

# I-STEM

EDUCATION INITIATIVE

Science, Technology, Engineering, and Mathematics Education | University of Illinois at Urbana-Champaign

## I-STEM EDUCATION INITIATIVE ANNUAL REPORT

January 2013



 ILLINOIS

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## From the Desk of the I-STEM Director

As the state of Illinois and the nation face severe economic challenges, issues of STEM preparedness, workforce development, and global competitiveness assume even greater importance in determining our future. *Illinois* faculty, staff, and students; our external education and business partners; and peer institutions across the nation are all eager for new opportunities in science, technology, engineering, and mathematics. Our collective desire is to increase students' interest and engagement in STEM disciplines; create accessible, high-quality STEM programs at all levels; improve the magnitude and quality of our STEM workforce, including teachers; and advocate for policies and funding to support STEM education in Illinois and the nation at large. Much of what we have done since the creation of I-STEM is to bring together these interest groups, explore common interests and promote collaboration, and define a program of work around our shared goals. The momentum continues to increase as we identify more and more areas of synergy, opportunities for federal and state support, and exciting partners. We are beginning to see the benefits of increased collaboration and entrepreneurship in STEM education and are hopeful that the energy and impact will continue to grow in 2013!



A handwritten signature in white ink, which appears to read "Lizanne DeStefano".

Lizanne DeStefano  
Director

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# I-STEM PARTNERS



## COLLEGES AND SCHOOLS

- College of Agricultural, Consumer, and Environmental Sciences
- College of Applied Health Sciences
- Institute of Aviation
- College of Business
- College of Education
- College of Engineering
- College of Fine and Applied Arts
- Division of General Studies
- Graduate College
- School of Labor and Employment Relations
- College of Law
- College of Liberal Arts and Sciences
- Graduate School of Library and Information Sciences
- College of Media
- College of Medicine
- School of Social Work
- College of Veterinary Medicine

## CAMPUS UNITS

- Beckman Institute for Advanced Science & Technology
- Center for Education in Small Urban Communities
- Division of Biomedical Sciences
- Institute for Genomic Biology
- Office for Mathematics, Science, & Technology Education
- NCSA (National Center for Super-Computing Applications)
- University of Illinois Extension-4H
- Osher Lifelong Learning Institute

## EXTERNAL PARTNERS

- American Chemical Society
- American Physical Society
- American Society of Materials



## EXTERNAL PARTNERS (CONTINUED)

- Association of Public Land-Grant Universities (APLU)
- Caterpillar Foundation
- Chicago Community Trust (CCT)
- Chicago Public Schools (CPS)
- Department of Commerce & Economic Opportunity (DCEO)
- FIRST/FIRST Lego League
- Illinois Biotechnology Industry Organization (iBIO)
- Illinois Business Roundtable (IBRT)
- Illinois Math and Science Academy (IMSA)
- Illinois Science Olympiad
- Illinois Science Teachers Association (ISTA)
- Illinois State Board of Education (ISBE)
- John Deere Foundation
- Museum of Science and Industry
- National Center for Women in Information Technology
- Office of the Governor, State of Illinois
- O'Donnell Wicklund Pigozzi & Peterson, Inc. (OWP/P)
- Physics Teacher Education Coalition
- Saint Louis Science Center
- Urban Schools Initiative
- University of Illinois at Chicago

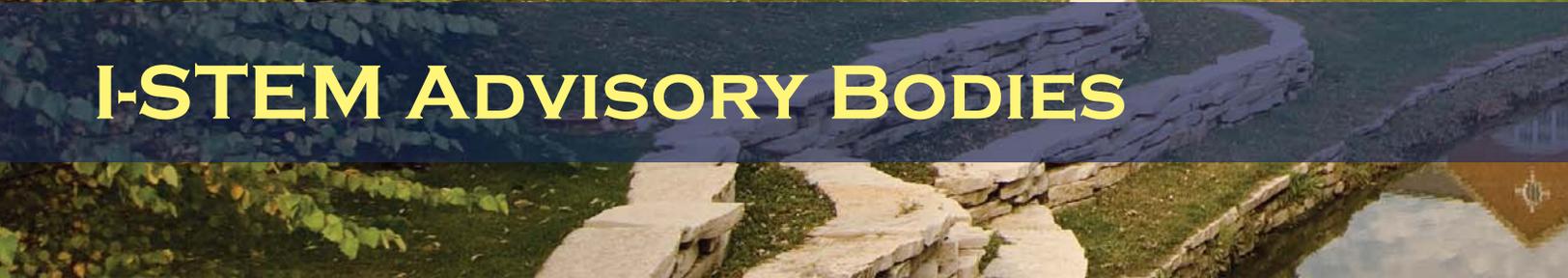
## LOCAL PARTNERS

- Booker T. Washington STEM Academy
- Campus Middle School for Girls
- Champaign Unit 4 School District
- Champaign-Urbana Community Fab Lab
- Champaign-Urbana Schools Foundation
- Don Moyer Boys and Girls Club
- McClain County Unit 5 School District
- Thornton Community Unit High School District 205
- University Laboratory High School
- Urbana School District 116





# I-STEM ADVISORY BODIES



## CAMPUS COUNCIL OF DEANS

- Robert Hauser, Dean, Agricultural, Consumer, and Environmental Sciences
- Tanya Gallagher, Dean, Applied Health Sciences
- Tom Emanuel, Interim Director, Institute of Aviation
- Larry DeBrock, Dean, Business
- Mary Kalantzis, Dean, Education
- Michael Bragg, Interim Dean, Engineering
- Edward Feser, Dean, Fine and Applied Arts
- Keith Marshall, Associate Provost and Executive Director, Campus Center for Advising and Academic Services
- Joe Martocchio, Interim Dean, Labor & Employment Relations
- Bruce Smith, Dean, Law
- Ruth Watkins, Dean, Liberal Arts and Sciences
- Allen Renear, Interim Dean, Library and Information Science
- Jan Slater, Interim Dean, Media
- Uretz Oliphant, Interim Regional Dean, Medicine
- Wynne Korr, Dean, Social Work
- Herbert Whiteley, Dean, Veterinary Medicine

## CAMPUS ADMINISTRATION

- Robert Easter, President of the University of Illinois
- Phyllis Wise, Vice President and Chancellor
- Ilesanmi Adesida, Provost & Vice-Chancellor for Academic Affairs
- Peter Schiffer, Vice-Chancellor for Research
- Renée Romano, Vice Chancellor for Student Affairs
- Dan Peterson, Vice Chancellor for Institutional Advancement
- Debasish Dutta, Associate Provost & Dean, Graduate College
- Jimmy Hsia, Associate Vice Chancellor for Research for New Initiatives



## **CAMPUS INTERDISCIPLINARY UNITS**

- Jennifer Eardley, Interim Director, Division of Biomedical Sciences
- Gene Robinson, Director, Institute for Genomic Biology
- Art Kramer, Director, Beckman Institute
- Thomas Dunning, Director, National Center for Supercomputing Applications (NCSA)

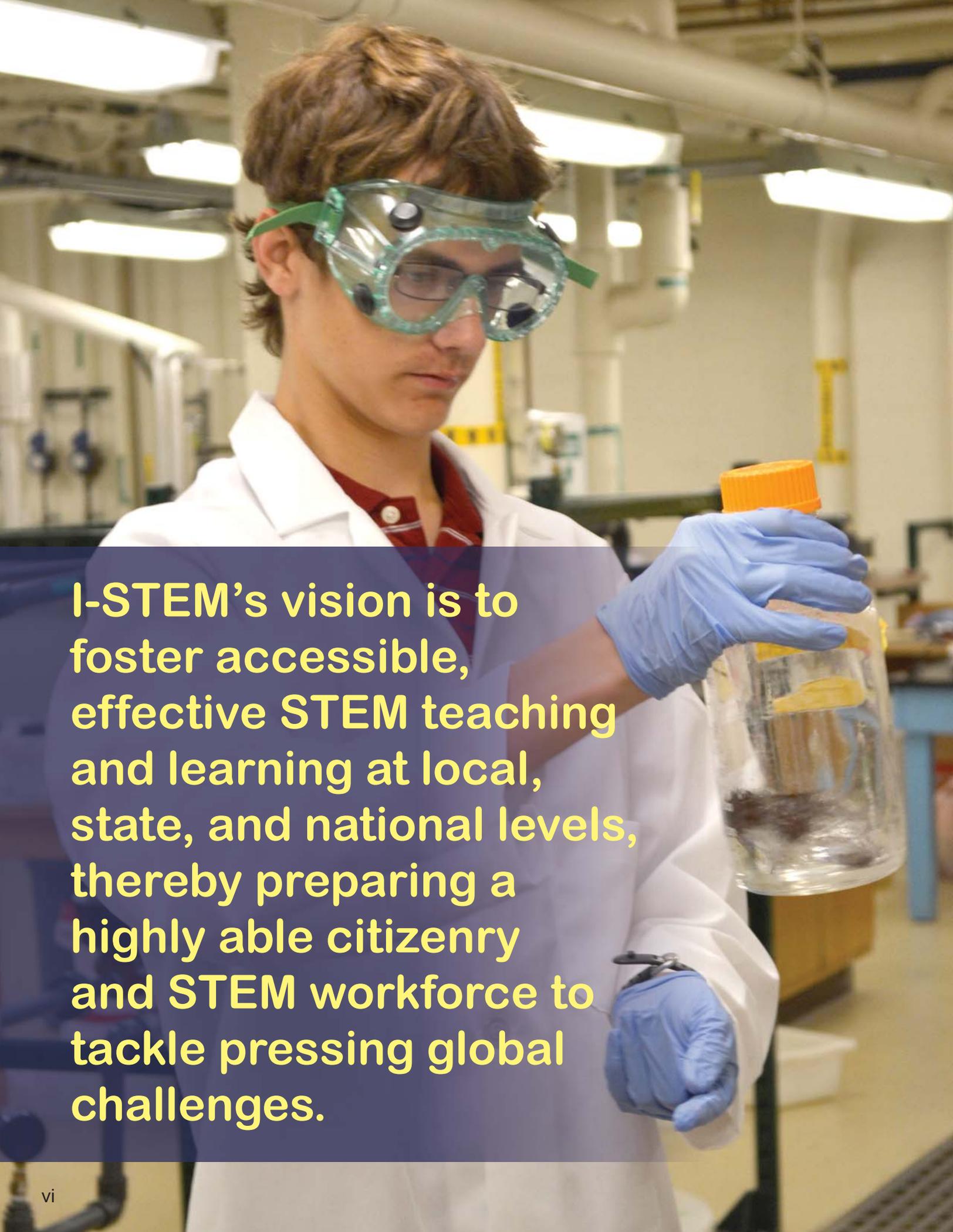
## **I-STEM EXTERNAL ADVISORY BOARD**

- Jason Tyszko, Deputy Chief of Staff, Department of Commerce and Economic Opportunity, and Office of the Governor, State of Illinois
- Max McGee, President, Illinois Mathematics and Science Academy
- Judy Wiegand, Superintendent, Champaign Unit 4 School District
- Preston Williams, Superintendent, Urbana School District 116
- Gail Rost, Executive Director, Champaign Urbana Schools Foundation

## **I-STEM CORPORATE ADVISORY BOARD**

- Caterpillar Foundation
- Motorola Foundation
- Abbott Laboratories
- Boeing Company
- John Deere Foundation
- State Farm Foundation



A young man with brown hair, wearing a white lab coat over a maroon shirt, safety goggles, and blue gloves, is holding a clear plastic bottle with an orange cap. He is looking down at the bottle, which contains a dark substance. The background shows a laboratory setting with various equipment and bright lights.

**I-STEM's vision is to foster accessible, effective STEM teaching and learning at local, state, and national levels, thereby preparing a highly able citizenry and STEM workforce to tackle pressing global challenges.**

# I-STEM's Mission and Goals

**I-STEM** (the *Illinois* Science, Technology, Engineering, and Mathematics Education Initiative) completed its fourth full year of operation in January 2013. I-STEM further developed its role in support of STEM education at the University of Illinois at Urbana-Champaign (*Illinois*) as it partnered with STEM education academic units and major research units on campus and increased the number of partners across the state of Illinois and the nation. While striving to fulfill its mission to improve the access, quality, and efficiency of STEM education activities at *Illinois* and throughout the state, I-STEM has also begun to serve as a model for other universities seeking to improve the number and quality of their own STEM education programs.

## WHY A CAMPUS FOCUS ON STEM EDUCATION?

Our world increasingly relies on science and technology to solve some of today's most intractable problems. As noted in the National Academy of Sciences report, *Rising Above the Gathering Storm* (2005 & 2010), U.S. student interest and performance in science, technology, engineering, and mathematics (STEM) fields is in decline. Perhaps at no time in our nation's history has a strong, comprehensive system of education been so essential. As challenges mount in such areas as national defense, climate change, health, energy, economic growth, food safety and accessibility, and environmental protection, so does the demand for highly able scientists, engineers, and health professionals. As the flagship campus of one of the nation's premier land-grant research universities, *Illinois* is committed to playing an active role in the improvement of STEM education at all levels.

I-STEM is organized around four primary goals, which are:

- ◆ **Goal 1: Facilitate P–16 STEM Education Outreach.** Cultivate sustained, coordinated preschool through undergraduate partnerships to engage students in STEM experiences early and consistently, involving university faculty and students to meet STEM education challenges.
- ◆ **Goal 2: Improve STEM Teacher Training and Professional Development Quality.** Revitalize STEM teacher preservice education, induction, and professional development programs that attract and prepare a diverse group of P–16 STEM teachers and promote their effectiveness, retention, lifelong learning, and continued involvement in research.
- ◆ **Goal 3: Foster Undergraduate and Graduate STEM Education Reform.** Stimulate accessible, engaging, undergraduate and graduate STEM programs and research experiences to promote interest and success in STEM fields, including teaching, for diverse students.
- ◆ **Goal 4: Shape Policy and Advocate for STEM Education.** Stimulate partnerships with Illinois business and industry, government agencies, educational institutions, and professional associations to understand the STEM pipeline, mainline and workforce development needs, opportunities, and challenges, and to serve as advocates within the state.

*I-STEM's mission is to improve the access, quality, and efficiency of STEM education activities on the Illinois campus and throughout the state.*



Above: During an outreach activity at Booker T. Washington STEM Academy, a local student uses a flashlight in a darkroom to study the color spectrum in white light. Opposite (p. vi): A local high school student experiences authentic research in an *Illinois* lab.



Above: A GIRRRLS camper makes mirrors for a kaleidoscope. Below, a GIRRRLS camper participates in Nano-CEMMS activity making a superball from polymers.



## OVERVIEW OF I-STEM YEAR FOUR ACTIVITIES

During its fourth year of operation, I-STEM performed a variety of activities, both to foster STEM education locally, in the state, and in the nation, and to serve as a resource to improve/increase STEM education on campus. Major I-STEM activities in 2012 included:

- 1. Fostering dialogue among key campus and external stakeholders**, including internal and external advisory bodies and partners, to discuss ways to improve STEM education on campus, in the state, and throughout the nation (see pages ii–iii for lists of I-STEM partners and pages iv–v for lists of I-STEM advisory bodies).
- 2. Working with campus units to plan, develop, and submit external funding proposals for STEM education.** I-STEM personnel, who have significant expertise in both education and evaluation of educational programs, were key in the development of education and/or evaluation components for numerous proposals. I-STEM will be evaluating these projects should they receive funding.
- 3. Enabling discourse and networking among STEM educators about effective pedagogy and program components** via meetings, seminars, presentations, and discussion groups, such as the Biology Coordinating Committee; interactive directories; and a campus-wide listserv (see I-STEM's communication resources below).
- 4. Disseminating information about campus STEM education programs and funding opportunities.** I-STEM's website plays a prominent role in highlighting effective programs/funding sources that promote, foster, and improve STEM education for I-STEM's four target groups (see communication resources below and on page 37).
- 5. Promoting K-12 Outreach Activities.** I-STEM staff played significant roles in a variety of K-12 outreach activities during 2012, such as the Illinois Science Olympiad, I-STEM's High School Research Experience, and STEM education camps and technology clubs in a number of schools, such as Booker T. Washington.
- 6. Helping to improve campus STEM education programs by performing summative and formative evaluations.** I-STEM evaluates numerous programs, which are listed and described throughout this report.

## COMMUNICATION RESOURCES

- **I-STEM Website.** Incorporates information from a variety of sources to produce and maintain focused, current information on campus STEM education activities for both internal and external audiences. Resources, such as the Directory of Externally-Funded Projects and STEM Education Funding Opportunities by I-STEM Goal are organized by target group. url: <http://www.istem.illinois.edu>
- **I-STEM-News Listserv.** Provides campus community, faculty, and staff with announcements of STEM education funding opportunities and events, such as seminars, meetings, and workgroup activities. url: [listserv@listserv.illinois.edu](mailto:listserv@listserv.illinois.edu)
- **I-STEM Affiliates Directory.** Provides visibility to individuals involved in STEM education research, programming, training, outreach, and policy activities. url: [http://www.istem.illinois.edu/resources/affiliates\\_A.html](http://www.istem.illinois.edu/resources/affiliates_A.html)
- **Public Engagement Portal.** This campus outreach activities database includes campus STEM education outreach programs. url: <http://engage.illinois.edu/>

## I-STEM'S ROLE IN FOSTERING STEM EDUCATION

I-STEM's involvement in facilitating STEM education targets four goals/audiences—K-16 students, STEM educators, undergraduate/graduate students, and STEM education policymakers (see page 1 for goal descriptions)—both on campus, throughout the state of Illinois, and in the nation. To accomplish its goals, I-STEM seeks to 1) foster communication and collaboration via networking and/or partnering; 2) provide funding opportunity information and assist with grant writing; 3) provide expertise on evaluation and/or education; and 4) disseminate information about campus STEM education programs and outreach.

**Foster Communication/Collaboration.** I-STEM holds regular meetings with STEM education coordinators from campus colleges and units and with STEM researchers who want assistance in implementing education, outreach, or evaluation components in their projects. The I-STEM-News listserv facilitates communications about STEM education seminars, meetings, and working groups; the I-STEM Affiliates Directory fosters networking and collaboration. (See opposite page and page 37 for lists of communication resources and online access links).

**Provide Funding Opportunity Information.** I-STEM's website offers several resources regarding current STEM education funding opportunities involving our target groups of P-16 students, STEM educators, undergraduate/graduate students, and policymakers: Upcoming Funding Deadlines<sup>1</sup> lists imminent deadlines by date; STEM Education Funding Opportunities<sup>2</sup> presents the information by I-STEM goal. The I-STEM-News listserv apprises *Illinois* researchers about upcoming funding opportunities. Also, I-STEM staff have worked with numerous researchers in writing proposals or by contributing evaluation or education components.

**Provide Evaluation/Education Expertise.** To assess the impact of outreach activities, teacher development, reform efforts for undergraduate/graduate programs, or policy, both to improve STEM education in a variety of settings and to improve recruitment to *Illinois*, I-STEM continues to serve in an evaluation capacity for a number of programs and also serves in an advisory capacity to units who want to add education components to their research grants/projects. In these roles, I-STEM continues to gather information about our target groups and the impact programming is having on instruction, student achievement, and recruitment into STEM fields.

**Disseminate STEM Education Program Information.** I-STEM works to disseminate information to stakeholders in a variety of ways. I-STEM's Externally Funded Projects Directory includes sections targeting K-16 students, STEM educators, undergraduate/graduate students, and STEM education policymakers. Routine maintenance of these resources involves on-going research to catalog and make available information about newly awarded funding with STEM education components or funding opportunities based on I-STEM's four goals. While I-STEM's primary method of disseminating information is through the website, information is also sent electronically via email and the I-STEM-News listserv and electronic and printed materials, including evaluation reports, I-STEM's annual report, flyers, and posters.

<sup>1</sup><http://www.istem.illinois.edu/funding/upcomingdeadlines.html>

<sup>2</sup><http://www.istem.illinois.edu/funding/fundingopp.html>

## GLOSSARY OF TERMS

- APLU: Association of Public and Land-grant Universities
- CCLI: Course, Curriculum, and Laboratory Improvement
- CCMB: Cellular & Molecular Mechanics & BioNanotechnology
- CPS: Chicago Public Schools
- EBICS: Center for Emergent Behaviors of Integrated Cellular Systems
- EnLiST: Entrepreneurial Leadership in STEM Teaching & Learning
- FIPSE: Funding for the Improvement of Post-Secondary Education
- G.A.M.E.S.: Girls' Adventures in Mathematics, Engineering, and Science
- ICLCS: Institute for Chemistry Literacy through Computational Science
- IGERT: Integrative Graduate Education & Research Traineeship
- iEFX: Illinois Engineering Freshman Experience
- iRISE: Illinois Researchers in Partnership with K-12 Science Educators
- ISO: Illinois Science Olympiad
- M-CNTC: Midwest Cancer Nanotechnology Training Center
- MIST: Merit-Based Immersion for Students & Teachers
- NanoCEMMS: Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems
- NCSA: National Center for Supercomputing Applications
- NSF: National Science Foundation
- PD: Professional Development
- REU: Research Experiences for Undergraduates
- SMTI: Science and Mathematics Teacher Imperative
- USI: Urban Schools Initiative
- XSEDE: Extreme Science and Engineering Discovery Environment

A young boy with short dark hair, wearing a dark blue zip-up jacket, is looking up and to the right with a wide, happy smile. His hands are held out in front of him, palms up. To his right, an adult's hand is holding a large, green and yellow grasshopper. The background shows a classroom setting with a wooden cabinet and a black metal frame. The text is overlaid on a dark blue semi-transparent box on the left side of the image.

**I-STEM is partnering with local schools, such as Booker T. Washington STEM Academy, to foster interest in science among Illinois K–12 students.**

# Goal 1: Facilitate P–16 STEM Education Outreach

## P-16 STEM EDUCATION OUTREACH ACTIVITIES

Following are the types of P–16 STEM education outreach activities in which I-STEM was involved in 2012, including specific partners or projects with whom staff collaborated or about whom I-STEM disseminated information.

### ◆ Identify campus STEM P–16 outreach activities.

*Illinois* hosts numerous STEM Education P–16 outreach activities sponsored by individual faculty, units, or colleges. I-STEM has been systematically identifying and prominently displaying these outreach activities via the I-STEM website. Information about activities is organized by stakeholder group, including *P–16 teachers*<sup>3</sup> seeking professional development or to reinforce STEM classroom instruction with additional activities for their students, and parents (and/or the students themselves) seeking STEM education opportunities in the form of *summer camps*<sup>4</sup> or *academic year activities*.<sup>5</sup>

I-STEM has also identified a number of programs which serve as examples of highly effective STEM education P–16 outreach programs, such as I-STEM’s High School Research Experience (see page 11), Research Experiences for Undergraduates (see page 30), and the G.A.M.E.S. Camp (see page 8). Many of these were featured on the I-STEM website in 2012.

### ◆ Partner with state and national organizations.

To ensure that *Illinois* is strategically positioned to promote collaboration and leverage resources to improve STEM education experiences for P–16 students in the state, especially those from underrepresented groups, in 2012, I-STEM partnered with several state and national STEM P–16 outreach entities, such as the Illinois P-20 Council (see page 9), the Illinois Science Olympiad (see page 10), and the Saint Louis Science Center (see page 12).

### ◆ Evaluate P–16 STEM outreach activities.

In order to improve the impact of *Illinois*’ STEM P–16 outreach activities, I-STEM continues to assess programs to systematically collect standardized data on participant and school demographics, satisfaction, and impact on STEM interest and content knowledge. These data, aggregated, represent campus-level impact and assess the degree to which *Illinois*’ STEM outreach activities are easily accessed by families and educators, extend across all grade levels, align with local school needs, and attract demographically diverse participants. Table 1, which follows on page 6, lists selected P–16 outreach programs I-STEM evaluated in 2012.



Above: A CPS student examines an insect at the Pollinarium during a campus tour. Opposite on page 4: A Booker T. Washington student enjoys an outreach event presented by *Illinois* entomologists.

***In 2012, I-STEM partnered with several state and national STEM P–16 outreach entities, such as the Illinois P-20 Council, the Illinois Science Olympiad, and the Saint Louis Science Center.***

<sup>3</sup><http://www.istem.illinois.edu/resources/goal2resources.html#teacherdevelop>

<sup>4</sup><http://www.istem.illinois.edu/resources/goal1resources.html#summercamps>

<sup>5</sup><http://www.istem.illinois.edu/resources/goal1resources.html#acadyear>



**Table 1: Selected P-16 Outreach Programs Evaluated by I-STEM**

Program	Principal Investigator(s)
CMMB (Cellular & Molecular Mechanics & BioNanotechnology) IGERT (Integrative Graduate Education & Research Traineeship)	Rashid Bashir, Electrical & Computer Engineering & Bioengineering; Martha Gillette, Cell & Developmental Biology; Jimmy Hsia & Taher Saif, Mechanical Science & Engineering
EBICS (Center for Emergent Behaviors of Integrated Cellular Systems) High School Research Program	Rashid Bashir, Engineering Lizanne DeStefano, I-STEM
M-CNTC: Midwest Cancer Nanotechnology Training Center	Rashid Bashir, Electrical & Computer Engineering; Ann Nardulli, Molecular & Integrative Physiology
Nano-CEMMS: Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems: K-12 Education Programs	Placid Ferreira & John Rogers, Engineering
Neuroengineering IGERT	Douglas Jones, Electrical & Computer Engineering
Research Experiences for Undergraduates (REU) for 1) Chemistry, 2) EBICS, and 3) Nano-CEMMS	1) Alexander Scheeline, Chemistry 2) Rashid Bashir, Engineering 3) Placid Ferreira & John Rogers, Engineering
XSEDE (Extreme Science and Engineering Discovery Environment)	John Towns, NCSA (National Center for Supercomputing Applications)
VINTG (Vertically Integrated Training with Genomics) IGERT	Andrew Suarez, Entomology



Clockwise from above: Camp instructor Drew Coverdill shows campers how to fill a bottle rocket in preparation for launching it. Left: Campers fill a bottle rocket prior to launch. Top left: I-STEM Associate Director Robert Coverdill helps a camper fly the glider she built during the 2012 Uni High Summer Enrichment Camp engineering session.

◆ **Work with and disseminate information about STEM P-16 partners and campus STEM demonstration sites.**

To help *Illinois* attain its goal of reaching 100% of local elementary, middle, and secondary school students annually through campus STEM outreach, and to ensure that activities span all age ranges and demographic groups, campus STEM demonstration sites are working to increase recruitment of local schools not engaged with STEM outreach and boosting outreach activities for primary and middle school students. In 2012, more than 2500 local school students engaged with STEM researchers either during visits to the *Illinois* campus or off-site activities. I-STEM continued to identify and promote *Illinois*' numerous P-16 STEM outreach activities, featuring a number on its website.

◆ **Increase the number of Chicago Public School students who graduate from *Illinois* in STEM.**

This campus strives to repeatedly engage talented 7th through 11th grade Chicago Public School (CPS) students via after-school programs, summer camps, mentors, internships, and campus visits through programs like the Urban Schools Initiative in order to increase the number of CPS students graduating from *Illinois* in STEM fields.



A CPS student helps Physics Professor Kevin Pitts demonstrate the conservation of angular momentum.



Above: A CPS student on a campus tour experiences the electrifying effect of a Van de Graaff generator. Right: An *Illinois* graduate poses with her parents during commencement in 2012.

*This campus strives to repeatedly engage talented 7th through 11th grade CPS students via after-school programs, summer camps, mentors, internships, & campus visits.*





Counterclockwise from above: Students use lasers to measure light transmission in Bioengineering professor Sua Myong's after-school program at Jefferson Middle School. Below: Professor Myong works with a student during a lesson on plasmids. Bottom right: Campers cheer on their robots during the Robotics session of the G.A.M.E.S. camp for high school girls.



## ◆ Increase external funding for P-16 STEM education and outreach.

To establish an adequate, sustainable campus funding base of \$2 million for STEM education outreach, I-STEM participated in the submission of more than 50 external funding proposals totalling approximately \$44 million in requested funds for P-16 STEM education and outreach in 2012. Efforts are also being made to centralize funds awarded to campus by NSF's Education and Human Resources Directorate (approximately 15% of direct costs) to support a sustainable P-16 STEM education outreach program (see page 37 for a list of I-STEM funding resources).

## P-16 STEM EDUCATION OUTREACH PROGRAMS

**Booker T. Washington STEM Academy (BTW).** In 2012, I-STEM continued its partnership with BTW; I-STEM staff collaborated with school staff, providing support on a number of projects, including a poster presentation on University/BTW partnerships presented at the 2012 Public Engagement Symposium, an after-school technology club planned and run by Mechanical Science and Engineering students, and BTW's first STEM summer camp.

**DNA/Cell Measurement After-School Program.** The brainchild of Bioengineering professor Sua Myong, this year-long, after-school outreach program funded by the Center for the Physics of Living Cells exposed Jefferson Middle School students to techniques used to measure things in cell biology. Using lots of hands-on activities, the program sought to make science fun and approachable, while exposing Bioengineering undergrads, who helped plan and teach the lessons, to science education as a potential career choice.

**G.A.M.E.S.** Girls' Adventures in Mathematics, Engineering, and Science, an annual week-long camp, offered academically talented middle-school girls an opportunity to explore engineering and scientific fields through demonstrations, classroom presentations, hands-on activities, and contacts with women in these exciting technical fields. Data have shown that participating in G.A.M.E.S. increased girls' engineering content knowledge and helped change their attitudes about women in engineering and what it means to be an engineer.





**Illinois Math and Science Academy (IMSA).** I-STEM shares IMSA's goal of improving STEM education, talent development, and teacher preparation and professional development in the state of Illinois. In 2012, Dr. DeStefano worked with IMSA on assessment and accountability programs.

**Illinois P–20 Council.** The state of Illinois P–20 Council<sup>6</sup> has been charged with guiding education policy and developing an integrated P–20 system in Illinois. As Coordinator of the Council, Dr. DeStefano serves on all Council committees. Several made significant progress in 2012, including the Educator Licensure Steering Group, which reviewed and made recommendations to the state regarding potential grade span configuration, teacher preparation, and the educator pipeline. The Postsecondary and Workforce Readiness subcommittee drafted a definition of “College and Career Readiness” for the state. The Longitudinal Data System (LDS) working group developed a governing structure for the LDS, while the Military Council Steering Committee sought educational opportunities for the children of military families.

<sup>6</sup><http://www2.illinois.gov/gov/P20/Pages/default.aspx>



Clockwise from above: During an outreach activity at BTW, a local student discovers what's inside a ball and the properties that make balls bounce. Below: During an iRISE hands-on activity, an Edison Middle School student explores the properties of light that make a laptop monitor work. Bottom left: Jefferson Middle School students use lasers to measure light transmission during Myong's after-school program. Upper left: Campers cheer on robots executing the programs they wrote during the G.A.M.E.S. camp for high school girls.





Clockwise from above: A 2012 Illinois Science Olympiad Tournament (ISO) contestant competes in the Microbe Mission event. Upper right: Two ISO contestants prepare for the Robotics event during the tournament held on campus in April 2012. Bottom right: A high school student participating in I-STEM's High School Research Experience is exposed to research in an *Illinois* lab. Bottom left: Two ISO contestants wait to compete in their Food Science event.

**Illinois Science Olympiad Competition.** *Illinois* hosted the Illinois Science Olympiad (ISO) State Tournament in April 2012, with 1800+ student participants representing all regions of the state. I-STEM staff were involved in preparations and also volunteered in a number of capacities during the competition, including photography, hospitality, and the closing awards ceremony. In addition, in 2012, I-STEM held meetings to recruit current *Illinois* students who are former Science Olympiad participants to help in local competitions and schools interested in starting Science Olympiad programs. Assisted by Associate Director Robert Coverdill, these students formed a registered student organization, the Science Olympiad Alumni Association.





Clockwise from above: Illinois Science Olympiad contestants prepare for launch in the Bottle Rocket event. Top right: Edison middle school student displays her work during a hand-on lesson taught by Nano-CEMMS educators. Bottom right: Booker T. Washington kindergartener uses polymers to make a superball during a hands-on project taught by Nano-CEMMS educators. Bottom left: Nano-CEMMS educator Joe Muskin helps a BTW student drill a hole in a golf ball during the superball hands-on activity.

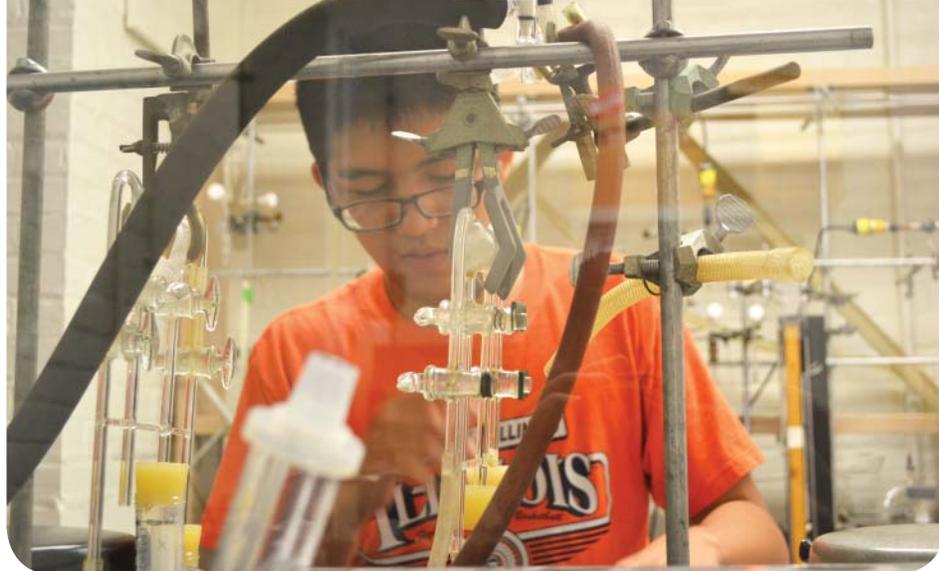


**I-STEM High School Summer Research Experience.** In 2012, I-STEM offered summer research experiences to 25 students from two local high schools, University Laboratory High School and Central High School. Chosen on the basis of both their performance in STEM and an essay on their interest in science and how participating would prepare them for a possible career in science, these students received an authentic research experience in *Illinois'* state-of-the-art labs and were mentored by some of the premier researchers in their fields.

**Nano-CEMMS K–12 Education Programs.** I-STEM is evaluating the Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems education programs: in-school, K–12 programs on nanotechnology-related topics and future nanotechnology career opportunities, and an after-school program for high school students. In 2012, I-STEM also featured Nano-CEMMS' education coordinators and innovative K-12 outreach programs in a number of web articles.

*Through I-STEM's High School Summer Research Experience 2012, students received an authentic research experience and were mentored by some of the premier researchers in their fields.*





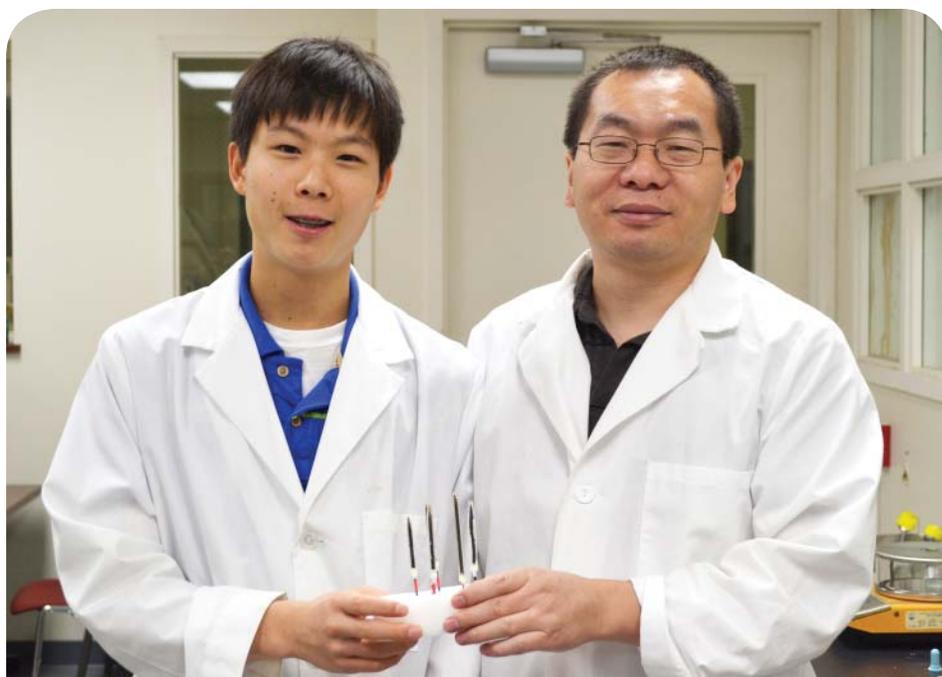
**Saint Louis Science Center.** In 2012, I-STEM established a partnership with the Saint Louis Science Center, whose mission is informal science education. I-STEM Director, Lizanne DeStefano, represented the University at meetings of the Center’s Board of Trustees, working to encourage increased collaboration between the Center and the University.

**Technical Assistance for Student Assignment Plans (TASAP).** In 2012, I-STEM evaluated TASAP, Champaign School District Unit 4’s plan to promote educational equity via a choice-based, race-neutral student assignment plan to assign students to schools within the district.

**UIC College Preparatory High School Campus Visit.** I-STEM arranged a campus visit for 179 juniors from this Chicago school. Students had an opportunity to learn about the application process at *Illinois*, tour campus, and were treated to demonstrations by Food Science and Human Nutrition and Chemistry instructors.

**University Laboratory High School Summer Enrichment Camp.** Uni High’s summer camp not only exposes local, underserved youngsters to STEM disciplines, but also gives Uni High students who serve as camp counselors a more diverse, global perspective while introducing teaching in STEM education as a viable career choice.

Clockwise from above: A high school student performs research in an *Illinois* lab. Top right: A local student analyzes bone samples in Dr. Kristin Hedman’s lab. Bottom right: A high school researcher with Dr. Junhua Jiang, Illinois Sustainable Technology Center Senior Research Engineer. Below: A student helps Dr. Jerrod Henderson explore the impact of dyes on cell growth.





**Urban Schools Initiative.** I-STEM is partnering with the Urban Schools Initiative (USI) to establish and retain Science Olympiad teams in Illinois urban schools. USI included 26 CPS middle and high schools (360+ students) in the 2011–2012 school year. In 2012, I-STEM staff worked to foster relationships with several Chicago Public Schools and other school districts throughout the state who have expressed an interest in developing teams. In addition, I-STEM hosted a visit by ten USI high school and middle school teams, who experienced campus as VIP guests of the University the day before competing in the 2012 Illinois Science Olympiad state tournament.

**Unit 4 Magnet School Assistance Program Grant.** I-STEM is working with Champaign Unit 4 as the district converts three schools to magnet schools to promote diversity, educational innovation, and quality instruction to improve student learning/achievement. Thematic curricula will emphasize International Baccalaureate (Garden Hills); STEM (Booker T. Washington); and Leadership in a MicroSociety (Stratton).



Clockwise from left: A possible future aeronautics engineer watches radio-controlled models fly during Uni High's Summer Enrichment Camp 2012.

Above and below: Campers at Uni High's Summer Enrichment Camp 2012 prepare to fly gliders built during the engineering session. Bottom left: A USI student learns about physics during a campus tour the day before the 2012 Illinois Science Olympiad Tournament.





I-STEM is partnering with campus projects, such as MIST, to improve the quality of STEM teacher training and professional development.

## Goal 2: Improve STEM Teacher Training and Professional Development Quality

### STEM EDUCATION TEACHER TRAINING/PROFESSIONAL DEVELOPMENT IMPROVEMENT ACTIVITIES

#### ◆ Increase the number and quality of STEM teachers who graduate from *Illinois*.

I-STEM is working to increase the number of STEM teachers who graduate from *Illinois*, improve their retention in the field, and increase their impact on student performance. I-STEM is working with organizations, such as SMTI, and campus projects, such as MIST (described on page 18), which share this same goal.

#### ◆ Evaluate STEM teacher training and professional development projects.

In 2012, I-STEM evaluated several NSF-funded STEM teacher training and professional development projects operating at *Illinois*, including ICLCS and EnLiST, two Math and Science Partnership grants which provide teacher leadership training, and MIST and Nano-CEMMS, which also provide professional development for STEM teachers (see Table 2 on page 18). I-STEM supported these activities by providing on-campus evaluation services, ensuring important continuity and cross-fertilization opportunities among the initiatives, as well as the engagement of state-of-the-art STEM program evaluation models, both on campus and in coordination with external evaluators.



*I-STEM is working to increase the number of STEM teachers who graduate from Illinois, improve their retention in the field, and increase their impact on student performance.*



Clockwise from above, including the opposite page (p. 14): Illinois K–12 science teachers participate in MIST summer 2012 professional development at *Illinois*.





Above: An *Illinois* Entomology student works with Booker T. Washington students during an outreach presentation. Bottom right: A graduate student mentors a local high school student. Below: An *Illinois* student works with Edison Middle School students during an iRISE outreach.

◆ **Coordinate and strengthen campus STEM teacher professional development.**

I-STEM is working to institutionalize a comprehensive, high-quality continuum of professional development (PD) for STEM teachers, including induction and mentoring, graduate disciplinary coursework and degree options, research experiences, and leadership development leading to improved STEM teacher retention, reduced out-of-field teaching, and increased student performance.

Because past participants have often reported a duplication of services and professional development topics offered by University programs, I-STEM is working to coordinate across campus STEM teacher PD programs offering workshops and training so educators have access to unique PD experiences in a logical sequence. In addition, I-STEM encourages programs to target teachers in high-need districts/regions in order to improve retention and student performance. I-STEM's database of STEM teacher PD opportunities is continuously updated, posted on the I-STEM website, and sent to campus stakeholders (many of whom are I-STEM Affiliates) via the I-STEM listserv. (See pages 2 and 37 for communication resources and online access links.)

◆ **Increase external funding for teacher preparation and professional development.**

In 2012, I-STEM assisted with numerous campus STEM teacher development proposals to NSF and other funding agencies. I-STEM encourages faculty writing new proposals involving STEM teacher professional development to incorporate existing campus teacher development programs into them as a way to sustain and institutionalize these teacher preparation and professional development programs. Also, K–12 school districts have been encouraged to take advantage of campus professional development resources. Campus units have also worked to increase the number of funded campus Research Experiences for Teachers included in large research projects and labs (see Table 3 on page 19).

*I-STEM has encouraged units/projects interested in increasing their numbers of teacher education candidates to include components where students perform outreach in the community.*



## ◆ Increase teacher education candidates/student volunteers.

Exposing STEM majors to service learning opportunities in schools and other educational settings not only benefits the youngsters with whom students are working by exposing them to STEM, but increases the possibility that the STEM majors might themselves choose teaching as a career. Thus, I-STEM has encouraged units/projects interested in increasing their numbers of teacher education candidates to build components into their projects where students perform outreach in the community. In 2012, *Illinois* staff and students volunteered in numerous outreach programs targeting K–12 students:

- **Bioengineering DNA/Cell Measurement After-School Program.** This after-school program (see pages 8–9) at Jefferson Middle School not only introduces middle school students to cell biology, but exposes bioengineering undergrads to teaching.
- **Booker T. Washington STEM Academy (BTW) Partnerships.** Numerous units/programs have partnerships with BTW and provided outreach in 2012. For instance, Professor Pat Shapley used Uni High students and Chemistry undergraduates to teach hands-on lessons in Chemistry. The College of Applied Health Sciences staff and students collaborated with BTW in numerous programs. Physics of Living Cells staff and students taught BTW students about microscopes and the color spectrum.
- **Booker T. Washington (BTW) STEM Academy Technology Club.** This after-school club exposes BTW students to engineering via fun, hands-on activities. I-STEM staff helped begin the club, seeking out Mechanical Science and Engineering students, who, hoping to influence youngsters to choose STEM careers, planned, coordinated, and taught the club in 2012.
- **Illinois Science Olympiad.** A large number of *Illinois* personnel volunteered in the 2012 state tournament held on campus, including current *Illinois* students who had participated in Science Olympiad themselves. I-STEM recruited these students to participate in local Science Olympiad competitions.
- **I-STEM High School Summer Research Experience.** This I-STEM program paired high school students with research projects in *Illinois* labs, where graduate students and researchers mentored them.
- **NSF-funded Robert Noyce Teacher Scholarship Program grant.** Co-led by the departments of Curriculum and Instruction and Mathematics, the program offers fellowships to math teacher candidates and encourages students to work with K–12 students.
- **University Laboratory High School outreach programs.** Not only university students, but Uni High students themselves worked in several K–12 outreach programs, such as the **Summer Enrichment Camp 2012**, which used high school students as camp counselors.
- **iRISE (Illinois Researchers in Partnership with K–12 Science Educators).** iRISE had several programs in 2012 to train and encourage K-12 educators, research professionals in STEM fields, and iRISE graduate students to conduct effective educational outreach programs for middle school students. Part of the training included actual outreach programs for middle school students.

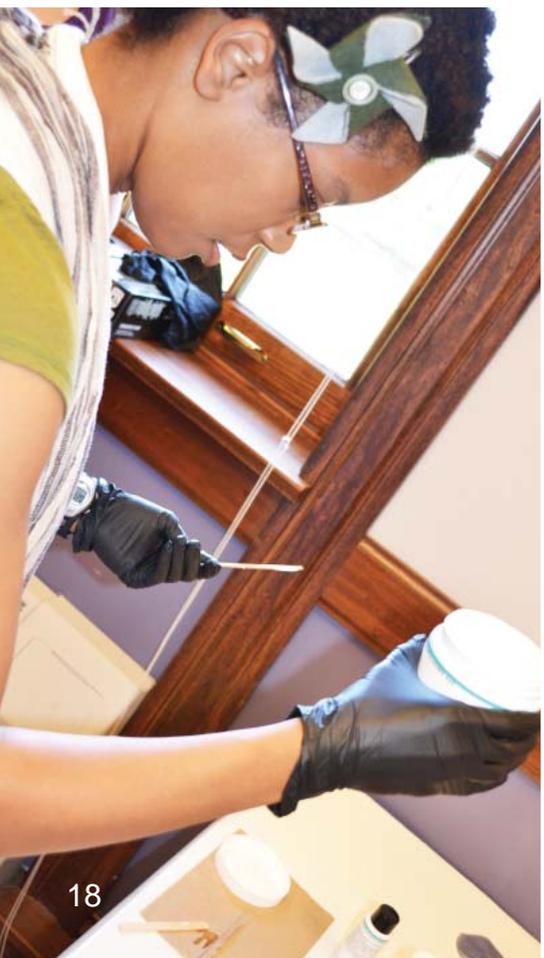


Above: Nano-CEMMS' Matt Alonso works with an Edison Middle School student during a hands-on lesson on 3D printing he taught for iRISE outreach. Below: Chemistry undergraduates work with BTW students on an "Egg Drop" lesson.





Above: A science teacher blow dries the mirror she created during an EnLiST nanotechnology session in summer 2012. Below: An EnLiST workshop participant works on a hands-on nanotechnology project making a super ball from polymers.



## STEM EDUCATION TEACHER TRAINING/PROFESSIONAL DEVELOPMENT IMPROVEMENT PROGRAMS

**APLU/SMTI.** As a member institution of the Association of Public and Land-grant Universities (APLU), *Illinois* is committed to APLU's Science and Mathematics Teacher Imperative (SMTI), a national effort to increase the number and improve the quality and diversity of science and mathematics teachers universities prepare. Dr. DeStefano attended SMTI's National Conference held in June 2012. *Illinois* also participates in SMTI's Mathematics Teacher Education (MTE) Partnership to foster collaboration between universities and K-12 districts to transform math teacher preparation. As such, *Illinois* teamed up with the Champaign and Urbana school districts to improve math education.

**DCEO Coal Education Program.** I-STEM is conducting an evaluation of the Department of Commerce and Economic Opportunity's Coal Education Program, which trains K-12 educators about coal.

**EnLiST.** Entrepreneurial Leadership in STEM Teaching & Learning works to develop entrepreneurial skills for teacher leaders in physics and chemistry.

**ICLCS.** Institute for Chemistry Literacy through Computational Science trains science teachers to use virtual tools for teaching chemistry concepts. According to evaluation data, teachers who completed ICLCS had greater knowledge of chemistry content, increased use of computational tools in the classroom, and more student-centered teaching techniques; moreover, the levels of these three teacher-related things were important predictors of student achievement.

**MIST.** The Merit-Based Immersion for Students and Teachers (MIST) program in Chemistry, Math, and Integrative Biology encourages undeclared majors to consider STEM education careers. I-STEM's evaluation found that teaching assistants considering teaching after graduation attributed their decisions to MIST. MIST summer 2012 workshops exposed high school STEM teachers to Merit program structure and teaching strategies. I-STEM's evaluation found workshop-trained teachers used more critical thinking questions and small groups in classrooms and credited pedagogical adjustments to the workshop.

**Table 2: Teacher Development Programs Evaluated by I-STEM**

Program	Principal Investigator(s)
EnLiST: Entrepreneurial Leadership in STEM Teaching & Learning	Mats Selen, Physics Patricia Shapley, Chemistry Fouad Abd-El-Khalick, Curriculum & Instruction; Raymond Price, Engineering
ICLCS: Institute for Chemistry Literacy through Computational Science	Thomas Dunning, Chemistry & NCSA
MIST: Merit-Based Immersion for Students & Teachers: Teaching Careers & Summer Teacher Workshops	Lizanne DeStefano, I-STEM
Nano-CEMMS: Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems: Teacher Institutes	Placid Ferreira, Engineering John Rogers, Engineering
Robert Noyce Master Teaching Fellowship Program	Thomas Dunning, Chemistry & NCSA



Above, right, bottom right, and bottom left: EnLIST science teachers participate in hands-on activities during the project's summer 2012 workshop.

**Nano-CEMMS.** Engineering's Nano-CEMMS Center offers summer workshops to help teachers learn how scientists and engineers work to manipulate matter at the molecular level, as well as online teaching modules for classroom use.

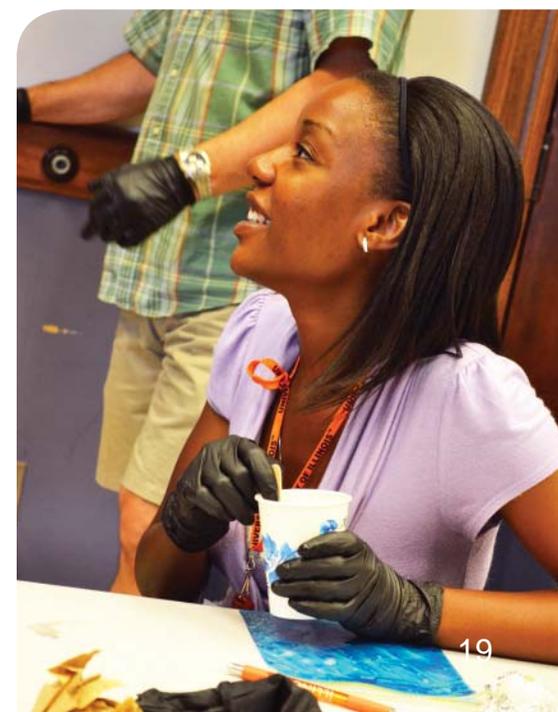
**REMSI: Research and Evaluation of Math and Science Implementation.** I-STEM is evaluating this NSF REESE (Research and Evaluation on Education in Science and Engineering) grant at the University of Chicago which measures the use of innovations in mathematics and science education and factors that contribute to and/or inhibit their implementation, spread, and sustainability.

**Robert Noyce Master Teaching Fellowship Program.** The Noyce program allows teachers who serve in high-needs school districts to earn their board certification. These fellows are exemplary rural high school math and science teachers selected because of their leadership work in the ICLCS program (see page 18).



**Table 3: Externally Funded Campus Research Experiences for Teachers**

Years	Number
2008–2009	4
2009–2010	8
2010–2011	12
2011–2012	13
2012–2013	13





**I-STEM is working to promote our students' success in STEM fields through the creation of accessible and effective undergraduate and graduate STEM programs and engaging research experiences.**

# Goal 3: Foster Undergraduate and Graduate STEM Education Reform

## UNDERGRADUATE/GRADUATE STEM EDUCATION REFORM ACTIVITIES

### ◆ Improve undergraduate STEM courses to increase accessibility, engagement, and success.

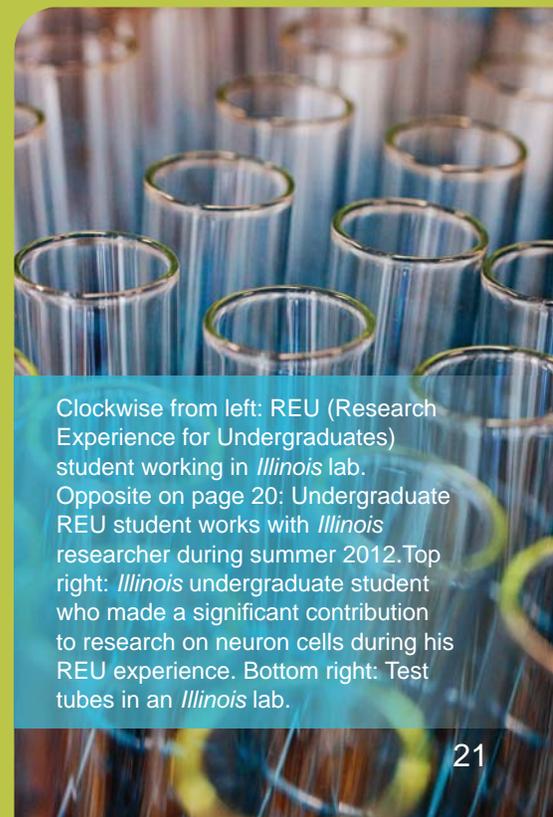
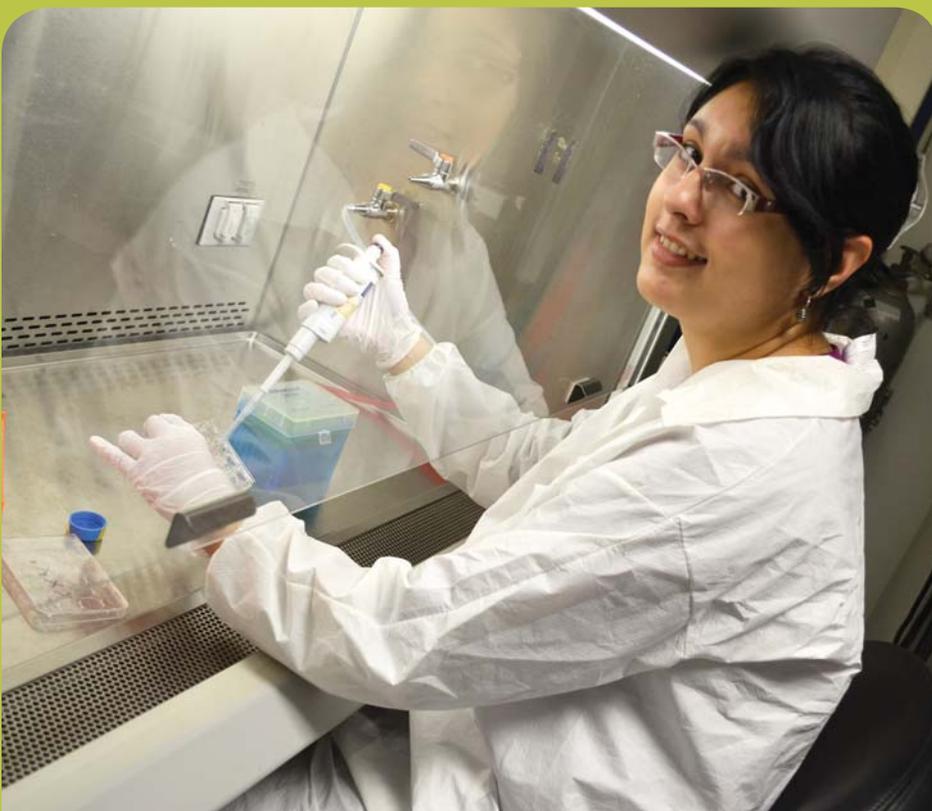
To reduce attrition and increase student performance in introductory STEM courses and increase graduation rates for STEM majors, especially for students from underrepresented groups, I-STEM has continued to identify and coordinate campus undergraduate STEM educational reform activities. Meetings with faculty address research findings, best practices, and effective pedagogy and models in STEM teaching and learning, especially around increasing diversity and performance of underrepresented groups.

### ◆ Evaluate and analyze undergraduate and graduate STEM education reform projects.

I-STEM analyzes campus STEM academic programs to identify strengths and gaps and to serve as the basis for developing effective, scalable, and sustainable STEM education to bridge and support models for the campus, including exploring the use of on-line courses as a means of bridging with high schools and community colleges. To improve their academic offerings, STEM departments have engaged both campus- and externally-funded reform projects. I-STEM has been invited to conduct evaluations of a number of these projects, many of which are listed in Table 4 on page 23.



*The Biology Coordinating Committee meets regularly to coordinate and publicize biology initiatives on campus and to plan an evaluation addressing satisfaction among biology students.*



Clockwise from left: REU (Research Experience for Undergraduates) student working in *Illinois* lab. Opposite on page 20: Undergraduate REU student works with *Illinois* researcher during summer 2012. Top right: *Illinois* undergraduate student who made a significant contribution to research on neuron cells during his REU experience. Bottom right: Test tubes in an *Illinois* lab.



Clockwise from above: An Engineering Summer Scholars team works on an Android phone app *Illinois* students could use to navigate campus. Bottom right: B<sup>3</sup>SI Taiwanese trainees work in a lab during a cellular and molecular biology module. Below: Mechanical Science and Engineering course instructor Mike Philpott poses with a student and the 2012 Hybrid SAE car students built and raced as part of his course.



◆ **Perform student satisfaction/climate studies.**

Another I-STEM priority is helping units understand student data patterns regarding performance, reasons students choose/leave STEM majors, and impacts of reform on student performance. As such, I-STEM provides expertise to campus units interested in self-evaluation, such as Chemistry (see page 24) and Engineering (see page 26). Lizanne DeStefano is also a member of the Biology Coordinating Committee, which meets regularly both to coordinate and publicize the various biology initiatives on campus and to plan an evaluation addressing satisfaction among biology students, whose courses are offered across various STEM disciplines.

◆ **Develop support programs to improve recruitment, retention, and graduation of STEM students.**

While a variety of student support programs (i.e., learning communities, mentoring, and bridge programs) are useful to improve recruitment, retention, and matriculation of students in STEM fields, they are often not well coordinated or sustainable and may lack academic support beyond the freshman year. In addition, students are often unaware of these programs, necessary qualifications, or how to access services. I-STEM recommends that units seeking to improve their undergraduate programs adapt some of the unique strategies of successful *Illinois* programs which can serve as models for increasing student support, such as MIST (see page 29) and iFoundry's *Illinois* Engineering Freshmen Experience (iEFX; see page 27).

◆ **Increase external funding to improve undergraduate and graduate STEM education.**

To ensure adequate funding to support undergraduate and graduate STEM education reform for consistent, sustained, high-impact programming, I-STEM encourages units to apply for educational improvement resources from the numerous programs major external funders offer. In 2012, I-STEM was involved in more than 50 grant submissions, representing seven colleges and 21 departments. To assist faculty, I-STEM provides support via a variety of mechanisms (see page 3; links are available on pages 2 and 37).





**Table 4: Undergraduate/Graduate STEM Programs I-STEM Evaluated in 2012**

<ul style="list-style-type: none"> <li>BEACON (Bio/computational Evolution Action Consortium) Climate Study Evaluation</li> </ul>
<ul style="list-style-type: none"> <li>CCI SusNano (Center for Chemical Innovation: A Molecular Basis for Sustainable Nanotechnology)</li> </ul>
<ul style="list-style-type: none"> <li>Chemistry CCLI (Course, Curriculum, &amp; Laboratory Improvement): Discovering the Nanoworld: Module for Teaching About Molecules/Bonding in Chemistry</li> </ul>
<ul style="list-style-type: none"> <li>Chemistry Student Experiences Study</li> </ul>
<ul style="list-style-type: none"> <li>Chemistry REU (Research Experience for Undergraduates)</li> </ul>
<ul style="list-style-type: none"> <li>CMMB IGERT (Cellular and Molecular Mechanics &amp; BioNano-technology Integrative Graduate Education &amp; Research Traineeship)</li> </ul>
<ul style="list-style-type: none"> <li>M-CNTC (Midwest Cancer Nanotechnology Training Center)</li> </ul>
<ul style="list-style-type: none"> <li>Digital Forensics</li> </ul>
<ul style="list-style-type: none"> <li>EBICS (Emergent Behaviors of Integrated Cellular Systems): GEM4, REU, Graduate Teaching Consortium</li> </ul>
<ul style="list-style-type: none"> <li>Engineering Climate Study</li> </ul>
<ul style="list-style-type: none"> <li>iFoundry/IEFX (Engineering Freshman Experience)</li> </ul>
<ul style="list-style-type: none"> <li>MIST (Merit-Based Immersion for Students &amp; Teachers) Undergraduate Courses</li> </ul>
<ul style="list-style-type: none"> <li>NanoCEMMS REU (Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems Research Experience for Undergraduates)</li> </ul>
<ul style="list-style-type: none"> <li>Neuroengineering IGERT (Integrative Graduate Education and Research Traineeship)</li> </ul>
<ul style="list-style-type: none"> <li>Physics CCLI: Enhancing Student Learning in Physics Through Multimedia Learning Modules</li> </ul>
<ul style="list-style-type: none"> <li>SIIP-Engineering (Strategic Instructional Initiative Program)</li> </ul>
<ul style="list-style-type: none"> <li>S-STEM (Scholarships in Science, Technology, Engineering, and Mathematics): Merit Fellows Scholarship Program</li> </ul>
<ul style="list-style-type: none"> <li>UBM Group: Biomathematics</li> </ul>
<ul style="list-style-type: none"> <li>VINTG IGERT (Vertically Integrated Training with Genomics Integrative Graduate Education and Research Traineeship)</li> </ul>
<ul style="list-style-type: none"> <li>XSEDE: TEOS (Extreme Science and Engineering Discovery Environment: Training, Education, and Outreach Services)</li> </ul>



Clockwise from above: A Chemistry REU (Research Experience for Undergraduates) student examines gold nanoparticles. Below: An Engineering Summer Scholars team with their power-generating stationary bicycle. Top left: Jimmy Hsia shows trainees an instrument during the BioSensing BioActuation BioNanotechnology Summer Institute.





Clockwise from above: B<sup>3</sup>SI Taiwanese participants work in a lab during a cellular and molecular biology module. Bottom right: B<sup>3</sup>SI graduate student trainee works on a mechanobiology module in the bioengineering lab. Below: B<sup>3</sup>SI participant works on a device during the Institute's microfluidics and enabling technologies module.

## UNDERGRADUATE/GRADUATE STEM EDUCATION PROGRAMS/INITIATIVES

### AAU Initiative to Improve Undergraduate STEM Education.

*Illinois* is participating in the Association of American Universities' (AAU) 5-year initiative on STEM undergraduate teaching. Focused on the first two years of college, the initiative seeks to help higher education institutions assess the quality of STEM teaching, share best practices, and use the most effective STEM teaching methods. I-STEM Director Lizanne DeStefano is the *Illinois* liaison on the technical advisory committee of experts in undergraduate STEM teaching and learning which will help guide the initiative.

### BioSensing BioActuation BioNanotechnology Summer Institute 2012.

Held on campus in summer 2012, the two-week-long B<sup>3</sup>SI institute trained participants at the intersection of biology and engineering and fostered networking with other researchers. The three main sponsoring projects were the CMMB IGERT (Cellular and Molecular Mechanics and BioNanotechnology Integrative Graduate Education and Research Traineeship), the M-CNTC (Midwest Cancer Nanotechnology Training Center), and the BioSensing, BioActuation grant. I-STEM assessed the effectiveness of the Institute as part of its evaluations for the three sponsoring projects.

**Chemistry Student Experiences Study.** During 2012, I-STEM staff met with Chemistry representatives to report the results of the 2011 study and to plan a follow-up study in 2013 investigating undergraduate and graduate students' experiences in the Department of Chemistry, including programmatic requirements, financial support, department resources, race/ethnicity, gender, and student satisfaction. Chemistry is using these data to aid decision-making to better serve its students.

**Digital Forensics:** This multidisciplinary project seeks to develop an undergraduate curriculum in digital forensics, which focuses on the recovery and investigation of data found in digital devices.

*I-STEM assessed the effectiveness of the BioSensing BioActuation BioNanotechnology Summer Institute 2012 as part of its evaluations for three projects: CMMB IGERT, M-CNTC, and the BioSensing, BioActuation grant.*





**Discovering the Nanoworld.** Funded through NSF's Course, Curriculum, & Laboratory Improvement Program (CCLI), this project is designing and implementing a new chemistry undergraduate curriculum using modules for teaching about molecules/bonding in chemistry.

**EBICS: Emergent Behaviors of Integrated Cellular Systems.** The NSF-funded EBICS Center at *Illinois*, MIT, and Georgia Tech will advance research in complex biological systems and develop programs to attract students to STEM fields. I-STEM provides leadership for the education component and assists in the evaluation of educational activities: the GEM4 (Global Enterprise for MicroMechanics and Molecular Medicine) summer school series, the Research Experiences for Undergraduates program, and the Graduate Teaching Consortium.

**Extreme Science and Engineering Discovery Environment (XSEDE).** Led by *Illinois'* National Center for Supercomputing Applications (NCSA) and supported by NSF, XSEDE provides cyber infrastructure and services to a broad range of researchers, allowing scientists nationwide to collaborate remotely while computing large collections of data on NCSA's supercomputers and data analysis systems. I-STEM is conducting the external evaluation for TEOS (Training, Education, and Outreach Services).



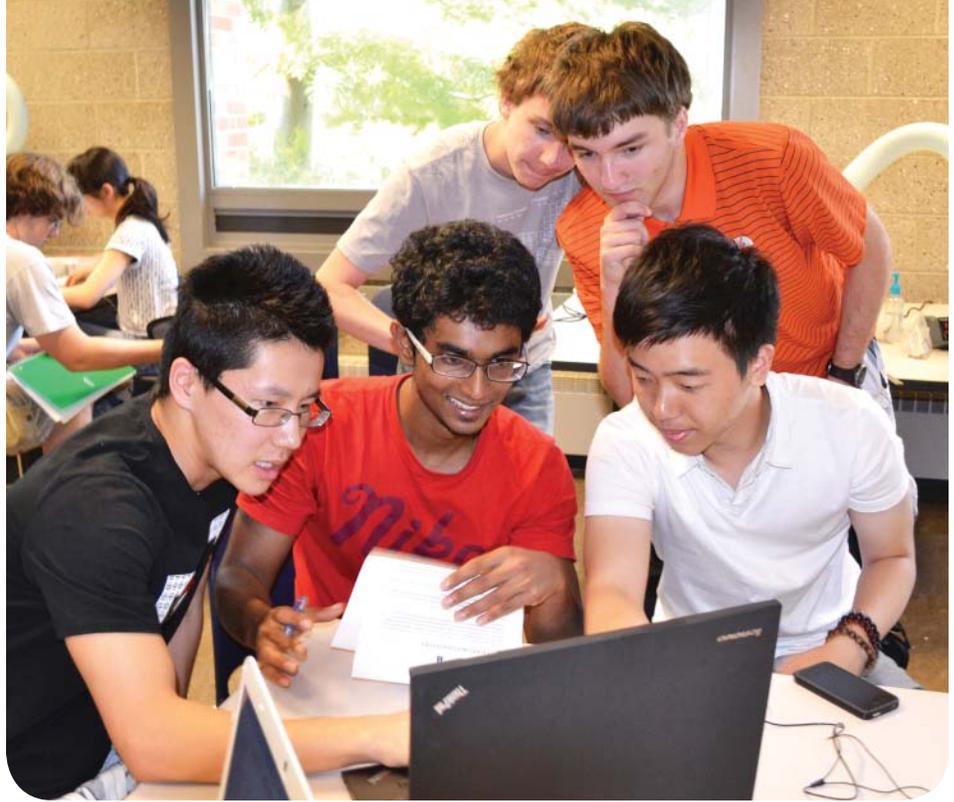
Clockwise from above: Engineering senior at the University of Illinois. Bottom left: High school student who attended the B<sup>3</sup>SI as part of EBICS' High School Research Experience component receives her certificate of completion from Professor Rashid Bashir and I-STEM Director Lizanne DeStefano. Upper left: Neuro-engineering IGERT fellow working in *Illinois* professor Martha Gillette's lab in Morrill Hall.



*I-STEM provides leadership for EBICS' education component and assists in the evaluation of educational activities: the GEM4 summer school series, the Research Experiences for Undergraduates program, and the Graduate Teaching Consortium.*



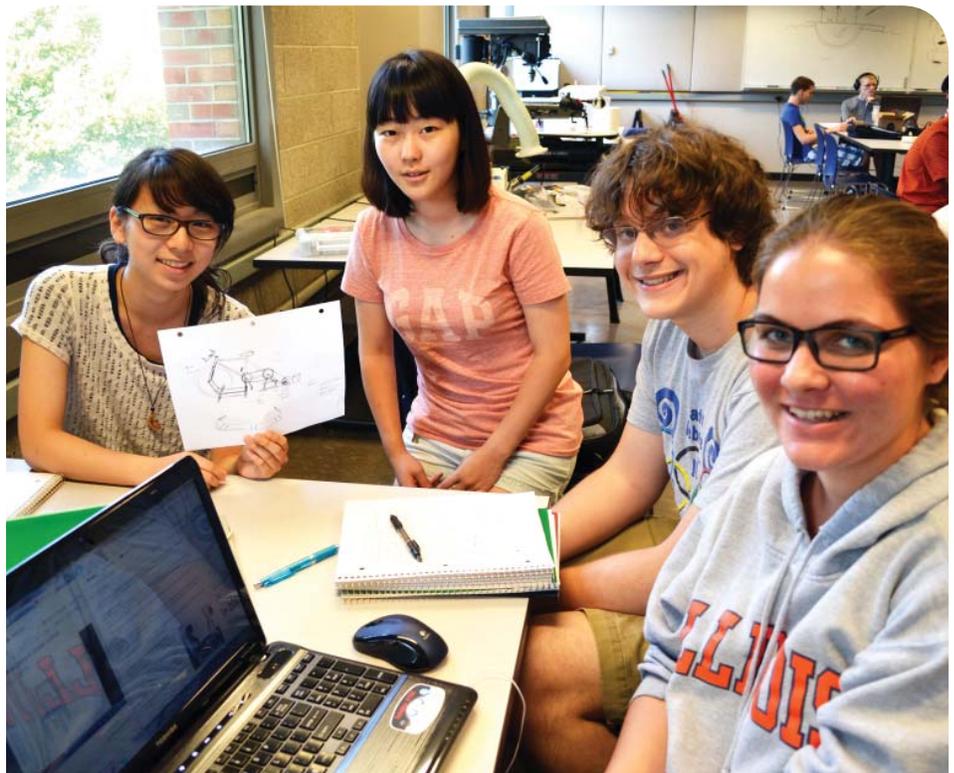
Clockwise from above: Bioengineering seniors display their Senior Design project. Top right: Engineering Summer Scholars work on their project: an Android phone app for *Illinois* students. Bottom right: An Engineering Summer Scholars team displays the design of their power-generating stationary bicycle project.



**Engineering Climate Study.** In 2012, I-STEM staff met with different groups of Engineering stakeholders to report on the results of the 2011 survey commissioned by the College. Staff also met with Engineering representatives to design a third study to be implemented in 2013. This follow-up to the 2009 and 2011 studies will investigate undergraduate and graduate students' experiences in the College, plus barriers and opportunities to increasing recruitment and retention.

**Engineering Education Minor or Certificate.** I-STEM staff have been meeting with the Dean of the Graduate College to discuss the creation of an Engineering Education Minor or Certificate which would appear on students' transcripts to underscore successful completion of engineering education courses.

*In 2012, I-STEM evaluated the Engineering Summer Scholars program, designed to reduce attrition among incoming engineering freshmen by helping them adjust to life as students, become familiar with campus, and form support groups before the influx of students in the fall.*





Neuroengineering IGERT students look at data from a brain cap that measures a person's brain activity.

**iFoundry/iEFX.** *Illinois Foundry for Innovation in Engineering Education* is a College of Engineering curriculum incubator seeking to transform undergraduate education to prepare engineers for the challenges of a global, creative era through conceptual and philosophical planning, collaborative organization and experiences, shared technology, and other innovations. I-STEM participates in iFoundry's planning, development, and formative and summative evaluation processes, including the *Illinois Engineering Freshmen Experience* (iEFX).

**Engineering Summer Scholars.** In 2012, I-STEM evaluated this iEFX (see above) summer program designed to reduce attrition among incoming engineering freshmen. The scholars came to campus two months early and took courses during the summer, including one projects course they took together. The program's focused resources and mentoring component were designed to help them adjust to life as students, become familiar with campus, and form support groups before the influx of students in the fall. The goal: create a small-campus feel.



Clockwise from above: B<sup>3</sup>SI participant displays the device she made during the microfluidics and enabling technologies module. Bottom right: Bioengineering seniors display their Senior Design project. Bottom left: Two B<sup>3</sup>SI trainees listen while another presents her research during a poster session.

*Illinois programs, such as MIST and iFoundry's Illinois Engineering Freshmen Experience (iEFX) can serve as models for increasing student support.*





Clockwise from above: Two Neuroengineering fellows measure brain waves in a Beckman lab.

Top right: Neuroengineering IGERT fellows demonstrate how electromyography, electrical activity generated by muscle contraction, can be harnessed to fly a remote helicopter. Below: A Neuroengineering IGERT fellow acts as a guinea pig to have his brain waves analyzed.



### **IGERT (Integrative Graduate Education and Research Traineeship) projects.**

Funded by the National Science Foundation, the IGERT program seeks to develop a diverse, globally-engaged science and engineering workforce via innovative graduate education models in collaborative research. In 2012, I-STEM evaluated the following three *Illinois* IGERTs.

**CMMB IGERT: Cellular and Molecular Mechanics and BioNanotechnology.** The CMMB IGERT provides a highly interdisciplinary environment to train the next generation of leaders in cellular and molecular mechanics and bionanotechnology. These students will have knowledge in both biology and engineering, as well as in science and technology, and a network of resources (people, facilities, international connections) helpful in their future careers. Via lab rotations, co-advisement, a two-track curriculum, and an introductory CMMB course, students will learn core concepts in both their field (biology or engineering) and their complementary field.

**Neuroengineering IGERT.** The Neuroengineering IGERT trains students at the intersection of neuroscience and engineering. Its students, many of whom were recruited to *Illinois* through the IGERT, come from a range of disciplines. Thus, while the chief goal of the program is to foster interdisciplinary collaboration, it has also been useful as a recruiting tool.

**VINTG (Vertically Integrated Training with Genomics) IGERT.** The goal of the VINTG IGERT is to train students in the interdisciplinary field of genomics. While the project serves as a recruiting tool, VINTG staff also seek to broaden participation, particularly from groups typically underrepresented in the sciences.

**IOLAB: Using Technology to Transform Introductory Physics Labs.** IOLAB is an innovative online approach to interactive laboratory learning for introductory physics courses. Using SmartLab, which allows students to do hands-on experiments anywhere—in their home, dorm, or classroom—students measure real-world things guided and evaluated by SmartLab’s learning software and online database.

**ME 199: Interdisciplinary Research and Education in Biology, Engineering, and Health Science.** As part of the NSF-funded EBICS (Emergent Behaviors of Integrated Cellular Systems) Center (see page 25 for a full description), ME 199 is introducing students to interdisciplinary education and preparing them to become future researchers and leaders in the new EBICS discipline, with expertise in both biology and engineering.

**Merit Fellows Scholarship Program.** Funded by NSF, this S-STEM (Scholarships in Science, Technology, Engineering, and Mathematics) grant provides financial support for academically talented, financially needy students from the Merit program (see MIST below) who are majoring in mathematics, chemistry, or integrative biology.

**MIST: Merit-Based Immersion for Students and Teachers.** The MIST program, co-sponsored by the Chemistry, Mathematics, and Integrative Biology Departments, seeks to increase the number of students who choose STEM majors by targeting undergraduates who have not yet declared majors. I-STEM’s evaluation found that MIST students enrolled in more STEM courses and had higher GPAs and exam scores, while TAs attributed their increased confidence and decisions to consider careers in teaching to MIST.

**Nano-CEMMS.** Since the inception of the Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems, Lizanne DeStefano has played a formative role in the design and evaluation of its education programs. This collaboration includes evaluation of multi-faceted Nano-CEMMS components: two summer research programs for undergraduates; an undergraduate scholarship program; graduate student enrichment programs; the promotion of educational collaboration among various research projects involved; and professional development, including foreign training opportunities.



Clockwise from above: VINTG IGERT fellow works with a trap-jaw ant on which she has just painted a miniscule green dot for identification purposes. Below: VINTG IGERT fellow at work in the bee enclosure at the University’s Bee Research Facility. Bottom left: Honeybees at the Bee Research Facility swarm to the sugar water held by the VINTG IGERT fellow.





Clockwise from above: Two engineering seniors whose relationship, formed as freshmen at the Women in Engineering (WIE) camp, has been a source of support during their careers at *Illinois*. Bottom left: Camper works to master the challenge course's "Tire Traverse" station during WIE camp. Upper left: Bioengineering undergrad who participated in EBICS' summer 2012 Research Experience for Undergraduates.

**Research Experiences for Undergraduates.** I-STEM has continued to encourage units to employ research experiences for undergraduates as a viable way to increase the number of students choosing careers in STEM fields. In fiscal year 2012, at least 149 projects offered research experiences for undergraduates (see Figure 1 to the right). Many of these were through NSF's Research Experiences for Undergraduates (REU) program; many were NSF-funded research projects offering research for a few undergraduates; five were NSF REU Sites and engaged a number of students in research; some campus research experiences were through funders other than NSF.

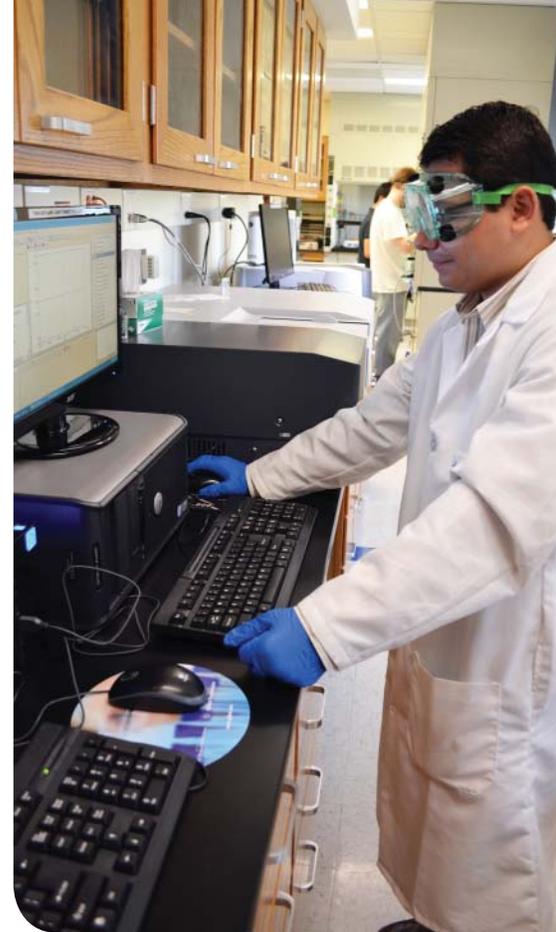
In addition, of the many campus programs that offer undergraduate research experiences, I-STEM evaluates three which engage a number of students: Chemistry, an NSF-funded program specifically for REUs, plus two that offer REU components along with a variety of other STEM education emphases: EBICS (Emergent Behaviors of Integrated Cellular Systems Science and Technology Center), and Nano-CEMMS (Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems).



Campers cheer on a teammate using the rope swing at the “Tarzan” station at Allerton Park 4-H Memorial Camp’s Challenge Course during Women in Engineering’s Freshman Orientation Camp.

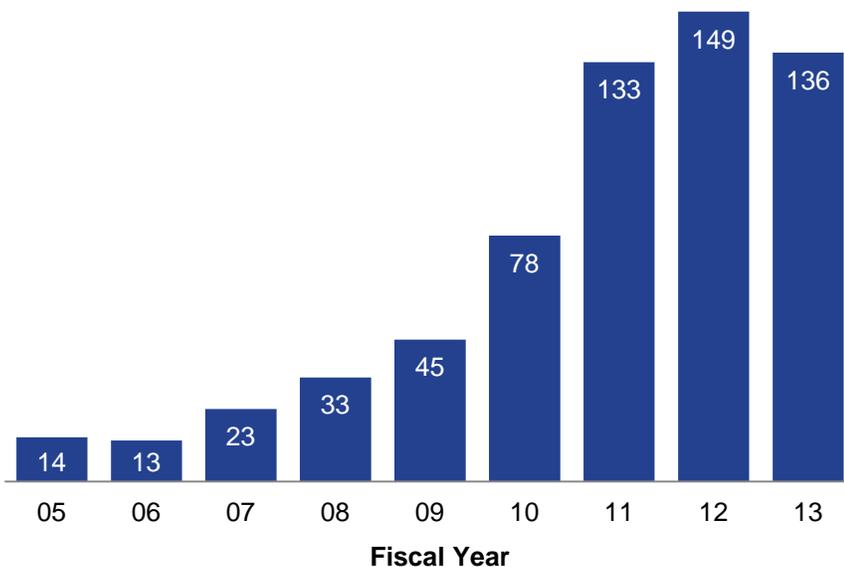
**SIIP (Strategic Instructional Initiative Program).** This College of Engineering initiative strives to improve the pedagogy of targeted large, foundational undergraduate courses in order to improve student engagement and learning outcomes.

**Women in Engineering (WIE).** This Engineering program, which is focused on the recruiting and retention of women in Engineering, addresses attrition among women engineering students through programs such as the WIE Freshman Orientation Camp, which offers team-building exercises applicable to real life and helps the students form support groups by fostering networking with other students.



Above: Chemistry REU (Research Experience for Undergraduates) student analyzes the catalytic properties of cadmium selenide quantum dots. Below: Freshman engineering students at the WIE Freshman Orientation Camp use a rope swing at the “Tarzan” team-building station.

**Figure 1: Research Experiences for Undergraduates, 2005–2013 Fiscal Years**





I-STEM is working to stimulate partnerships to understand the Illinois STEM pipeline and workforce development needs and to serve as an advocate within the state of Illinois.

# Goal 4: Shape Policy & Advocate for STEM Education

## STEM EDUCATION POLICY AND ADVOCACY ACTIVITIES

### ◆ Network to advocate for funding, incentives, and programmatic support for STEM education.

In 2012, I-STEM Director Lizanne DeStefano, Associate Chancellor Peg O'Donoghue, and I-STEM Associate Director Robert Coverdill continued to network at the local, state, national, and international levels to advocate for STEM education programs and resources.

**On the local level...** I-STEM staff regularly discussed STEM education with campus administration and researchers. I-STEM staff presented at unit-level meetings, such as with College of Engineering administrators; cross-campus events, such as the Faculty Development Brown Bag Series and Jumpstarting New Faculty Careers; and interdisciplinary focus groups/events, like the Biology Coordinating Committee and the BioSensing BioActuation BioNanotechnology Summer Institute (pages 22 and 24, respectively).

### On the state level...

Dr. DeStefano participated in a number of events in her capacity as the Coordinator of the P–20 Council, including Session III of the World Class Education Colloquium. Dr. DeStefano participated in the Research and Development STEM Coalition, one of Illinois' Learning Exchanges (see the Illinois Pathways Initiative section on page 35).

**On the national level...** I-STEM staff served on several STEM education committees and task force groups and advocated for STEM education with policymakers. Dr. DeStefano served on NSF's Research in Disabilities Education and EPSCoR review panels; the NAEP Validity Study Panel (see page 36); and the Institute of Education Sciences' Technical Working Group. Robert Coverdill met with lawmakers and national after-school STEM programs to discuss how these programs can impact STEM education and represented I-STEM at the Triangle Coalition's 2012 conference.

**On the international level...** Lizanne DeStefano visited Japan in February 2012 to establish a relationship between I-STEM, I<sup>2</sup>CNER (International Institute on Carbon-Neutral Energy Research), and Japan's Ministry of Education. Robert Coverdill participated in the French/U.S. Science Festival in Chicago which promoted cross-cultural exchange of K-12 STEM programs.



Clockwise from above: Edison Middle School students participate in a NanoCEMMS lesson on rapid prototyping (3D printing). Below: Edison students do hands-on activities taught by an *Illinois* graduate student. Opposite (p. 32): Illinois Science Olympiad contestant looks through a microscope during the 2012 tournament.



**In 2012, I-STEM staff served on several STEM education committees and task force groups and advocated for STEM education with policymakers.**





Clockwise from above: Chemistry Professor Don Decoste demonstrates the properties of liquid nitrogen during an informal learning opportunity at a local summer day camp. Top right: Edison students do hands-on activities taught by *Illinois* graduate students. Bottom right: Don Decoste and Jesse Miller from the Department of Chemistry demonstrate to local day camp students that chemistry can be fun.



◆ **Document trends and needs in Illinois' STEM teaching and learning, teacher preparation, workforce, and STEM pipeline and mainline.**

In 2012, I-STEM continued its work on STEM workforce development via participation in STEM Learning Exchanges. Designed to foster student interest in STEM careers, these types of programs to strengthen the state's STEM pipeline can contribute to workforce development as students choose STEM careers.

◆ **Evaluate and analyze STEM policies.**

One of I-STEM's roles is to examine broad policy initiatives affecting STEM education at all levels. This often includes formal evaluation of policies and initiatives, such as for NAEP (see page 36).

◆ **Identify STEM education reform projects at *Illinois*.**

I-STEM identifies and catalogues *Illinois*' current external funding projects and potential resources (see links on page 37) and conducts an annual, campus-wide appraisal of external STEM education investments on campus (see pages 37–39).

***I-STEM identifies and catalogues Illinois' current external funding projects and potential resources (see links on page 37) and conducts an annual, campus-wide appraisal of external STEM education investments on campus.***



## STEM EDUCATION POLICY/ADVOCACY PARTNERS, PROJECTS, AND EVENTS

**Champaign-Urbana Schools Foundation.** In 2012, Peg O'Donoghue served on the Board of Directors and Lizanne DeStefano on the Advisory Board of this local partner committed to facilitating STEM and other educational initiatives in Champaign-Urbana schools.

**Illinois Interdisciplinary Health Sciences Initiative (IIHSi).** This Division of Biomedical Sciences (DBS) planning group's goal is to harness campus expertise and infrastructure to establish *Illinois* as a provider of innovative health solutions and address health issues through interdisciplinary research, education, and outreach.

**Illinois P-20 Council.** In addition to Dr. DeStefano's work as Coordinator and member of numerous committees (see page 9), in October 2012, the P-20 Council<sup>7</sup> met on campus, where state education policy leaders were joined by University of Illinois President Robert Easter, Chancellor Phyllis Wise, and Illinois Governor Pat Quinn.

**Illinois Pathways Initiative.** This program's STEM Learning Exchanges are partnerships to promote collaboration and engagement of K-12 students in real-life scientific problems via web resources. Students who are interested in specific STEM careers may access these websites, which provide information about and links to career-related educational programs, activities, job/career fairs, expos, etc. Dr. DeStefano was a member of the research and development steering committee for STEM Learning Exchanges in 2012.

**Learning Performance Management System.** Funded by the Department of Education, the System will use NCSA's cutting-edge, petascale computing equipment to track student performance from pre-school through workforce to learn about effective STEM pathways—ways of moving through the system and entering STEM careers. During 2012, Dr. DeStefano participated in a working group which met to discuss how to build the system's infrastructure.

<sup>7</sup><http://www2.illinois.gov/gov/P20/Pages/default.aspx>



*The Learning Performance Management System will use NCSA's petascale computing equipment to track student performance from pre-school through workforce to learn about effective ways of moving through the system and entering STEM careers.*



Clockwise from above: University of Illinois President Robert Easter (left) and Governor Pat Quinn during a P-20 Council meeting held at *Illinois*. Below, Chancellor Phyllis Wise speaks to the Council about *Illinois'* involvement in the Coursera project. Bottom left: A REU undergraduate student works with an *Illinois* researcher.





Clockwise from above: A CPS student examines a sample through a microscope during a campus tour by USI school students prior to the 2012 Illinois Science Olympiad. Top right: Booker T. Washington STEM Academy (BTW) students pet a goat during a field trip to Prairie Fruits Farm. Bottom right: BTW student experiences a bed of chives during a hands-on botany activity at Prairie Fruits Farm.



**National Academies Northstar Summer Institute on Undergraduate Education in Biology.** This Institute held at the University of Minnesota in 2012, emphasized the importance of new pedagogical approaches to teaching on undergraduate science education. Dr. DeStefano attended and, as a result of her work there, was named a National Academies Education Fellow in the Life Sciences.

**National Assessment of Education Progress (NAEP).** In 2012, I-STEM staff attended the NAEP Validity Studies Panel Meeting sponsored by the U.S. Department of Education. I-STEM also participated in a project creating accessible blocks that promote the involvement of special education students and English-language learners on the NAEP Reading assessment. This project built on I-STEM's 2010 redevelopment of the NAEP Math Assessment to include accessible blocks for this population of students who were previously excluded from testing but are now included, as a result of these blocks.

**STEM Diversity & Higher Education Forum.** Dr. DeStefano participated in this White House forum about fostering STEM diversity in higher education institutions, which was held in Washington, D.C.

**S-STEM Subject Matters Expert Meeting.** Dr. DeStefano attended this 2012 meeting of experts convened by the National Science Foundation regarding its Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) grants program.

**WitsOn (Women in Tech Share Online).** WitsOn is an online class for female undergraduate STEM students designed to promote recruitment and retention of women in STEM. Lizanne DeStefano served as the WitsOn project liaison on campus. WitsOn is a joint project by Harvey Mudd College and Piazza, a course-management website.

**World Class Education, Birth To 20: What Will It Take in Illinois?** In 2012, Dr. DeStefano took part in Session III of this colloquium on providing Illinois students a world-class education. It was sponsored by the University of Illinois at Chicago, the McCormick Foundation, the Chicago Community Trust, the Illinois State Board of Education, the P-20 Council, and Chicago Public Schools.

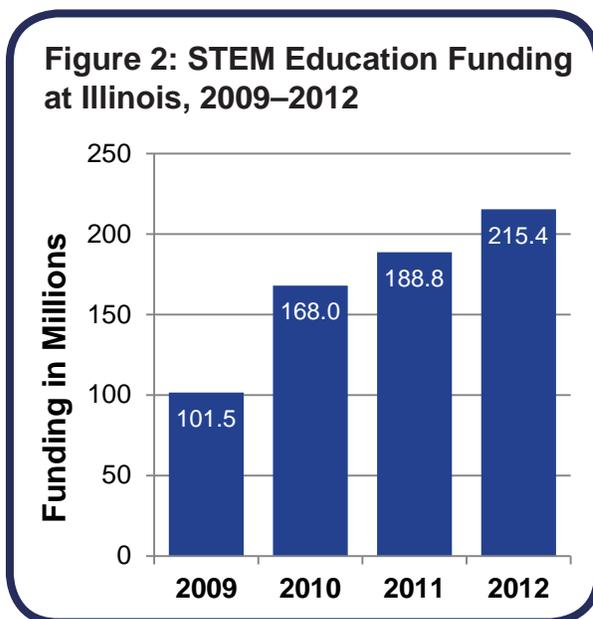


## STEM EDUCATION EXTERNAL FUNDING AT ILLINOIS

I-STEM annually performs an in-depth appraisal of existing resources campus-wide to create a picture of active external STEM education investments on campus. To build as comprehensive a database as possible to create this snapshot, I-STEM researches available campus databases, such as the Proposal Data System of *Illinois'* Division of Management Information, as well as electronic databases operated by funding entities themselves.

Because funding awards may be completely or only partially dedicated to STEM education, we estimate the STEM education amount by calculating a percentage of the total award. For example, for projects whose sole thrust is STEM education or its evaluation, we calculate 100% of the award. For STEM research projects not focused entirely on education, but with substantial education components, we estimate that 30% of the award is devoted to education (i.e., NSF CAREER funding, which requires education or outreach components targeting underrepresented populations). For large centers which have STEM education components, we estimate that 15% of the award is devoted to STEM education. These estimates apply to the calculations for Figure 2 below and Figures 3 and 4 on pages 38 and 39, respectively.

Figure 2 presents estimated STEM Education funding at *Illinois* from 2009 to 2012. For each year, both numbers of awards and estimates of award amounts for STEM education are based on information available at the time of publication of I-STEM's past annual reports and are not necessarily inclusive of all grants awarded to the University of Illinois in the area of STEM education.



For 2012, the estimated total of \$215.4 million in active STEM education investments by funding sources (see Figure 3 on page 38) spans federal agencies (i.e., the National Science Foundation, the U.S. Department of Education, and National Institutes of Health); the state of Illinois (i.e., the Illinois State Board of Education and Illinois Board of Higher Education); as well as private and corporate support.

This external investment supports substantial STEM education activities across 16 academic, research, and campus-level administration units (see Figure 4 on page 39). Projects include STEM P–16 outreach; teacher training and professional development; undergraduate/graduate disciplinary training programs and research experiences; graduate and postdoctoral fellowship support; STEM education research and evaluation; as well as STEM research projects and centers not focused entirely on education, as discussed above.

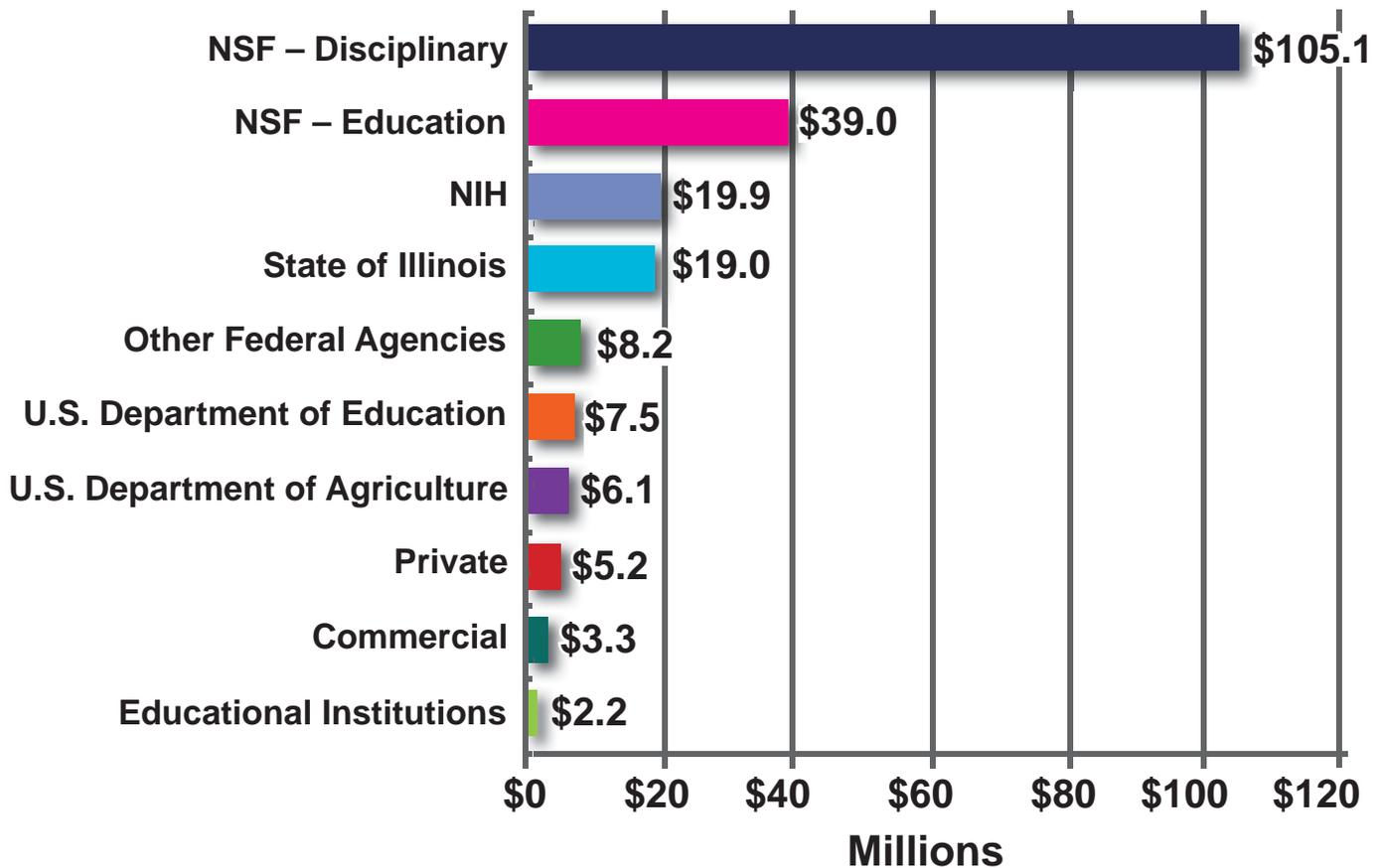


BTW student smells chives during a hands-on botany activity while on a field trip to Prairie Fruits Farm.

### I-STEM Website Externally Funded Projects and Funding Resources

- **Directory of Externally Funded STEM Education Projects**  
url: <http://www.istem.illinois.edu/stemed/stemed.html>
- **STEM Education External Funding Opportunities, by I-STEM Goal**  
url: <http://www.istem.illinois.edu/funding/fundingopps.html>
- **Upcoming Funding Deadlines**  
url: <http://www.istem.illinois.edu/funding/upcomingdeadlines.html>
- **STEM Education Annotated Bibliography**  
url: <http://www.istem.illinois.edu/resources/resources.html#bibliography>

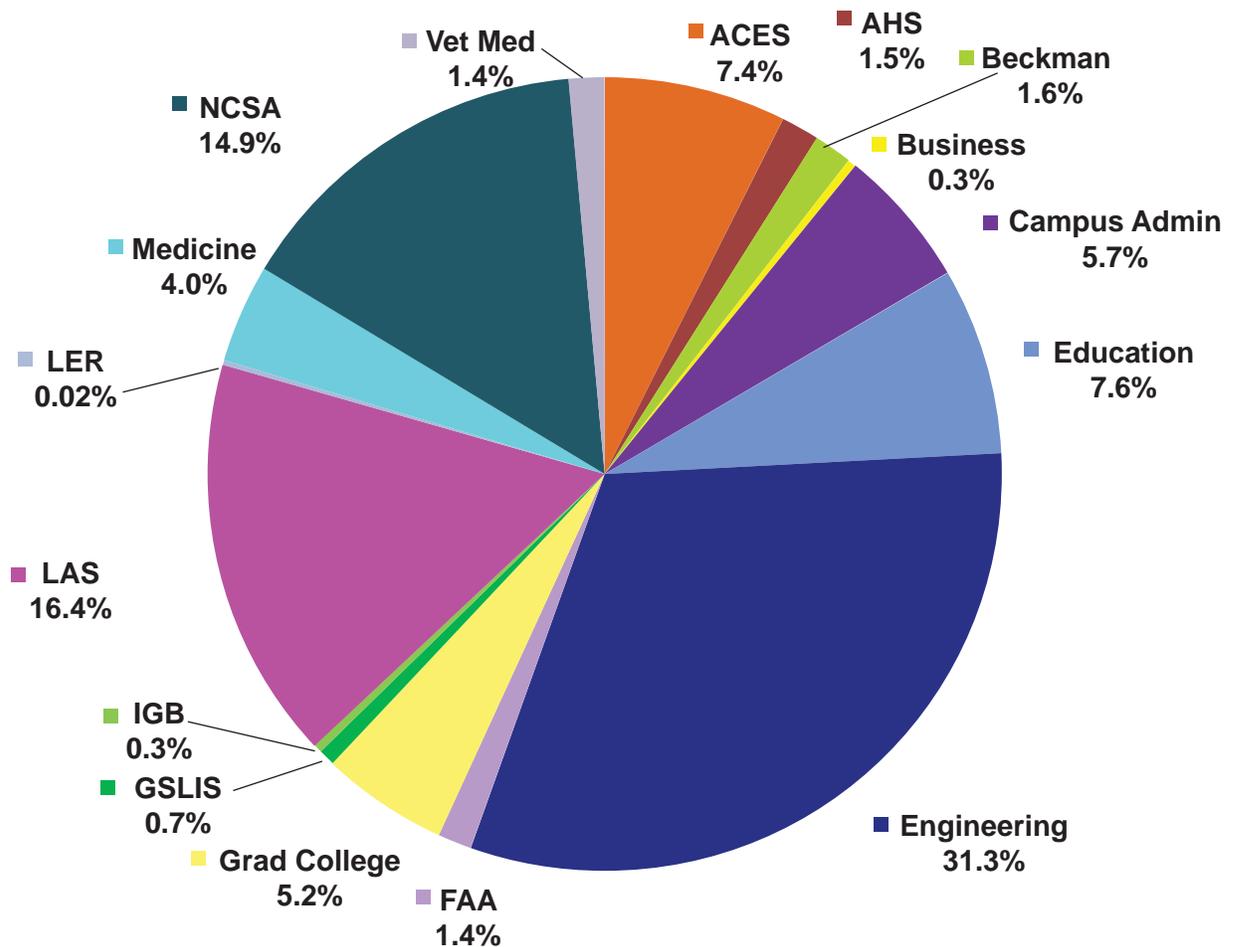
**Figure 3: Active External Investment in STEM Education at Illinois for 2012, by Funder**



FUNDER	INVESTMENT
National Science Foundation—Disciplinary Directorates/Other Offices (NSF–Disciplinary)	105,058,726
National Science Foundation—Education & Human Resources Directorate (NSF–EHR)	38,886,080
State of Illinois Agencies (State of Illinois)	19,852,223
National Institutes of Health (NIH)	18,988,898
U.S. Department of Education (DoED)	8,247,476
Other Federal Agencies (DoD, DoE, NASA)	7,488,989
Private (Foundations, Associations)*	6,145,306
U.S. Department of Agriculture (USDA)	5,171,875
Educational Institutions	3,296,313
Commercial*	2,200,742
<b>Total</b>	<b>\$215,446,629</b>

Note: As discussed on page 37, we calculated the estimated STEM education amounts for Figure 3 above and Figure 4 on page 39 using 100%, 30%, or 15% of the total funding award, respectively, for projects focused solely on STEM Education or its evaluation; research, but which include education components; and for large centers with STEM education components. \*Notable private and corporate support for STEM education projects includes Sloan Foundation, Caterpillar Foundation, Hewlett Packard Co., Ford Foundation, the National 4-H Council, Abbott Laboratories, John Deere Foundation, Motorola Foundation, Shell Oil Company, and ExxonMobil, as well as others.

**Figure 4: Active External Investment in STEM Education at Illinois for 2012, by Campus Unit**



CAMPUS UNIT	INVESTMENT
Agricultural, Consumer and Environmental Sciences (ACES)	15,934,204
Applied Health Sciences (AHS)	3,312,887
Beckman Institute	3,356,081
Business	717,680
Campus/University Administration	12,369,686
Education	16,385,304
Engineering	67,501,247
Fine and Applied Arts (FAA)	2,931,367
Graduate College	11,107,675
Graduate School of Library and Information Sciences (GSLIS)	1,438,852
Institute for Genomic Biology (IGB)	742,069
Liberal Arts and Sciences (LAS)	35,270,068
Labor and Employment Relations (LER)	430,529
Medicine	8,635,764
National Center for Supercomputing Applications (NCSA)	32,201,135
Veterinary Medicine (Vet Med)	3,112,082
<b>Total</b>	<b>\$215,446,629</b>



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