

III. EDUCATION

1A. EDUCATIONAL OBJECTIVES

Mission: To integrate validated educational practices with the research and scientific content of CMDITR so that a diverse population of students can obtain instruction and guidance in the technical, scientific and professional issues necessary to meet the needs of the academic and industrial information technology communities.

- Goal 1:** To recruit and train a diverse population of students in the science and engineering (S&E) career pipeline.
- Goal 2:** To support innovative teaching and learning at the graduate and undergraduate levels through the creation and national dissemination of legacy materials based upon interdisciplinary CMDITR research.
- Goal 3:** To incorporate the understanding of responsible conduct of research (RCR) practices and intellectual property (IP) issues into the educational curriculum of CMDITR students.
- Goal 4:** To foster community-building in support of knowledge transfer and partnerships with educational, industrial, and community organizations.

2B. EDUCATIONAL PERFORMANCE AND MANAGEMENT INDICATORS

This report describes the outputs of the Education and Partnership Program (EPP) over the past year. The successes of these outputs in the context of the goals outlined above were measured by the following performance and management indicators:

- Number of undergraduates involved in gateway and capstone summer research experiences
 - *34 undergraduates took part in last year's summer REU program, 18 of which were female and 14 from underrepresented minority groups. CMDITR is actively targeting Gateway undergraduates, or students with no exposure to research at their home institutions. The number of Gateway students participating has increased from 6 (27%) in 2004 to 15 (44%) in 2005 to a projected 19 (79%) in Summer 2006.*
- Pursuit of external funding for education programs
 - *During this funding period CMDITR received a grant for \$138,000 from NSF for our International Research Exchanges program (Elisa Riedo-PI), starting January 2006, as well as \$200,000 over two years from a Discovery Corps Fellowship for one of our post-docs (R. Morgan-Theall) to work with local high school students in the development of science exhibits. In previous years we received external funding from NSF for our Hooked-on-Photonics REU site proposal (\$222,000 over three years, 2005-2007) and with the implementation of a new Ph.D. program in Advanced Materials Science and Engineering at Norfolk State University (\$47,925). Continued development of the K-12 web modules is funded externally through the Arizona Board of Regents Improving Teacher Quality program (\$116,035 over two years).*
- Number of education programs that have been professionally assessed

- *External assessments have been carried out for our REU program, K-12 web modules, RCR discussion series, and the joint NSU-CMDITR special topics course. Results and recommendations from these assessments have been useful to guide further development of our education programs.*
- Extent of partnerships with regional community colleges and campus diversity and educational outreach projects
 - *See III.4 and IV.3 for a description of partnerships with community colleges, including Edmonds Community College- WA, Diné College- AZ, and campus and local outreach projects (e.g. STEP at GT).*
- Participation of students and faculty in Center sponsored professional development experiences
 - *Center students and post-docs are very active in attending professional conferences, both nationally and internationally (see VIII.2).*
- Development of collaborations with external entities
 - *CMDITR proposal for international exchange was ranked highest among centers and is promoting interaction with leading research groups world-wide.*
 - *Our online RCR modules have been made available to all STCs and other educational organizations via a dedicated website at: <http://responsibleresearch.org>.*
- Number of Center participants 'certified' in Responsible Conduct of Research using web-based training program
 - *Currently, 80% (172/216) of STC participants are certified through completion of our online RCR modules. Since the modules were implemented in Year 2, 330 STC members have completed this training.*
- Number of Center participants attending seminar and case-study discussions on Responsible Conduct of Research and number of such sessions
 - *Following on from five sessions conducted in year-3, 2 sessions were held at GT in year-4 with attendance of 60 faculty and students and 1 session was held at UW with attendance of 50. Further seminars are scheduled for 2006.*

1C. EDUCATIONAL CHALLENGES

Following a 2004 NSF site visit recommendation, the EPP refocused on educational programs at the undergraduate and graduate levels. This year we made progress on the development of the Center's web-based, modular resource for teaching and learning for graduate and undergraduate education in fields related to optoelectronics and photonics.

Our 2005 NSF Site Visit Panel recommended that efforts be made to develop a greater sense of research community among Center participants. The EPP has addressed this by implementing several community-building efforts including, i) the formation of a Graduate and Postdoctoral Advisory Council (GPAC) with representation from each partnering institution and a website at <http://stc-mditr.org/students/gpac/>; ii) devoting a session at the Annual Retreat to discussion of current education goals and activities; iii) encouraging student participation in the Responsible Conduct of Research discussion series; iv) organizing research seminars for students and faculty; v) promoting the CMDITR travel grant program for graduates students and postdoctorates to enhance interaction among Center partner campuses; and vi) developing tools for communication and feedback initiatives such as graduate and postdoctorate surveys and focus groups, a center-wide listserv facility, and a web-based discussion forum to facilitate interactions among center participants.

2. EDUCATIONAL ACTIVITIES

a. Internal Educational Activities

Activity Name	CMDITR Signature Course Development
Led by	EPP and CMDITR faculty
Intended Audience	Graduate students and upper division undergraduates
Approx Number of Attendees	All CMDITR students

Background: Now the centerpiece of CMDITR's educational effort, we have taken the first steps towards developing signature courses with associated web-based resources. The goal of this effort is to develop the instructional infrastructure to provide students with an understanding of the end-to-end issues associated with development of photonic and organic optoelectronic materials, devices, and systems for IT, and to equip them with the interdisciplinary training needed to be effective members of the workforce. Toward this end, we are developing educational materials for graduate and undergraduate courses that will provide an opportunity for Center students to gain knowledge of the breadth and scope of CMDITR research. The intent of these courses is to provide interdisciplinary content and to highlight interconnections in a manner that expresses the uniqueness of the Center. This goal is being realized through the production of interdisciplinary modules that can be combined in diverse configurations to form stand-alone courses or integrated into existing courses. The overall objectives of this project, therefore, are to: 1) define/create/capture content materials; 2) define/create/adapt a content navigation system appropriate to the content; 3) pilot test and evaluate these new materials with students and postdocs; 4) refine and disseminate to users and educational institutions nationwide.

This program seeks to address Goals 1 and 2.

Status: A prototypical survey course "Introduction to Advanced Optoelectronic Materials and Devices" was piloted at NSU in Spring 2005. Feedback from CMDITR faculty, students and external evaluators is being used to guide the development of these courses. Modules are currently being developed at the University of Arizona to support Prof. Armstrong's CHEM 529 course. These modules combine material from chemistry and physics to explain the function of an Organic Light-Emitting Diode (OLED). Further complementary modules are being developed by Prof. Kippelen at Georgia Tech that will cover the physics of charge mobility and aspects of engineering related to the design of OLED displays.

Building upon this experience, course content and modules are under development for the spring-quarter offering of CHEM 484 at the University of Washington. This course combines elements of chemistry, solid-state physics, and electrical engineering to provide students with an initial exposure to photonic materials. Course content was determined collectively by Profs. Xia, Ginger, Bartholomew, Robinson and Reid. Modules are now under development to support the content; initial modules are scheduled for completion in Summer 2006.

CMDITR faculty are working to outline content and learning objectives for a wide range of graduate courses. Planned topics include: Electro-Optic Materials, Light Modulation in Photonic Devices, Optoelectronic Polymer Materials and Devices, Self-Assembly and Fabrication of

Organic Electronic Devices, and Conducting and Semiconducting Organic Polymers. CMDITR has contracted with Tegrity (a learning technology company) for a license that allows all STC members to produce and capture lecture materials in their local offices without the need for high-level technical assistance or significant post-production effort. Tegrity lecture-capture stations are now available at Arizona, Georgia Tech, and the University of Washington.

CMDITR faculty are actively involved in the development of new interdisciplinary courses at their institutions. At Georgia Tech, Prof Bredas is teaching CHEM 8873 (Chemistry of Electronic Materials) as a special topics course in polymer materials for students from chemistry, physics and electrical engineering. Prof Kippelen teaches ECE 8833A (Organic Optoelectronics) for a similarly diverse student body. This summer, Profs. Bredas, Marder and Perry will participate in the NSF-sponsored CWCS workshop "Advanced Functional Organic Materials Throughout the Undergraduate Curriculum", working with faculty from undergraduate institutions towards the incorporation of topics related to CMDITR research into new undergraduate courses. Their lectures as part of this workshop will be captured by the Tegrity system and made available to all CMDITR participants.

Activity Name	New Ph.D. Program Development at Norfolk State University
Led by	CMDITR and NSU faculty
Intended Audience	Undergraduate and Masters students
Approx Number of Attendees	4 students for 'Special Topics' course, Approximately 50 students for recruitment workshop

CMDITR received \$47,925 from NSF in 2004 under grant PHY0120999 (Enhancing Underrepresented Groups Participation in Science and Engineering through Specific Opportunities Fostered by NSF's Science and Technology Centers). The goal of this initiative is to create a new Ph.D. program in Advanced Materials Science and Engineering (AMSE) at Norfolk State University (NSU) to begin Fall 2006 or thereafter. This will be NSU's second Ph.D. program and only the second MSE Ph.D. program at an historically black college or university (HBCU). This program should contribute significantly to increasing workforce diversity in the areas of information technology, materials science, and nanotechnology. Specifically, CMDITR will:

- (1) assist NSU in preparing and piloting lecture and supplemental materials for two core courses
- (2) via videoconference and travel, provide assistance with the development of the 6 core, 19 elective, and 2 seminar courses that make up the Ph.D. curriculum
- (3) assist with design and delivery of a graduate student recruitment workshop to be held at NSU
- (4) make available the resources of the CMDITR, including a website that assists students with job placement.

This program seeks to address Goals 1 and 2.

Status: CMDITR PIs delivered a series of lectures at NSU during Spring 2005, and a video archive of these lectures is available on the CMDITR website. This course, "Introduction to Advanced Optoelectronic Materials and Devices" (MATS 710), will be given in-house at NSU during Spring 2006 by NSU faculty using material and lectures developed during the 2005 offering. Supplemental visits from CMDITR faculty to deliver lectures on related and additional material are scheduled for the duration of this course in 2006.

A formative evaluation of the individual lectures gave strong results overall. Individual comments received from students were generally very positive and suggested that the course had succeeded in providing an overview of the science behind CMDITR research and had given the students an idea of the opportunities available in related fields. Sample comments include "the subject matter was interesting, it really grabbed my attention", "the examples used helped me understand the importance of my own research" and "[the course showed] what you can do with the degree afterwards".

The AMSE Ph.D. proposal is under consideration by the Commonwealth of Virginia, with a decision expected in Summer 2006. A recruitment workshop for students into the NSU ASME Ph.D. program to be held in Summer 2006 is currently in the planning stages.

Activity Name	Hooked-on-Photonics (HoP): Research Experiences for Undergraduates in Photonics
Led by	EPP and CMDITR faculty
Intended Audience	Undergraduates from Community Colleges with little to no research experience (Gateway students) along with upper-level undergraduates from 4-year institutions with some research experience (Capstone students).
Approx Number of Attendees	34

Hooked-on-Photonics is a summer program for undergraduates, providing research experiences in CMDITR laboratories. These opportunities serve as Gateway experiences for undergraduates who are exploring new academic pathways and as more traditional Capstone experiences for undergraduates who have chosen majors in topics related to CMDITR research areas. This program is administered across multiple partner campuses (UW, UA, GT, NSU). HoP has been very effective at leveraging funds and resources. In 2005, UW received an NSF-REU award to supplement STC funds. CMDITR has also leveraged resources at our campuses by partnering with existing minority student summer programs. These programs allow our students to participate in seminars, poster sessions, and social activities, giving them valuable instruction and a larger campus perspective at minimal cost to the Center.

This program seeks to address Goal 1.

Status: The REU program continues to improve in its ability to recruit and retain female, minority, and gateway students (see chart below). These numbers reflect our high priority on providing opportunities to students with little to no research experience and to encourage and empower them to choose careers in the physical sciences and engineering.

	Total	Gateway	Female	Minority URG
Summer 2004	22	6 (27%)	12 (55%)	3 (14%)
Summer 2005	34	15 (44%)	18 (53%)	14 (41%)
Summer 2006 (projected)	24	19 (79%)	15 (63%)	10 (42%)

Extensive evaluations of the REU program have been performed annually at the beginning and end of each summer. In particular, at the conclusion of the program, students were asked to evaluate specific aspects of the program and to provide an overall assessment of the experience. Overwhelmingly, students would recommend the REU as a valuable experience to other students. Students also reported that their involvement in the program influenced their educational and career goals, increased their interest in doing scientific research, and contributed to their personal growth.

Activity Name	Responsible Conduct of Research (RCR) Tutorial Modules
Led by	CMDITR Management Team
Intended Audience	All CMDITR Participants
Approx Number of Attendees	All CMDITR Participants

As required by our Cooperative Agreement with NSF, the RCR Tutorial Modules provide an initial certification in ethics training for all Center participants (defined as those working on CMDITR projects for more than 160 hours per year). This web-based certification consists of three modules: (1) Rights and Obligations; (2) Collaboration, Communication and Grants Management; and (3) Intellectual Property.

This program seeks to address Goal 3.

Status: Currently, 80% (172/216) of STC participants are certified through completion of our online RCR. Since the modules were implemented in Year 2, 330 STC members have completed the training (this number is indicative of the high turnover in membership, particularly as a result of our reorganization in Year-3). The web module materials are now being shared with other STC's and organizations with educational missions. Four other educational groups are currently registered to use the modules.

Activity Name	Responsible Conduct of Research (RCR) Discussion Series
Led by	Individual partner institutions
Intended Audience	CMDITR faculty, post-docs, graduate students
Approx Number of Attendees	30-50 per institution, per seminar

The RCR Discussion Series augments the ethics training provided by the RCR Tutorials by addressing topics directly related to CMDITR research.

This program seeks to address Goal 3.

Status: In year-4, UW, GT, and UA each hosted three seminars. Attendance and participation by CMDITR faculty, post-docs, and graduate students were high at all institutions. Each session consists of a presentation by the keynote speaker and group case-study discussion with graduate students and postdocs. Subjects included general topics such as Authorship,

Intellectual Property, and Stewardship of Data along with CMDITR-specific material such as societal implications of THz Imaging Spectroscopy and use of RFID-Tags.

Activity Name	Travel Grant Program
Led by	EPP
Intended Audience	Graduate students and post-docs
Approx Number of Attendees	21 applications approved for travel thru 9/06

The Travel Grant Program is designed to encourage CMDITR students and postdoctorates to take advantage of the unique collaborative opportunities available within our Center. CMDITR offers travel grants of up to \$1,000 for travel between institutions and related expenses for the purpose of Center-related work, including access to instrumentation, training, collaborative research, presentations, and development of educational material.

This program seeks to address Goal 2.

Status: Since inception in fall 2004, 21 student applications have been accepted with 7 trips funded thus far in Year-4 and at least 9 more to follow before 2007. Many recipients have shared the result of their collaborations by authoring articles for the CMDITR newsletter. Next year we anticipate growth in these numbers as graduate students and postdocs become more aware of this opportunity and as the CMDITR community continues to grow stronger. Nine female graduate students will use Travel Grants to participate in upcoming COACH Workshops at GT and the national ACS meeting in fall 2006. CMDITR participants may apply for a travel grant online at our Members Only website.

Activity Name	International Research Exchange Program
Led by	GT
Intended Audience	CMDITR Graduate students
Approx Number of Attendees	12

In December 2005, CMDITR received \$138,000 in supplemental funding from NSF's Office of Integrative Activities for an International Research Experience Program. The PI on this project is Prof. Elisa Riedo, Assistant Professor of Physics at Georgia Tech. This program will encourage strong collaborative ties between its investigators and groups of key international institutions that have interests in organic electronics and photonics.

This program seeks to address Goals 1, 2, and 4.

Status: The International Exchange Program will send approximately twelve CMDITR students abroad for a period of at least 8 weeks to a variety of institutions including the Chinese Academy of Science, Beijing, CHINA; Osaka University, JAPAN; Universite de Mons-Hainaut, BELGIUM; the Russian Academy of Sciences, Moscow, RUSSIA; and ETH, Zurich, SWITZERLAND. These institutions have been chosen because: 1) strong ties already exist between faculty at CMDITR and the proposed institution, 2) in most cases at least one mentor

at the host institution has spent time working at a home institution of CMDITR faculty, 3) Russia and China are countries with large and developing economies. In each case CMDITR faculty have personally contacted mentors who have expressed enthusiasm about this program from both technological and educational perspectives. We expect that at least half of our visits will be reciprocated by students from host institutions. Mentors with research interests in modeling, synthesis materials characterization, and device fabrication and modeling have been identified to ensure that a broad spectrum of students can be accommodated. The first set of exchange visits are planned for Summer 2006.

b. External Education Activities

As in previous years, a significant number of Center participants have been involved in communicating their research to the K-12 community and the general public. In 2005-2006, Center participants have been engaged in: (i) local science fairs, (ii) presenting lectures to the business community, (iii) presenting at teacher workshops, (iv) mentoring high school students and teachers and performing classroom science demonstrations; (v) disseminating news articles about center results to middle school students and the community. To highlight the interdisciplinary nature of CMDITR research, CMDITR faculty have been actively engaged in giving talks in academic departments external to their own disciplines, and have served as guest lecturers and have taught courses outside their own departments.

Activity Name	K-12 Web Modules
Led by	Neal Armstrong, Michael Bruck, Vicente Talanquer
Intended Audience	Students in grades 6-8, 912
Approx Number of Attendees	11 Teachers, ~1000+ students

This program develops web modules that allow users to explore specific scientific concepts primarily through a series of interactive web-based manipulatives. The modules are designed to support materials for core components of the physical science curriculum in grades 6-12, and are based on technical applications related to the Center.

This program seeks to address Goal 1.

Status: After the award of an Arizona Board of Regents Improving Teacher Quality grant (described in the previous Annual Report), Prof. Talanquer (UA) has worked with 11 secondary school science teachers from the Tucson area in the development of 8 additional web-based interactive educational modules. During the summer of 2005 the teachers worked with a team of scientists, web development experts and educational professionals to design the modules which were then developed by programmers during the Fall of 2005. The different modules *include a total of 29 interactive manipulatives* that can be used as stand-alone educational tools. The materials are currently being tested by secondary school teachers in their classrooms and will be ready for dissemination by the end of July 2006. During this year, Prof. Talanquer and his group also worked on the development of a website that gives students and teachers direct access to all modules (**a total of 16**) and manipulatives (**a total of 85**) in a variety of formats. Each module has been created to meet National Science Education Standards and AAAS Benchmarks.

Activity Name	Middle School Outreach via <i>SciScape</i>
Led by	EPP
Intended Audience	Middle school students and their science teachers
Approx Number of Attendees	Approx. 2,500

SciScape is an online magazine published by the University of Washington Department of Technical Communication aimed at cultivating among youth a life-long appetite for learning about developments in science and technology through the news media.

This program seeks to address Goal 4.

Status: An issue of *SciScape* online dealing with photonics content was developed and disseminated in the winter 2006 issue and a notice was sent by mail to teachers in Washington and Oregon about the launch of the website. The issue features the work of Profs. Jen, Mescher, and Kippelen.

Activity Name	Public Outreach via Northwest Science & Technology Online Magazine
Led by	EPP
Intended Audience	General Public, business community, local/national media, educators, legislators
Approx Number of Attendees	Many thousands of website visitors

CMDITR Guest speakers and articles about CMDITR research were a part of the UW science and technology writing program this year.

This program seeks to address Goal 4.

Status: An article on the Hooked-on-Photonics Program was disseminated in the fall 2005 issue of NWS&T Online.

Activity Name	Science in the City
Led by	Rachel Morgan Theall, Vicente Talanquer, Neal Armstrong
Intended Audience	Students in grades 9-12
Approx Number of Attendees	25 Students

This program works with Tucson-area high school students to create science exhibits that are important and relevant to their lives. Students identify scientific issues relevant to their community, pose researchable questions, then design and develop exhibits based on their research.

This program seeks to address Goal 1 and 4.

Status: In August of 2005 Dr. Morgan Theall received an NSF Discovery Corps Fellowship for this project (CHE 0513527). At the beginning of the 05-06 school year Dr. Morgan Theall identified and began working with 25 students from two local high schools to develop two separate exhibits. The schools are both minority-serving institutions, with an average of 41% Hispanic and African American students. During after-school clubs and a specially designed class these students researched a topic of their choosing and planned an exhibit. Topics chosen were caffeine and alternative fuels. The students are currently in the final stages of building and beta-testing their exhibits at local science fairs and community events. Flandrau Science Center committed to displaying both exhibits at their current location on the University of Arizona campus in Fall 2006. Dr. Morgan Theall has identified two additional schools to work with during the next academic year.

c. Integrated Research and Education

All EPP programs are designed to be integrated closely with CMDITR research. In this regard, many of the efforts of the Center are detailed in the individual activity descriptions given above. In particular, material for our cross-disciplinary graduate courses is based on state-of-the-art research from CMDITR laboratories. CMDITR faculty and students are encouraged to contribute actively to the development of this material. Some have already taken advantage of the lecture-capture technology by, for example, employing Tegrity to pre-record their presentations for the CMDITR Annual Retreat.

In addition, the Center actively encourages participants to see the integration of education and research through a variety of methods. Throughout our Annual Retreat, education and research issues are considered in tandem. Research session participants were asked to consider questions regarding what educational materials and curriculum components may be needed to support future research in their area. Educational opportunities are closely tied with research articles in our reformatted newsletter, "Light Works" <http://www.stc-mditr.org/newsletter/>. We have also prepared a CMDITR handbook as a useful resource for CMDITR participants, enabling them, for example, to quickly look up a member's telephone number, to discover the research expertise of an unfamiliar professor, or to locate a specialized piece of equipment.

d. Professional Development Activities

Many Center students and post-docs have attended professional conferences, both nationally and internationally; more than 25 posters or talks were given at regional or national meetings. CMDITR students have attended or will attend professional development events such as GEM's Future Faculty and Professionals Symposium and the COACH Workshop series (detailed description in Section V). An entire afternoon at the 2006 CMDITR Annual Retreat in Tucson was devoted to an excellent Career Development Workshop for students and postdocs, led by Prof. Denise Wilson.

3. FUTURE DIRECTIONS

Our plans for the next reporting period focus on the further development and implementation of undergraduate and graduate-level education programs, specifically continued progress towards the creation of interdisciplinary courses for CMDITR students and assistance with the realization

of the AMSE Ph.D. program at NSU. We will continue to work closely with external evaluators to guide and inform the progress of these projects.

4. EXTERNAL EDUCATION PARTNERSHIPS

CMDITR members have been interacting with local schools, colleges, and educational initiatives to establish a broad network of partnerships to enhance interest in and awareness of science and engineering research and also specific CMDITR research activities. Examples include:

- Hooked-on-Photonics REU: Sara Selfe, a faculty member at Edmonds Community College, WA is co-PI on this program.
- Norfolk State University: our collaboration to assist with the development of instructional materials for their forthcoming new Ph.D. program in Advanced Materials Science and Engineering has been described in detail above. This collaboration has stimulated interest towards increasing interactions with other HBCUs including Jackson State University and Alabama A&M.
- Members of the Bredas and Marder research groups at GT have participated in several high-school and undergraduate teaching initiatives in the Atlanta area, including GIFT (Georgia Intern Fellowships for Teachers), STEP (Student and Teacher Enhancement Program) and AURA (Atlanta Undergraduate Research Association).
- Prof. Marder is an active member of the Focus Research Program at Georgia Tech. A new proposal was submitted that, if funded, will enable implementation of RCR training across all departments at Georgia Tech.
- Flandrau Science Center: Rachel Morgan-Theall at UA has an ongoing collaboration with the Flandrau Science Center in Tucson; her NSF Discovery Corps Fellowship will enable continuation of this partnership and will lead to science exhibits designed by high-school students on permanent display in the museum.
- Improving Teacher Quality program: Vicente Talanquer at UA leads this professional development opportunity for Arizona high school teachers as described above. In addition, Prof. Talanquer took part in several workshops and presentations for Tucson-area high school teachers, students and their parents.
- Prof. Peyghambarian and graduate students from UA have participated in the 'Upward Bound' program at Diné College, a program providing educational services and college preparatory assistance to area high school students located at Diné College on the Navajo Reservation in Northern Arizona. CMDITR funded a postdoctoral researcher to teach a general science course at Diné in Summer 2005.