The Integration of Research, Teaching and Learning: Preparation of the Future STEM Faculty

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What CIRTL is About
The challenge in undergraduate STEM education now lies less in knowing what works and more in getting people to use proven techniques.

- Fairweather 2008
- PCAST 2012
Center for the Integration of Research, Teaching and Learning

Mission

To develop a STEM faculty committed to implementing and advancing effective teaching practices for diverse student audiences as part of their professional careers.
Strategy: Leveraging the System

Undergraduate Education

Comprehensive University
2-yr College
Liberal Arts
Masters University
Research University

80% Ph.D.’s

108 Research Universities
The Core Ideas of CIRTL

- **Teaching-as-Research**
  - Dynamic engagement of STEM faculty in advancing learning

- **Learning Community**
  - Functional connections for learning and knowledge building

- **Learning-through-Diversity**
  - Engaging the diverse experiences of all in the learning of all
Teaching-as-Research

• Engagement in teaching as engagement in STEM research

• Aligns with skills and inclinations of STEM graduates—through-faculty

• Leads to self-sustained improvement of STEM education
Teaching-as-Research

- Engagement in teaching as engagement in STEM research
  - Learning foundational knowledge
  - Developing goals and hypotheses for improved learning
  - Defining measures of success and the required evidence
  - Implementing practices within an experimental construct
  - Collecting and analyzing data
  - Reflecting, evaluating, and iterating
Assessment of student performance with and without active learning material
Although the assessment of the first implementation proved to be somewhat inconclusive, the more rigorous assessment of the “Heart of a Fuel Cell” LO during the second implementation revealed a large improvement in the pre- and post-quiz scores from 42% to 80% ($n = 35$). In this case, the
Learning Communities

- Counter to the traditional solitary teacher
- Functional connections for learning and knowledge building
- Leads to self-sustained communities on campus and beyond
Learning Community

![Graph showing participation trends over academic years]
Learning Community
Inter-Generational and Inter-Disciplinary Connections

AY 2010-12 through AY2013-14

Career Stage
- Grad Student (927)
- Postdoc (160)
- Faculty (197)
- Other/Not Reported (214)
- Staff (178)

Discipline
- Biological Sciences (628)
- Physical Sciences (257)
- Other/Not Reported (265)
- Eng. (204)
- Math (29)
- Humanities (32)
- Education (77)
The Learning Community in Action

CIRTL @ UW

College Classroom: Multi-campus
- Gillian-Daniel (Delta)
- Manske (Delta)
- Petto (UWM)

Teaching Statistics
- Nordheim (Stats)

College Classroom
- Walz (MATC)
- Balster (Soil Science)

Workshops
- Bubenzer (L&S)
- Masters (BioEng)
- Timbie (Physics)

Roundtable Dinners
- Ackerman (AOS)
- Callahan (Grad School)

Internships
- Gillian-Daniel (Delta)
- Mathieu (Astro)
- Manske (Delta)

Workshops
- Bubenzer (L&S)
- Masters (BioEng)
- Timbie (Physics)

Delta Certificate
- Gillian-Daniel (Delta)

Informal Ed.
- Crone (Eng. Physics)
- Dunwoody (Jourm)

Research Mentor Training
- Pfund (Delta)
- STEM faculty and staff

Expeditory Learning
- Harris (Zoology)
- Desmond (Delta)
- Underwood (Physics)

Instructional Materials Development - Biology
- Tong (CBE)
- Jeanne (Entomology)

Effective Teaching w. Tech
- Blanchard (Eng. Phys)
- Wolf (DoIT)

College Classroom: Online
- Courter (ELC)
- Gruber (Biochem)

Diversity in the College Classroom
- Gillian-Daniel (Delta)
- Manske (Delta)

International Faculty, International Students
- Barger (WCER)
- Wu (CEE)

Teaching Large Classes
- Balser (Soil Science)

Broader Impact Workshops
- Masters (BioEng)
- Pfund (Delta)
- Gillian-Daniel (Delta)
Inclusive teaching is the first step

Engaging the diverse experiences of all in the learning of all

 Leads to *self-sustained* culture where excellence and diversity are necessarily intertwined
<table>
<thead>
<tr>
<th>Auburn University</th>
<th>Northwestern University</th>
<th>University of Delaware</th>
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<tbody>
<tr>
<td>Boston University</td>
<td>Oregon State University</td>
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<td>University of Maryland, Baltimore County</td>
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<td>The University of Texas at Arlington</td>
<td>University of Missouri</td>
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Learning-through-Diversity

Cross-Network Learning Community

CIRTL MOOCs!

CIRTL Network Learning Community

Cross-Network Participations by Year

SCHEDULE

Diversity in the College Classroom

Instructors

Dan Gillen-Diamond, Academic Director, Delta Program, UML-Madison and Carleton College; Assistant Professor, Madison State University

SCHEDULE

Wednesday - January 19, 2011 through April 27, 2011
11:00-12:15 ET / 8:00-10:15 CT / 9:00-11:00 MT / 10:00-12:00 PT

Course Description

The Cross-Network Learning Community provides an opportunity for graduate students to reflect on and discuss the complex issues of diversity and how we address them effectively in our classroom practice. Current graduate students and faculty recognize that the way we teach differently impacts the success of all students. This course is for graduate students and faculty who are interested in being part of a diverse and inclusive learning environment. Participants in the course will reflect on their own personal and professional development in teaching and learning. The course will also focus on the diversity of our disciplinary topics. Participants will also create a diversity/teaching plan of action for their future teaching practice.

Effective Use of Technology in Teaching and Learning

Instructors

Alan Wells, UML-Madison, Center for Biology Education and Fisheries, Haverford, University, Professor of Chemistry

SCHEDULE

Wednesday - January 26, 2011 through April 27, 2011
11:30-12:45 ET / 8:30-10:45 CT / 9:30-11:45 MT / 10:30-12:45 PT

Course Description

The Cross-Network Learning Community provides an opportunity for graduate students to reflect on and discuss the complex issues of diversity and how we address them effectively in our classroom practice. Current graduate students and faculty recognize that the way we teach differently impacts the success of all students. This course is for graduate students and faculty who are interested in being part of a diverse and inclusive learning environment. Participants in the course will reflect on their own personal and professional development in teaching and learning. The course will also focus on the diversity of our disciplinary topics. Participants will also create a diversity/teaching plan of action for their future teaching practice.

CIRTL Network Exchange Program

The CIRTL Network Exchange Program is a two- to three-day visit to a host campus within the Network. This program is designed to give applicants the opportunity to give a Teaching-as-Research colloquium and interact with disciplinary colleagues at the CIRTL Network institutions. Participants also have the opportunity to practice professional skills before entering the job market.

The opportunity to present or do disciplinary research at another university is often a formative experience in a graduate student’s career. The same is true of teaching-as-research, and indeed disciplinary and teaching-as-research activities will each enhance the other. Our experience shows that providing a research presence both in the discipline and in teaching increases the appeal and respect of each.

Visit www.cirtl.net

Network Exchange for more Information and to Apply

www.cirtl.net

CIRTL Online Coffee Hour

WHERE DO YOU WANT TO WORK?

TEACHING AND RESEARCH AT DIFFERENT INSTITUTIONS

October 21st, 2010

www.cirtl.net

CIRTL

www.cirtl.net
CIRTL Outcomes

Learning Outcomes
- Future Faculty

Longitudinal Outcomes
- Faculty

Educational Research

Undergraduate Learning
CIRTL Outcomes – Future Faculty

CIRTL Learning Goals for Future Faculty Participants

When asked about teaching, a CIRTL participant’s answer would include:

1. Discussion of learning goals for the students, the nature of learning and effective teaching strategies that can support specific learning goals
2. Discussion of student learning and ideas about how to assess what students have learned
3. Awareness of literature related to teaching and learning and of research findings about high-impact teaching
4. Introductory knowledge of learning theory
5. Reference to the meaning of a learning community in terms of functional relationships and goals
6. A broad definition of diversity
7. Discussion of at least one way that a teacher might leverage the diversity of the students to enhance the learning of all
8. Discussion of the role the scholarship of teaching and learning plays within the larger nature of a faculty’s work life
9. Ability to see themselves and their teaching process as part of larger communities, including their classrooms, their colleagues, their departments, their institutions and the nation
1) What major concepts are you taking away from this Delta course, program, or activity that will affect your practice as an educator? If possible, please give two to three specific examples.

2) Suppose that you are preparing to teach some scientific concept from your discipline (e.g., the nitrogen cycle, amplitude, redox reactions). Describe the steps that you will take, based on what you’ve learned in this course, program, or activity.

These two questions were included on participant surveys for 39 instances of nine different Delta courses and programs across 12 terms (spring, summer, and fall; n = 312) between fall 2005 and fall 2009.

- Pfund, Mathieu, Austin et al., 2012
Research shows that undergraduate learning will be advanced by STEM faculty who characterize and engage in their teaching similarly to these future faculty.

- Ambrose et al., 2010; Svinicki & McKeachie, 2010; Weimer 2002
Participants later use skills and concepts known to improve student learning.

76% had found ways to apply gained knowledge and skills in their early careers.

In order of frequency of response, participants report:

• Delivering instruction that increases student engagement (e.g., through active learning techniques, inquiry-based learning)
• Outcomes-based design; learning goals in course planning
• Methods of ongoing assessment aligned with learning goals.
• Ways to include diverse student perspectives

Participants cite integrating teaching and scientific research as valuable currently.
CIRTL Outcomes – Early-Career Faculty

Participants use skills in other than classroom settings.
- Lab supervision, mentoring, and advising
- Outside academia working with clients

Programs help those looking for academic jobs.
- Sense of readiness for academic jobs
- Apply for a wider range of positions
- Knowledgeably discuss teaching in job interviews

Programs support early career success.
- Begin quickly in new positions
- Fostered fast starts in research programs
A number of participants reported that skills and concepts they had learned as doctoral students had become essential to their current educational practice – an inseparable part of their individual technique and philosophy.

“It’s just part of what I do now,” one participant said. Underlining the point, another participant alluded to what had become a reflexive and intuitive use of [teaching development] concepts and skills. “It kind of morphed,” he explained, “into something that is a given.”

- Connolly et al. 2012
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- Connolly et al. 2012
Impact on the Institution

Enhanced Undergraduate Education

1000 students per year

Exam grade (%)

40 50 60 70 80 90 100

First 5-week exam
Final exam

P-value = 0.004

Less than 75% Clicker Use
More than 75% Clicker Use

Percent Clicker Use

Percent Exam Score

Cllicker Use

Cllicker Use

Perclicker Use

First 5-week exam
Final exam

Cllicker Use

Cllicker Use

Perclicker Use

0 20 40 60 80 100

2004
“Jenny has been a great PhD student. She has accomplished so much in research and graduate with at least 4 first author papers to her credit. Jenny is my first PhD student and I am therefore especially vested in her success. While I was able to contribute in her research journey, her training in teaching would not have been possible had it not been for the Delta program. Thanks to the Delta program for training students like Jenny in the art and science of teaching, which were central to her success in moving right into a faculty position.

I look forward to contributing to the Delta program. So please let me know how I can help.”

Assistant Professor, Obstetrics and Gynecology
Advisor, Asst. Professor, Augustana College
Impact on the Institution

Enhanced Research Funding

Leveraging the NSF Broader-Impacts Criterion for Change in STEM Education

By Robert D. Mathieu, Christine Pfund, and Don Gillian-Daniel

The call for a more scientifically literate society is a constant drumbeat coming from the mainstream media and from reports of concerned organizations like the National Academy of Sciences. And they see improved education and outreach from institutions of higher learning as key to any proposed solution to this major national challenge. In higher education, the need to integrate research, teaching, and learning has been a theme woven through decades of calls for improvement. In reality, the weight of external research fund-
“[This proposal] describes a systematic program that will involve both graduate students learning to teach and undergraduate students learning organic chemistry, within a strong infrastructure at Wisconsin (... CIRTL, an NSF Center) dedicated to similar educational objectives... possibly the most important impact of the work will be the preparation of faculty-to-be for teaching at the university level. American faculty receive outstanding training in research, but ... often never understand fundamental issues related to quality learning. Any project addressing these problems is significant.”

Panel review for funded NSF CAREER proposal

*Department of Chemistry, UW-Madison*
Impact on the Institution

Enhanced Research Funding

Materials Research Science
And Engineering Center

Center for Limnology

Center for Sustainability and the Global Environment

University of Wisconsin-Madison
Center for Neuroscience

Cooperative Institute for Meteorological Satellite Studies
Impact on the Institution

Summary

• Legacy of enhanced learning on campus
• Growth of teaching and learning community
• Enhanced research success (funding and performance)
• Expanded impact of graduate education
• Faculty success (tenure, student hiring … )
• Enhanced recruitment of grad. students and post-docs

Institutional change toward integrating research, teaching and learning
Impact on the Institution

Institutionalization of CIRTL@UW

Percentage of Support

- NSF funds
- U. Wisc. Budget
- Volunteer

Operations Budget
Instructors

Impact on STEM Higher Education

80% Ph.D.'s

108 Research Universities
Impact on Higher Education

A decade from now we envision that current STEM graduate students will be leaders of a national faculty for whom evidence-based, high-impact teaching is taken as a given, and that they will have the skills and abilities to make it happen.