

I-STEM

EDUCATION INITIATIVE

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

I-STEM EDUCATION INITIATIVE ANNUAL REPORT

January–December, 2015



From the Desk of the I-STEM Director:

In spite of the severe economic challenges at both the local and state levels, 2015 was an eventful year in STEM Education initiatives at the University of Illinois at Urbana-Champaign. With well-known dedication, faculty, graduate students, and undergraduates on our campus extended their research and teaching expertise by working together and participating in interdisciplinary activities to design accessible, high-quality, innovative STEM Education programs.



Concentrating our efforts to improve STEM education does not serve only to prepare the future STEM workforce, but also to respond to the interests and values of all legitimate stakeholders, in particular those traditionally not heard in the STEM education context. Technology inventions, scientific discoveries, engineering applications, and mathematical models cannot happen in a homogenously expressed environment. This I-STEM report illustrates that it is essential to have and ensure diversity of perspectives and thinking in classrooms and laboratories to maintain the vitality of STEM creativity.

We hope you will recognize the benefits of the contextually powerful STEM initiatives in this report and of the increased collaboration and entrepreneurship in STEM education in our campus. They bring new perspectives to what traditionally has been perceived as only disengaged scientific research. We are hopeful that the energy and impact of these STEM initiatives will continue to grow in 2016!

A handwritten signature in black ink, appearing to read 'Rosu'.

*Luisa-Maria Rosu
Interim Director*

Front cover: Left to right: Two SACNAS members, Brenda Andrade, a Chemistry Ph.D. student, and Sandy Perez, an undeclared undergraduate, teach Leal students about acids and bases during Cena y Ciencias.
Back cover: Vet Med student Katelyn Bagg, who staffed a booth on reptiles and amphibians at the fall 2015 Vet Med Open House, introduces visitors to her animal friend, Pepper the Snake.

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I-STEM PARTNERS



COLLEGES AND SCHOOLS

- College of Agricultural, Consumer, and Environmental Sciences
- College of Applied Health Sciences
- 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
- National Center for Super-Computing Applications (NCSA)
- Office for Mathematics, Science, & Technology Education (MSTE)
- Osher Lifelong Learning Institute (OLLI)
- University of Illinois Extension—4H

EXTERNAL PARTNERS

- American Chemical Society
- American Physical Society
- American Society of Material
- Association of Public Land-Grant Universities (APLU)



EXTERNAL PARTNERS (CONTINUED)

- 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
- Next Generation School
- 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
- Larry DeBrock, Dean, Business
- Mary Kalantzis, Dean, Education
- Andreas Cangellaris, Dean, Engineering
- Kathleen Harleman, Dean, Fine and Applied Arts
- Keith Marshall, Associate Provost and Executive Director, Campus Center for Advising and Academic Services
- Fritz Drasgow, Interim Dean, Labor & Employment Relations
- Vikram David Amar, Dean, Law
- Brian Ross, Interim Dean, Liberal Arts and Sciences
- Victor Prybutok, Interim Dean, Library and Information Science
- Jan Slater, Dean, Media
- Uretz Oliphant, Interim Regional Dean, Medicine
- Wynne Korr, Dean, Social Work
- Peter Constable, Dean, Veterinary Medicine

CAMPUS ADMINISTRATION

- Timothy Kileen, President of the University of Illinois
- Barbara Wilson, Interim Vice President and Chancellor
- Edward Feser, Provost & Vice-Chancellor for Academic Affairs
- Peter Schiffer, Vice-Chancellor for Research
- Renée Romano, Vice Chancellor for Student Affairs
- Ed Ewald, Interim Vice Chancellor for Institutional Advancement
- Wojtek Chodzko Zajko, Associate Provost & Dean, Graduate College



CAMPUS INTERDISCIPLINARY UNITS

- Jennifer Eardley, Associate Vice Chancellor for Research and Interim Director, Division of Biomedical Sciences
- Gene Robinson, Director, Institute for Genomic Biology and Swanlund Chair of Entomology
- Art Kramer, Director, Beckman Institute and Swanlund Chair and Professor of Psychology and Neuroscience
- H. Edward Seidel, Director, National Center for Supercomputing Applications

I-STEM EXTERNAL ADVISORY BOARD

- José M. Torres, President, Illinois Mathematics and Science Academy
- Judy Wiegand, Superintendent, Champaign Unit 4 School District
- Donald Owen, Superintendent, Urbana School District 116
- Molly Delaney, Executive Director, Champaign-Urbana Schools Foundation

I-STEM CORPORATE ADVISORY BOARD

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





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 seventh full year of operation in January 2016. I-STEM partnered with STEM (science, technology, engineering, and mathematics) academic and research units at the University of Illinois at Urbana-Champaign (*Illinois*), and increased the number of partners across the state and nation. I-STEM seeks to improve the access, quality, and efficiency of STEM education activities at *Illinois*, in the state and the nation, serving as a model for other universities seeking to improve the number and quality of their own STEM education programs.

WHY 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 Science and Technology Council report, *Federal Science, Technology, Engineering, and Mathematics (STEM) Education Strategic Plan (2013)* improving STEM education will continue to be a high priority. However, U.S. student interest and performance in 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 one of the nation's premier land-grant research universities, *Illinois* is committed to improving STEM education at all levels.

I-STEM's activities are organized around four primary goals:

- **Goal 1: Facilitate P–20 STEM Education Outreach.** Cultivate sustained, coordinated preschool through graduate partnerships to engage students in STEM experiences early and consistently. Involve university faculty and students to help meet STEM education challenges.
- **Goal 2: Improve STEM Teacher Training & Professional Development Quality.** Revitalize STEM teacher preservice education, induction, and professional development programs that attract/prepare a diverse group of P–16 STEM teachers and promote their effectiveness, retention, life-long learning, and involvement in research.
- **Goal 3: Foster Undergraduate & 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 & Advocate for STEM Education.** Stimulate partnerships with, government agencies, educational institutions, business and industry, and professional associations to understand STEM pipeline; mainline; and workforce development needs, opportunities, and challenges. Serve as advocates in the state and nation.



Above: A 2015 Aerospace Engineering GAMES camper waits to test the glider she built.

Opposite (page vi): Seated in the Formula SAE racing car, this Formula SAE team member showed up to woo high school visitors during MechSE's Open House.

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



Above: In the aftermath of a drenching, MechSE Professor Sameh Tawfick, one instructor for the spring 2015 ME370, celebrates one team's success.

Below: MechSE Ph.D. student Sezer Ozerinc, who helped teach ME 370 in spring 2015, patiently anticipates a drenching.



OVERVIEW OF I-STEM ACTIVITIES

During its seventh year of operation, I-STEM performed a variety of activities, both to serve as a resource to improve/increase STEM education on campus and to foster STEM education locally, in the state, and in the nation. Major I-STEM activities in 2015 included:

1. **Fostering and participating in dialogue among key campus and external stakeholders** 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. **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.
4. **Enabling discourse and networking among STEM educators about effective pedagogy and program components** via meetings, seminars, presentations, and discussion groups; interactive directories; and a listserv that serves educators on campus and beyond (see our communication resources below).
5. **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 41).
6. **Promoting K–12 Outreach Activities.** I-STEM has developed an extensive network of STEM outreach projects and organizations. I-STEM staff played a significant role in recruiting volunteers for a variety of K–12 outreach activities during 2015, as well as sponsoring campus visits by several Illinois schools.

Communication Resources

- **I-STEM Website.** Incorporates information about campus STEM education outreach activities and upcoming funding opportunities for both internal and external audiences. The STEM Education news stories and Directory of Externally-Funded Projects are organized by target audience. The STEM Education Funding Opportunities, are organized both chronologically and by funder. urls: istem.illinois.edu/index.html; istem.illinois.edu/funding/upcomingdeadlines.html; istem.illinois.edu/funding/fundingopp.html
- **I-STEM-News Listserv.** Informs campus and non-university listserv members about current STEM-education-related news, events, and upcoming funding opportunities. url: <https://lists.illinois.edu/lists/info/i-stem-news>
- **I-STEM Print/Electronic Resources.** In addition to this Annual Report, I-STEM produced a new magazine: *2015: The Year in STEM Education*. A new outreach programs flyer is scheduled to be released in spring 2016. url: istem.illinois.edu/resources/resources.html

I-STEM'S ROLE: FOSTER STEM EDUCATION

I-STEM's involvement in facilitating STEM education targets four goals/ audiences on campus and throughout the state of Illinois and the nation: 1) **P–20 students**, 2) **STEM educators**, 3) **undergraduate/graduate students**, and 4) **STEM education policymakers** (see page 1 for descriptions). To accomplish our 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.

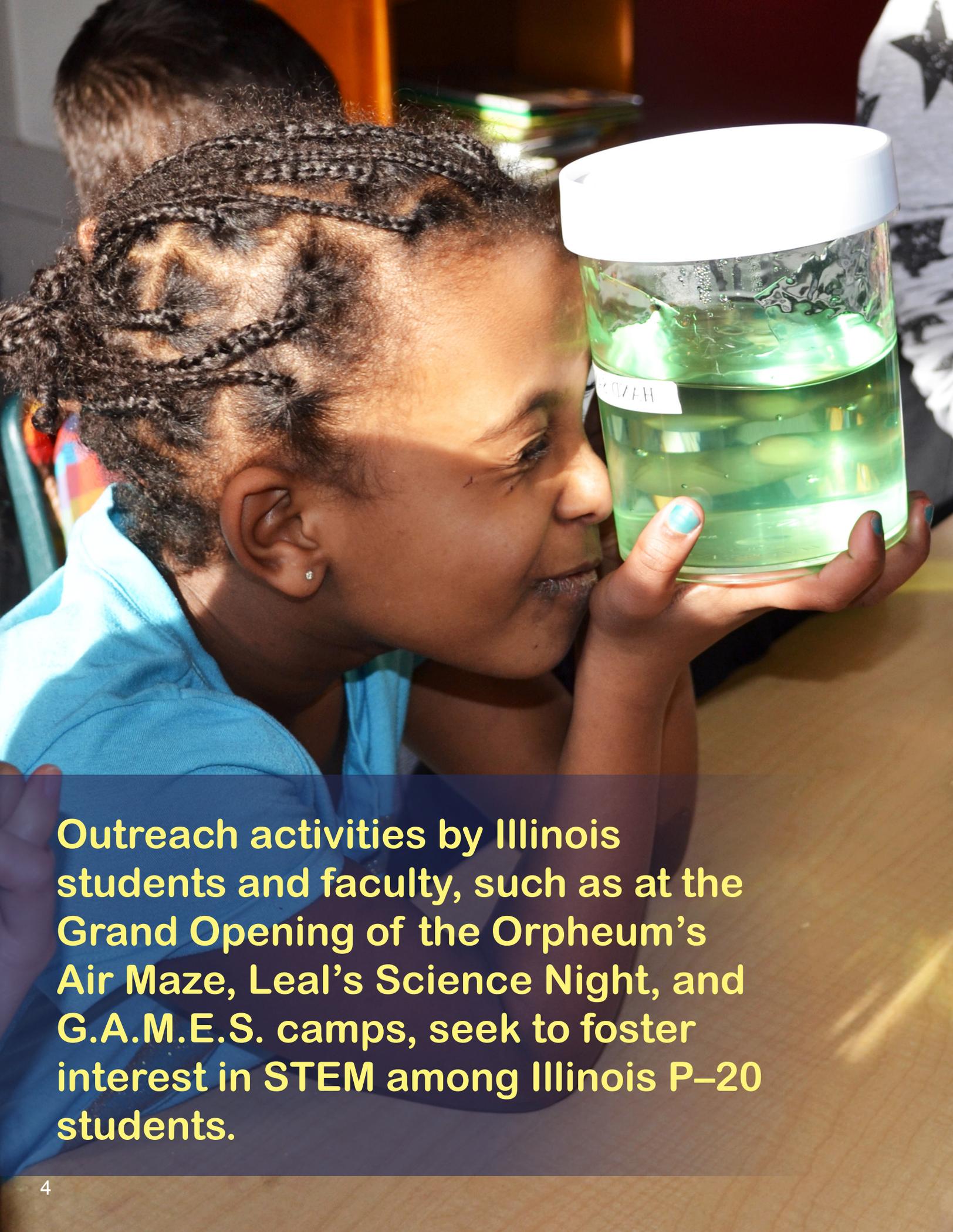
- ★ **Foster Communication/Collaboration.** I-STEM meets regularly with campus STEM researchers and STEM education coordinators regarding education, outreach, or evaluation components in their projects. The I-STEM-News listserv facilitates communications about STEM education news, upcoming opportunities and events. I-STEM also connects the general public with university groups/projects who perform outreach activities (see pages 2 and 41 for communication resources and links).
- ★ **Funding Opportunities.** I-STEM's website offers resources regarding upcoming STEM education funding opportunities involving our target groups: Upcoming Funding Deadlines¹ lists impending deadlines by date; STEM Education Funding Opportunities² organizes data by funder. The I-STEM-News listserv apprises subscribers of upcoming funding opportunities. I-STEM staff routinely research funding sites and perform maintenance of I-STEM's resources to catalog and make available current information.
- ★ **Provide Grant-Writing/Education/Evaluation Expertise.** I-STEM serves in an advisory capacity to faculty, researchers, or units, and assists in writing education, outreach, and/or evaluation components for their proposals and/or research grants/projects. I-STEM assesses the impact of various programs' outreach activities, teacher development, undergraduate/graduate program reform efforts, or policy, both to improve STEM education in a variety of settings and to improve recruitment to *Illinois*. In these roles, I-STEM gathers information about its target groups and the impact of programming on instruction, student achievement, and recruitment into STEM fields.
- ★ **Disseminate STEM Education Program Information.** While I-STEM disseminates information to stakeholders in a variety of ways, it is primarily through the website, where new STEM education articles related to I-STEM's four goals and their target groups (see above), and/or newly awarded funding with STEM education components are posted regularly. Routine maintenance of external funding resources involves on-going research to both post information, organized by funder and upcoming deadlines, and to send it electronically via email and the I-STEM-News listserv. I-STEM's evaluation reports, annual reports, magazine, STEM education outreach flyer, and posters are available electronically or in printed form.

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

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

Glossary of Terms

- APLU: Association of Public and Land-grant Universities
- BTW: Booker T. Washington STEM Academy
- 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
- 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
- MechSE: Mechanical Science and Engineering Department
- M-CNTC: Midwest Cancer Nanotechnology Training Center
- NIH: National Institutes of Health
- NCSA: National Center for Supercomputing Applications
- NSF: National Science Foundation
- PD: Professional Development
- RET: Research Experiences for Teachers
- REU: Research Experiences for Undergraduates
- RSO: Registered Student Organization
- SMTI: Science and Mathematics Teacher Imperative
- STEM: Science, Technology, Engineering and Mathematics
- Uni High: University Laboratory High School
- XSEDE: eXtreme Science and Engineering Discovery Environment



Outreach activities by Illinois students and faculty, such as at the Grand Opening of the Orpheum's Air Maze, Leal's Science Night, and G.A.M.E.S. camps, seek to foster interest in STEM among Illinois P-20 students.

Goal 1: Facilitate P–20 STEM Education Outreach

P–20 STEM EDUCATION OUTREACH

Following are the types of P–20 STEM education outreach activities in which I-STEM was involved in 2015, including specific partners or projects with whom staff collaborated or about whom I-STEM disseminated information.

◆ Identify campus STEM P–20 outreach activities.

Illinois hosts numerous STEM Education P–20 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 and in printed or electronic materials. Information about activities is organized by stakeholder group, including *P–20 teachers*³ seeking professional development or to reinforce STEM classroom instruction with additional activities, and parents and/or the students themselves seeking STEM education opportunities via *summer camps*⁴ or *academic year activities*.⁵

I-STEM has also identified programs which serve as examples of highly effective STEM education P–20 outreach programs, such as G.A.M.E.S. Camp (see page 15) and Research Experiences for Undergraduates (see page 22). I-STEM evaluated many of these in 2015, or featured them on our website.

◆ Partner with state and national organizations.

To ensure that *Illinois* is strategically positioned to promote collaboration and leverage resources to improve P–20 STEM education experiences for students in the state, especially those from underrepresented groups, I-STEM partnered with state and national STEM P–20 organizations/initiatives, such as Illinois' P–20 Council and AAU's (Association of American Universities) Undergraduate STEM Education Initiative (see pages 8 and 24, respectively).

◆ Evaluate P–20 STEM outreach activities.

In order to improve the impact of *Illinois*' STEM P–20 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 a number of P–20 outreach programs I-STEM evaluated in 2015.

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

⁴<http://www.istem.illinois.edu/resources/goal1resources.2.html#summercamps>

⁵<http://www.istem.illinois.edu/resources/goal1resources.2.html#acadyear>



Above: During Leal Science Night, a 3rd grader at the Physics Van table dips a blossom into liquid nitrogen, which caused it to quickly freeze and turn stiff.

Opposite on page 4: During the Grand Opening of the Orpheum's Air Maze, a Martin Luther King third grader examines a flunny fluid.

I-STEM partnered with state and national STEM P–20 organizations in 2015, such as the Illinois P–20 Council and the American Association of Universities' Undergraduate STEM Education Initiative.



Clockwise from above: During the Next Generation School's Science and Engineering Fair, an *Illinois* researcher (center) interacts with a student.

Bottom right: David Bergandine's class of students from Uni High appreciate seeing researcher Marty Burke's molecule-making machine up close.

Bottom left: A local girl proudly displays a structure she made at the civil engineering table during the fall 15 Mommy, Me, and SWE outreach.



Program	Principal/Co-Principal Investigator(s)
Center for Sustainable Nanotechnology (CSN)	Robert Hamers, Chemistry, UW-Madison
CMMB (Cellular & Molecular Mechanics & BioNanotechnology) IGERT	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
Research Experiences for Undergraduates (REU) 1) Bioimaging 2) CSN 3) Chemistry 4) EBICS 5) Nano@Illinois	1) Stephen Boppart, Chemistry 2) Robert Hamers, Chemistry, UW-Madison 3) Alexander Scheeline, Chemistry 4) Rashid Bashir, Engineering 5) Cathy Murphy, Chemistry
VINTG (Vertically Integrated Training with Genomics) IGERT	Andrew Suarez, Entomology
XSEDE (eXtreme Science and Engineering Discovery Environment)	John Towns, NCSA (National Center for Supercomputing Applications)



◆ **Work with and disseminate information about STEM P–20 partners and campus STEM demonstration sites.**

To help *Illinois* reach more elementary, middle, and secondary school students 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 2015, thousands of P–20 students engaged with STEM researchers and students during campus visits or off-site activities. I-STEM promoted *Illinois*' P–20 STEM outreach activities via its website, plus developed an informal network of campus outreach groups and served as a liaison to apprise them of outreach opportunities (see pages 10–13.)

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

To increase the number of Chicago Public School (CPS) students graduating from *Illinois* in STEM fields, *Illinois* strives to repeatedly engage talented 7th–12th grade CPS students via after-school programs, summer camps, mentoring, internships, and campus visits through programs like *Illinois*' Chicago Pre-College Science and Engineering (ChiS&E) STEM enrichment program, the R&D STEM Mentor-Matching Engine, and I-STEM-facilitated campus visits.

◆ **Increase external funding for P–20 STEM education and outreach.**

To establish an adequate, sustainable campus funding base for P–20 STEM education and outreach, I-STEM participated in the submission of at least 48 external funding proposals totaling approximately \$92 million in requested funds in 2015. I-STEM also supports the centralization of funds awarded to campus by NSF's Education and Human Resources Directorate (approximately 15% of direct costs) to support sustainable P–20 STEM education and outreach (see pages 41–43 for I-STEM's analysis of STEM education funding on campus).



Above: Garden Hills students doing a hands-on activity during Brady STEM Academy will soon be able to boast that they have mixed polymers.

Below: Two Environmental Engineering G.A.M.E.S. campers test the water in Boneyard Creek.

Bottom left: A young student (left) from Chicago's Foundations 4 Advancement Christian College and Career Readiness Academy shows off the marshmallow-toothpick structure he built during a campus visit in fall 2015.





Above: I-STEM evaluator Christine Shenouda hands out surveys at a showing of CADENS' "Solar Superstorms."

Bottom right: An *Illinois* MakerGirl (right) with one of the MakerGirl regulars, who is showing off the gear she made.

Below: 2015 Computer Science GAMES campers wait to compete robots they built.



P-20 STEM EDUCATION OUTREACH PROGRAMS

Programs I-STEM Evaluated in 2015⁶

- ★ **Centrality of Advanced Digitally Enabled Science (CADENS).** This three-year, NSF-funded project uses visualization of computational data to develop high-resolution dome shows, documentary programs, and supplementary educational material for the general public. Thus far, the project has produced *Solar Superstorms*, a dome show narrated by Benedict Cumberbatch, that visualizes the inner workings of the sun and is being shown at planetariums across the country. Several other shows and documentaries are also being developed. I-STEM evaluates the accessibility of the visualizations and the clarity of the accompanying script and supplementary materials to assess these films' impact on children's and adults' understanding of and interest in the scientific material and the importance of computational data and visualization.
- ★ **Community Outreach and Translation Core (COTC).** COTC serves as an organizing hub of information about health effects on the developing infant, child, and adolescent that comes from exposure to everyday chemicals, combined with diets high in packaged foods. Funded by the U.S. Environmental Protection Agency and the National Institute of Environmental Health Sciences, COTC aims to link scientific investigators from *Illinois'* I-Kids Children's Environmental Health Research Center with various community stakeholders. I-STEM evaluates the Community Advisory Board which assists the COTC in translating this information through community-based research and community engagement.
- ★ **Center for Emergent Behaviors of Integrated Cellular Systems (EBICS).** As part of EBICS' evaluation, I-STEM staff visited three African-American high schools in Atlanta, Georgia in which EBICS does outreach: the Business, Engineering, Science, and Technology Academy; Coretta Scott King Young Womens' Leadership Academy, which is all female students; and KIPP Atlanta Collegiate.

⁶Expands upon and provides details on programs included in Table 1 (see page 6).



★ **Illinois P–20 Council.** Illinois' P–20 Council⁷ guides education policy and seeks to develop an integrated P–20 system in the state. In 2015, Dr. DeStefano served on all its committees: the Coordinating Committee; Family, Youth, and Community Engagement; Implementation Review; Joint Education Leadership; Postsecondary & Workforce Readiness; Teacher & Leader Effectiveness; and the Research & Development STEM Coalition Steering Committee⁸ (see pages 39 and 40 for more on the P–20 Council).

★ **MakerGirl.** I-STEM is evaluating this after-school program begun and run by female *Illinois* students hoping to pique girls' interest in STEM. Held in the Business Instructional Facility's MakerLab, MakerGirl offers 3D printing sessions to local 7–10-year-old girls. Themed sessions introduce girls to the science behind 3D printing. Girls watch a short presentation, then use free, web-based software for kids, Tinker CAD, to create 3D designs then print them.

★ **Mississippi River Transportation Distribution and Logistic Consortium (MRTDL).** I-STEM evaluated this consortium of nine community colleges representing eight states that border the Mississippi. MRTDL seeks to advance the region's economic development by using Trade Adjustment Assistance Community College Career Training funds to train unemployed workers, such as veterans and members of other underserved groups, and place them in high-wage, high-skill occupations.

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

⁸<http://stemlearningexchange.org/>



Above and below: Local girl scouts use TinkerCAD to make 3D designs during MakerGirl.





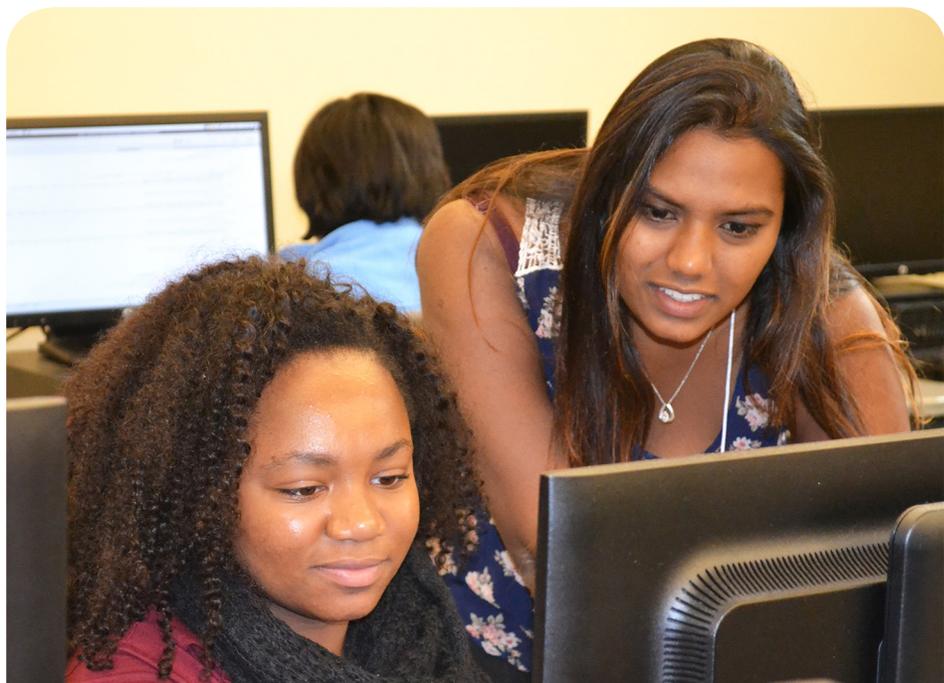
★ **Research & Development STEM Learning Exchange (RDLE).** Dedicated to educating, recruiting, and retaining the next generation of STEM talent for Illinois industry research and development (R&D), RDLE connects students, teachers, families, universities/colleges, federal laboratories, student organizations, not-for-profits, and private sector employers so Illinois students can participate in authentic, high-quality, student-driven R&D. RDLE's three initiatives include STEM Challenges, the Mentor-Matching Engine, and a STEM Resource Repository⁸. Funded by the Illinois Science & Technology Institute, I-STEM's evaluation seeks to provide program managers useful information to guide program improvement, effectiveness, and suitability. In addition, in 2015, I-STEM organized two Mentor-Matching Engine recruitment luncheons to recruit *Illinois* STEM graduate students to mentor Illinois high schoolers.

Above and top right: Local children who participated in REEEC's outreach about Russian, East European, and Eurasian culture enjoy a Family Fun Day.

Bottom right: An Illinois CS student helps a high school student during the fall 2015 ChicTech retreat.

Below: A Microbiology PhD student and member of SACNAS works with a Leal student during a *Cena y Ciencias* hands-on activity about acids and bases.

★ **Russian, East European, and Eurasian Center (REEEC).** In spring 2015, REEEC conducted an outreach program to expose Savoy Head Start students to Russian, East European, and Eurasian cultures. I-STEM's evaluation included individual interviews with REEEC's program coordinator and Savoy Head Start classroom teachers and attendants, plus observations of classrooms as well as an end-of-the-program Family Fun Day event.





STEM Education Outreach Programs⁹

- **Booker T. Washington STEM Academy (BTW).** Numerous units/programs provided outreach at BTW in 2015. Following are a number of programs/activities.
 - **Engineering Club.** At BTW's after-school Engineering Club, MechSE and Aerospace students taught BTW students engineering via fun, hands-on activities.
 - **NanoSTRUCT.** Graduate students introduced BTW 3rd graders to nanoscience and nanotechnology.
- **Brady STEM Academy.** Faculty member Jerrod Henderson started this after-school program targeting male African-American students at Booker T. Washington and Garden Hills Schools. Activities are led by STEM undergraduate and graduate students, many from *Illinois'* Chemical and Biomolecular Engineering.

Top left: Three Garden Hills students proudly display the congealed polymers they made during Brady STEM Academy.

Above: Community Health Ph.D. student, Kelsie Kelly, works with a student during the Brady STEM Academy after-school program.

Below: Two BTW students build their tower even taller prior to giving it the final Jello-earthquake-shake test during BTW's Engineering Club.

Bottom left: Left to right: Two NanoSTRUCT grad students engage BTW 3rd graders during a demonstration.

⁹STEM disseminates information about these campus groups/outreach programs and informally networks with them to help meet STEM education outreach needs/requests locally and statewide.





Above: A Uni High student prepares to add an ingredient to the purification module of "The Machine."

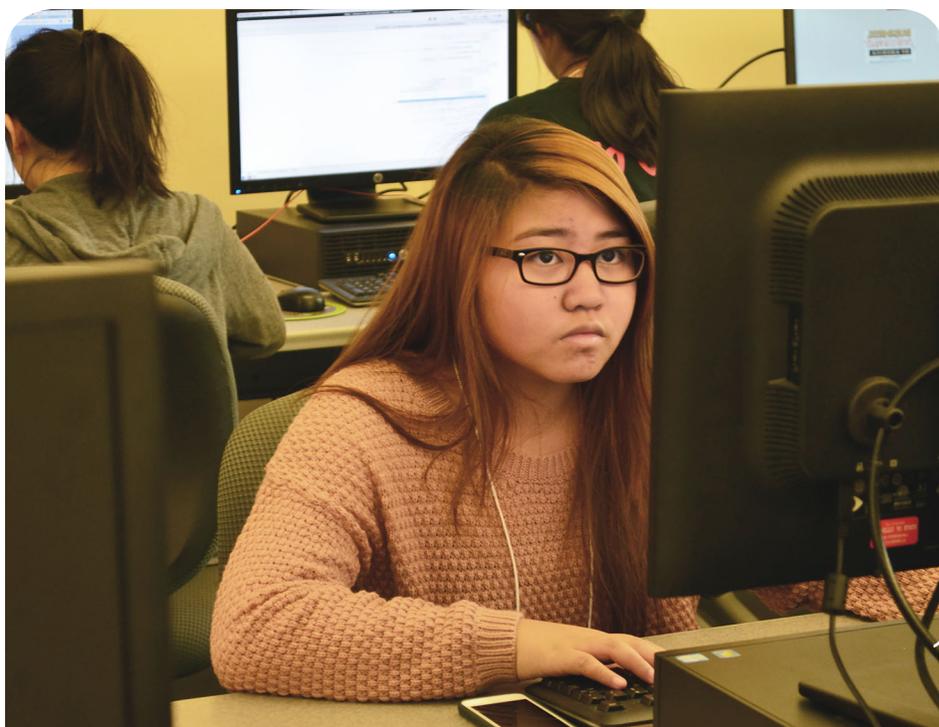
Bottom right: A high school student works on her project during a ChicTech workshop.

Below: A young Cena y Ciencias participant does a hands-on activity about acids and bases.



Above: Ph.D. student Michael Schmidt (left), a member of Burke's research group, explains molecule synthesis to Uni High students.

- **Burke Lab Outreach.** Students in a University Laboratory High class were invited to researcher Marty Burke's lab to learn about creating molecules that replicate the function of proteins and to experience Burke's new invention, a molecule-making machine. Burke's Lab Partners program also exposes students from rural high schools to his lab's research.
- **Cena y Ciencias.** Spanish for Supper and Science, Cena y Ciencias met Monday nights once a month with Dual-Language Program K-5 students from Leal and Prairie Elementary Schools. Conducting the outreach were *Illinois* graduate and undergraduate students who are members of SACNAS (Society for Advancement of Hispanics/Chicanos and Native Americans in Science).
- **ChicTech.** A number of *Illinois*' female Computer Science (CS) students devoted an entire weekend in November 2015 to host a group of high school girls as part of the 2015 ChicTech Retreat, which is sponsored by Women in Computer Science, a student organization for female CS students at *Illinois*.



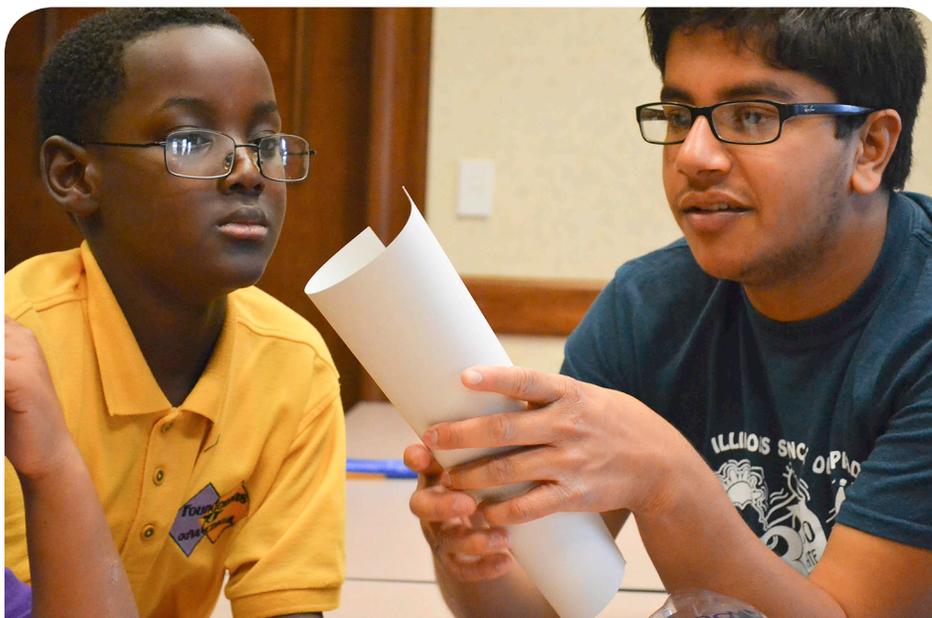


- **ChiS&E.** *Illinois'* Chicago Pre-College Science and Engineering (ChiS&E) STEM enrichment program exposed Chicago Public School 5th through 7th grade students to math and physics activities in both the fall and spring semesters. Staffing the activities are *Illinois* graduate and undergraduate students from math and engineering, as well as other disciplines.
- **Engineering Open House.** The 2015 iteration of this annual, student-led event featured exhibits that showcase the talent and ingenuity of *Illinois'* engineering students. This outreach drew thousands of visitors, ranging from families with preschoolers, to teachers bringing their classes on field trips, to high school students considering *Illinois'* engineering program.
- **Foundations 4 Advancement campus visit.** In fall 2015, 30 Chicago youngsters, P–5th grade (the youngest was 3) visited campus for a tour and some hands-on STEM activities led by a number of engineering students.
- **G.A.M.E.S. Camp.** *Illinois* graduate and undergraduate students served as instructors and counselors at the 2015 G.A.M.E.S. Camp, which exposed high school girls to engineering disciplines.

Top left and above: CPS students use i>clickers to vote during ChiS&E's fall 2015 end-of-the-semester event at the Physics Building.

Below: A local youngster appreciates a water flume during Engineering Open House.

Bottom left: Engineering student Athrey Nadham (right) and a group of Foundations 4 Advancement students discuss the best type of material to use to make their stomp rocket.





Above: At Leal Science Night, Physics Van student Brian Korn (left) blows on a liquid-nitrogen-shriveled balloon animal to heat the gas inside it to make it expand.

Top right: Two Animal Biology graduate students encourage Leal Science Night visitors to identify the skeleton in the case (it's a cat's).

Below: A Leal student prepares in case the next Physics Van demonstration produces a loud noise. (It didn't).



- **Illinois Science Olympiad.** Numerous *Illinois* personnel volunteered in the 2015 state tournament held on campus, including current students who had participated in Science Olympiad themselves.
- **iRobotics.** Members of iRobotics, an RSO comprised mostly of engineering students, participated in several STEM-related events in 2015, both to share their love of the sport and to get kids interested in STEM.
- **Leal Science Night.** Numerous STEM students, student organizations, and professionals shared their love of STEM with local students and their parents at Leal School's annual Science Night, including Physics Van, REACT, MechSE undergraduate student Patrick Slade, and two graduate student groups: PBAGS (Plant Biology Association of Graduate Students) and GEEB (Graduates in Ecology and Evolutionary Biology). Also participating were graduate and undergraduate student members of SACNAS (Society for the Advancement of Chicanos/ Hispanics and Native Americans in the Sciences).
- **MechSE Open House.** *Illinois'* Department of Mechanical Science and Engineering held a fall 2015 Open House which featured numerous exhibits by students, staff, and professors, and introduced visitors/current students to a number of student societies, labs, and professors' research.
- **Next Generation School (NGS) Partnerships.** In 2015, *Illinois* staff and students participated in a number of programs at the local school: for example, around 20 *Illinois* researchers and graduate students judged the school's 2015 Science Fair.
- **Physics Van.** This outreach by mostly undergraduate Physics students did outreach in schools and community STEM events, such as the Leal Science Night in spring of 2015.
- **REACT.** REACT chemistry students visited most of the local schools as well as other community events to help teach local youngsters about chemistry via hands-on demonstrations.



- **Rheology Zoo.** Students who are part of MechSE professor Randy Ewoldt's research group performed outreach about rheology (non-Newtonian fluids) at numerous events, such as EOH and MechSE Open House, and the grand opening of the Orpheum Children's Science Museum Air Maze.
- **SWE.** In the Society of Women Engineers' (SWE) many outreach events (Mommy, Me, and SWE; High School Engineering Round Robin, Introduce-a-Girl-to-Engineering Day, DADDS (Dads and Daughters Do Science); FKO (For Kids Only); Step-Up; and CU Special Recreation Outreach), female engineering students experienced what teaching is like while exposing kindergarten through high school students, plus some parents, to engineering.
- **University Laboratory High School Engineering Class.** Uni High's engineering class designed and built an air maze for the Orpheum Children's Science Museum.
- **Vet Med Open House.** At the fall 2015 Open House, Vet Med students provided fun, hands-on activities for visitors, both young and old, to show the public what goes on at an animal hospital.
- **WYSE Camps.** Illinois' 2015 WYSE (Worldwide Youth in Science and Engineering) camps, which expose high school students to engineering, helped a number of engineering graduate and undergraduate students discover how rewarding teaching can be.



Top left: A Civil Engineering student (right) teaches visitors about structures at SWE's Mommy, Me, and SWE outreach.

Above: Students from Randy Ewoldt's lab demonstrate how one non-Newtonian fluid found in Ewoldt's Rheology Zoo differs from a Newtonian fluid, like water.

Below: A Leal student (right) designs a structure during SWE's FKO outreach.

Bottom left: A Vet Med student (right) teaches a young visitor about heartworms in animals at the Vet Med Open House.





I-STEM partners with campus projects, such as the Nano@Illinois RET, which provides research experiences for teachers.

Introduction

The Illinois Integrated RF Micro utilizes nano and micro-electro systems (N/MEMS), integrated compound semiconductor technology to develop chip-scale hybrid micro communication, sensing, and imaging applications. [1]



The nano@Illinois Research Experience Teachers (RET) challenged a high school integrated physical science teacher through the MEMS fabrication process.

Project Description

The Product
A Piezoelectric AIN MEMS Resonator



Structures & Features

- Consists of a micro-scale piezoelectric plate, electrodes, leathers and a releasing pit.
- Vibrates laterally when a time-varying electrical signal is applied.
- Sends feedback to an amplifier to produce an oscillation of high frequency (~GHz).

University of Illinois Center for Nanoscale Science and Technology

Goal 2: Improve STEM Teacher Training and Professional Development Quality

STEM TEACHER TRAINING/PROFESSIONAL DEVELOPMENT IMPROVEMENT

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

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 works with organizations like APLU/ SMTI (see page 18) and campus units which share this same goal.

◆ Evaluate STEM teacher training and professional development projects.

In 2015, I-STEM evaluated several NSF-funded STEM teacher training and professional development projects operating at *Illinois*, including the NASA Astrobiology Institute Teacher Workshop and Nano@*Illinois* RET, which exposed STEM teachers to cutting-edge research in nanotechnology. 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.

◆ Strengthen campus STEM teacher professional development.

I-STEM works to help *Illinois*' teacher education programs provide a comprehensive, high-quality continuum of professional development for STEM teachers, including induction and mentoring; graduate disciplinary coursework and degree options; research experiences; and leadership development in order to improve STEM teacher retention, reduce out-of-field teaching, and increase student performance.



Above: Nano@*Illinois* RET participant Bharathi Subramaniasiva works on her research on Self-Rolled Up Membranes in MNTL's cleanroom lab.

On opposite page, (page 14): a 2015 RET participant presents the results of her research to a visitor to the Nano@*Illinois* RET final poster session.

Table 2: Selected Teacher Development Programs I-STEM Evaluated in 2015

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
nano@ <i>illinois</i> Research Experience for Teachers (RET)	Xiuling Li, Chemistry Lynford Goddard, ECE
NASA Astrobiology Institute Teacher Workshop	Nigel Goldenfeld, Physics Brouce Fouke, Geology

I-STEM works to help Illinois' teacher education programs provide a comprehensive, high-quality continuum of professional development for STEM teachers.



Above: An *Illinois* graduate student (left) works with a young BTW student who is testing the “apple battery” he created during Brady STEM Academy.

Top right: A REACT chemistry student (left) helping out during Brady STEM Academy teaches a Garden Hills student how to measure a liquid correctly.

Bottom right: A Nano@Illinois RET participant does research on strain-induced, self-rolled-up membranes in MNTL’s cleanroom lab.



To prevent duplication of services and professional development topics offered by university programs, I-STEM is working to ensure that educators have access to unique PD experiences in a logical sequence across campus STEM teacher PD programs that offer workshops and training. I-STEM also encourages programs to target teachers in high-need districts/regions in order to improve retention and student performance. STEM teacher PD opportunities are posted on I-STEM’s website and sent to interested stakeholders via I-STEM’s listserv. (See pages 2 and 41 for communication resources.)

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

In 2015, I-STEM worked with several units who were submitting STEM teacher development proposals to funding agencies. I-STEM encourages faculty writing proposals to incorporate existing campus teacher development programs into them as a way to sustain and institutionalize these teacher preparation and professional development programs. I-STEM also encourages K–12 school districts to take advantage of campus professional development (PD) resources. In addition, I-STEM recommends that projects/labs offer Research Experiences for Teachers (RET; see Table 3 to the left). In 2015, 46+ campus projects fostered collaboration with K–12 teachers by offering PD, lesson plans, and/or research opportunities.

Table 3: Campus Research Experiences for Teachers

Years	Number
2008–2009	4
2009–2010	8
2010–2011	12
2011–2012	13
2012–2013	16
2013–2014	17
2014–2015	12
2015–2016	17





Kelsie Kelly, an *Illinois* Ph.D. student in Community Health, works with a Garden Hills student during the Brady STEM Academy after-school program.

◆ **Increase teacher education candidates/student volunteers.**

Encouraging STEM majors to participate in outreach in schools and other informal educational settings may produce benefits beyond exposing youngsters to STEM. These students may discover that they enjoy teaching and choose to continue doing similar activities once they graduate...or even choose teaching as a career. Thus, I-STEM recommends that units/projects include components where students perform community outreach with the goal of increasing the number of teacher education candidates and fostering commitment to outreach. In 2015, *Illinois* staff and students volunteered in numerous programs targeting P-12 students, including camps, open houses, and outreach in schools.

In 2015, I-STEM developed an informal network of *Illinois* projects and student organizations that conduct outreach activities which feature *Illinois* students volunteering in schools and at other informal educational settings and the types of activities in which they participated in 2015. (See pages 10-13 for an incomplete listing of these organizations/projects and outreach activities.) Additionally, as part of I-STEM's mandate to disseminate information about STEM education activities, web articles were published on I-STEM's website about many of these student groups/outreach activities.



Above: A Booker T. Washington student does a hands-on activity led by *Illinois* engineering students.

Below: Caitlyn Deegan, a sophomore in Materials Science and Engineering, helps a young MakerGirl with her design.

Bottom left: During *Cena y Ciencias*, two Microbiology Ph.D. students demonstrate how the color of the solution changes during an acid/base reaction.





STEM EDUCATION TEACHER TRAINING / PROFESSIONAL DEVELOPMENT PROGRAMS

★ **APLU/SMTI.** 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/diversity of science and math teachers. SMTI's Mathematics Teacher Education Partnership fosters university-K–12 district collaboration to transform math teacher preparation.

★ **Bridging Cultures.** This Center for Global Studies initiative provides cross-cultural, international programming on educational practice, pedagogy, and policy. International secondary educators from 20 countries and a cohort of American teachers gained a multicultural perspective while exploring each others' cultural and educational practices. Collaboration in workshops, discussions, and lesson planning fostered relationship-building. I-STEM staff conducted a focus group to assess program effectiveness.

★ **Distinguished Teacher-Scholar Project.** Gretchen Adams, Chemistry Merit Program Director and I-STEM affiliate, taught a monthly workshop series, "Instructional Strategies That Increase the Retention and Academic Performance of Underrepresented Students on Campus" from fall 2014 through spring 2015. The goal of the workshop was to help faculty identify issues related to underrepresented groups in their classrooms, explore research-based programs and instructional strategies for improvement, and design an evaluation plan. I-STEM evaluators observed sessions and administered surveys.

Above and top right. Bridging Cultures participants engage in a lively discussion during one of the sessions.

Bottom right: Participants in Gretchen Adams' Distinguished Teacher-Scholar Project enjoy a discussion during one of the workshops.

Below: Gretchen Adams shares with participants attending her workshop about her work with underrepresented students in the Merit/MIST Program.



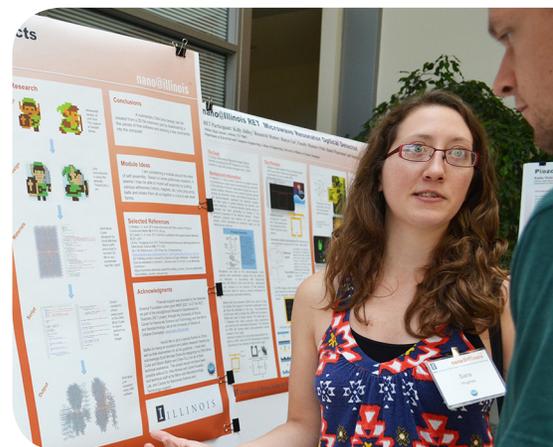
★ **Fulbright Early Career Scholar Fellowship.** In 2015, I-STEM's Luisa-Maria Rosu spent nine months in Romania as a Fulbright Early Career Scholar. The overarching theme of her Fulbright project was to understand how conversations about quality criteria reveal the espoused values of various stakeholders in the Romanian education programs in higher education (students in education, future teachers, faculty members, or members of the Educational Studies Institute) and refine the conceptualization of the educative approach of evaluation (Ryan & DeStefano, 2000). Prior work on theory-based and responsive evaluation contributed to the conceptualizations of the evaluator's role as an educator and of the program evaluation as an educative springboard for alternative plans for social action (Cronbach & al, 1980; Greene, J. 2005; Stake, R. 2004; Weiss, H., 1998). These studies have advanced supporting frameworks for the educative approach evaluation. While the current project used these conceptualizations, it did so by giving attention to the lesser-studied aspect of the researcher's educational thinking in relation to the contextual power of the educational program and practice studied. The quality representations of educational initiatives in STEM disciplines are particularly of interest because their contextual power is often limited to the quality criteria from content area and/or pedagogy. Few quality criteria also consider narratives of power, equity, and diversity. The aim was to relate particular questions of quality representations in educational evaluation to puzzling issues in STEM teacher education research: internal tensions related to meritocracy and equity, the value added model for teacher evaluation, and the assessment of teaching and learning.

★ **Nano@Illinois RET.** I-STEM evaluates the NSF-funded Nano@Illinois Research Experience for Teachers (RET). The RET aims to expose a diverse set of in-service and pre-service STEM teachers and community college faculty from across the nation to cutting-edge research in nanotechnology. In 2015, teachers conducted research and attended professional development at *Illinois* over six weeks during the summer, with four follow-up sessions during the academic school year.

According to the 2015 evaluation report, the majority of professional development activities were rated as useful or very useful by teacher participants. Activities teachers rated as most useful were: interaction with graduate students, stipend, *Illinois* campus, interaction with other RET participants, networking opportunities, and social outings.



I-STEM's Luisa-Maria Rosu presents her research as part of her Fulbright Early Career Scholar Fellowship.



Above, below, and bottom left: 2015 Nano@Illinois RET teachers present their research at the RET's end-of-summer poster session.



A young woman with long dark hair, wearing a white lab coat, is smiling and looking at the camera. She is holding two clear plastic test tubes with blue caps. The tube in her right hand is tilted, showing a yellow liquid inside. The tube in her left hand is held upright. The background shows a laboratory setting with shelves, papers, and equipment.

I-STEM is working to promote student 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.

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

◆ Perform student satisfaction/climate studies.

I-STEM also provides expertise to help campus units interested in self-evaluation understand student data patterns regarding performance, why students choose/leave STEM majors, and impacts of reform on student performance. In 2015, I-STEM assessed student satisfaction with a large course for Biology, whose courses are offered across various STEM disciplines (see page 27).

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

Student support programs (i.e., learning communities, mentoring, and bridge programs) can improve recruitment, retention, and matriculation of students in STEM fields, but are often not well coordinated or sustainable or lack academic support beyond the freshman year. Plus, students are often unaware of these programs, qualifications, or how to access services. To improve undergraduate programs, and thus improve recruitment and retention in STEM fields, I-STEM recommends that units adapt strategies successful *Illinois* programs, like Merit, have used to increase student support, and to incorporate Research Experiences for Undergraduates (see page 22).

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

I-STEM identifies strengths and gaps in campus STEM academic programs to assist in developing effective, scalable, and sustainable STEM education models, including bridge and support models, such as exploring the use of on-line courses to bridge with high schools and community colleges. To improve academic offerings, STEM departments have implemented both campus- and externally-funded reform projects. In 2015, I-STEM conducted evaluations of several of these (see Table 4 on page 23), including several IGERTs and REUs.



Above: A student working in an *Illinois* lab.

Opposite on page 20: A summer 2015 Nano@*Illinois* REU participant displays samples of gold nanoparticles she worked with while doing research in Professor Rohit Bhargava's lab.

I-STEM identifies strengths and gaps in campus STEM academic programs to assist in developing effective, scalable, and sustainable STEM education models.



Above: A VINTG IGERT graduate student works with a trap-jaw ant on which she has just painted a minuscule green dot for identification purposes.

Top right: A VINTG IGERT fellow works with honeybees at the Bee Research Facility on campus.

Below: 2015 EBICS REU student Solomon McBride at work in ECE professor Gabriel Popescu's lab in Beckman Institute.



IGERTs. Funded by NSF, the Integrative Graduate Education and Research Traineeship (IGERT) program seeks to develop a diverse, globally-engaged science and engineering workforce via innovative graduate education models in collaborative research. IGERTS also seek to broaden participation, particularly from groups typically underrepresented in the sciences. In 2015, I-STEM evaluated the CMMB and VINTG IGERTs, described later in this section.

Research Experiences for Undergraduates. I-STEM advocates employing research experiences for undergraduates (REUs) to increase the number of students choosing STEM careers. In 2015, at least 248 campus projects offered research experiences for undergraduates (see Figure 1 on page 23). Some were funded through NSF's REU (Research Experiences for Undergraduates) program, such as the five NSF REU Sites on campus which each engaged a number of students in research. In addition, many NSF-funded, as well as non-NSF-funded campus projects, offered research experiences for one or more undergraduates.

I-STEM evaluated six NSF-funded REU programs in 2015: three were individual REUs (Bioimaging, Chemistry, and Nano@Illinois REUs); three were for larger centers, which offered REU components as one of their STEM education emphases: CBMM (the Center for Brains, Minds, and Machines), CSN (the Center for Sustainable Nanotechnology), and EBICS (Emergent Behaviors of Integrated Cellular Systems Science and Technology Center). Individual programs are described in more detail in the following section.

◆ **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 major external funders. In 2015, I-STEM was involved in a number of grant submissions seeking to improve undergraduate and graduate STEM education. I-STEM provides support to faculty via a variety of mechanisms (see pages 2 and 41).



Figure 1: Research Experiences for Undergraduates, 2005–2015

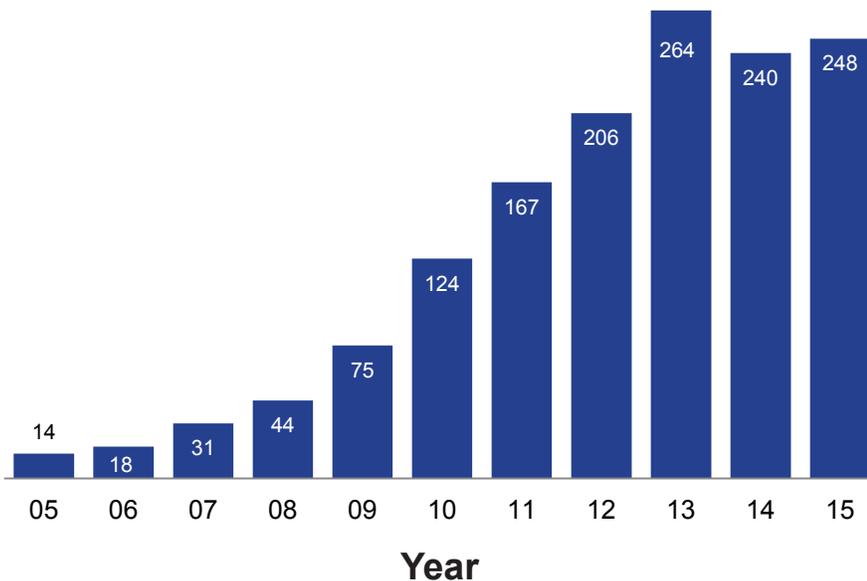


Table 4: Selected Undergraduate/Graduate STEM Education Programs I-STEM Evaluated in 2015

AAP (Access and Achievement Program) STEM Initiative
Bioimaging Research Experience for Undergraduates
Chemistry CCLI: Discovering the Nanoworld: Module for Teaching About Molecules/Bonding in Chemistry
CMMB (Cellular & Molecular Mechanics & BioNano-technology) IGERT
CBMM (Center for Brains, Minds, and Machines)
CSN (Center for Sustainable Nanotechnology)
EBICS (Emergent Behaviors of Integrated Cellular Systems)
Illinois Cyber Security Scholars Program (ICSSP)
M-CNTC (Midwest Cancer Nanotechnology Training Center): Training the Next Generation of Researchers in Cancer Nanotechnology at the NCIM
Merit Fellows Scholarship Program (S-STEM)
Network for Computational Nanotechnology - NanoBIO Node
Program in Digital Forensics
REU Site: nano@illinois REU: Research Experience for Undergraduates
REU Site: Research Experience for Undergraduates at Illinois (Chemistry)
Sustained-Petascale In Action: Blue Waters Enabling Transformative Science And Engineering: Blue Waters Community Education
VINTG (Vertically Integrated Training with Genomics) IGERT
XSEDE: eXtreme Science and Engineering Discovery Environment

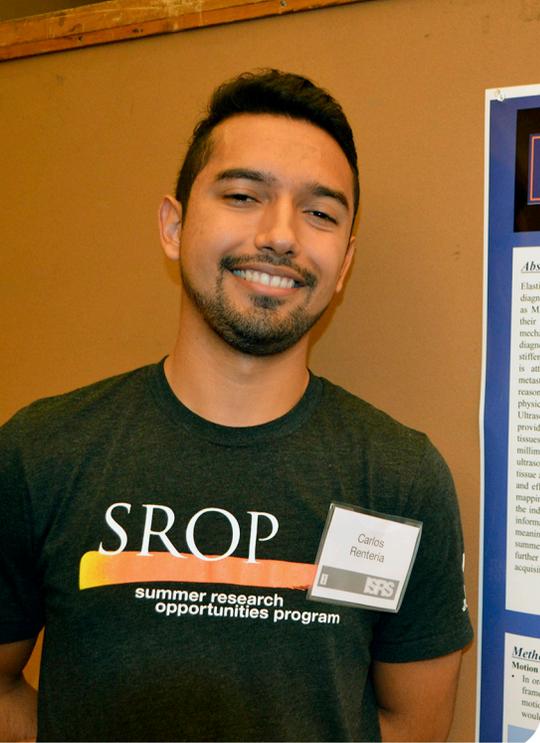


Above: Students working in an *Illinois* chemistry lab.

Below: A Merit Scholar (left) with her dad in attendance, has just received an award at the Merit Scholar Luncheon at the end of the spring 2015 semester.



UNDERGRADUATE/GRADUATE STEM EDUCATION PROGRAMS/INITIATIVES



Above: 2015 Bioimaging REU participant Carlos Renteria, a rising senior in Biomedical Engineering at Arizona State University, presents his poster at the 2015 Illinois Summer Research Symposium. Renteria indicates that his REU experience helped him decide to get a Ph.D. in bioengineering and eventually go into research.

Below: 2015 Bioimaging REU student Casey Troccoli, who is double majoring in Engineering Physics and Optical Engineering at Rose-Hulman Institute of Technology in Terre Haute, Indiana. Troccoli says working in researcher Stephen Boppart's lab helped her decide to go on to graduate school.

★ **AAP STEM Initiative.** The Access and Achievement Program (AAP), a student-centered academic program within *Illinois'* College of Liberal Arts & Sciences (LAS), seeks to provide matriculation services to both declared and undeclared LAS students affiliated with the President's Award Program and Educational Opportunities Program at the University. In 2015, AAP administrators, in conjunction with the departments of Biology, Chemistry, and Microbiology, requested that I-STEM's evaluators assess the effectiveness of prescribed course-taking patterns on the matriculation of AAP students into and through STEM degree programs. Data spanning six AAP cohorts are being used to conduct the assessment. Two meetings were held with the stakeholders during the fall of 2015; a final report will be submitted to AAP administrators and department representatives in spring 2016.

★ **AAU Initiative to Improve Undergraduate STEM Education.** *Illinois* participates in AAU's (Association of American Universities) 5-year initiative on STEM undergraduate teaching. The initiative helps higher education institutions assess the quality of STEM teaching, share best practices, and use the most effective STEM teaching methods. In 2015, Lizanne DeStefano served on the technical advisory committee of experts in undergraduate STEM teaching and learning which guides the initiative.

★ **Bioimaging REU.** Discoveries in Bioimaging Research Experience for Undergraduates (REU) exploits the link between Bioscience, Discovery, and Bioimaging which is employed at all scales in a state-of-the-art, interdisciplinary, research environment. This 10-week program targets undergraduate students from underrepresented populations. The program utilizes team-based research and integrated social and professional activities to supply a multi-tiered mentoring strategy. I-STEM's 2015 evaluation found that REU participants regarded Bioimaging REU's inaugural year as a success.





Participants in Blue Waters' Petascale Institute enjoy a tour of the Petascale Facility, home of the Blue Waters Supercomputer.

★ **Blue Waters.** I-STEM evaluates the Community Engagement programs for *Illinois' Blue Waters*, one of the world's most powerful supercomputers. In 2015, I-STEM assessed the quality of its educational outreach programs, internship program for undergraduate students, fellowship program for the graduate students, and also virtual school courses for students across the country. I-STEM also collected data with all the participants through the symposium, workshops, interviews, and focus groups to study the program's community engagement aspects. NSF reviewed the assessments and concurred that the assessment process was sound and the findings were informative and substantive. Following are several Blue Waters education outreach components I-STEM evaluated:

- **Blue Waters Symposium.** I-STEM evaluators conducted an evaluation of the 2015 Blue Waters Symposium for Petascale Computing and Beyond. Attending the symposium were innovative thinkers in science who shared keynotes; leaders in petascale computing who shared successes and challenges; and Blue Waters science teams who presented their work and summarized recent activities. Participants also had opportunities to share and discuss specific topics of interest. Based on participant survey responses, open-ended responses, and evaluator observations, the Symposium had extremely high participant satisfaction.
- **Petascale Institute.** A joint program of both the Blue Waters and XSEDE projects, this two-week institute introduces mostly non-computer-science undergraduate and graduate students to HPC (High-Performance Computing).
- **VSCSE (Virtual School of Computational Science and Engineering).** I-STEM conducted the evaluation of the spring 2015 Designing and Building Applications for Extreme Scale Systems course. Provided in three different institutions, *Illinois*, and two other universities, North Dakota, and Wyoming, this course was largely seen as valuable.



A 2015 Blue Waters Intern who participated in the Petascale Institute gets to see Blue Waters up close.

I-STEM evaluates the Community Engagement programs for Illinois' Blue Waters, one of the world's most powerful supercomputers. NSF reviewed the assessments and concurred that the assessment process was sound and the findings were informative and substantive.



Above: Two Neuroengineering students take readings with a brain cap.

Top right: Image of a braincap.

Below: A Uni High student exhibits the helmet Beckman Institute researchers use in their study on how the brain changes with age.



★ **Center for Brains, Minds, and Machines (CBMM).** In 2015, I-STEM evaluated CBMM, a multi-institutional collaboration headquartered at Massachusetts Institute of Technology. CBMM seeks to develop an understanding of intelligence and the ability to engineer it; to train the next generation of scientists and engineers in the emerging field of Science and Engineering of Intelligence; and to foster cross-fertilization among the many disciplines comprising the field. I-STEM evaluated the following educational outreach activities.

– **CBMM Teacher Workshop.** The goal of this program is to provide a one-week summer research workshop in collaboration with the department of Brain and Cognitive Sciences (BCS) to provide K–12 teachers research opportunities in the fields of computational and cognitive neuroscience. The ultimate goal of this program is to provide students with a strong research experience in preparation for graduate school and to encourage them to pursue careers in neuroscience.

The purpose of the evaluation is to provide valid and useful information to CBMM leadership, program managers, and NSF funders to guide planning and decision making; inform program improvement; assess short- and long-term effectiveness and impact; and increase the likelihood of sustainability. Teachers found the Teacher Workshop to be very informative and useful overall as they plan to integrate new material into their classroom curricula.

– **CBMM REU.** The 2015 iteration of the CBMM Research Experience for Undergraduates (REU) took place at MIT from June to August 2015. The goal of the CBMM REU program was to provide a 10-week summer research internship in collaboration with the department of Brain and Cognitive Sciences (BCS) for advanced undergraduates from institutions with limited research opportunities to introduce women, students from under-represented minority groups, first-generation college students, students with disabilities, and students from economically disadvantaged backgrounds to the fields of computational and cognitive neuroscience.

CBMM's REU seeks to provide students with a strong research experience in preparation for graduate school and to encourage them to pursue careers in neuroscience. Results suggest:

1. Participant satisfaction regarding interactions and communication with faculty advisors and graduate student/post doc mentors was high.
2. Substantial technical skills were gained as a result of the REU program. Participants also experienced a gain in their self-confidence as a result of their REU program participation.

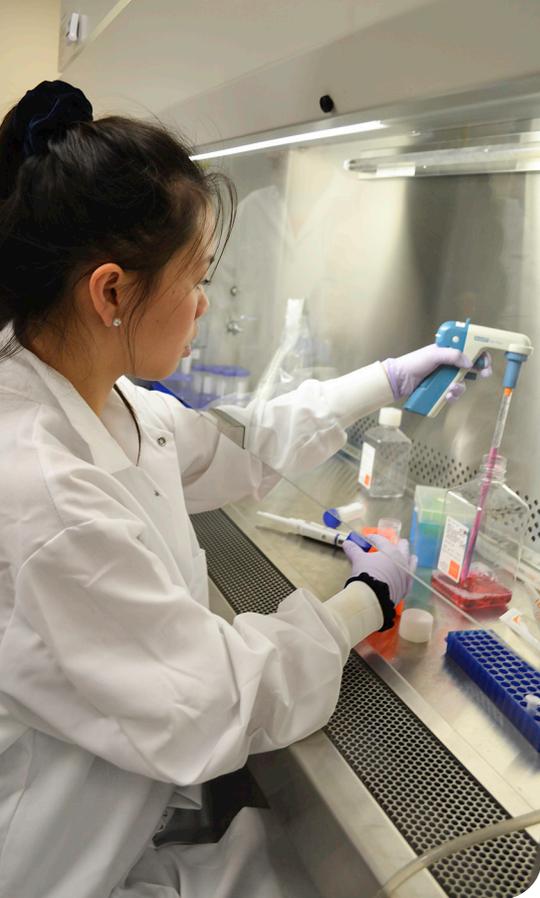


- ★ **Climate Studies.** I-STEM conducts evaluations for campus units and provides expertise to units interested in self-evaluation to help them understand student data patterns regarding performance, why students choose/leave STEM majors, and impacts of reform on student performance. I-STEM also met with decision makers from several units to plan future climate studies. Following are several climate studies I-STEM performed in 2015 or will conduct in 2016.
 - **Biology Climate Study.** In 2015, as part of the Biology climate study, I-STEM surveyed 500+ students in Integrative Biology 150 to obtain their perceptions of course quality, aspects of the course they found the most or the least helpful to their learning, usefulness of course components, and how the course could be improved.
 - **Chemistry Student Experiences Study.** As a follow-up to I-STEM's 2011 and 2013 Chemistry climate studies, in 2015, I-STEM staff met with chemistry faculty and decision makers to plan a study for 2016 regarding undergraduate and graduate students' experiences in the Department, including programmatic requirements, financial support, department resources, race/ethnicity, gender, and student satisfaction. Chemistry uses these data to aid in decision making to better serve its students.
 - **Engineering Climate Study.** During 2015, I-STEM staff met with faculty and decision makers to plan a follow-up study in 2016 regarding undergraduate and graduate students' experiences, plus barriers and opportunities to increasing recruitment and retention. The College and individual departments have considered data from I-STEM's 2009, 2011, and 2013 studies during decision making to determine to what degree policy changes and course reforms implemented over the last seven years have impacted students' satisfaction and perceptions of climate.
 - **Mathematics Department.** I-STEM will conduct a 2016 climate study addressing satisfaction of graduate students in the Mathematics Department.
 - **Center for the Physics of the Living Cells (CPLC).** I-STEM will also conduct a 2016 climate study addressing satisfaction of graduate students in the Center for the Physics of the Living Cells (CPLC) in Physics.
- ★ **CMMB IGERT.** The Cellular & Molecular Mechanics & BioNano-Technology (CMMB) IGERT seeks to train the next generation of leaders in cellular and molecular mechanics and bionanotechnology.
- ★ **Community Outreach and Translation Core COTC.** The COTC is designed to serve as an organizing hub of information about health effects on the developing infant, child, and adolescent from exposure to everyday chemicals combined with diets high in packaged foods. Funded by the U.S. Environmental Protection Agency and the National Institute of Environmental Health Sciences, COTC aims to link scientific investigators from *Illinois'* I-Kids Children's Environmental Health Research Center with various community stakeholders. I-STEM evaluates the Community Advisory Board that aims to assist COTC in translating this information through community-based research and community engagement.



Above: A sophomore in Civil Engineering explains to high school visitors about career possibilities available in her discipline during the Society of Women Engineers' fall 2015 outreach, High School Engineering Round Robin.

I-STEM conducts evaluations for campus units and provides expertise to units interested in self-evaluation to help them understand student data patterns regarding performance, why students choose/leave STEM majors, and impacts of reform on student performance.



Above: A Bioengineering undergrad performs research inside a biosafety hood during the new BIOE 306 course created as a part of EBICS.

Bottom right: 2015 EBICS REU participant Solomon McBride uses a microscope in ECE professor Gabriel Popescu's lab in Beckman Institute.

Below: A Bioengineering undergrad, Audra Storm, works with the biobots she made as a final project for BIOE 306.



★ **Center for Sustainable Nanotechnology (CSN).** A multi-institutional partnership, CSN is an NSF Center for Chemical Innovation which investigates fundamental molecular mechanisms by which nanoparticles interact with biological systems. CSN seeks to use fundamental chemistry to enable the development of nanotechnology in a sustainable manner for societal benefit. I-STEM evaluates the educational and outreach activities.

– **CSN REU/REV.** CSN's 2015 REU program provided a 10-week, authentic research experience for undergraduate students, exposing them to advanced degree options and careers in the chemistry fields with the goal of increasing the number of students, especially those from underrepresented groups, who go on to graduate school in chemistry-related fields.

★ **Discovering the Nanoworld.** This NSF-funded project developed teaching modules about molecules and bonding in general chemistry. A cohort of 200 students will be taking the new post-Chem102 course in spring 2016. In 2015, I-STEM staff held meetings with PI David Woon of Chemistry to discuss the 2016 evaluation.

★ **EBICS.** Emergent Behaviors of Integrated Cellular Systems (EBICS) STC is an NSF-funded Center at *Illinois*, MIT, and Georgia Tech to advance research in complex biological systems and develop programs to attract students to STEM fields. In 2015, I-STEM provided leadership for the education component and evaluated educational activities, i.e., EBICS' Graduate Teaching Consortium, Project ENGAGES (see page 8), and REU.

– **BioE 306 course.** In fall 2015, Bioengineering piloted a new course, BioE 306, BioFabrication Lab, which introduced undergraduate students to biointegrated machines, or biobots. The course distilled down cutting-edge EBICS research and initiated eight juniors and seniors into the mysteries of building with biology.

– **Project ENGAGES.** This EBICS STEM outreach program targets four African-American high schools in Atlanta, Georgia, partnering high school students with Georgia Tech graduate students engaged in scientific research and engineering projects.

– **EBICS REU.** The 2015 REU exposed five undergraduates to cutting-edge research and what being a graduate student is like.



★ **Illinois Cyber Security Scholars Program (ICSSP).**

ICSSP is open to *Illinois* undergraduate and graduate students in computer science and computer engineering, as well as to law students. Funded by NSF, the program is designed to financially and academically support qualified students to pursue careers in Information Assurance (IA) and computer security. I-STEM's evaluation found that ICSSP provides students adequate financial support, opportunities to develop as IA professionals, and a good educational experience overall.

★ **iFoundry.** The *Illinois* Foundry for Innovation in Engineering Education (iFoundry), a cross-disciplinary curriculum incubator in the College of Engineering, is dedicated to transforming undergraduate education and experiences to align with 21st Century challenges and opportunities. In 2015, I-STEM evaluated iFoundry's James Scholar Quest Program:

– **James Scholar Quest Program.** Begun in 2013, this program continued its collaboration with both Civil and Environmental Engineering and Mechanical Science and Engineering Departments to engage James Scholar students in a dialogue about:

1. Department support and community building for James Scholars.
2. Ways to broaden choices to get honors credit.
3. Research, entrepreneurship, and leadership interests.

The task of I-STEM's evaluation was to better understand students' motivation to remain in Engineering's James Scholars program, which, as with many other colleges at *Illinois*, is a college-level honors program. Students can be admitted to the program prior to freshman enrollment or can apply for admission once on campus. Students in the program are expected to maintain a minimum 3.3 GPA, complete a course with an Honors Credit Learning Agreement during their freshman year, and fulfill the yearly requirements of an honors contract prior to graduation. Students in the James Scholar program receive priority registration, access to honors-only courses, and are awarded James Scholar distinction at graduation.

Just over 300 James Scholar alumni, representing 13 engineering majors and nine cohorts, responded in part or in full to an online survey. Out of 271 respondents, over half selected important or very important when asked if pursuing a minor or second degree motivated them to remain in the program. Nearly 75% of 272 respondents selected important or very important when asked if being able to mention the James Scholars Honors program on their resume provided motivation to remain in the program. Dissemination activities will include a final report to key stakeholders. Additionally, a manuscript proposal, based on this work, will be submitted for presentation at the 2016 Association for the Study of Higher Education (ASHE) conference.



Above: Aeronautical Engineering freshman Katie Carroll at work in Grainger Library.

Below: MechSE junior Patrick Slade works with several prostheses he 3-D printed in the Brett lab.





Above: Merit Fellow Dimeji Williams presents his research at the Illinois Undergraduate Research Symposium in April 2015.

Bottom right: Gretchen Adams (right) presents an award to a Chemistry student who is part of the NSF-funded Merit Fellows Scholarship Program.

Below: Merit Fellow Arzeena Ali at work in researcher Dr. Yi Lu's lab on campus.



★ **Indiana University Advanced CyberInfrastructure Value Assessment.** In 2015, Indiana University's Office of the Vice President for IT and CIO asked I-STEM to assess faculty perceptions of IU's cyberinfrastructure. During this short, one-month project, I-STEM conducted 23 faculty and senior administrator interviews and provided a comprehensive report on the findings to inform system-wide decisions regarding cyberinfrastructure.

★ **Master of Arts in EU Studies Degree Program (MAEUS) Program.** In spring 2015, I-STEM conducted an evaluation of MAEUS, a Master's Degree program in European Union Studies of the European Union Title VI Center. As part of the evaluation, I-STEM staff conducted an exit survey and interviews with students who graduated from MAEUS in 2015. Overall, the majority of respondents indicated high levels of satisfaction with the degree program's quality, and recommended improving promotion strategies both on and off-campus, showcasing the unique nature of the program as one of the few Master's program in European Union studies in the country and emphasizing the research opportunities, interdisciplinary emphasis, language study, study-abroad/internship, and funding components.

★ **Midwest Cancer Nanotechnology Training Center (M-CNTC).** I-STEM evaluates M-CNTC, which seeks to train the next generation of leaders who will define the new frontiers and applications of nanotechnology in cancer research. It also seeks to build a community of faculty, PhD students, postdocs, and colleagues from clinical institutions to collaborate on education and research. Thus, participants will not only be trained in the interdisciplinary area of cancer biology, nanotechnology, and nanoengineering, but also develop a network of resources (people, facilities, international connections) beneficial in their future careers.

★ **Merit Fellows Scholarship Program.** I-STEM evaluates this NSF-funded S-STEM (Scholarships in Science, Technology, Engineering, and Mathematics) grant, which provides financial support for academically talented, financially needy Merit program students majoring in mathematics, chemistry, or integrative biology.



★ **Nano@Illinois REU.** The NSF-funded Nano@Illinois Research Experience for Undergraduates (REU) program seeks to provide undergraduates with interdisciplinary research and educational nanotechnology experiences across a range of disciplines and applications to address many grand challenges facing our world. By embedding participants in a rich environment, the REU provides integrated research experiences to a diverse set of REU trainees in Nanoelectronics, Nanophotonics, Nanomanufacturing, Nanomaterials, and Nanobiotechnology, and infuses critical thinking, leadership, communication, team building, and ethics training in innovative ways. I-STEM's 2015 evaluation sought to help program administrators improve the REU experience in regards to student content knowledge, research skills, leadership building, and graduate recruitment outcomes.

★ **NanoBIO Node.** The NSF-funded NanoBIO Node is a resource for nanobiotechnology. This resource, a collaboration between *Illinois* and the University of California at Merced, provides simulation building blocks and educational resources for use in nanobio device engineering. It aims to create a community of researchers and students who are interested in using nanoscale tools and methods to drive progress and research in biotechnology and bridge engineering and biology through strategic partnerships and outreach activities. I-STEM evaluators conducted an interview of External Advisory Board members regarding their knowledge, familiarity, feedback, and roles for the NanoBIO node. In addition, evaluators surveyed graduate students, researchers, and faculty in order to identify the needs for development of simulation software for nanobio applications.

★ **Program in Digital Forensics (PDF).** Funded by NSF, PDF is developing an interdisciplinary undergraduate educational curriculum focusing on the recovery and investigation of data found in digital devices. Unlike most digital forensics programs, which mainly focus on computer science, PDF is also incorporating aspects of law, sociology, accounting, and psychology. Once the curriculum is developed, PDF will then work for its acceptance as the national digital forensics standard. I-STEM's 2015 evaluation found that students enjoyed the course, viewed its interdisciplinarity as a strength, were satisfied with material covered, and provided insight into potential areas for improvement.



Above: Nano@Illinois REU student Nikou Pishevarfahani (left) and her graduate student mentor in Dr. Yi Lu's lab on campus.

Below: A Nano@Illinois REU participant explains his research on the Optical Stimulation of Metal Nanostructures to a visitor at the Illinois Summer Research Symposium poster session.

Bottom left: I-STEM evaluator Gabriela Garcia (right) administers a survey to a student taking a new course the Program in Digital Forensics has developed.





Above: Emily Rohman, a sophomore in Community Health in AHS, by her STRONG KIDS poster on Endocrine Disruptors in Plastics.

Below: An XSEDE international HPC Summer School participant.



★ **Readying Illinois Students for Excellence (RISE).** In 2015, I-STEM evaluated RISE, a summer program offered by *Illinois'* Office of the Dean of Students New Student Programs, Office of Inclusion and Intercultural Relations, and Office of the Provost. RISE participants, incoming freshmen who are first-generation and/or underrepresented students, attend a three-day, on-campus program to facilitate transition to college life. I-STEM began the evaluation in 2015. In order to guide program activities for future participants, I-STEM is tracking RISE participants throughout their freshman year at *Illinois* in order to document their experience.

★ **Science in the Classroom.** I-STEM evaluated this long-standing service program of the Northwestern University chapter of Phi Lambda Upsilon (PLU). In this science outreach program, PLU graduate students provided monthly hands-on science experiences for 3rd and 4th grade classes at Chicago's Hayt school. Plus, for the final event of the year, Hayt students attended a science show on Northwestern's campus.

★ **Summer Internship for Native Americans in Genomics (SING).** SING, a one-week workshop about the uses, misuses, and limitations of genomics as a tool for Native American communities, also trains Native Americans in the concepts and methods currently used in genomics. I-STEM's 2015 evaluation included a focus group to determine the effectiveness of SING's programs.

★ **STRONG Kids.** As part of STRONG Kids, a Family Resiliency Center program, students enroll in an undergraduate research course, HDFS 494, conduct interdisciplinary research related to children's health and obesity, then, during the Undergraduate Research Symposium at the end of the Spring semester, present their research to the public. I-STEM evaluated this project in 2015.

★ **Summer Training in Translational Biomedical Research.** I-STEM staff met with PI Lois Hoyer in 2015 to plan the evaluation for this NIH-funded, 10-week Summer Research Training Program to identify and train veterinary students who have the ability and motivation to become research scientists. Ten students will be matched with faculty mentors who share similar research interests. Each trainee will formulate a hypothesis, design experiments, collect and analyze data, and report the conclusions via an abstract submitted to a national meeting, a poster presentation, and a short manuscript to a scientific journal. Instruction in research will include orientation week activities and a seminar series on veterinary career opportunities and scientific writing. Trainees will present their work at an in-house poster session and at NIH's Veterinary Scholars Symposium. I-STEM will begin the evaluation in 2016.

★ **Transdisciplinary Obesity Prevention Research Sciences (TOPRS).** The aim of TOPRS is to develop and implement a transdisciplinary curriculum for undergraduate students that focuses on the causes and consequences of childhood obesity. The curriculum's "flip-the-classroom" format consists of students viewing video lectures prior to attending class then spending class time on interactive group activities. The evaluation is designed to contribute to the quality and implementation of TOPRS during the first year of implementation.



XSEDE Scholar Wanda Moses, a military veteran who is a Ph.D. student in Computer Science at Clemson University.

★ **Vertically Integrated Training with Genomics (VInTG) IGERT.** VInTG IGERT seeks to train students in the interdisciplinary field of genomics—how an organism’s traits emerge from, and are shaped by, a complex interplay of genetic information stored in DNA and environmental information the organism experiences throughout its life. In 2015, I-STEM administered surveys and an end-of-course focus group for VInTG’s Integrative Biology Tropical Biology course.

★ **eXtreme Science and Engineering Discovery Environment (XSEDE).** NSF-funded XSEDE, led by *Illinois’* National Center for Supercomputing Applications offers advanced digital resources and services to a broad range of researchers. XSEDE allows scientists nationwide to collaborate remotely on over 16 supercomputers and high-end visualization and data analysis resources. Some highlights of I-STEM’s 2015 external evaluation for XSEDE’s Training, Education, and Outreach Services include:

- Development and testing of student program application forms to reduce selection bias and increase the number of diverse participants in high-performance computing (HPC). I-STEM’s application form is currently being used and tested by cyberinfrastructure organizations in Canada, the European Union, Japan, and the United States.
- Development and implementation of an interactive, live dashboard for tracking project-wide metrics. Historically, longitudinal tracking within XSEDE required considerable effort and planning. Program managers and coordinators can now view and track their program’s success at the click of a button. Due to the reduction of effort, XSEDE is now shifting to even more proactive decision making and strategic planning.



Above: XSEDE Scholar Sidafa Conde, a PhD student at the University of Massachusetts, Dartmouth enjoying a session of the Petascale Institute.

Bottom right: XSEDE Scholars Juan Castro-Garcia (left) and Efrain Vargas Ramos (right) during one of the Petascale Institute sessions.





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 2015, I-STEM staff members continued to network at the local, state, national, and international levels to promote STEM education and advocate for STEM education programs and resources.

On the local level...

I-STEM staff regularly met with campus administration and researchers and presented at unit-level meetings, such as with College of Engineering administrators. Former I-STEM Director Lizanne DeStefano served on the Office of Technology Management Advisory Committee and the Biology Coordinating Committee, which planned a climate study. Her research-related activities included the Campus Research Administrators' Working Group.

On the state level...

Dr. DeStefano was a member of the following organizations and committees: Illinois Research-Practice-Policy Partnerships on Children and Families, the Illinois State Board of Education's Technical Advisory Committee, the Early Learning FFT Validation Process Advisory Committee, and Illinois' Assessment in STEM Education: Some Conceptual and Pragmatic Considerations Taskforce. As P-20 Council Coordinator, she served on all P-20 committees (see page 8). I-STEM Interim Director Luisa Rosu also served as a member of the P-20 Council in 2015.



Above: At INTC's 2015 New Teacher STEM Conference a team of teachers build a tower out of straws.

Bottom left: A young Chicago student works with memory metal during a visit to *Illinois* in September 2015.

Opposite (page 34): POETS PI Andrew Alleyne listens to speakers during the Center's Kickoff Event.



In 2015, I-STEM staff members continued to network at the local, state, national, and international levels to promote STEM education and advocate for STEM education programs and resources.



Above: I-STEM Senior Research Specialist Lorna Rivera, who evaluates the XSEDE program (see page 33).

Top right: Lorna Rivera shares during SC15 (photo courtesy of Jung Sung).

Bottom right: Lizanne DeStefano (left), and Lorna Rivera (second from left) receive the Best Education, Outreach and Training Paper award at XSEDE15. Second from the right is Steve Gordon, Ohio State Professor Emeritus and coordinator of the course on which DeStefano and Rivera wrote the paper, and XSEDE PI John Towns (right). (Photo courtesy of XSEDE external relations)



On the national level...

I-STEM staff participated in and presented at a number of important conferences, STEM-related task forces, and committees in 2015.

- **American Evaluation Association 2015.** I-STEM Director Luisa-Maria Rosu gave a presentation at AEA 2015 in Chicago regarding her Fulbright research entitled, “Addressing Diversity of Values: The Educative Commitment of the Evaluator and the Educational Narrative Overreach.”
- **The 19th Colloquium for Information Systems Security Education (CISSE).** I-STEM Research Associate Gabriela Garcia presented “Utilizing a Workshop Format to Foster Discussion: Multidisciplinary Undergraduate Curriculum in Digital Forensics Development” at CISSE.
- **SC15: The International Conference for High-Performance Computing, Networking, Storage, and Analysis.**
 - At SC15, I-STEM evaluator Lorna Rivera took part in a panel hosted by Intel Corporation about diversity in high-performance computing (HPC) which addressed the following questions:
 1. What would you like to see implemented during SC’16 that would improve the cultural perception around diversity?
 2. How do start to tackle gathering a community headcount around diversity within the HPC community?
 3. What are 2 or 3 key things that the SC’16 committee could do/offer, in order to draw more diversity at the conferences?
 4. What can we collectively create at SC’16 that would promote a healthy pipeline of professional growth during the conference?

On the national level, I-STEM staff participated in and presented at a number of important conferences, STEM-related task forces, and committees in 2015.



- During SC15’s “Best Practices in HPC Training Workshop,” Lorna Rivera presented, “Best Evaluation and Assessment Practices for HPC Training,” regarding I-STEM’s XSEDE evaluation. Rivera presented the evaluation’s framework, questions, methods, and longitudinal tracking mechanisms before an international audience.
- Rivera also gave the keynote presentation, “Women in HPC: Changing the Face of HPC,” at the “Women in HPC Workshop” at SC15. Rivera presented on I-STEM’s evaluation findings during the development and testing of student program application forms to reduce selection bias and increase the number of diverse participants in HPC.

- **XSEDE 15 Conference.** Lorna Rivera presented a paper, “Extending Access to HPC Skills Through a Blended Online Course” at the XSEDE 15 Conference in July 2015 in St. Louis, Missouri.

On the international level...

- **Fulbright Think Tank Workshop: “U.S. Culture & Society in the English Class.** Luisa-Maria Rosu presented on her Fulbright study: “Investigations of Quality Criteria in Teacher Education Programs.”
- **International Supercomputing Conference (ISC) 2015.** In July 2015, Lorna Rivera gave the keynote presentation, “Women in HPC: Changing the Face of HPC,” at the “Women in HPC” workshop” at ISC 2015 in Frankfurt, Germany. Rivera addressed I-STEM’s evaluation findings on the development and testing of student program application forms to reduce selection bias and increase the number of diverse participants in HPC.

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

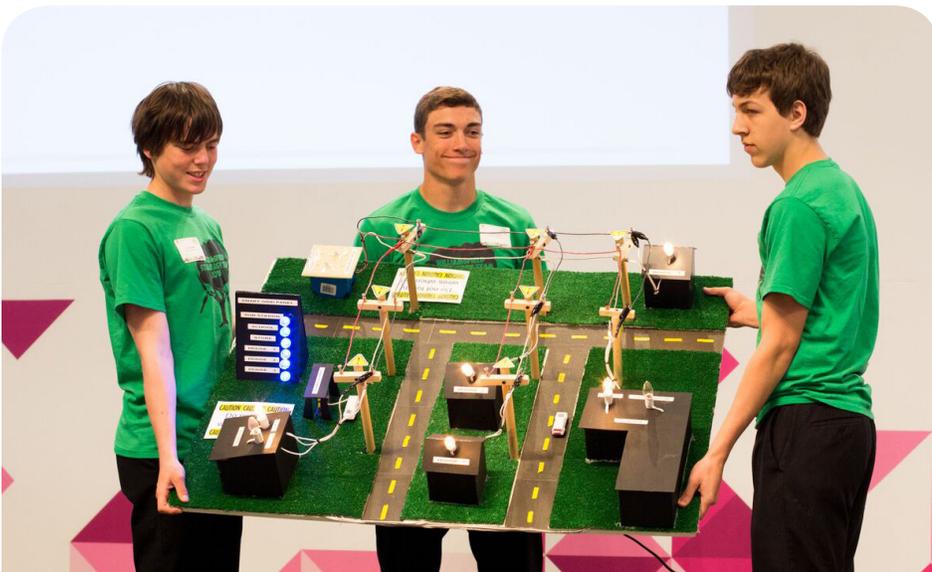
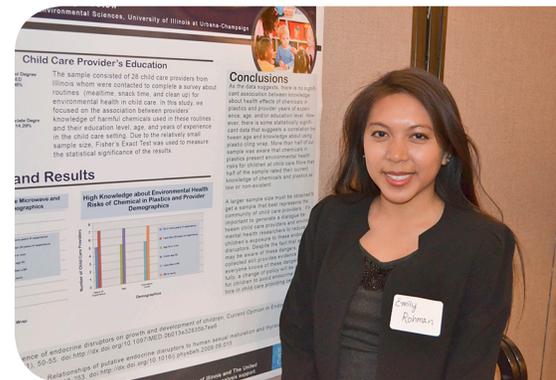
I-STEM worked with programs designed to increase student interest in STEM careers, strengthen the state’s STEM pipeline, and foster STEM workforce development. Dr. DeStefano served on the Entrepreneurship Roundtable Committee and worked with the Illinois Pathways Initiative’s R&D STEM Learning Exchange Resource Repository and Mentor-Matching Engine (see pages 9 and 39).



Above: Luisa-Maria Rosu (left) during the Fulbright Think Tank Workshop: “U.S. Culture & Society in the English Class.”

Below and bottom right: Illinois students present their research at Illinois’ Undergraduate Research Symposium as part of the STRONG Kids Project.

Bottom left: Illinois high school students who participated in the R&D STEM Learning Exchange program present their STEM Challenge at the final event.





Above: Provost Edward J. Feser (left), I-STEM Interim Director Luisa-Maria Rosu (center), and Chuck Tucker, Vice Provost for Undergraduate Education and Innovation during the Lt. Governor's visit to I-STEM.

Top right: Lt. Governor Evelyn Sanguinetti (left) and (left to right) Ph.D. students Maria Chavarrigo, Brenda Andrade, and Ariana Bravo, all members of the SACNAS organization, during the Lt. Governor's visit to I-STEM in September 2015.



◆ 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, like the study on the Implementation of Key Illinois Education Initiatives done for the P-20 Council (see page 38).

◆ Identify STEM education reform projects at *Illinois*.

I-STEM identifies and catalogs *Illinois'* current external funding projects, as well as potential resources. As part of this, we conduct an annual review of current external STEM education investments on campus (see pages 41–43). I-STEM reports on many of these in the Current STEM Ed Highlights of istem's home page, the News section, STEM Ed Projects section of the I-STEM website¹⁰. Regarding identifying potential resources for STEM education reform, I-STEM lists potential funding resources in the Funding Opportunities section of the website, plus routinely sends out upcoming funding opportunities via I-STEM's listserv (see pages 2 and 41).

I-STEM identifies and catalogs Illinois' current external funding projects, as well as potential resources. As part of this, we conduct an annual review of current external STEM education investments on campus.

STEM EDUCATION POLICY/ADVOCACY PARTNERS, PROJECTS, AND EVENTS

- ★ **Danielson Framework Validation Study.** I-STEM evaluates this project for Illinois State University's Center for the Study of Education Policy. It aims to validate and examine the appropriateness of the Charlotte Danielson Framework for Teaching as a tool for evaluating Pre-K to 3rd grade teachers. This comprehensive, research-based protocol identifies aspects of teachers' responsibilities proven to promote improved student learning.
- ★ **Illinois Lt. Governor's Visit to *Illinois*.** In September 2015, the State of Illinois' Lt. Governor, Evelyn Sanguinetti, contacted I-STEM to arrange a visit to campus in order to dialogue with *Illinois* administrators, faculty, staff, and students, as well as I-STEM evaluators, regarding increasing the number of underrepresented students in STEM. During the meeting, faculty, staff, and students showcased their outreach projects and the impact *Illinois* is having on exposing underserved students to STEM.

¹⁰<http://www.istem.illinois.edu/index.html>



Above: A team of Illinois high school students who participated in the R&D STEM Learning Exchange program present their STEM Challenge at the final event.

★ **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 the web, which students may access for career-related educational resources. In 2015, Dr. DeStefano served on the Illinois Pathways Steering Committee. I-STEM staff contributed information about university P–12 STEM education programs to the STEM Research and Development committee’s new STEM Learning Exchange Resource Repository¹¹, which enables organizations to provide enhanced learning experiences for students and teachers, and its Mentor-Matching Engine¹² program, which connects STEM graduate students and professionals to serve as mentors for the students.

★ **Learning Performance Management System.** Using NCSA’s petascale computing equipment to track student performance from pre-school through workforce, this system will learn about effective STEM pathways—ways of moving through the system and entering STEM careers. During 2015, Dr. DeStefano continued to participate in a working group to design the system’s infrastructure.

★ **National Assessment of Education Progress (NAEP).** Dr. DeStefano continued to serve as a member of the NAEP Validity Studies Expert Panel.

¹¹<http://stemlearningexchange.org/>

¹²<http://coolhub.imsa.edu/web/mentor-matching-engine>



Above: A Chicago student and his mom do a hands-on activity during his school, Foundations 4 Advancement, visit to campus in September 2015.

Below (left to right): A mother and daughter do a hands-on engineering activity at Mommy, Me, and SWE, a Society of Women Engineer (SWE) fall outreach event for girls and their moms.

Bottom left: Students in Next Generation School’s STEAM Studio test a robot on grassy terrain during entomology Professor Andy Suarez and Ph.D. student Tanya Josek’s lesson about bioinspiration.





Above: A 2015 GLEE camper shakes off a previous moment of frustration over something that didn't go quite right while building her LED calculator.

Below: Illinois Engineering student Athrey Nadham (left) helps a group of Chicago students launch stomp rockets they made during a campus visit in fall 2015.



A Chicago student from Foundations 4 Advancement Academy tests the low heat output made by an LED light bulb.

★ **Statewide Study of Feedback on Implementation of Key Illinois Education Initiatives.** I-STEM staff conducted a statewide study for the Illinois P-20 Council obtaining feedback on the implementation of four key Illinois education initiatives: rigorous, internationally benchmarked student learning standards; a standards-based student assessment; a redesigned educator performance evaluation system; and the P-20 longitudinal education data system.

The study consisted of both focus groups and an online survey targeting specific stakeholder groups, namely school administrators, business community members, local community members, parents, and teachers. Seventy focus groups were conducted across the state and over 2700 stakeholders took the online survey. The majority of survey respondents were teachers (59%) who identified as White (87.2%). The majority of focus group participants resided in Cook County (61.4%) and were parents (52%). Based on feedback from survey and focus-group participants, the following takeaways were submitted to the P-20 Council:

- Some factors are independent of direct teacher or administrator control but have a significant impact on student learning and educator impact. Such factors include parent involvement, socioeconomic status, attendance, other student characteristics, as well as disciplinary or behavioral issues
- Regular contact and communication with parents is essential.
- Consideration for all education policy discussions need to reflect that all students, including college bound and workforce bound students, receive life preparation skills to meet the need to become productive and successful citizens.
- Due to the timing of the survey and focus groups, data on PARCC must be considered in the context of the pre-test administration period.

★ **UI-CPS Joint Task Force.** In 2015, Dr. DeStefano was a member of this task force that seeks to improve coordination of programming between the University of Illinois and Chicago Public Schools.

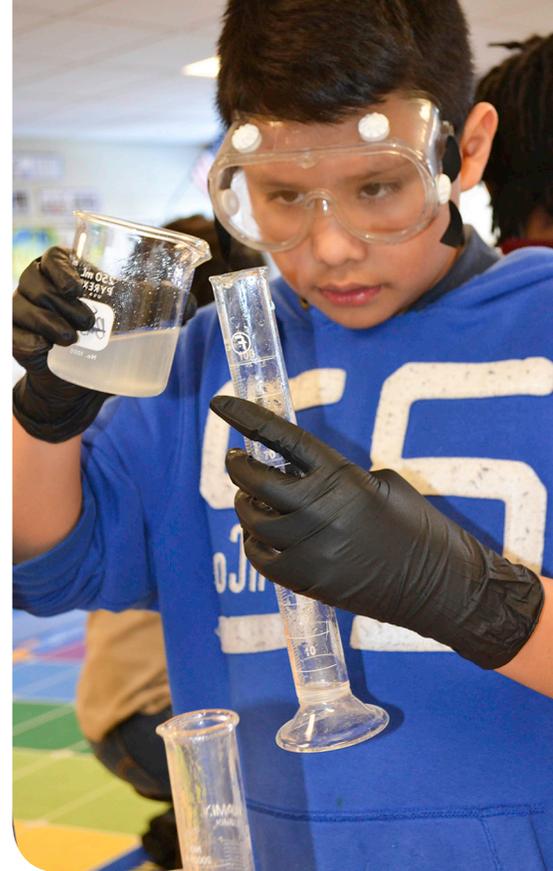
STEM EDUCATION EXTERNAL FUNDING AT ILLINOIS

I-STEM annually assesses existing resources campus-wide to create a snapshot of active external STEM education investments on campus. To build a comprehensive database, I-STEM researches available campus databases, such as the Proposal Data System of *Illinois'* Division of Management Information, as well as funders' electronic databases.

Since 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 with education components, we estimate that 30% is devoted to education (i.e., NSF CAREER funding requires education or outreach components). For large research centers, we estimate that 15% of the award is devoted to STEM education components. These estimates apply to calculations for Figure 2 below and Figures 3 and 4 on pages 42 and 43, respectively.

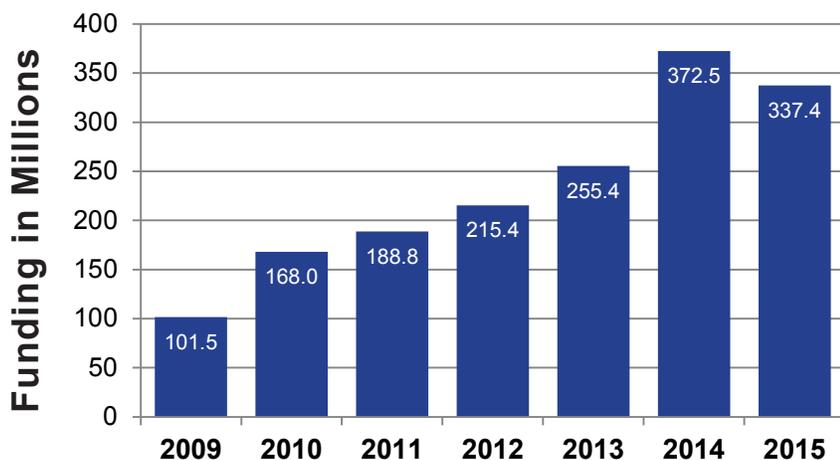
Figure 2 below presents estimated STEM Education funding at *Illinois* from 2009 through 2015. Estimates of STEM education award amounts per year are based on data retrieved by the time each year's annual report is published and are not necessarily inclusive of all grants awarded to the university in the area of STEM education over the seven-year period. For 2015, the estimated total of \$337.4 million in active STEM education investments by funding sources (see Figure 3 on page 42) 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 STEM education activities across 16 academic, research, and campus-level administration units (see Figure 4 on page 43). Projects include STEM P–20 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 with education components.



A Garden Hills student learns how to measure accurately during Brady STEM Academy hands-on activity.

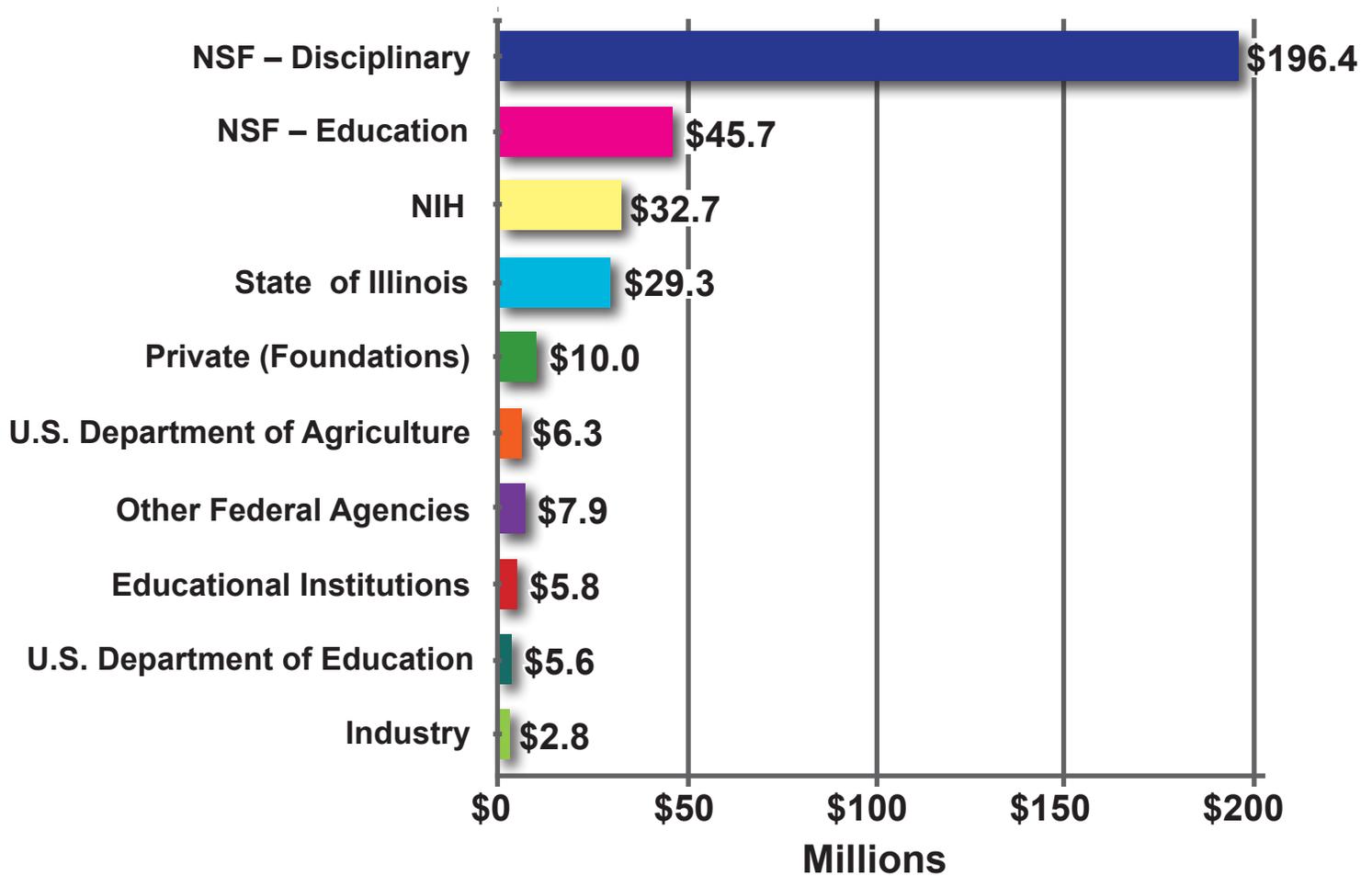
Figure 2: STEM Education Funding at Illinois, 2009–2015



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 Funder**
url: <http://www.istem.illinois.edu/funding/fundingopps.html>
- **Upcoming Funding Deadlines**
url: <http://www.istem.illinois.edu/funding/upcomingdeadlines.html>
- **I-STEM-News Listserv**
url: <https://lists.illinois.edu/lists/info/i-stem-news>

Figure 3: Active External Investment in STEM Education at Illinois for 2015, by Funder

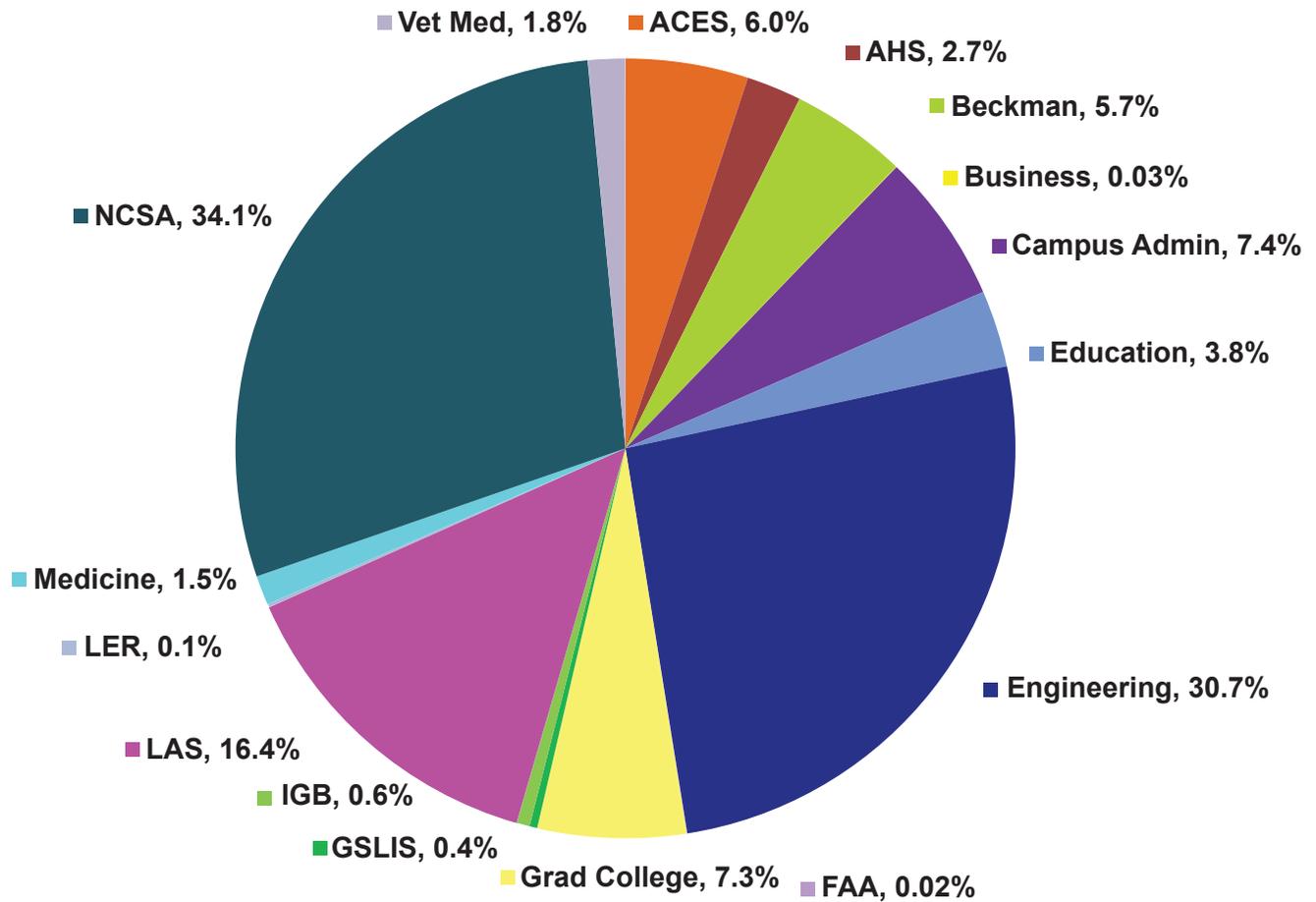


FUNDER	INVESTMENT
National Science Foundation—Disciplinary Directorates/Other Offices (NSF–Disciplinary)	\$196,440,790
National Science Foundation—Education & Human Resources Directorate (NSF–EHR)	\$45,743,368
National Institutes of Health (NIH)	\$32,692,944
State of Illinois Agencies (State of Illinois)	\$29,294,184
Private (Foundations, Associations)†	\$10,006,855
U.S. Department of Agriculture (USDA)	\$6,275,251
Other Federal Agencies (DoD, DoE, NASA)	\$6,182,032
Educational Institutions	\$4,604,040
U.S. Department of Education (DoED)	\$3,357,343
Industry†	\$2,795,073
Total	\$337,391,879

Note: STEM education resources in Figures 3 and 4 were calculated based on a percentage (100%, 30%, 15%) of each funding award (see the discussion on page 41).

†Notable private support for STEM education projects includes numerous foundations and associations, such as: American Educational Research Association, American Society of Heating, Refrigeration, and AC Engineers, Howard Hughes Medical Institution, National 4H Council, National Academy for Nuclear Training, Neisen Foundation, and the Sloan Foundation. Corporate/industry support includes companies such as Abbott Laboratories, AbbVie, Eli Lilly & Company, Intel, IBM, John Deere & Co, and Microsoft

Figure 4: Active External Investment in STEM Education at Illinois for 2015, by Campus Unit



CAMPUS UNIT	INVESTMENT
Agricultural, Consumer and Environmental Sciences (ACES)	20,332,678
Applied Health Sciences (AHS)	6,916,326
Beckman Institute	14,592,998
Business	76,755
Campus/University Administration	18,879,463
Education	9,674,457
Engineering	78,295,441
Fine and Applied Arts (FAA)	45,704
Graduate College	18,627,226
Graduate School of Library and Information Sciences (GSLIS)	973,671
Institute for Genomic Biology (IGB)	1,625,233
Labor and Employment Relations (LER)	41,915,939
Liberal Arts and Sciences (LAS)	376,320
Medicine	3,731,218
National Center for Supercomputing Applications (NCSA)	115,158,797
Veterinary Medicine (Vet Med)	6,169,652
Total	\$337,391,879



I-STEM STAFF AND STUDENTS



Above (left to right): Sarai Coba and Emily Gates.

Below (left to right): Ayesha Tillman, Dominic Combs, and Marlon Mitchell.

Bottom left: Gabriela Garcia (right) hands a survey to a student in the PDF course.



Above: Some of the I-STEM team (clockwise from the left): Betsy Innes; Ayesha Tillman; former Director, Lizanne DeStefano; Interim Director, Luisa Rosu; Christine Shenouda; Vijetha Vijayendran; Carie Arteaga; Gabriela Garcia; Jung Sung; and Lorna Rivera.

Bottom right: Left to right: Dominic Combs, Betsy Innes, Maggie Phan, Sergio Contreras, Luisa-Maria Rosu, Marlon Mitchell, Christine Shenouda, Sarai Coba, Derrick Houston, Lorna Rivera, Sherla Carpenter, Jung Sung

I-STEM DIRECTORS

- Lizanne Destefano, I-STEM Founder and Former Director
- Luisa-Maria Rosu, I-STEM Interim Director

I-STEM RESEARCHERS/AFFILIATES

- Gretchen Adams, I-STEM Affiliate, Director of the Chemistry Merit Program, the Merit Fellows Program
- Sarai Coba-Rodriguez, Graduate Research Assistant. Projects: COTC, TOPRS, RDLE, Danielson Framework Validation Study
- Dominic Darrell Combs, Graduate Research Assistant. Projects: Nano@Illinois RET, CBMM Teacher Workshop and REU, CSN REU/REV
- Sergio Andres Contreras Pinto, Graduate Research Assistant. Project: XSEDE.
- Gabriela Garcia, Graduate Research Assistant. Projects: Program for Digital Forensics, Merit Scholars (S-STEM), COTC, TOPRS
- Derek Houston, Graduate Research Assistant. Projects: P-20 Council Study; AAP STEM Initiative; Engineering James Scholar Program
- Marlon Mitchell, Graduate Research Assistant. Projects: REEC; VinTG IGERT; Bioimaging REU, Nano@Illinois REU, EBICS Project ENGAGES and EBICS REU
- Maggie Phan, Graduate Research Assistant. Project: NanoBio Node



- Lorna Rivera, Senior Research Specialist. Projects: XSEDE, RISE
- Christine Shenouda, Research Specialist. Projects: CADENS, MakerGirl
- Ayesha Tillman, former Research Associate, is currently an Assistant Professor at University of North Carolina. Projects: REUs, EBICS, CBMM, CSN
- Jung Sung, Visiting Research Specialist. Projects: Blue Waters, IB150

I-STEM SUPPORT STAFF

- Sherla L. Carpenter, Extra Help Office Associate Two
- Elizabeth Innes, Communications Specialist. Projects: I-STEM website, I-STEM Magazine, I-STEM Annual Report
- Debby Ann Reynolds, Administrative Assistant

I-STEM UNDERGRADUATE STUDENTS

- Emily Alameda, an undeclared freshman, hopes to be a Chemistry professor.
- Cherie Chin, a senior in ACES, Finance in Agribusiness, minor in Business, who hopes to be an analyst in a financial technology company
- Derrick Domi, a senior in Technical Systems Management, with a minor in Business, who will be seeking a Master's in Technology Management at *Illinois*.
- Valentina Gill, a senior in Speech and Hearing Science with a minor in Spanish Linguistics. Gill hopes to be a Bilingual Speech Language Pathologist, and will attend graduate school in fall 2016 in Communication Disorders.
- Anna Jedralski, Materials Science and Engineering major
- Deepa Kote, Materials Science and Engineering major
- Payal Malik, a sophomore in Economics, finance; Payal's career goal is to be the chief economist of some small, open economy
- Paulina Rodriguez, a freshman in Psychology with a concentration in Behavior Neuroscience, premed track and a minor in Chemistry; Paulina hopes to attend medical school to become a neurosurgeon.
- Megan Sullivan, Mathematics major
- Nicoletta Wagner, Psychology major
- Chelsea Wilson, a senior in Earth, Society & Environmental Sustainability, hopes to become a GIS analyst for an environmental engineering firm or a global security corporation.

I-STEM Funding

Funding for I-STEM comes from a variety of sources. Funding for the office overhead and support staff comes from state money through the Provost's Office. Funding for I-STEM's director comes from state funds, as well as through externally funded projects. Additionally, much of the director's focus is on helping faculty write proposals, which, if funded, could supply additional revenue. The communications specialist/webmaster, who is tasked with disseminating information about STEM education projects across the campus, is also funded by state funds. Many of I-STEM's evaluators and the undergraduate students are funded through the evaluation projects themselves.

This report contains as complete a listing as possible of the many evaluation projects I-STEM worked on in 2015; some were funded externally, such as those funded by NSF, which now requires evaluations for its projects. Climate studies, like those performed for Engineering or Chemistry, were funded internally by the units themselves. Additionally, I-STEM completed several pro bono projects in hopes that these might become a source of revenue in the future.



Above (left to right): I-STEM undergrads Derrick Domi and Paulina Rodriguez.

Below (clockwise from bottom): I-STEM undergrads Payal Malik, Cherie Chin, Emily Alameda, and Valentina Gill





Co.				
Sheep				
Goat	81-200			
Camel	83-600	88-100	40-60	10-30



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