AC 2011-2275: CIRTL: IMPACTING STEM EDUCATION THROUGH GRADUATE STUDENT PROFESSIONAL DEVELOPMENT

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Center for the Integration of Research, Teaching and Learning: Impacting STEM Education through Graduate Student Professional Development

Abstract

This paper summarizes findings of a national, multi-institutional effort to reform STEM undergraduate education through the implementation of graduate student professional development programs focused on improving teaching practice. This paper describes the work of the Center for the Integration of Research, Teaching and Learning (CIRTL) including: (a) its philosophical pillars; (b) the types of opportunities offered to graduate students; and (c) the types of interactions within the network to promote learning and development inter-institutionally. In addition, the paper draws upon the data collected over the last seven years as part of an on-going case study of the multi-institutional network to discuss (a) evidence of success, (b) obstacles to succeeding in implementing these programs, and (c) future challenges for CIRTL as an expanding inter-institutional network.

Background

Several prominent national and governmental organizations have called for increased attention to the preparation of college graduates in STEM fields.[1, 2] These concerns are especially prominent in the field of engineering. Engineering, along with the physical sciences and computer sciences, are identified as the fields with the greatest net attrition.[3, 4, 5] Furthermore, there is concern that today's domestic graduates are ill-prepared to thrive in the rapidly evolving global economy.[6, 7] In response to the concerns with engineering education nationally, there are many efforts underway to address the inability of the U.S. to adequately attract, retain and prepare students in the STEM disciplines[8].

One of the major drivers of research in STEM education has been the findings of Seymour and Hewitt on student departure from STEM fields. Their study found that students leave STEM fields due to their frustration with the quality of teaching, advising, and curriculum.[9] In the wake of Seymour and Hewitt's seminal work and on-going national concern, the push for pedagogical and curricular reform has intensified due to its dual impact on the production of STEM graduates and quality of undergraduate education. The Center for the Integration of Research, Teaching and Learning (CIRTL) is one such reform effort, which seeks to improve undergraduate STEM education by targeting the professional development of graduate students. CIRTL aims to influence the knowledge, attitudes and behavior of these future college instructors. The pipeline of future STEM faculty through graduate education at research universities serves as a critical leverage point. Currently 80% of all STEM Ph.D.s are educated at approximately 100 universities nationally. These graduates then serve the over 4000 colleges and universities nationwide. Therefore a concerted national effort to reform the training of STEM doctoral students has the potential to significantly impact STEM education nationally.

Recent research on doctoral education and training characterizes the experience as an intense socialization process. Historically doctoral education, especially in STEM fields, has focused primarily on the research apprenticeship providing students with little training as

teachers.[10] Further, the current doctoral student socialization process has been criticized for: (a) being insufficient for the various faculty roles, especially teaching; (b) providing conflicting messages about the importance of teaching; (c) lacking feedback to students regarding their preparation for academic careers; and (d) offering few opportunities for graduate students to learn about the diversity of academic careers available to them.[11] Thus there has been a gap in the training provided to doctoral students seeking faculty positions, especially those in STEM fields.

CIRTL is specifically designed to address these parallel concerns regarding the socialization of doctoral students and the need to improve undergraduate STEM education. Informed by the research on effective teaching practice and professional development needs of graduate students, CIRTL aims to prepare the next generation of STEM faculty as both effective teachers and researchers through a series of professional development opportunities embedded within an intentional learning community of like-minded scholars.

Purpose of Paper

In this paper, I will describe CIRTL including its aims, philosophical underpinnings, and membership. This paper highlights CIRTL's efforts to impact STEM education at all levels through its professional development programs for graduate students. The paper will focus primarily on describing the work of CIRTL including (a) what role the philosophical pillars play, (b) what resources have been created; (c) what types of opportunities exist for graduate students, and (d) how the network supports and enhances graduate student development efforts. In addition, the paper will draw upon the data collected over the last seven years as part of an on-going case study of the multi-institutional network to discuss (a) evidence of success, (b) obstacles to succeeding in implementing these programs, and (c) future challenges for CIRTL as an inter-institutional network.

Center for the Integration of Research, Teaching and Learning (CIRTL)

To improve the quality of undergraduate instruction in the STEM fields by addressing the inadequate preparation of future faculty, a group of universities has created an inter-institutional collaboration, the Center for the Integration of Research, Teaching and Learning (CIRTL), funded in part by the National Science Foundation. CIRTL focuses on graduate education as the key leverage point in preparing future STEM faculty. The purpose of CIRTL is to prepare STEM doctoral students as both effective teachers and researchers, and thus, ultimately, to strengthen undergraduate STEM education.

Three philosophical "pillars" are the foundation of CIRTL: (a) learning communities; (b) teaching-as-research; and (c) learning through diversity. The learning community pillar refers to CIRTL's commitment to foster collaborative learning through shared discovery and co-creation of knowledge. In CIRTL these learning communities exist among future and current faculty at a single institution, among individuals across multiple institutions (i.e., across the CIRTL Network), as well as among institutions engaging in the development of effective graduate student professional development programs. The teaching-as-research pillar refers to CIRTL's commitment to encouraging doctoral students and faculty to use their skills as researchers to

inform the development, implementation, and improvement of their teaching methods[12]. Similar in many ways to the scholarship of teaching and learning approach and classroom-based assessment techniques, teaching-as-research seems to have special resonance with scientists in conveying the importance of deliberately and systematically measuring student learning to inform teaching practice. Third, the learning-through-diversity pillar acknowledges that diversity among instructors and learners is vital to the educational process. CIRTL supports doctoral students and faculty in learning to build on such diversity to enhance the learning of all of their students and to consider the diversity of student experiences in creating equitable learning opportunities for students. With commitment to these philosophical perspectives, the CIRTL Network aims to be a learning community of diverse research universities reforming STEM doctoral student professional development in teaching and learning by engaging in the exchange and creation of strategies, programs and research.

In its early years, CIRTL focused on developing a prototype approach to STEM graduate student professional development at the University of Wisconsin-Madison (UW). During this early process, two other institutions also worked on developing and implementing CIRTL approaches on their respective campuses and joined with UW-Madison to form the early stages of the CIRTL Network. During that time, the institutions embarked upon a collaboration where sharing of ideas, refining of programs and evaluating impact could be done collectively. This initial partnership built upon the significant development work at UW-Madison while benefiting from the intellectual, programmatic and evaluative resources currently in place, or being designed in parallel, at the other institutions.

Out of this initial collaboration, the CIRTL Network developed into a learning community of institutions who share the goal of collectively improving the preparation of future STEM faculty. The institutions exchange ideas and resources, and engage in a process of learning and discovery about effective means of transforming graduate student professional development in the STEM disciplines. Currently CIRTL consists of six participating institutions: (a) Howard University; (b) Michigan State University (MSU); (c) Texas A&M University (TAMU); (d) Vanderbilt University; (e) University of Colorado-Boulder (CU-B); and (f) University of Wisconsin-Madison (UW).

CIRTL Resources

From the outset, one of the intended outcomes was a series of resources to allow other institutions to benefit from CIRTL's research and development process regarding effective graduate student professional development in STEM. During the first NSF grant, UW-Madison's team devoted significant effort to the development of effective programs for the Delta Program in Research, Teaching and Learning. To disseminate the results of this effort, Delta created a series of guidebooks that provide detailed content and instructions for implementing their courses and internship program. These resources are publicly available on the CIRTL website (http://www.cirtl.net) and are used by current institutional partners in their implementation efforts.

These efforts have continued in the present. The CIRTL Network has emphasized efforts to develop and expand the resources available to promote learning through diversity. The online

CIRTL Diversity Resources (http://www.cirtl.net/diversityresources) include: (a) a resource book of teaching tips; (b) a case book of exercises on diversity; (c) a bibliography of articles and books on diversity issues in teaching; (d) a virtual workshop to promote awareness of diversity; (e) examples of innovative syllabi that incorporate learning through diversity; and (f) a list of web site about diversity in technical fields. This work continues with a current CIRTL Network initiative to compile case examples of excellence in teaching and learning through diversity at member institutions that will result in new educational resources on the topic.

CIRTL Programs

CIRTL operates programming at two levels: (a) institutional level; and (b) network level. This section outlines the key elements of institutional and network programming, including examples to illustrate these points.

Institutional Programs

Each institution is responsible for developing a CIRTL learning community which includes a set of graduate student professional development programs and activities that align with the philosophical pillars of CIRTL (teaching-as-research, learning-through-diversity and learning communities). These programs vary considerably as institutions determine how best to incorporate CIRTL concepts into their local institutional culture.

The programs currently in place vary in terms of the pillars on which they focus, the level of engagement required of participants, and the stage of graduate students' careers targeted. The diversity of offerings along these dimensions depends on the goals of the local campus community and the ability of the institution to support a range of programs. All CIRTL institutions aim to provide at least one local program that can be classified as high-engagement (i.e., requiring at least a semester-long commitment) and to offer access to programs that address all three of the CIRTL pillars. To illustrate the types of programs offered, I will provide examples of low, medium and high engagement activities highlighting their purpose, content, and, where appropriate, evidence of success.

Low engagement programs are usually events that require minimal investment of time (e.g., 1-2 hours) and do not require regular meetings. In general, these programs are designed to either promote CIRTL work to the campus community including faculty, staff, and administrators, or to introduce CIRTL to graduate students through a program with minimal individual investment. One example of a low engagement activity is the Delta Roundtable Dinners at UW-Madison. These monthly dinners are open to STEM faculty, graduate students and post-doctoral researchers who are interested in the topic for discussion, which typically aligns with one of the CIRTL pillars. UW-Madison uses these dinners both to gather together individuals active in CIRTL and as an opportunity to reach out to members of the STEM community who are not currently involved in the Delta Program, thus identifying potential new members or informing the broader community about CIRTL. In addition to these outreach efforts, UW-Madison leverages these dinners as an opportunity to link participants and instructors in their program into a larger community of scholars with shared interests. Research on the impact of this low engagement activity demonstrates that participants (a) strengthened

their self-identification with the Delta learning community, (b) cultivated a shared language, and (c) demonstrated sustained involvement including participating, leading or instructing, and creating other activities for the Delta program[13].

Some institutions have implemented mid-level engagement activities as part of their local implementation of CIRTL. Mid-level engagement activities normally require greater than a couple of hours of time committed to the activity, but do not extend over an entire semester or academic year. One example is the University Teaching Certification Institute at MSU which is a weekend-long, intensive program that exposes graduate students to various teaching and learning topics in higher education including teaching with technology, assessing teaching and learning and teaching and learning through diversity. In addition, participants work on their teaching portfolios and develop a teaching-as-research project plan for later implementation. In line with the CIRTL pillars, this program develops a short-term, but intensive, learning community atmosphere while exposing participants to the teaching-as-research and learning-through-diversity concepts. Evaluation of the program indicates that it is very well-received by participants with 94% agreeing that they would recommend the institute to a friend. In addition, nearly 60% of participants agreed that they both understood how to develop a teaching portfolio and had outlined an effective teaching-as-research project as a result of participating in the institute.[14] The latter finding indicates that participants concluded the institute with a clear plan to engage in reflective teaching practice.

The most common high-level engagement CIRTL program is a mentored teaching-as-research project. Although implemented differently at each institution, these programs provide graduate students an opportunity to engage in a project to improve undergraduate learning. The teaching-as-research project requires graduate students to develop research questions about effective teaching, design the research project, collect data, analyze the data and report the findings. For example, Vanderbilt University implemented the Teaching-as-Research Fellows Program. A small group of graduate students is selected each year to participate in a semester-long learning community supporting students' teaching-as-research projects with a STEM faculty member. A professional staff member from their Center for Teaching facilitates the group by providing weekly support for each stage of the project's development. Further, students learn from each other at the weekly sessions where they discuss challenges and issues from their individual projects. At the end of the semester, each graduate student will have completed a teaching-as-research project assessing a pedagogical or curricular intervention in an undergraduate STEM course. The findings are presented at a local campus event; some students further develop the ideas for presentations at national conferences including ASEE. A recent assessment of the program at Vanderbilt indicates that the projects resulted in significant engagement of the faculty instructors and substantive changes to the instruction of the course. In addition, participants reported the following outcomes: (a) heightened awareness of student diversity and potential learning problems in the classroom; (b) greater appreciation of the link between research in teaching including the role of using data to improve teaching; (c) new view of good teaching as not an innate trait, but a skill that is planned, studied and improved; (d) increased confidence in their ability to teach; (e) increased interest in faculty careers; and (e) stronger identification with the larger CIRTL community on campus.[15]

Network Programs

At the network level, the CIRTL Network offers programs that enable graduate students from multiple institutions to participate. Often these programs are offered across the Network because the specific program benefits from the diversity of students and instructors able to participate. By bringing together participants from across the Network, these programs can enhance learning and introduce participants to a broader community of scholars committed to excellence in STEM education. Furthermore these Network programs enable individual or institutional expertise to be shared or distributed across all of the institutions. In other words, scaling up the program to the Network level enables graduate students from all institutions to benefit from programs that otherwise are based solely at an individual institution.

The least formal network programs offered by the CIRTL Network are online events hosted on a one-time basis. Currently there are two formats used for this purpose. The first type of program is the CIRTL Coffee Hour. These one hour programs are available online through an interactive portal where discussions related to graduate student professional development are facilitated. For the spring semester of 2011, the monthly Coffee Hours focus on academic careers and the job search process. The second type of program is the CIRTLCast. CIRTLCasts are lectures presented by STEM and education faculty from around the country on education reform in STEM. Some examples of CIRTLCasts include the use of clickers in STEM classrooms, and the use of environmental case studies to engage students in learning through diversity.

There are two more intensive network programs. First, there are CIRTL Network courses. The semester-long courses are taught by faculty from CIRTL Network institutions and are based on the CIRTL pillars. The courses are taught synchronously online through an interactive portal. For the 2010-11 academic year, four courses were taught online: (a) Research Mentor Training; (b) Preparation for Teaching; (c) Diversity in the College Classroom; and (d) Effective Use of Technology and Learning. Preliminary findings from a meta-analysis of course evaluations indicate that students are very satisfied with these courses and appreciate the strong focus on diversity and issues of cultural competence. When reflecting on the impact of students and instructors from other campuses, participants most often cited the openness of the classroom dialogue and the diversity of experiences among classmates and instructors as being beneficial. Participants note that they were exposed to an increased diversity of ideas and feedback because of the various institutional contexts represented in the course, thus broadening their understanding of how other institutions organize and manage courses.

The second more formal network program is the CIRTL Network Exchange Program. This program enables graduate students from one Network institution to visit another Network campus to present their educational and disciplinary research. Through the Exchange Program, highly-engaged graduate students participate in a campus visit similar to those required for faculty positions as well as connect with disciplinary colleagues and other CIRTL participants at the host campus. The host campus also can leverage the visits to reach out to departments unfamiliar with the work of CIRTL. Preliminary findings from these exchanges suggest that participants are uniformly enthusiastic about the experience and feel it prepares them for job talks and presentations on their research agendas. Furthermore, participants report that the experience helped widen their appreciation for educational research within STEM disciplines,

providing encouragement that balancing their interest in educational research with disciplinary research is possible.

Summary of Key Outcomes

Through the array of programs both at the institutional and network level, CIRTL is impacting the preparation of the future faculty in STEM fields. In summary, some of the key outcomes thus far include:

1. Promoting reflective teaching practice

Through the philosophical pillar of teaching-as-research, CIRTL is introducing the practice of applying research skills to the improvement of instructional practice. Graduate students participating in CIRTL have many opportunities to learn about the practice of modifying instruction in response to classroom assessments. Furthermore, graduate students who participate in high-engagement CIRTL activities gain practical experience implementing a teaching-as-research project.

2. Increasing understanding of the role of diversity in instructional practice

CIRTL emphasizes the impact of diversity on teaching and learning throughout its programming. Many CIRTL programs inform future faculty about the various forms of diversity in the classroom and the potential benefit of leveraging the diversity to enhance student learning. Further CIRTL has developed various resources to broaden the dissemination of these concepts both within and beyond the Network.

3. Developing a learning community of scholars interested in improving STEM education

At multiple levels, CIRTL introduces participants to like-minded individuals interested in reforming STEM education. In the evaluation of CIRTL programs, participants identify meeting faculty and other graduate students with similar enthusiasm about teaching and learning as a significant benefit. These findings are reported both in response to institutional programs and network-wide programs. Often graduate students report that they hope to remain engaged in this type of community as they progress into their faculty careers.

4. Deepening and broadening interest in faculty careers.

From program evaluations, two interesting findings have emerged related to faculty careers. In some cases, graduate students report that participation in CIRTL has deepened their interest in pursuing an academic career. In addition to increasing interest in academic careers, some high-engagement participants also report a broadening of their understanding of potential options for faculty work; they have better appreciation for different types of faculty work at different types of institutions.

Future of the Network

The CIRTL Network will continue its efforts to develop a robust learning community of institutions committed to reforming STEM education by impacting graduate student professional development and disseminating research and resources related to effective programming. Given CIRTL's focus on leveraging the production pipeline of the future STEM faculty, the Network also plans to increase its efforts by adding partners. Currently the CIRTL Network is solidifying plans to add up to 19 additional universities to create a partnership of 25 universities committed to this endeavor. These new partners are expected to integrate the CIRTL pillars into their graduate student professional development program, to contribute to and participate in Network activities, and to commit to the research and evaluation of their efforts with the aim of disseminating their findings.

Expanding the CIRTL Network to 25 members presents interesting challenges for the project. One component of the evaluation and research for the project is studying the process of institutional change in response to the externally-funded project as well as the process of network development. Preliminary findings highlight the benefits of a network that acts as a learning community of institutions: (a) sharing information, (b) learning through the diversity of future and current faculty participants, (d) co-creating knowledge related to graduate student professional development and benefiting from the distributed expertise found in the Network. At the same time, the findings identify critical organizational challenges that remain for the expanding Network: (a) cultivating trust among institutional partners; (b) bridging gaps in culture and preparedness to engage in the work; (c) fostering the norms and shared values of a functional inter-institutional learning community; and (d) providing opportunities for new members to connect to the network interpersonally. These challenges represent the obstacles facing the CIRTL Network as the project is scaled up from its current form to more rapidly impact the future STEM faculty.

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