Chemistry Impact Grant Report

Project Committee

Chemistry members; Project lead
Ted Clark, Pilot Co-Instructor, Lead Evaluator

Chemistry members; Project contributors
Christopher Hadad, Department Liaison
Rick Spinney, Computer Support
Rosemary Loza, Pilot Co-Instructor
Mindi Rhoades, Assessment
Jessica Mamais (Olentangy Orange H.S.), Pedagogical Consultant

Executive Summary
Chemistry 161, which enrolls students majoring in Chemistry, was re-designed to combine lecture and recitation. During the Impact Grant project period, in and out of class activities were created, simulation-based learning activities were identified, and assessment criteria were established. The pilot course, taught during AU 10, was conducted in Central Classrooms 311. Findings included very high student engagement (in terms of course activity participation), statistically superior final exam scores to Chemistry 121, dramatic learning gains in areas not traditionally evaluated in a general Chemistry course, and a significant majority (95%) of students favoring the re-designed course over a traditional general Chemistry course format.

Problem / Opportunity
Introductory Chemistry courses at OSU are almost exclusively taught in a traditional lecture format, with a lab component and (perhaps) a recitation (taught by a teaching assistant). The lack of student-led inquiry tasks in these courses leads to an absence of in-class problem solving and does not promote critical thinking within the class period. Using in-class computer simulations that are robust and open-ended, when coupled with inquiry-focused tasks and the use of in-class group assignments, have the potential to dramatically alter the traditional course framework. In this course, students will experience traditional lectures, but will also have the opportunity to manipulate "experiments" in class, observe phenomena, and collect, analyze, and discuss data with classmates.
Project Goal(s)

- Increase the number of in-class authentic inquiry tasks, especially ones employing computer simulations, within a technology-rich version of Chemistry 161.
- Increase additional learning opportunities (practice modules) outside of class using computer simulations (to promote anytime/anyplace learning).
- Assess project program, focusing on concept retention and student engagement.
- Change course instruction dynamics so that verbal instruction and enhancement of concepts occur in class and student work is accomplished outside of class.

Success Criteria

- Topics for simulation-based learning activities identified.
- Evaluation scheme for Chem 161 established.
- Assessment criteria for potential simulations established.
- Evaluated material and support documentation of simulation option.
- Explored logistical and pedagogical options for integrating lectures and simulations.
- IRB approval obtained.
- Course framework redesigned to include simulations.
- Implemented and established simulations during Fall 2010 for Chem 161.
- Implemented simulations into two lecture sections taught in 311 Central Classrooms.
- Simulations used and evaluated in Fall 2010.
- Participants remained within time and budgetary constraints of Impact Grant and Departmental resources provided for the project.
- Document produced describing student learning outcomes.
- Transition from LT personnel and financial support does not disrupt Chem 161 teaching and learning.

2010 Impact Grant Pilot Experience

Students affected by pilot:

120 students

Anticipated number of students affected by new course design in 2011:

130-230

About 130 students if used for Chemistry 161 (very probable). Adding another section of students, such as from the Scholar’s program, would add another 100 students.
### Approximate time spent by Chemistry faculty and staff on the revision project:

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Approximate Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ted Clark</td>
<td>500+</td>
</tr>
<tr>
<td>Rosemary Loza</td>
<td>80+</td>
</tr>
<tr>
<td>Mindi Rhoads</td>
<td>20+</td>
</tr>
<tr>
<td>Jessica Mamais</td>
<td>20</td>
</tr>
<tr>
<td>Richard Spinney</td>
<td>10</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>630+</strong></td>
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</tbody>
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### Approximate total cost (not including LT staff time):

<table>
<thead>
<tr>
<th>Resource</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Release Time for Rosemary Loza</td>
<td>$8,500</td>
</tr>
<tr>
<td>Compensation for Rick Spinney</td>
<td>$2,500</td>
</tr>
<tr>
<td>Compensation for Ted Clark</td>
<td>$2,500</td>
</tr>
<tr>
<td>Compensation for Jessica Mamais</td>
<td>$1,000</td>
</tr>
<tr>
<td>Conference Expenses</td>
<td>$2,000</td>
</tr>
<tr>
<td>Student support Expenses</td>
<td>$3,000</td>
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<tr>
<td>Educational Assessment Consultants</td>
<td>$7,500</td>
</tr>
<tr>
<td>Compensation for Karen Irving</td>
<td>$2,500</td>
</tr>
<tr>
<td>Compensation for Mindi Rhoads</td>
<td>$1,500</td>
</tr>
<tr>
<td>Gift cards for student contributors</td>
<td>$925</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$31,925</strong></td>
</tr>
</tbody>
</table>

### Impact Grant outcome summary:

- Chemistry 161, a novel course incorporating a wide range of innovative practices, many of which were informed by ideas and learning objectives gleaned from the Chemical Education community, was revised in the autumn quarter of 2010 with support from a Learning Technology Impact grant.

- The central goal of this pilot study was to design, implement, and evaluate an introductory chemistry course (Chemistry 161) that utilized a novel classroom space with the potential to dramatically increase active learning, student engagement, and learning. Also, the identification of best practices that could transcend this particular environment and be transferred to large-enrollment General Chemistry courses was a parallel goal.
• As noted above, a very significant amount of time was dedicated to this project. Initial tasks included the identification and testing of computer simulations suitable for use in the technology-rich classroom. Participants also designed and tested student-centered worksheets to support the simulations. It soon became apparent that the use of such simulations required a re-working of about 50% of the course (necessitating entirely new lectures). Dr. Clark took the lead on this portion of the course, with some support from Dr. Spinney and Ms. Mamais. The next task was to modify those portions of the course that would not employ simulations, but instead emphasize active learning practices, such as small group problem-solving, use of whiteboards, etc. Incorporating such practices once again required a dramatic revision of the traditional lecture format. Decisions pertaining to the use of outside of class resources, most notably the use of Mastering Chemistry (a software application supporting the course’s textbook), was another major undertaking that Dr. Loza completed.

• The implementation of these innovations in the Fall of 2010 was a major undertaking. Even with this extensive framing of the course, it soon became apparent that a dynamic environment such as this required continual planning and real-time adjustments. The “final product” presented to students had the same level of professionalism that accompanies a traditional lecture; this belied the fact that frantic real-time adaptations and revisions were occurring on a daily basis. Having two instructors on-site for every lecture was of considerable importance.

• A “Class Activity” is provided as supporting documentation. It describes specific innovations present in Chemistry 161 and student perceptions of these activities.

Assessment highlights:

• Student engagement and satisfaction with the course’s interactive format was high, with activities including feedback, discussion, and problem-solving being highly valued.

• Learning objectives for the course were expansive and evaluated with an extensive assessment program featuring pre- and post- tests, open-ended surveys, and exam performance.

• Student proficiency with algorithmic problem-solving and memorization of chemistry facts, as described by a cumulative final exam, are comparable with previous cohorts of Chemistry 161 students.
• In addition to these traditional measures, substantial gains are quite evident in conceptual understanding as assessed by using the Chemistry Concept Inventory in a pre-and post-format. Conceptual gains in selected areas are truly exceptional and the overall change clearly surpasses gains associated with standard General Chemistry instruction.

• Finally, a more sophisticated understanding of the Nature of Science consistent with the GEC learning objectives for the course is apparent for many students.

• Follow-up group interviews are planned with Chemistry 161 students. Several interwoven topics merit further attention, including a) the value of active-learning environments, b) the use of simulations and visual representations of chemical concepts, c) student epistemology and their attitude toward learning, and d) student insights into, and understanding of, scientific models.

Several end-of-course surveys were used to describe and evaluate student experiences and learning. Extensive follow-up focus group interviews are planned for Winter 2011. An extensive discussion of preliminary findings is provided as supporting documents. A few highlights worth noting:

• Student engagement in the course was very high, evidenced by the considerable “buy-in” for outside of class on-line activities and the very high attendance in class.

• Student perceptions of their learning in this novel course format is very encouraging, with about 95% of students favoring this environment over a traditional General Chemistry format at this time.

• Dramatic learning gains occurred in areas not typically evaluated (or taught) in General Chemistry at OSU, such as conceptual understanding of chemistry topics and insights in aspects of the Nature of Science (NOS). The extent to which these gains are enabled by the technology-rich environment will be probed in focus group interviews.

**Data comparison from control or previous course:**

• Traditional achievement measures, such as a cumulative final exam, indicate student performance this quarter was statistically superior to that associated with traditional Chemistry 121 courses, and statistically equivalent to other cohorts of Chemistry 161 students. Chem 121 is the standard first course of General Chemistry unless students are enrolled in a special section. Special sections include Honors (about 100 students), 161 for majors (about 100), and remedial courses (about 200). Chem 121 enrolls several thousand.

**Reflections on the grant process – what went well:**

All interactions with the Digital Union were enjoyable, efficient, and highly productive. The level of professionalism Rob Griffiths displayed throughout the process was exceptional.
Reflections on the grant process – what did not go well:
None.

Suggestions for future recipients:
None.

Ah-ha moment of the grant process:
The first two weeks of class were crucial. This was an inflection point bridging 8 months of planning and the subsequent 10 weeks of implementation.

Next steps:
Winter quarter (WI 11) will be an exciting period as the assessment portion of the project is emphasized with focus group interviews. Spring quarter (SP 11) will include travel to AERA 2011, the American Educational Research Association 2011 Meeting.

Working with LT staff:
In three words:
1. Professional
2. Enjoyable
3. Thought-provoking (ok, that may be sneaking in an additional word)

Evaluation of working with LT staff during the grant project:
1) I am satisfied with the communication I received from the LT staff.
   a. Strongly Agree
2) I am satisfied with the project contributions I received from the LT staff.
   a. Strongly Agree
3) I have learned the skills necessary to continue related work on my own.
   a. Agree (may have some questions)
4) I found the LT staff approachable.
   a. Strongly Agree
5) The lessons learned during this pilot will guide future course design.
   a. Strongly Agree
6) Additional comments or feedback:
   a. Our team began work on this project in December 2009. The large amount of work done in the initial months of the Winter and Spring quarters were crucial to the project’s success. It is important to impress upon future grant recipients that the scale of these projects require an “early start”. Our experiences would have been markedly inferior if we had begun more slowly. Having tangible “checkpoints” early in the grant is an excellent way to ensure such initial effort.

Vice Chair for Undergraduate Studies Statement of Impact
December 29, 2010

Digital Union
Office of the Chief Information Officer
Ohio State University
CAMPUS

Dear Colleague:

The Digital Union Impact Grant that the Chemistry department received in December 2009 resulted in dramatic changes in Chemistry 161 in autumn quarter, 2010 and should be the impetus for continued innovations for several years to come. The timing of this grant was quite fortuitous since Chemistry 161, General Chemistry for Chemistry (and Biochemistry) Majors, is a relatively new course that is establishing its identity and distinguishing the necessary characteristics for an important cohort of students.

This year, Chemistry 161 became a course that significantly expanded “what counts” in terms of teaching and learning in General Chemistry as the technology-rich environment promoted an active learning space that could address students’ conceptual understanding of chemistry and led to students gaining insights into the Nature of Science. Such an expanded course offering is consistent with the salient objectives of General Chemistry pedagogy across the country but, to date, have only received limited attention here at OSU. It is anticipated that the best practices learned in our offering of Chemistry 161 (~150 students) in these areas will be transferred to other General Chemistry courses (>3500 students) in the future.

A second noteworthy accomplishment has been the high level of collaboration that accompanied the project. Within the Chemistry department, the co-instructors for the course, Dr. Rosemary Bartoszek-Loza and Dr. Ted Clark, along with the department’s instructional technology expert, Dr. Rick Spinney, worked together for several months, with all clearly benefiting from the other’s expertise and perspectives. Such collaborations are far too infrequent here at OSU. Another significant collaboration occurred between the staff of the Digital Union and the personnel in the Chemistry department, again with both parties benefiting. Future collaborations in this area are, once again, highly desirable.

Plans are currently underway to learn from the innovative teaching and learning practices present in Chemistry 161 and to transform other introductory Chemistry courses at OSU. An important variable to consider is, to what extent, the novel Central Classroom space drove the pedagogical changes or whether the traditional lecture hall environment would also benefit. There are also spatial limitations in these decisions as the 72-person Central Classroom location is very limited for offering a general chemistry experience to the >3500 students in the similar course during a single academic quarter.

Even in this current academic year, the current students in Chemistry 161 will migrate to a “traditional” lecture environment in Chemistry 162 and 163 – assessment of the learning opportunities from the novel Central Classroom format in Chemistry 161 to the full lecture format in Chemistry 16 and 163 will be evaluated in the short term.

The development of courses for semesters is also an ideal time to consider such questions and it is anticipated that lessons learned from Chemistry 161 will inform these future decisions. There are many opportunities ahead of us, and the innovative approach for teaching the Chemistry 161 course has provided valuable information for evaluation going forward.

Sincerely,

Christopher M. Hadad
Professor of Chemistry and Vice Chair for Undergraduate Studies
LT involvement

LT Project lead
Robert Griffiths

Approximate time spent by LT staff on the revision project:
50 hours

Reflections on the grant process – what went well:
This project worked well due to dedicated, open, collaborative project leads, in addition to strong departmental support. The instructors were very dedicated to the project, put in the time to really consider how to create a course to inspire and engage students. We worked closely with the project leads to work through problems with the rooms and course structure and found solutions that were enthusiastically implemented. Often in our work, we may see enthusiasm wax and wane over the course of time, but this team seemed to be consistently in high gear to prepare, practice, test, change, practice, test their materials during the course the year. To say they were energetic doesn’t do this team justice.

The team was less hands-on than the Math team, but it stemmed from a different preferred working style that worked well for this team. Other parts of the project that worked well was the training and optimization for using Central Classrooms 311 for their pilot course, as well as purposefully using OCIO resources for Carmen training and brainstorming for formatting mediated activities for in-class and online, asynchronous participation.

Other general processes that went well were having the Idea Labs with the Math team to promote collaboration and encourage questions that strengthened both projects. The phased funding approach of the grant afforded an opportunity to concentrate on the project goals and objectives, as well as assessment in a meaningful way.

Reflections on the grant process – what did not go well:
Really this project had few, if any, hiccups, both in terms of the process working with the Chemistry team and with the technology used...both in the physical classroom space and the online solutions that were implemented. A few areas of improvement could have been made by spending more time working in Carmen to synergize the tools and experience.

Also, on our end, we could have spent more time observing the classroom experience and providing ideas for more effective ways to use the unique set-up in Central Classrooms 311. This could have afforded us additional expertise when working with future instructors in not only CC311 but the other unique spaces we have on campus, such as the Learning Collaboration Studio (Science and Engineering Library) and LearnLab (Baker Systems).
Generally, some additional lessons learned we gained from the grant process was to define DU blog post deadlines to enhance the transparency of our projects by having more regular posts. Also, we learned about communicating and setting-up instructor expectations about the technology being used and expectations how the instructor could mitigate potential problems. This, in turn, helped us to proactively inform all instructors using an Impact Grant project classroom to understand how all instructors are using the space in order to be sensitive to everyone’s uses and needs.

**Working with the Chemistry team:**
In three words:

1. Insightful
2. Enthusiastic
3. Inspiring