Please hand-deliver your completed grant proposal (cover page, 4 pages, plus attachments),
the original plus 15 copies, to:
Susan DeWoody, 1530 Wallace (Bldg 5)
by 4:30 p.m.
Friday, May 1, 2009.
No hand written proposals will be accepted.
Notification of awards will be made by Friday, May 29, 2009.

Project Title: **Organic Chemistry: An Innovative Studio-Based Approach**

<table>
<thead>
<tr>
<th>Name</th>
<th>Telephone</th>
<th>Dept.</th>
<th>College</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Christina Collison</td>
<td>475-2634</td>
<td>Chemistry</td>
<td></td>
<td></td>
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<tr>
<td>Dr. Jeremy Cody</td>
<td>475-2545</td>
<td>Chemistry</td>
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</table>
A. Project Title:

Organic Chemistry: An Innovative Studio-Based Approach

Summary of proposed project:

The traditional method for most chemistry courses (organic chemistry included) is to teach a lecture three times per week accompanied by a weekly 4-hour lab. Our data shows that this traditional method for teaching organic chemistry is flawed and the following problems arise:

I. Compartamentalization of the material.
II. Perception that lab material out-of-sync with lecture.
III. Minimized stress on lab techniques.
IV. No forum for reflection and critical thinking.

These problems can be best addressed by teaching organic chemistry using a studio-approach. A "Chemistry Studio Classroom" combines lecture and lab activities into one space, and encourages students to learn science through a continuous cycle of observation, reasoning, and experiment. The studio model is not a novel concept and has been implemented in chemistry, physics, biology, and mathematics programs across the country to wide acclaim. However, a studio-approach has never been reported in an organic chemistry curriculum. A professor in Physical Sciences and Engineering at Truman College states, “The studio classroom model is most appropriate for basic and general chemistry. It is not suitable for organic chemistry due to ventilation, plumbing, and hazardous chemical requirements of those classes.”

In summary, we will pioneer a studio-based approach to a portion of organic chemistry I and compare our results with the same topic taught in the traditional method. In June 2008, one of two organic chemistry laboratories at RIT was renovated into an academically novel, industrially-inspired teaching space (see attached photos). These laboratories were redesigned with the ultimate intent to move towards a studio classroom. Our new lab features a smart classroom in the center of the lab with three walls of industrial hoods. As such, we are equipped with the appropriate infrastructure to support a studio-classroom curriculum in organic chemistry.

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1 See attached student survey data collected April 2009.
2 Studio Chemistry: Combining laboratory and lecture into one spaceCharles Abrams, Truman College, Chicago IL. cabrams@ccc.edu http://faculty.ccc.edu/cabrams/studio/BCCE2008AbramsHandout.pdf
4 http://faculty.ccc.edu/cabrams/studio/#Vision
B. Targeted learners or population (include cluster, departments, year level, number of learners impacted).

The students impacted by this model will be first- and second-year students taking the 400-level organic chemistry sequence (1013-431, 1013-432, 1013-433). These students all major in chemistry, biochemistry, or chemical engineering.

C. The number of students who will be affected.

The students impacted by this model will be 50+ first- and second-year students per academic year.

D. Present a rationale for your project, as it relates to the area you have chosen.

The rationale for a studio-based approach in organic chemistry stems from the four common problems inherent when teaching in the traditional manner:

I. Compartmentalization of the material. What is learned in the class stays in the class and what is learned in the lab stays in the lab. This effect is further fostered by the fact that both the lab and the lecture have their own textbooks and their own credit hours. Only 17% of the students polled perceived a high correlation between Orgo I lecture and Orgo I lab. By Organic III half of the class still did not see a high correlation between the lecture and lab.1

   • Solution: Integrated lab and lecture. By holding the lecture in the same space as the lab, we will break down that first dividing line between the lecture and lab. Additionally, the rhythm of the course delivery will be conducive to “best practices” for teaching: 20-minute intervals of varying techniques. We will observe (perform an experiment and collect data), reason (come up with an explanation for our observation), and test (try our hypothesis on a different case). This process will involve: going to the hood for experiments, sitting back down and working in groups, independent problem-solving time, and short bursts of explanations/help from the instructor.

II. Perception that lab material out-of-sync with lecture. 100% of the students surveyed told us that they prefer seeing the material either in the lecture before seeing it in the lab or simultaneously with the lab itself.1 They explain that it gives them enough pre-lab preparation to have a better idea about what’s actually happening in the lab. It’s not impossible to take the first 10-20 minutes of lab for a pre-lab lecture. However, if you are introducing material for the first time during the pre-lab, there is far less time for the student to absorb it before putting it into practice at the bench. Additionally, students often do not recognize the direct correlation between what they are doing in the lecture with what they are doing in the lab. No matter how beautifully aligned some labs and lectures are, many students still miss the correlation.

   • Solution: Experiential Learning (Hands-on training that links to coursework) The organic chemistry studio-model will directly place the students in the lab at all times. The concepts they learn and problems they face will be derived from their actual wet chemistry experiments and not from their textbook. The material will no longer be introduced before a lab or after a lab. The organic
concepts/reactions will be seamlessly presented simultaneously with the wet chemistry. The direct correlation between lab and lecture will become undeniably obvious to the student.

III. **Minimized stress on lab techniques.** 71% of the students surveyed rated “learning to perform lab techniques properly” as very important with respect to their future career in chemistry. Ultimately, the students we train as chemistry and biochemistry majors will go on to graduate programs or industrial jobs. In either case, our students will spend the majority of their time in a lab conducting experiments. In our current 3 + 1 credit system, we are, in effect, placing emphasis on the lecture over the lab. Does the student need to understand concepts and derive mechanisms and predict reactivity? Yes. But equally as important is the knowledge acquired with learning a technique and honing bench skills. If a student is struggling in the course or has only a finite amount of time to put into their work, they will invest that time in the coursework and allow their lab techniques and reports to take a backseat by rushing through and leaving from lab early.

- **Solution:** **Exams that integrate lab knowledge.** With the lecture and lab all rolled into one, the student must study both their techniques and their organic material. It will thus be feasible for the exams to incorporate concepts about lab work in addition to traditional organic problems.

IV. **No forum for reflection and critical thinking.** Once a traditional lab is completed, the students have their TA sign their notebook and they leave. The student is thus on their own reflecting on the lab and answering tough questions about their results. We have found that the lab reports are written well until the conclusions section where little to no thought is put in to their overall analysis. The students’ ability to troubleshoot is very poor because they cannot make a connection between what’s on paper and what’s in the flask.

- **Solution:** **Self-guided discovery combined with group-based learning.** The organic chemistry studio-model will be structured in a way to allow more time for the students to develop better critical-thinking and problem-solving skills. The new studio-based structure will also be conducive to group work that will further hone the students’ communication skills and accountability. If the lecture and lab are fully integrated, the contact hours can be used more efficiently. As a result, students will not be leaving the lab at different times and thus group discussions may be conducted upon an experiment’s completion.

**E. Anticipated impact on teaching and/or learning.**

The studio-based course in organic chemistry would be highly unique and innovative in the true spirit of a category-of-one university. As stated above, the incorporation of an integrated lab and lecture, experiential learning, self-guided discovery and group-based learning will greatly impact the way we deliver the organic chemistry curriculum. This challenging teaching strategy will largely re-invent the long-standing way in which organic has been taught and will influence other institutions to emulate our efforts.
F. How will your project impact student success (i.e., retention, innovation, in society)?

In today’s globally competitive arena, quality techniques and scientific critical thinking are essential tools for success. Thus bridging the theoretical portion and the experimental portion of the organic course will undeniably foster such tools. Our model will provide students with the skills to succeed in either an industrial or academic setting. The studio-model will enable our students to acquire “good hands”. In order to gain “good hands” in the lab, the organic chemist must attach their brain to their hands or, in other words, think about his/her chemistry as he/she is doing the experiments and not just blindly follow a recipe. Providing our students with a studio-based approach will give them the best chance to succeed and will catapult the organic chemistry curriculum into a truly effective learning experience.

G. How you will measure the course impact, and what could you share about your project in a faculty forum.

The class (1013-431) is naturally divided into two groups based on the lab sections. One half of the class will be taught the subject matter of one lesson using the traditional model (control group) and the other half will be taught the same subject matter as a studio-model (test group). The groups will be given a quiz in their respective labs that will test their knowledge of the subject matter and critical thinking questions pertaining to the results in the lab. The student success data from both the control and test cases will be analyzed for statistically significant differences between the models effectiveness in decompartmentalizing the material and enhancing critical-thinking skills. The test and the control group will also be asked to complete a survey to ascertain the students comfort with the subject material among other things.

We fully intend to publish any relevant findings in the Journal of Chemical Education (peer-reviewed). We also intend to present this work at the National ACS Meeting in Boston, MA on August 22nd, 2010. Additionally, if our efforts support successful student outcomes, we intend to write a CCLI grant for full conversion of our organic curriculum to a studio-model.

H. Provide a timetable of the development of the course.

Summer AY2008:
- Develop integrated lab/lecture for a 4 hour block.
- Develop an assessment lecture quiz and thought-questions for the lab.

Fall AY2009:
- Run the control and test case (PLIG funds used for student stipend)

Winter AY2009:
- Analyze the data

Spring AY2009:
- Write a peer-reviewed article on findings

Summer AY2009:
- Present findings at National American Chemical Society Meeting in Boston on August 22nd, 2010 (PLIG funds used for travel to meeting).
- Begin writing a CCLI
Before and After Photos of the RIT Organic Lab

RIT- Un-renovated traditional organic lab (08-2219)

![Un-renovated lab](image)

RIT-newly renovated organic lab (08-2219)

![Smart classroom](image)

Smart classroom (desks and chairs not shown)
The students asked to participate in this survey are all currently taking both Organic III lecture and the lab and have completed 7 weeks of this last course in the sequence.

1. Arrange the following tasks in the order you put most of your time. (1= most time and 4= least time). Please consider all three quarters of organic when answering this question.

<table>
<thead>
<tr>
<th>Rank</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE homework</td>
<td>25%</td>
<td>33.33%</td>
<td>33.33%</td>
<td>8.33%</td>
</tr>
<tr>
<td>Pre-labs</td>
<td>0%</td>
<td>8.33%</td>
<td>8.33%</td>
<td>83.33%</td>
</tr>
<tr>
<td>Studying for organic Exams</td>
<td>54.17%</td>
<td>20.83%</td>
<td>20.83%</td>
<td>4.17%</td>
</tr>
<tr>
<td>Lab report write-ups (with final questions)</td>
<td>20.83%</td>
<td>37.50%</td>
<td>37.50%</td>
<td>4.17%</td>
</tr>
</tbody>
</table>

2. With respect to your future career in chemistry, indicate the level of importance for each skill.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Unimportant</th>
<th>Of Little Importance</th>
<th>Moderately Important</th>
<th>Important</th>
<th>Very Important</th>
<th>Not Applicable</th>
<th>did not answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing mechanisms</td>
<td>0%</td>
<td>12.50%</td>
<td>16.67%</td>
<td>29.17%</td>
<td>41.67%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Predicting products</td>
<td>0%</td>
<td>0%</td>
<td>12.50%</td>
<td>41.67%</td>
<td>45.83%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Learning proper lab techniques (distillation, TLC, Column Chromatography, recrystallization...)</td>
<td>0%</td>
<td>0%</td>
<td>12.50%</td>
<td>16.67%</td>
<td>70.83%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Operating Instruments</td>
<td>0%</td>
<td>8.33%</td>
<td>12.50%</td>
<td>25%</td>
<td>54.17%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Interpreting spectra (NMR, IR...)</td>
<td>0%</td>
<td>4.17%</td>
<td>8.33%</td>
<td>37.50%</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
3. For the following question, indicate the level of correlation you perceived between the labs and the lecture courses.

<table>
<thead>
<tr>
<th>Labs</th>
<th>Highly Correlated</th>
<th>Somewhat Correlated</th>
<th>Not Correlated at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Quarter Organic Lab I (Techniques quarter: Recryst., TLC, Distillation, Extraction...)</td>
<td>16.67%</td>
<td>66.67%</td>
<td>16.67%</td>
</tr>
<tr>
<td>Second Quarter Organic Lab (Reactions quarter: running experiment from start to finish)</td>
<td>50%</td>
<td>45.83%</td>
<td>4.17%</td>
</tr>
<tr>
<td>Third Quarter Organic Lab (Qualitative Analysis: Characterization of 5 unknowns)</td>
<td>58.33%</td>
<td>41.67%</td>
<td>0%</td>
</tr>
</tbody>
</table>

4. My preference for the order in which a lab was taught:

- 54.17% - I preferred to learn the material in lecture before coming to the lab
- 0% - I preferred learning the material in the lab before seeing it in lecture
- 45.83% - I would like to learn lecture material and lab material simultaneously

5. Currently, the breakdown of credits for Organic Chemistry (Fall and Winter) is 3 credits for the lecture and 1 credit for the lab. I, the student, would like to see the following:

- 83.33% - 3 credits lecture and 1 credit lab (no change)
- 12.50% - 4 credits total (combined lecture and lab grade)

Other Responses (1)

- Lab should be worth more credit, it often requires longer work hours
6. Please comment on any techniques or methods that the organic faculty could adopt relative to the LECTURE that would make the material easier to understand/learn.

- Mechanisms in class over and over can get boring sometimes. It helps to change things every once in a while. The same mechanism over and over again becomes too repetative by the third quarter.
- I think that putting more emphasis on mechanisms is important. If a student can't remember a product but can do the mechanism and understand conceptually what should happen, they don't necessarily need to memorize reactions.
- More in class examples and allow students ample time to work in small groups on problems prior to discussing them as a class.
- I learned the most when the professor worked directly from the book in addition to writing everything out on the board with an explanation. Repetition of key concepts is important.

7. Please comment on any techniques or methods that the organic faculty could adopt relative to the LAB that would make the material easier to understand/learn.

- Attempt to make the student more independent in lab so they don't rely on the teacher's guidance for every little thing.
- Make the material coincide with lecture.
- Just make sure the lab and lecture are on the same page... keep them in sync to help students learn a concept and then apply it in lab and see it in action.
- Lab material should be in sync with the lecture material. The lab should also cover the material before the exam. Lab is essential to pull the material together in time for the exam.
- Correlating with lab more.
- Pre-lab lectures could include more theory behind the reaction including mechanisms rather than attempting to understand the mechanisms simply through Prelab write-ups. Discussions could also be held prior to the pre-lab write up to help students understand what is happening so the pre-lab reading and write-up are more than just copying down what was in the book. Post-lab discussions may be useful in the event that material was not understood or the connections between lab and class were not made.
- Nothing really, maybe a little more overview at the beginning.
- All the current techniques and methods are really good.
- I think that the biggest thing would be to better align the lecture and laboratory material. I would be more interested in learning material if I could see an example of how it is useful to me.