, he asked his students whether they now had a better sense of the geologic timeline and the enormity of geologic time, and most students said, “Yes” and/or nodded their heads in the affirmative. (2) During the outdoor activity, Alex also used subtle humor to pique and, perhaps, gauge student comfort and interest. For example, as he discussed the idea that life evolved from the ocean, he remarked, “So, we are all our own self-contained walking oceans.” The chuckles that emerged from the group of students were an indication that the students were still paying attention and on the same page as Alexis. Alex is a confident instructor who is also comfortable in providing Casey opportunities to develop his own teaching abilities. We are lucky to have such an excellent teaching role-model and mentor teamed with Casey!

A Few Images to Capture the Day:

Alex and Casey reel out geologic time!

Casey lectures about absolute age dating.

Alex and Casey consulting with each other.

Casey assisting students with their learning.
Learning Assistant Program in GEOL Department
Class Observations & Comments

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<td>Stephanie Higgins</td>
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<tr>
<td>Learning Assistant</td>
<td>Geoff Burtner</td>
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<tr>
<td>Observer</td>
<td>Leilani Arthurs</td>
</tr>
<tr>
<td>Location</td>
<td>Benson Earth Sciences Building, room 145</td>
</tr>
<tr>
<td>Date</td>
<td>Tuesday, March 31st, 2009</td>
</tr>
</tbody>
</table>

Overall Structure of Class Meeting:
I. The class meeting began with students completing their mid-term class presentations.
II. When the mid-terms were finished, I entered the room and tucked myself in the back corner, which was a good vantage point for viewing the entire classroom and most of the students.
III. Stephanie gave a 5-minute introductory lecture on the representation of ridges and rivers on topographic maps.
IV. Stephanie gave a 5-minute description of the 4 different work stations that comprised the activities for today’s lab meeting. One work station required students to build a 3-D model of features on a topographic map using Play-Doh. Another station provided students the opportunity to draw contour lines of a model landscape using incrementally increasing levels of water around the landscape (which was in a plastic container). At another station, students worked on completing a worksheet. At a fourth station, students worked with a topographic map to answer questions specific to that map.
V. For the remainder of the time, the students worked through the activities at the 4 different work stations while Geoff and Stephanie circulated around the room to work with students. There was no particular order in which the students needed to go to each station; they simply needed to get to all 4 of them.
VI. When students finished their lab exercises, they turned in the required components and left.

Perceived Overall Learning Goal(s) for Students:
I. Distinguish the difference between ridges and rivers represented on topographic maps.
II. Practice reading a topographic map and practice visualizing 3 dimensions (by constructing a 3-D model based on a 2-D topographic map).
III. Build a conceptual understanding of what contour lines represent on topographic maps (by creating a pseudo contour map of a model landscape).
IV. Familiarize selves with components of a topographic map such as the scales, latitude and longitude, etc.
V. Create a cross-section from a transect on a topographic map.

Student Interactions and Student-Specific Observations:
At the time that I took a head count, 16 students were in the room. During the class meeting, the students usually worked in groups of 2-4 at the different stations. Overall, the students worked very well together, with seeming comfort with each other, ease of discussion, and positive attitude. Usually,
more than 1 student was at a particular station at any one time. The Play-Doh station, however, was the exception; some students worked at this station solo. Even though some students worked solo at this station, they still had productive interactions with other students. For example, at 12:45, a female student working solo at this station asked a male student who was passing by whether he had already done this activity and how he did it. He said that he had and kindly gave her some tips on how to start, then moved on to the next station where he worked on creating pseudo contour map.

In general, I could not make out the specific conversations students were having with each other in this class because many students were talking at the same time, which resulted in an almost continuous buzz of discussion, and because individual student voices seldom raised higher in volume than this overall buzz. Therefore, I can not comment to the quality of the student-student discussions. However, I can say that the students were often engaged in conversation with each other (as well as with the TA and LA) and actively engaged in the activities they were completing.

For the most part, students appeared to work collaboratively with each other and relatively independently of the TA and LA. There was, however, a female student who spent more of her time talking with primarily the LA and then the TA. In particular, she seemed to require more step-by-step hand holding with the map reading work station.

Overall, the students in this class appeared to work in very collaborative and productive groups. It would be worthwhile to discuss with the TA and LA what they think they did help foster these positive working group dynamics.

**LA-Specific Observation & Comments:**

Geoff assisted in setting up the work stations, and he assisted in facilitating the in-class activities. He circulated around the room to both check in on how students were progressing and to respond to students flagging him down with questions. While checking in with students, he asked questions such as, “How are things going over here?” or “Do you have a question?” Geoff was flagged down on at least 8 different occasions by male (3 times) and female (5 times) students who had questions. The types of questions that were audible to me dealt with clarifying different topics (e.g. scale, longitude vs. latitude, and contour lines) and checking students’ work (e.g. “Hey, Geoff, is this the correct way to …?”).

In general, Geoff was constantly circulating around the room and interacting with one student or a group of students at any given time. He demonstrated correct content knowledge and ease with the application of that content knowledge to the activities at hand. For example, in a group discussion with 4 female students, he was able to clearly explain latitude and longitude and to answer students’ follow up questions that indicated that they did not yet understand these key concepts. At the end of this ~5 minute discussion, one of the students in the group successfully put the idea of latitude into her own words, and Geoff said, “Yeah, exactly.” As another example, with other students, Geoff helped them approach creating a cross-section from transect on a topographic map by explaining how he does it as well as the rationale behind his approach.

In addition, Geoff also had supplementary information to share with the students, to help give them a bigger picture of the context into which some of the work they were doing falls and that also reflected his knowledge and deep interest in geology. For example, on different occasions, he talked about sources of maps, kinds of maps, how topography is measured, and vertical exaggeration. None of these things related to specific questions that students needed to answer through the lab activities; however, the students nevertheless listened attentively and seemed interested in what Geoff had to say. At one point, a student asked, “How do you know all of this?” Geoff replied by saying, “I just love maps. ....”
TA-LA Team-Specific Observations & Comments:

Stephanie and Geoff had few observed personal interactions with each other during this class meeting. Nevertheless, it was evident that they were operating in accord with one another. At one time, Stephanie said that she thought they needed another piece of equipment and Geoff tried to help by letting her know where he thought she might be able to find it. At another time, they casually passed each other while circulating around the room, briefly chatted with each other (inaudible to me), smiled, and continued to circulate and work with students.

It was clear that Stephanie and Geoff were each knowledgeable, competent, and approachable. Again, it was also evident that they were working in accord with one another. These combined attributes made them a high functioning TA-LA team that was able to assist the students more effectively than a single instructor in the room could have. Throughout the entire class period, they were usually engaged at the same time with different students. The TA-student ant and LA-student interactions (that were audible from my location in the room) usually centered around students’ questions and questions posed to the students by the TA/LA. Depending on the nature of the question, the TA/LA either simply answered the question or assisted the students in working through problems to figure out the solution on their own.

Observations of and Comments to Partnering TA:

Stephanie delivered a brief (5 min.) lecture to introduce the differences between ridges and rivers, as they are represented on topographic maps. The content of the lecture was relevant to the activities planned for today’s lab. However, the pace at which it was covered was rather fast. One student said, for example, “Wait. What?” A few comments on how the lecture content might be made more accessible to the students include:

1. Slow down the pace at which the content on each slide is covered. A number of tricks to do this include: (a) walk away from the computer in between slides so you can’t advance the slides quickly and (b) use the black board to write some of the things you are saying.

2. Clarify the features you are talking about on a given slide by physically pointing them out. Strategies for doing this include: (a) use a wooden/laser pointer or your finger to outline the “A-shapes” and “U-shapes” to which you referred, (b) highlight these features by inserting PowerPoint autoshapes (e.g. circles or boxes) around them, (c) trace out these features by inserting PowerPoint autoshapes (e.g. curve, scribble).

3. Engage the students in the material covered in different slides. For example, you could point out an example of a ridge or river, and then ask a pair of students come up to the screen, pick out an appropriate example, show it to you, and explain why they picked it.

Stephanie also spent 5 minutes describing the activities at each of the work stations. The pace at which she went over the descriptions was similar to the pace she used in the introductory lecture. Even though the pace was relatively fast, the content (i.e. descriptions of activities at each work station) was straight forward and required less time for mental processing. Therefore, the pace of coverage (relatively fast) was compatible with the cognitive load (relatively low) required by the students.

During the time that the students were completing the activities at each work station, Stephanie circulated around the room to field questions from the students and assist them in working through the activities. Not only was she knowledgeable and able to accurately answer students’ questions, she was also able to assist students in thinking through questions for themselves. For example, one female student working with the Play-Doh station said, “I’m not sure how to start.” Stephanie provided a starting point and fostered a collaborative approach by replying, “Okay, start with a mountain top. Let’s find a mountain top.” She then asked follow up questions such as, “Is that a ridge or a river?” Another kind of follow-up question useful for student learning that she might have asked but that I could not hear would be: “Why do you think it’s a ridge/river?” (Similarly, how do you know it’s ... or what’s your
reasoning for saying it’s ... kind of questions are also useful for promoting student learning.) In this sense, Stephanie did an excellent job of helping students think about the activities and how to approach them instead of simply telling them what to do or simply giving them answers.

Stephanie designed creative approaches to engage students in learning about topographic maps through 4 different work stations. One female student commented, “Doing this in class makes it a lot easier to understand than just doing the reading.” Stephanie is comfortable with her content knowledge, the applications of that content knowledge, designing creative and engaging activities, and interacting with the students. Moreover, she is comfortable and confident enough in her own content knowledge and teaching abilities to be a supportive and encouraging mentor to Geoff. For example, as observed this day, she allowed him to work independently in fielding students’ question. Also, as I’ve been told (i.e. not observed on this day), she also supported and facilitated Geoff’s goal of preparing the materials for and leading an entire lab session (Coal Creek Canyon).

Given the excellent knowledge base and teaching potential of both Stephanie and Geoff, it seems likely that they can learn much from each other and that they are able to compliment each other well during class meetings in a way that students can only benefit. We are lucky to have such a knowledgeable and supportive mentor teamed with Geoff!

A Few Images to Capture the Day:

Geoff and Stephanie assist many students at the same time.

The fish I caught was this big! (Geoff talks with students at topographic map work station.)

Stephanie listens to a student’s reasoning.

Stephanie and Geoff check in with each other part way through the class meeting.