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The Pennsylvania State University

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CIRTL 3rd Year Review Report

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I. The CIRTl Mission

A. The Objective

The Center for the Integration of Research, Teaching, and Learning (CIRTl) will create a model interdisciplinary professional development program in teaching and learning that will prepare graduate students, and with them post-doctoral researchers and current faculty (hereinafter “*graduates-through-faculty*”) to meet the future challenges of national STEM higher education. . . . CIRTl seeks to influence graduate-through-faculty development at a significant number of research institutions throughout the nation. Developing effective methods of adapting programs successful at one research university to another is central to the CIRTl scope of work . . . Ultimately the vision is to . . . create STEM faculties at all higher education institutions committed to ongoing improvement of student learning.

— CIRTl Strategic Plan, 2003

B. The Pillars of CIRTl

Three ideas are at the foundation of all that CIRTl does: Teaching-as-Research, Learning Community, and Learning-through-Diversity. The teaching-as-research and learning community ideas formed the basis of the CIRTl proposal and strategic plan. Enhancing learning for all students has been woven into all CIRTl initiatives since the beginning, but only late in the 1st year of the project did we recognize the importance of making learning-through-diversity an explicit third foundational concept. We have come to call these three ideas the *pillars* of CIRTl.

We have invested considerable effort in developing deeper and more sophisticated understandings of these three pillars. Here, we give a brief definition of each pillar; in Appendix A, we provide one-page descriptions as well as frameworks that describe developmental steps of participants as they put these ideas into action.

- **Teaching-as-research** is the deliberate, systematic, and reflective use of research methods by science, technology, engineering, and mathematics (STEM) instructors to develop and implement teaching practices that advance the learning experiences and outcomes of both students and teachers.
- **Learning communities** bring together groups of people for shared learning, discovery, and generation of knowledge. To achieve common learning goals, a learning community nurtures functional relationships among its members.
- **Learning-through-diversity** capitalizes on the rich array of experiences, backgrounds, and skills among STEM undergraduates and graduates-through-faculty to enhance the learning of all. It recognizes that excellence and diversity are necessarily intertwined.

We have found these pillars to operate powerfully at multiple levels within CIRTl. First, they lie at the heart of our learning objectives for graduate-through-faculty participants in the CIRTl professional development program. Each CIRTl course and program seeks to enable participants to practice teaching-as-research, develop learning communities of their students, and enhance the learning of all students.¹ Second, the graduate-through-faculty participants as a whole form a learning community that enables all members to investigate and enhance the learning of their students and that capitalizes on the diversity of participants in race/ethnicity, gender, discipline, career status, and other factors. Third, the Center itself is a community of more than 100 graduates-through-faculty who bring expertise and experience from many disciplines in STEM and the social sciences and apply their research skills to the ongoing success and improvement of the project.

II. CIRTl Professional Development Program

A. The Prototype: The Delta Program in Research, Teaching, and Learning

The primary objective of the CIRTl strategic plan for the first 2 years was the development, implementation, and evaluation of a prototype professional development program in teaching and learning for STEM graduates-

¹ CIRTl includes a strong emphasis on preparing future faculty to do effective informal education. In this report, the word *students* is intended to include learners outside the classroom.

through-faculty based on the three CIRTl pillars. The University of Wisconsin–Madison (UW) has been the primary laboratory for this development and implementation. The target date for implementing the prototype was September 2003, 9 months after the project start date. This goal was achieved on schedule.

The prototype at UW is called the *Delta Program in Research, Teaching, and Learning*. An important early design decision was to fully separate CIRTl and Delta Program operations, staffing, and accounting, in order to lay the organizational foundation for institutionalization. In so doing, the Delta Program immediately became an independent university program with its own identity, rather than a program identified with CIRTl and the Wisconsin Center for Education Research (CIRTl’s administrative home). Thus, for example, graduate-through-faculty participants consider themselves to be in the Delta learning community, and indeed may have no knowledge of CIRTl’s existence. Similarly, the Delta Program is the unit for purposes of campus planning and funding discussions and, critically, is not tied to CIRTl’s 5-year lifetime. The primary roles of CIRTl with respect to the Delta Program are (a) initial development and funding and (b) evaluation and research on the program’s impact on graduate-through-faculty participants and on UW as an institution.

As of March 2005, the Delta Program consists of:

- **Courses** (for graduate students, post-docs, graduate-through-faculty teams in IMD)
 - Effective Teaching with Technology (weekly for semester)
 - Informal Education (semester, summer)
 - Instructional Materials Development (semester)
 - Internship Seminar (semester, summer)
 - Teaching in the College Classroom (semester, summer)
- **Small-Group Facilitated Programs** (graduates-through-faculty)
 - Creating a Collaborative Learning Environment (weekly for year)
 - Expeditionary Learning (weekly for semester)
 - Roundtable Dinners (monthly)
- **Delta Internships** (graduate students and post-docs, mentored by faculty and staff)
- **Delta Certificate** (graduate students, post-docs)
- **Workshops** (graduates-through-faculty)
 - Developing Teaching Portfolios
 - How to Broaden the Impact of Your NSF Graduate Fellowship
 - Instructional Materials Brownbag Seminar
 - Integrating Broader Impact into Research Proposals and Programs

Each component of the Delta Program weaves together the three pillars and is designed around research models familiar to STEM graduates-through-faculty. For example, all of the courses are project-based, requiring students to define a learning problem, explore the literature, hypothesize a solution, design and implement a product, and acquire and analyze data to measure learning outcomes. The Delta internships are essentially “teaching-as-research assistantships” in which a graduate student or post-doc partners with a faculty or academic staff member to solve a learning problem. (The internships take place either at UW or at nearby 2- and 4-year colleges and universities.) The Delta Certificate—indeed the entire Delta Program—is designed to provide each graduate student or post-doctoral participant with a portfolio, letters of recommendation, and possibly publications in teaching and learning, in analogy to their disciplinary curriculum vita. And finally, every course in the Delta Program is team-taught by research-active STEM and social science faculty and staff. These instructor pairings have turned out to provide powerful combinations of real-world experience, theoretical foundation, and role modeling for STEM future faculty.

A core hypothesis of CIRTl is that this research-based approach to teaching and learning will resonate with STEM graduates-through-faculty, and participation in the Delta Program to date supports that hypothesis. As of March 2005 (middle of the 4th semester), nearly 600 STEM graduates-through-faculty have participated in the Delta Program. The disciplinary affiliations and career statuses of these participants are shown graphically in Appendix B. Of the 600 participants, 56% were graduate students, 16% faculty, 14% post-docs, and 14% academic staff. The Delta community is highly interdisciplinary, drawing particularly strongly from the biological

sciences, physical sciences, and engineering; participation from mathematics has been low.² We note that nearly 200 of the Delta participants have made major investments in the program—for example, participating in semester-long courses or programs. The Delta internship program, begun in fall 2004, is arguably the most intensive commitment and is averaging eight graduate student and post-doctoral participants per semester. Fifteen students are declared candidates for the Delta Certificate, which requires 4 semesters of participation, including an internship.

We note that in the CIRTL proposal, our goal for the UW program at the end of the project was “to annually serve 200 graduate students and post-doctoral researchers and to support 50 minor or certificate programs in STEM education during the academic year, and to serve comparable numbers of graduates-through-faculty through summer programs and workshops.” We are at or near these targets already; indeed, one of our first lessons learned is that demand is high.

The Delta Program is an experiment in creating a learning community that is *of*—not just *for*—STEM graduates-through-faculty. By this we mean that many of the creators, implementers, and leaders of the Delta Program are drawn from the same research-active STEM graduates-through-faculty whom the program is intended to serve. The disciplinary backgrounds of the CIRTL Development Teams that created the Delta Program are given in Appendix C; more than half are graduates-through-faculty in STEM disciplines. As we enter the 4th semester of the Delta Program, a second generation of leaders, instructors, and program facilitators are being drawn from new STEM graduates-through-faculty in the Delta learning community. An example is the recently formed Delta Steering Committee (Appendix C), none of whose members were part of the original CIRTL Development Teams.

Another mark of a vital learning community is the generation of new ideas and initiatives. We are beginning to see such activity. For example, 20 STEM post-docs have formed their own weekly discussion group. An industrial engineering senior graduate student is developing a new course for fall 2005 titled *Diversity in the College Classroom: A Practicum for Scientists, Mathematicians and Engineers*. And a subset of the fall 2004 interns continues to meet regularly on their own initiative.

The prototype Delta Program allows meaningful estimates of program costs. The team-taught courses make use of 2.5 FTE faculty (9 people, Appendix C), who are drawn from three UW colleges (Letters & Science, Engineering, Agriculture and Life Sciences) and the School of Education. Delta Program operations,³ small-group programs, and internships are administered and facilitated by 1.5 FTE academic staff (3 people), 2 graduate student project assistants, and a 0.5 FTE faculty director (Appendix C). Finally, an historic house on campus serves as the home of the Delta Program.

The process of institutionalizing the Delta Program is both part of the prototype experiment and an objective by which success will be measured. At the outset the UW Graduate School was strongly supportive of the program and committed to a ramp up to full support of the Delta Program operations staff by Year 5; at the end of Year 2 25% of the operations staff are funded by the Graduate School. We are presently working with the deans of the STEM colleges, the School of Education, and the provost to develop a support plan for the faculty and staff teaching the Delta courses and leading the program. The required support varies greatly between colleges and schools, and even between specific faculty and staff within a college, so the plan is to develop a distributed model that provides funds that can be distributed flexibly each year.

Development of institutional support relies on evidence that the Delta Program is providing value to the institution. The large participation numbers, distributed over all three STEM colleges at UW, are vital in this regard. Equally important has been the role that the Delta Program plays in supporting the *research missions* of the colleges. We have made an intentional and extensive investment to assist graduates-through-faculty in responding to the calls from federal funding agencies for broader impact from research projects. We stress that the challenge to graduates-through-faculty is seldom the generation of ideas; rather it is the development of capacity to realize those ideas. The Delta Program provides an immediate means for graduates-through-faculty to develop the requisite capabilities and skills to create, implement *and evaluate* their broader impact ideas. Thus we provide consultation and workshops to graduate students applying for NSF Fellowships, for post-docs applying for NASA

² We have begun to draw participants from the social sciences, even though we have not targeted those disciplines to date. We will begin intentional marketing to social science departments in fall 2005.

³ Operational requirements include advising, publicity, course management, liaison with the university, daily operations, strategic planning, etc.

funding, for young faculty applying for CAREER awards, and for senior faculty applying for NIH training grants and NSF research funding. We promote research proposals including line item funding for Delta interns to assist in carrying out broader impact ideas (which thereby makes the internship program self-supporting and sustainable). And we maintain an archive of proposal reviews that cite the Delta Program or CIRTl as a positive factor toward funding of grants, and use this evidence to support institutionalization. Finally, we maintain similar records of employment histories for graduate students and post-docs who have participated in the Delta Program, again for the purpose of demonstrating that integrating research, teaching and learning benefit participants and the institution both within and beyond the teaching missions.

We intend that all components of the Delta Program will be made available to the CIRTl Network (section II.C)—through documents (*Product Portfolios*), exchanges of personnel, and collaboration—so that all members of the Network can benefit from the major investment in UW.

B. Teaching-as-Research in Action: Evaluation of the Delta Program

1. Institutional Impact

As the prototype development laboratory, UW is also the university where the most extensive evaluation of program impact and institutional change is taking place. We have laid the foundation for this evaluation in four ways.

Needs assessment. During the 1st year of the project, we conducted interviews with 61 UW academic staff, administrators, faculty, doctoral candidates, and post-docs in STEM fields. The aim of the resulting report was to inform the CIRTl Development and Leadership Teams about target population interests and to identify possible leverage points for change. The executive summary of this report appears in Appendix D. Needs assessments are nearing completion at Michigan State University (MSU) and the Pennsylvania State University (PSU). Abstracts of the MSU and PSU needs assessment studies are also included in Appendix D.

Census Study. During the 1st year of the project we developed survey instruments to determine the state of UW with respect to teaching-related attitudes and experiences, and specifically with respect to teaching-as-research, learning community, and diversity issues. These surveys have been administered separately to (a) all current UW STEM faculty and academic staff, (b) all STEM doctoral graduate students, and (c) all STEM post-docs. The data have been analyzed, and executive summaries of the findings are presented in Appendix D. The instruments will be readministered during the last year of the project.

Participant database. We have created a database and associated operational infrastructure with which we track the participation history and demographic data of every Delta participant. The database is now in routine operation and holds complete information from the start of Delta in summer 2003. These data permit ongoing analyses of program participation to assist in planning and management decisions, and the data will provide the foundation for research on participation pathways and on the relationships between number and types of participation and impact on participants.

Longitudinal study of participants. We have begun a longitudinal study of Delta Program impact on doctoral graduate students and post-docs, as described in more detail in section III.B.3. One goal of the baseline interviews will be to evaluate why participants chose to participate in Delta and to identify the characteristics of STEM graduate students and post-docs who do participate. In addition to supporting CIRTl's research goals, these baseline interviews also will be used to improve the design and marketing of the Delta Program so as to broaden the participant base.

Again, we intend that all of the instruments, protocols, and database tools will be made available to the CIRTl Network (section II.C).

2. Evaluation Liaisons: Applying Teaching-as-Research to the Delta Program

We have chosen to apply teaching-as-research to the Delta courses and programs ourselves, rather than rely on external evaluators. With this strategic decision, we “walk-the-talk” of CIRTl, and in addition we explicitly demonstrate to participants in the Delta Program how teaching-as-research can be done.

Recognizing that the CIRTl Development Teams are doing teaching-as-research for the first time themselves, we created a learning community of *Evaluation Liaisons* (Appendix C) from each CIRTl Development Team, guided by Mark Connolly and Matthew Clifford from the Evaluation and Research Team (ERT). The Evaluation Liaisons coordinate the teaching-as-research activities of each development team, share knowledge and

techniques for data acquisition, and communicate findings. The investment of ERT expertise (i.e., Connolly and Clifford) is modest, approximately 0.15 FTE. Typically, Evaluation Liaisons dedicate no more than .1 FTE to this endeavor, so their success relies on a learning community approach of collective activity, technology-facilitated connectivity, and the diverse talents and experiences of its members.

The Evaluation Liaisons have thus far produced 14 formative evaluation reports on Delta courses and programs that have guided the development of the Delta Program. An exemplar of these reports is presented in Appendix E, and all of the reports, a refereed journal article, and numerous presentations by evaluation liaisons are listed in Appendix F. In addition, the Evaluation Liaison approach to evaluation has developed teaching-as-research skills in eight STEM and social science graduates-through-faculty that will be carried to future positions and initiatives.

We envision the Evaluation Liaison model to be a sustainable approach to evaluation that can be implemented by other universities in the absence of major funding. Conceivably, this approach may not require evaluation expertise on site, although this model remains to be demonstrated.

C. Network Building

1. The Concept of the CIRTL Network

To change the future STEM faculty of the nation, CIRTL must have significant influence on graduate-through-faculty preparation beyond UW. We have proposed to incorporate 10 universities into a CIRTL Network by the end of the project. MSU and PSU are our laboratories for development of this network.

In both our proposal and our strategic plan, we used the expression “transfer the successes in the UW laboratory to other research universities.” We have come to recognize that this concept of *transfer* is not an appropriate conceptualization for the Network. Every university represents a different context, and every university brings its own successes to the Network. At the same time, the CIRTL investment in development and evaluation at UW represents an unusually rich set of resources for all in the Network.

Accordingly, we now view the CIRTL Network as a means of mutual dissemination and adaptation. We also now incorporate the three pillars in our conceptualization of the Network. Specifically, we see the Network as a learning community of research universities that shares the diverse experiences and successes at each institution and provides a peer community for teaching-as-research experiments throughout the Network. In this context, the realizations of models developed by CIRTL may take a number of different forms across the Network. The one common theme will be programs for graduate-through-faculty preparation in teaching and learning that are based on the three CIRTL pillars.

Finally, in our earlier documents we wrote of MSU and PSU as our “top-down” and “bottom-up” prototypes, respectively. This simple characterization does not do justice to the realities of a university. More usefully, we have come to see MSU as an experiment of network development beginning with university administration and PSU as an experiment beginning with STEM faculty.

2. Two Prototypes

Michigan State University: Begin with university administration. MSU’s involvement in CIRTL has been guided by a commitment to link the CIRTL ideas with goals to which MSU is already committed. From the start of the project, MSU Graduate Dean Karen Klomparens saw the goals of CIRTL as aligned with her plans for expanding professional development for doctoral students at MSU. She participated in the CIRTL strategic planning meeting, where she expressed her support for MSU’s involvement in CIRTL.

Ann Austin, MSU co-PI, and Klomparens worked closely to initiate the early network development at MSU. Each step has been strategically designed to build a base of interest for CIRTL at MSU and to connect CIRTL with other MSU priorities. Steps taken at MSU have included (a) a visit to MSU by Robert Mathieu, CIRTL PI; (b) a visit by a team of 11 MSU faculty, administrators, and graduate students to UW to interact with the CIRTL Development Teams; (c) an opening meeting for the MSU community held in April 2004, with about 40 individuals in attendance; (d) the 20% appointment of Rique Campa (Prof. of Fisheries and Wildlife) in the MSU Graduate School to serve as coordinator of CIRTL at MSU; (e) a Needs Assessment/Benchmarking Study of graduate student development opportunities at MSU, which also served to disseminate information about the overall goals of CIRTL; (f) regular meetings of Campa, Klomparens, and Austin to develop overall plans for integrating CIRTL goals and pillars into ongoing MSU priorities, plans, and activities for graduate student

development; and (g) the appointment by Klomprens of an initial steering committee charged with developing MSU's CIRTl involvement.

The plans for CIRTl at MSU build on, expand, and more closely link various opportunities for graduate student professional development already under way at MSU. There is excitement about the ways in which involvement in CIRTl will support and strengthen the already existing MSU interest in innovative approaches to professional development, and enthusiasm for interacting with colleagues at other universities around these ideas. The commitment of Klomprens and the leadership of Campa are key elements in the progress that has been made to date at MSU.

Pennsylvania State University: Begin with STEM faculty. The development of CIRTl at PSU began with three STEM faculty members recommended by their deans as active researchers with a demonstrated interest in improving education. Initially, their connection to CIRTl was primarily through small (\$20,000/year from CIRTl) funding support for their own CIRTl-like work. Specifically, Richard Cyr (Prof. of Biology) applied teaching-as-research to the development of online tools for biology education; Peter Jurs (Prof of Chemistry) implemented a professional development workshop and enhanced teaching-assistant training for chemistry graduate students; and Akhlesh Lakhtakia (Prof. of Engineering Science and Mechanics) developed a graduate course in informal education. Over time, these three faculty members, previously not collaborators, have developed an identity as a CIRTl team and now form the anchor point for CIRTl at PSU. Their projects involve a growing cadre of departmental and cross-disciplinary graduates-through-faculty. Cyr, for example, has developed an Interdisciplinary Consortium for Organized Research in E-learning (ICORE), which has representatives from four colleges working together to develop and evaluate online learning tools. A long-standing learning community of chemistry faculty and academic staff informally organized to enhance undergraduate learning has been introduced to the concept and practice of teaching-as-research. Building on informal education practices, Lakhtakia's department now requires non-technical abstracts for all graduate theses and has introduced a teaching-as-research evaluation component in its weekly symposia for graduates-through-faculty.

Co-PI Carol Colbeck has worked closely with STEM leaders Cyr, Jurs, and Lakhtakia to initiate broader CIRTl development at PSU. Steps taken at PSU include a May 2003 visit to PSU by Mathieu to introduce a group of deans and STEM faculty to CIRTl. In September 2004, several members of the CIRTl Leadership Team went to PSU for a multi-hour workshop on CIRTl with key deans and STEM faculty. Colbeck, Cyr, Jurs, and Lakhtakia met with the associate vice provost for research, the associate vice provost for faculty affairs, and the director of the Schreyer Institute for Teaching Excellence in December 2004 to begin planning a campus-wide Institute for Research on Teaching and Learning. The next step will involve deans in the selection of a larger community of STEM faculty leaders who will design the institute, which is likely to become the independent PSU incarnation of CIRTl. The Institute will be consistent with President Graham Spanier's vision of PSU as a student-centered university and will address concerns that surfaced from the PSU Needs Assessment about the need for improved communication and coordination of teaching improvement activities across the university.

3. Network Connectivity

Our new vision of the CIRTl Network as a learning community implies mutual exchange of successful strategies and programs based on the CIRTl pillars. We have found that the collegiality and respect inherent in this approach have led naturally to mutual support in program development at all three universities. We give here two of several examples. First, the Delta Certificate builds directly on the certificate program already in place at MSU, even to the extent of adapting the MSU manual. The formative evaluation implicit in the existing MSU certificate program, and the generous access to MSU knowledge and documents, allowed UW to bring up a certificate program in a matter of months rather than years.

Second, in summer 2004, the CIRTl Network held its first event organized collaboratively and serving participants from all three campuses. The Science and Engineering Scholars Program (SEESP) was a week-long summer seminar for new STEM faculty from throughout the Network, as well as from other universities across the nation. The program introduced new faculty to basic principles in teaching and learning within the context of the CIRTl pillars. Hosted by PSU, the organization of the SEESP was led by John Wise (PSU) and Sandra Courter (UW). The program drew 29 participants from eight research universities.

4. Preparation for Extending the CIRTL Network

As preparation for extending the CIRTL Network to seven additional research universities across the nation, James Fairweather (co-PI, MSU) and Jennifer Hodges (MSU) have completed a study classifying research universities along two primary dimensions: (a) doctoral production and (b) involvement in STEM professional development. This internal management report concludes by suggesting a list of 10 candidate universities for the CIRTL Network. In alignment with these findings, Fairweather has also completed an internal management report laying out an evaluation plan for the network development.

III. National Impact

A. The National Context

CIRTL is situated at the intersection of two major, ongoing national conversations. First, CIRTL is engaging with the research findings and programmatic initiatives concerning *graduate education* that have expanded considerably in recent years. In the 1970s and 1980s, research and professional development endeavors pertaining to doctoral students focused especially on the preparation and development of teaching assistants. In the 1990s, the focus of research studies expanded to include much broader examination of the doctoral experience and associated professional development. More recently, researchers are exploring how specific disciplinary contexts shape the doctoral experience in which students prepare for their futures as teachers and researchers. Programmatic initiatives have paralleled this expansion of the research on doctoral education. By contributing strategies especially relevant to the preparation of doctoral students in STEM fields, CIRTL is participating in a national conversation that includes the Preparing Future Faculty Program, the Carnegie Initiative on the Doctorate, the NSF AGEP and IGERT Programs, and the Woodrow Wilson Foundation's Responsive PhD Program.

Second, CIRTL incorporates the rich recent conversation around the *engagement of faculty in bringing their research perspective to teaching and learning*. With the publication of Boyer's *Scholarship Reconsidered*, the higher education community began to recognize more fully that, in addition to basic research, forms of scholarship can include integration, application, and teaching. Over the past fifteen years, scholars such as Hutchings and Shulman, among others, have explored the implications and possibilities of the scholarship of teaching and learning for faculty research and teaching. With its commitment to supporting graduates-through-faculty in engaging in teaching-as-research, CIRTL adds its voice to the international conversation about the meaning, strategies, and impact of addressing teaching issues with a research perspective.

Situated within the intersection of these two significant conversations concerning the scholarship of teaching and learning and the professional development of graduate students, CIRTL is poised to make a significant contribution to the preparation of future STEM faculty and thereby the enhancement of the learning of STEM students across the nation.

B. Connectivity

1. CIRTL Forums

On November 5–6, 2003, we hosted the first CIRTL Forum: *Preparing the Future STEM Faculty: Sharing Successful Strategies*. The goal of this Forum was to describe the present landscape of STEM graduate training in teaching and learning at research universities across the nation and to build connections among STEM graduate programs. This Forum was designed for those engaged in STEM graduate education at major research universities: graduate and college deans, STEM faculty and academic staff, and graduate students. In an effort to bring multiple perspectives to the Forum, we invited the provosts and graduate deans of research universities to bring a team of three to four leaders from their STEM graduate programs. The forum was attended by 246 people from 60 research universities (a summary of participants and a list of institutions are presented in Appendix G).

Keynote speakers included Joseph Bordogna (deputy director, NSF), Lee Shulman (president, Carnegie Foundation for the Advancement of Teaching), Jody Nyquist (PI emeritus, Re-envisioning the Ph.D., University of Washington), and Orlando Taylor (vice provost for research and dean, Howard University Graduate School). Carl Wieman (Nobel laureate in physics, University of Colorado) gave an evening CIRTL Distinguished Lecture on the interfaces of teaching and research. Dr. Wieman's keynote address was open to the public and attended by an estimated 425 people. The agenda also included panel discussions of research-based lessons from existing

graduate professional development programs. Finally, three breakout sessions provided participants with an opportunity to discuss topics central to graduate student professional development. These were among the most highly rated events. The Forum program is provided in Appendix H.

The Forum provided each university team the opportunity to present its graduate professional development programs through posters and through more extensive program overviews designed for Web dissemination. Forty-three teams brought posters and provided program overviews, all of which can be found on the CIRTl Web site.

The second CIRTl Forum, *Addressing the Student Learning Experience: Achieving Diversity in STEM Disciplines*, will be held May 25–26, 2005. The goal of the forum is to provide tools, resources, and strategies with which STEM graduates-through-faculty can directly improve the student learning experiences of women and underrepresented minorities. We will introduce the products of the CIRTl Diversity Institute (section III.C) and showcase exemplary programs at research universities throughout the nation. Panel discussions and workshops will focus on diversity research and best practices in graduate and undergraduate STEM education. Presenters will include Isaiah Warner (vice chancellor, Boyd and Phillip W. West Professor of Analytical and Environmental Chemistry, Louisiana State University), Michael Nettles (Educational Testing Service), Donna Nelson (Prof. of Chemistry, University of Oklahoma), James Stith (American Institute of Physics), and Alberto Cabrera (Prof. of Educational Policy and Leadership Analysis, UW). Public events will include *Conflict in the Classroom*, an interactive theater performance presented by University of Michigan's *CRLT^d Players*.

2. National Dissemination

We have an extensive ongoing investment in disseminating CIRTl nationally. Our CIRTl Web site (www.cirtl.net) provides access to resources, supports the Forums and provides a means of gathering feedback. The CIRTl Web site will take on added significance as the CIRTl Network grows and Reports, Briefs and Products are made available to Network institutions and to the STEM higher education community at large. We have also developed a substantial Delta Web site (www.delta.wisc.edu), which serves both as an internal resource for Delta participants and as a reference and prototype for national inquiries. We have presented CIRTl extensively at national and international meetings. In the 1st year, this involved publicizing CIRTl ideas and goals. In the 2nd year, our dissemination has begun to report on the programs and outcomes of Delta and the CIRTl initiatives at PSU and MSU. In total, we have presented 31 conference sessions, both nationally and internationally, and have written 15 papers for publication. Lists of our presentations and publications appear in Appendix F.

3. Organizational Collaborations

We have established close connections with the Carnegie Foundation for the Advancement of Teaching, the American Association for Higher Education (AAHE), the Howard Hughes Medical Institute (HHMI), the SCALE (System-wide Change for All Learners and Educators) Math and Science Partnership at UW, and the Center for the Advancement of Engineering Education (CAEE) at the University of Washington. The Carnegie Foundation for the Advancement of Teaching has under way the Carnegie Initiative on the Doctorate (CID), which focuses on departmental change initiatives within specific disciplines. Thus, CIRTl and CID are complementary experiments in different change models (e.g., interdisciplinary across institution versus disciplinary and departmental), and both have benefited from close communication. We also have connected with the Research University Consortium for the Advancement of the Scholarship of Teaching and Learning (RUCASTL), sponsored by the Carnegie Foundation and AAHE. This consortium, of which MSU is a member, encourages recognition of the scholarship of teaching and learning as critically important to the mission of research universities. CIRTl researchers have presented a paper at a conference associated with RUCASTL, and we intend to continue cultivating connections between these two national efforts. Our connections with HHMI are through the New Generation Program of HHMI Professor Jo Handelsman (Prof. of Plant Pathology, UW). Independently and nearly contemporaneously, Handelsman was funded to begin a graduate student professional development program in teaching and learning biology. Her highly successful program is based on the concept of *Scientific Teaching*; includes courses and programs in *Teaching College Biology*, *Instructional Materials Development*,⁵ and *Mentor Training*;⁵ and is establishing national connectivity through an annual summer institute. The Delta

⁴ Center for Research on Learning and Teaching.

⁵ In biology.

Program and these HHMI programs are closely aligned, and we are collaborating toward their integration. The collaboration with SCALE involves incorporating Delta interns in the SCALE initiative to create STEM immersion units and train K–12 teachers in their use. We see this as a prototype for a future initiative to engage STEM future faculty in preservice and in-service teacher education. Finally, the Center for the Advancement of Engineering Education is our partner NSF Center for Learning and Teaching in higher education, and we are sharing findings through the use of common evaluators, participation on each other's national advisory boards, and annual visits.

In a different but important direction, the Delta internship program is establishing close connections between UW and nearby colleges and universities. To date, the program has placed interns at the Madison Area Technical College and Edgewood College, and intern opportunities are being created at other Wisconsin System campuses, Luther College, and Lawrence University. On a national scale, Delta interns have been placed at the University of Colorado – Boulder and at PSU. These linkages provide broader opportunities for Delta interns; assist the Delta Program, and CIRTl broadly, in aligning offerings with employer needs; open channels of communication so that we may learn from the faculty development expertise of these partners; and have already provided a base for post-graduate placements.

C. Research in Progress

Research has played a central role in the CIRTl project in the first 2 years, both in providing a foundation for planning CIRTl initiatives and in understanding the outcomes of those initiatives. This research will play an ever-increasing role in the national impact of CIRTl as the project matures.

1. National Landscape

At the beginning of the project, we did a national scan of STEM graduate student professional development programs in teaching and learning, based on Web research. We found 95 programs, which we then classified according to their relevance to the various CIRTl Development Teams. The teams used these data as starting points for their development work. The database is now available on the CIRTl Web site. Descriptions of another 43 programs were captured through the first CIRTl Forum and are also available on the Web site. Roger Baldwin and Jeremy Hernandez (MSU) have synthesized these data to identify common themes among the programs. A CIRTl Brief, to be widely distributed to graduate deans, is completed; a CIRTl Occasional Paper is drafted; and a monograph is under consideration.

Needs assessments for UW, MSU, and PSU are all completed. Austin, Colbeck, Susan Millar (UW), and their colleagues will synthesize findings from these three studies in a monograph describing strategies for conducting needs assessments as well as issues concerning STEM-related faculty development and doctoral student preparation for the professoriate at large research universities. Highlights will be circulated as a CIRTl Brief, and a more extensive report will be proposed as a volume in a well-recognized higher education monograph series.

At the end of 2004, we initiated a study of the needs and hiring practices of academic employers to ensure that the learning objectives for participants in programs throughout the CIRTl Network are aligned with the qualifications sought by their future employers. Margaret Chmiel, Donald Gillian-Daniel, and Chris Pfund (UW) have completed a literature review about hiring practices, conducted a survey of themes in STEM position advertisements as a function of institution type, and developed a protocol for interviews of faculty and administrators at a diverse set of colleges and universities to explore actual hiring practices. The interviews will begin in April 2005.

2. Intellectual Foundation

The foundational idea of teaching-as-research draws on a rich heritage of action research in K–16 and more recently upon the Scholarship of Teaching and Learning. To understand our place in this history, Jana Gearhart (UW) completed a literature review: *A Taxonomy of Practitioner Research: Implications for Inter-framework Collaborations*. This paper has been accepted for presentation and publication at the 5th International Conference on the Scholarship of Teaching and Learning and will be distributed as a CIRTl Occasional Paper.

Clifton Conrad and Divya Gupta (UW) have completed a thought piece on teaching-as-research: *Teaching-as-Research: A Systematic Approach to Teaching-for-Learning* (to be submitted to the *Journal of Higher Education*). This paper advances the definition of teaching-as-research, lays a detailed conceptual foundation for its processes, and presents a systemic approach for its implementation.

National policy makers and institutional leaders have become interested in the relationships between teaching and research in other English-speaking countries. Colbeck has given presentations at two international conferences on *A Cybernetics Systems Model for Teaching and Research Production*, a framework for understanding contextual conditions that foster teaching-as-research and other links teaching and research. Colbeck will present a keynote speech on *The Integration of Teaching and Research in the U.S.* at the Canadian Summit on the Integration of Teaching and Research in August 2005.

3. Graduate-Through-Faculty Outcomes

We have laid the foundations for major research studies on the outcomes of CIRTTL programs. Susan Millar and Norman Webb (UW) have designed a major longitudinal study of Delta participants, built on two modes of data acquisition:

1. An intensive component will gather data via open-ended, structured interviews with a sample of 70 Delta participants representative of UW in discipline, sex and ethnicity, expectation of pursuing a faculty career and position sought, and type of institution granting bachelor's degree (interview protocol developed and baseline interviews under way); and
2. A broader cross-sectional study will gather data via surveys of all Delta participants at the end of each year from 2005 to 2007.

We envision continuing this longitudinal study beyond the lifetime of the CIRTTL project itself.

Connolly, Clifford, and Gearhart have begun focus studies on Delta participants to address two research questions: (a) how do participants define teaching-as-research and use the concept in their work with students? and (b) what factors (institutional, disciplinary, personal) affect the implementation and diffusion of teaching-as-research practices among STEM participants? They have completed a pilot study of seven STEM faculty and staff and are revising their protocols for the full study later in 2005.

Lisa Weaver (PSU) has begun a dissertation with Colbeck to study the effects of group membership and collective sense-making about teaching-as-research on individual instructors' professional identities as teachers and researchers. The key research questions are: (a) How, if at all, are the professional identities of individual members modified by individual and collective sense-making about the concept of teaching-as-research? (b) How do the individual characteristics of participants in the community of practice—including rank, gender, ethnicity, expertise, and professional identity—affect interactions within the community of practice? (c) How do characteristics of the community of practice—including norms, values, relative power of members, and the nature, topics, and types of communication—influence individual and collective sense-making?

Emily Janke (PSU) and Colbeck are evaluating the CIRTTL-funded teaching assistant training program and Professional Development Workshop for 1st-year doctoral students in the PSU Chemistry Department. They are conducting individual interviews with instructors and focus groups with graduate students to explore these participants' perceptions about (a) the ways in which these programs prepared them to assess student learning and work with undergraduates from diverse backgrounds and (b) the extent to which they are developing a learning community.

D. CIRTTL Diversity Institute

The challenge of addressing diversity in STEM higher education classrooms is of primary importance to CIRTTL. The project made a major investment during 2004–05 in the CIRTTL Diversity Institute, with the goal of synthesizing existing knowledge and tools to enhance the teaching of STEM subjects to diverse student audiences. The Diversity Institute involves three UW faculty (Judith Burstyn, Chemistry; Cabrera, Educational Leadership and Policy Analysis; Sherrill Sellers, Social Work), CIRTTL Scholars from around the nation, and a team consisting of a post-doctoral fellow, two project assistants, and two undergraduates (<http://cirtl.wceruw.org/DiversityInstitute/>).

The products of the Diversity Institute, all to be completed by the May 2005 CIRTTL Forum, include:

- **Literature review:** This annotated bibliography summarizes 100 articles on effective teaching practices for students, issues affecting the retention of underrepresented students, and equitable classroom practices conducive to learning.

- **Resource book:** This edited volume of original essays and published articles - *Reaching All Students: A Resource Book for Teaching in Science, Technology, Engineering and Mathematics* - models the infusion of diversity throughout teaching and encourages faculty to foster inclusiveness in many aspects of teaching that at first seem unrelated to diversity.
- **Case book:** The case book includes a selection of real situations faced by graduates-through-faculty related to diversity, intended to challenge users to evaluate the situations and develop possible solutions or interventions. The cases include varying contexts, including classrooms, labs, and study groups, and a range of diversity-related issues, including disability accommodation, sexual harassment, racial stereotypes, and academic preparation.
- **Inclusive syllabi:** This collection includes undergraduate- and graduate-level syllabi that substantively integrate STEM themes and topics with women's/gender studies themes and topics. Named Content Matters, the project is led by Mary Wyer, CIRTl Scholar from North Carolina State University, and is a collaborative project with the National Women's Studies Association Science and Technology Taskforce.
- **Self-Guided Diversity Workshop:** This workshop provides a foundation for thinking about diversity in STEM. The workshop begins with a broad discussion of privilege and then moves to specific ideas for how to create an inclusive learning environment.
- **Web resources:** In preparing the resource book, we reviewed over 100 Web sites and selected 25 to highlight on the Diversity Institute Web site.

These products are intended for use both within CIRTl professional development programs and more broadly by the national STEM faculty. Some are, and more soon will be, available at the Diversity Institute link on the CIRTl Web site and as a new module of the Innovations in STEM Education Web site (www.wcer.wisc.edu/nise/cl1) previously developed by the NSF-funded National Institute for Science Education and now supported by CIRTl. These products have begun to receive national attention—for example, being featured in the Association of American Colleges and Universities diversity Web site.

IV. Project Organization

A. The Organizational Model

The CIRTl strategic plan set the goal of creating a highly interactive, collegial system, while maintaining the clear lines of authority and responsibility necessary to ensure quality accountability, direction, and leadership. The project has achieved this goal. CIRTl has achieved the objectives established for the first 2 years on schedule and on budget. Equally important, all but one of the 20 original Team Leaders at the three partner universities remain deeply engaged in leading CIRTl.

As CIRTl begins its 3rd year, we are operating within an organizational model very similar to that presented in the strategic plan, but with important improvements that respond to changing demands and new initiatives. Here, we note those changes:

- **Leadership Team:** Due to major duties associated with leading the SCALE Math and Science Partnership, Terrence Millar (Prof. of Mathematics) stepped down in fall 2003 and was replaced by Burstyn as co-PI and member of the Leadership Team. This change reinforced the ever-increasing emphasis on the diversity goals of the project, as Burstyn is a leader of the CIRTl Diversity Team. In addition, Aaron Brower (Prof. of Social Work, UW) replaced Andrew Porter (Prof. of Educational Psychology, UW) as co-PI after Porter's departure for Vanderbilt University.
- **CIRTl Network development:** Because of a major overlap in both key personnel (Austin, Colbeck, Fairweather) and research questions, the CIRTl Network development was initially a responsibility of the ERT. However, as the Network development ramped up at the end of Year 2, it became clear that this structure was confusing and ineffective. Thus, as of January 2005, Austin has formally assumed leadership of the Network Development initiative, supported by the Leadership Team and the Development Team Leaders.
- **Cross-project coordination:** Our initial expectation was that cross-project coordination and communication would occur primarily at monthly Team Leader meetings. In practice, as in most communities, lines of communication developed naturally at many interfaces. Along with the Team Leader meetings, equally important cross-project communication occurs at weekly Leadership Team teleconferences, semi-monthly

meetings of the project assistants/project manager, and monthly meetings of the Evaluation Liaisons. All of these lines of communication developed in response to expressed needs, continue under their own momentum, and are vital to coordinated progress. Indeed, the importance to the entire project of the communication among the project assistants has led us to explore a similar model for the CIRTTL Network involving Teaching-as-Research Post-Doctoral Fellows at each of the Network institutions in addition to the primary institutional leaders. Finally, the newly appointed STEM faculty leaders for CIRTTL at MSU, the ongoing STEM faculty leaders at PSU, and the Delta Program leaders are joining in CIRTTL Team Leader meetings. We envision that by the end of 5 years, these will evolve into CIRTTL Network meetings of the institutional leaders throughout the network.

- **National Advisory Board:** The members of our National Advisory Board (Appendix I) have become invaluable partners in the success of the project. In addition to guidance at annual meetings, Board members have contributed substantively through counsel during the year, new ideas that are now part of the project, presentations at national meetings on behalf of CIRTTL, chairing and presenting at CIRTTL meetings, reviewing documents and protocols, promoting CIRTTL connections with national organizations, and advocating with university administrators.

B. Organizational Process

We have made every effort to incorporate the three pillars of CIRTTL in the management of the project itself. Specifically:

- **Teaching-as-research:** The ERT has provided formative evaluations of the organizational process, based on interviews with CIRTTL staff and observation of CIRTTL processes. Three such reports focused on top-level management structure, the CIRTTL learning community, and the CIRTTL Network development process. All led to change and improvement. For example, the formation of the Leadership Team was a response to the recognition that the project was too PI-centric in its early days.
- **Learning community:** The CIRTTL community comprises many vital, overlapping communities: the Leadership Team; the Development Teams, and their Team Leaders; CIRTTL Central (project manager and staff); the project assistants; the Evaluation and Research Team; the Evaluation Liaisons the Delta Program leadership; and the Network institutional leaders. All of these communities partially overlap, maintaining comprehensive connectivity, but no one person is a member of all communities. The project leadership ultimately resides with the Leadership Team, but each community has great flexibility in following the path the members think best. The distributed connectivity provides ongoing coordination.
- **Learning-through-diversity:** Since the very beginning, CIRTTL has been a vital collaboration of STEM and social science researchers; graduate students, post-docs, faculty, academic staff, and undergraduates; graduates-through-faculty from UW, MSU and PSU; women and men; and, regrettably to a lesser extent, people of color. Quite simply, without this diversity of people, the project would never have achieved the success that it has, and we actively seek to maintain such diversity in all that the project does.

V. Looking to the Future

In the first 2 years, we successfully created and implemented a prototype STEM graduate-through-faculty professional development program in teaching and learning. Further evaluation and improvement of this prototype remain to be done, especially better integrating the learning-through-diversity idea into the Delta Program courses and programs. This work will be greatly facilitated by the products of the Diversity Institute (section III.C) now in hand. During the first 2 years, we also explored the process of creating a network of research universities, using the three CIRTTL partners as laboratories. This process fundamentally changed our conceptualization of the CIRTTL Network, moving it from a transfer model to a collaborative model. Finally, we laid an extensive foundation for longitudinal studies of CIRTTL impact and for major research studies on processes of institutional change resulting from CIRTTL activities.

The 3rd year of CIRTTL will be a critical time of transition in the primary focus of activities. First, we will begin to extend the CIRTTL Network beyond the original CIRTTL universities (UW, MSU, PSU). We have positioned ourselves well for this initiative, having completed an analysis of research universities by which to choose candidate members, identified the programs and people associated with graduate-through-faculty

professional development at each candidate university, and begun to make informal contacts with key players on each campus. These are only the first steps; we anticipate that making the CIRTl Network an engaged collaboration of 10 research universities will be the primary challenge over the next 3 years.

Second, as a major initiative of the NSF in the preparation of future STEM faculty, CIRTl has a responsibility to join with and to foster the rich array of initiatives across the nation with similar goals. Over the next three years we will establish functional collaborative relationships with the other national programs, such as the Carnegie Initiative on the Doctorate, the NSF AGEP and IGERT Programs, and the Woodrow Wilson Foundation's Responsive PhD Program. We will also increase our connectivity with the diverse array of colleges and universities where most of the future STEM faculty will be teaching. We have a great deal to learn from their extensive experience in developing their own faculties so as to enhance student learning in STEM fields.

Third, the Evaluation and Research Team will be shifting its emphasis toward addressing the research questions in the strategic plan. We view this opportunity with excitement; we have developed an abundance of questions during the first 2 years of development work, and we have a wealth of data in hand with which to address them. Since most of the senior education researchers on the ERT are also heavily involved in CIRTl leadership, this increasing focus on research will require some evolution in the organizational structure.

Finally, the people involved in all facets of CIRTl to date have been remarkably talented and committed. Nonetheless, a center must anticipate inevitable transitions in personnel over a 5-year period. We have found that the learning community model that underlies every dimension of CIRTl provides us with a natural source of talented people. We also benefit from the fact that CIRTl has proven to be an exciting project that fills a strongly felt need. We look forward to bringing in new members of the CIRTl learning community and, with them, rich, innovative ideas for the future of CIRTl.