

I-STEM

EDUCATION INITIATIVE

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

I-STEM EDUCATION INITIATIVE ANNUAL REPORT

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ILLINOIS

www.istem.illinois.edu

704 South Sixth Street
Champaign, IL 61820

phone: 217.333.9625

fax: 217.244.3949

From the Desk of the I-STEM Director

As the state of Illinois and the nation face severe economic challenges, issues of STEM preparedness, workforce development, and global competitiveness assume even greater importance in determining our future. *Illinois* faculty, staff, and students; our external education and business partners; and peer institutions across the nation are all eager for new opportunities in science, technology, engineering, and mathematics. Our collective desire is to increase students' interest and engagement in STEM disciplines; create accessible, high-quality STEM programs at all levels; improve the magnitude and quality of our STEM workforce, including teachers; and advocate for policies and funding to support STEM education in Illinois and the nation at large. Much of what we have done since the creation of I-STEM is to bring together these interest groups, explore common interests and promote collaboration, and define a program of work around our shared goals. The momentum continues to increase as we identify more and more areas of synergy, opportunities for federal and state support, and exciting partners. We recognize the benefits of increased collaboration and entrepreneurship in STEM education and are hopeful that the energy and impact will continue to grow in 2014!



A handwritten signature in white ink, reading "Lizanne DeStefano". The signature is fluid and cursive, with the first name being more prominent.

Lizanne DeStefano
Director

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I-STEM PARTNERS



COLLEGES AND SCHOOLS

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

CAMPUS UNITS

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

EXTERNAL PARTNERS

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



EXTERNAL PARTNERS (CONTINUED)

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

LOCAL PARTNERS

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





I-STEM ADVISORY BODIES



CAMPUS COUNCIL OF DEANS

- Robert Hauser, Dean, Agricultural, Consumer, and Environmental Sciences
- Tanya Gallagher, Dean, Applied Health Sciences
- Tom Emanuel, Interim Director, Institute of Aviation
- Larry DeBrock, Dean, Business
- Mary Kalantzis, Dean, Education
- Andreas Cangellaris, Dean, Engineering
- Edward Feser, 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
- Bruce Smith, Dean, Law
- Brian Ross, Interim Dean, Liberal Arts and Sciences
- Allen Renear, Interim Dean, Library and Information Science
- Jan Slater, Dean, Media
- Uretz Oliphant, Interim Regional Dean, Medicine
- Wynne Korr, Dean, Social Work
- Herbert Whiteley, Dean, Veterinary Medicine

CAMPUS ADMINISTRATION

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



CAMPUS INTERDISCIPLINARY UNITS

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


I-STEM EXTERNAL ADVISORY BOARD

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

I-STEM CORPORATE ADVISORY BOARD

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





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 fifth full year of operation in January 2014. I-STEM further developed its role in support of STEM education at the University of Illinois at Urbana-Champaign (*Illinois*) as it partnered with STEM education academic units and major research units on campus and increased the number of partners across the state of Illinois and the nation. While striving to fulfill its mission to improve the access, quality, and efficiency of STEM education activities at *Illinois* and throughout the state and nation, I-STEM has begun to serve as a model for other universities seeking to improve the number and quality of their own STEM education programs.

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.

WHY A CAMPUS FOCUS ON STEM EDUCATION?

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

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

- ◆ **Goal 1: Facilitate P–20 STEM Education Outreach.** Cultivate sustained, coordinated preschool through graduate partnerships to engage students in STEM experiences early and consistently, involving university faculty and students to meet STEM education challenges.
- ◆ **Goal 2: Improve STEM Teacher Training and Professional Development Quality.** Revitalize STEM teacher preservice education, induction, and professional development programs that attract and prepare a diverse group of P–16 STEM teachers and promote their effectiveness, retention, life-long learning, and continued involvement in research.
- ◆ **Goal 3: Foster Undergraduate and Graduate STEM Education Reform.** Stimulate accessible, engaging, undergraduate and graduate STEM programs and research experiences to promote interest and success in STEM fields, including teaching, for diverse students.
- ◆ **Goal 4: Shape Policy and Advocate for STEM Education.** Stimulate partnerships with business and industry, government agencies, educational institutions, and professional associations to understand the STEM pipeline, mainline and workforce development needs, opportunities, and challenges, and to serve as advocates within the state and nation.



Above: A GLAM G.A.M.E.S. camper examines stem cells during a lab.

Opposite (page vi): A Bioengineering G.A.M.E.S. camper performs a step during the Glowing Bacteria session.



Above: MechSE Outreach Coordinator Joe Muskin explains an engineering principle during a summer 2013 iRISE workshop for local educators.

Below: Two high school girls analyze chocolate during a session of the GLAM G.A.M.E.S. camp.



OVERVIEW OF I-STEM YEAR FIVE ACTIVITIES

During its fifth year of operation, I-STEM performed a variety of activities, both to foster STEM education locally, in the state, and in the nation, and to serve as a resource to improve/increase STEM education on campus. Major I-STEM activities in 2013 included:

- 1. Fostering dialogue among key campus and external stakeholders**, including internal and external advisory bodies and partners, to discuss ways to improve STEM education on campus, in the state, and throughout the nation (see pages ii–iii for lists of I-STEM partners and pages iv–v for lists of I-STEM advisory bodies).
- 2. Working with campus units to plan, develop, and submit external funding proposals for STEM education.** I-STEM personnel, who have significant expertise in both education and evaluation of educational programs, were key in the development of education and/or evaluation components for numerous proposals. I-STEM will be evaluating these projects should they receive funding.
- 3. 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, such as the Biology Coordinating Committee; interactive directories; and a campus-wide listserv (see I-STEM’s 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 37).
- 6. Promoting K–12 Outreach Activities.** I-STEM staff played significant roles in a variety of K–12 outreach activities during 2013, such as the Illinois Science Olympiad, I-STEM’s High School Research Experience, and campus visits by a number of Illinois high schools.

COMMUNICATION RESOURCES

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

I-STEM'S ROLE IN FOSTERING STEM EDUCATION

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

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

Funding Opportunity/Grant-Writing Resources. I-STEM's website offers several resources regarding upcoming STEM education funding opportunities involving our target groups (see above): Upcoming Funding Deadlines¹ lists impending deadlines by date; STEM Education Funding Opportunities² organizes these data by I-STEM goal. The I-STEM-News listserv apprises *Illinois* researchers of upcoming funding opportunities. I-STEM staff routinely research funding sites and perform routine maintenance of I-STEM's resources to catalog and make available current information. Also, staff work with researchers in writing proposals or by contributing evaluation or education components.

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

Disseminate STEM Education Program Information. While I-STEM works to disseminate information to stakeholders in a variety of ways, the primary method is through our website, where new STEM education articles related to I-STEM's four goals and their target groups (see above) are posted regularly. I-STEM's Externally Funded Projects Directory is organized by these target groups. Routine maintenance of these resources involves on-going research to catalog and make available information about newly awarded funding with STEM education components or funding opportunities based on I-STEM's four goals. We also send information electronically via email and the I-STEM-News listserv and electronic and printed materials, including evaluation reports, I-STEM's annual report, flyers, and posters.

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
- 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
- NanoCEMMS: Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems
- NIH: National Institutes of Health
- NCSA: National Center for Supercomputing Applications
- NSF: National Science Foundation
- PD: Professional Development
- REU: Research Experiences for Undergraduates
- SIIP: Strategic Instructional Initiatives Program
- SMTI: Science and Mathematics Teacher Imperative
- USI: Urban Schools Initiative
- XSEDE: Extreme Science and Engineering Discovery Environment



Illinois outreach activities, such as the G.A.M.E.S. camps, seek to foster interest in STEM among Illinois K–12 students.

Goal 1: Facilitate P–20 STEM Education Outreach

P–20 STEM EDUCATION OUTREACH ACTIVITIES

Following are the types of P–20 STEM education outreach activities in which I-STEM was involved in 2013, 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. 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 for their students, and parents (and/or the students themselves) seeking STEM education opportunities in the form of *summer camps*⁴ or *academic year activities*.⁵

I-STEM has also identified a number of programs which serve as examples of highly effective STEM education P–20 outreach programs, such as I-STEM's High School Research Experience (see page 12), Research Experiences for Undergraduates (see page 30), and the G.A.M.E.S. Camp (see page 9). Many of these were featured on the I-STEM website in 2013.

◆ Partner with state and national organizations.

To ensure that *Illinois* is strategically positioned to promote collaboration and leverage resources to improve STEM education experiences for P–20 students in the state, especially those from underrepresented groups, I-STEM partnered with several state and national STEM P–20 outreach entities in 2013, such as the Illinois P–20 Council (see page 10) and the Illinois Science Olympiad (see page 11).

◆ 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 selected P–20 outreach programs I-STEM evaluated in 2013.

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

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

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



Above: A GLEE G.A.M.E.S. camper learns about how fiber optics work during a hands-on activity.

Opposite on page 4: Aerospace Engineering G.A.M.E.S. camp director Brian Woodward and a couple of campers follow the flight of a camper's rocket during a launch event at Dodds' Park.

In 2013, I-STEM partnered with several state and national STEM P–16 outreach entities, such as the Illinois P-20 Council and the Illinois Science Olympiad.



Above: A Danville youngster about to observe the Bernoulli principle for himself.

Bottom right: GLEE G.A.M.E.S. campers enjoy a hands-on activity making circuits.

Bottom left: An I-STEM high school researcher tests water samples in Dr. Helen Nguyen's lab.



Table 1: Selected P-20 Outreach Programs I-STEM Evaluated in 2013	
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
Neuroengineering IGERT	Douglas Jones, Electrical & Computer Engineering
M-CNTC: Midwest Cancer Nanotechnology Training Center	Rashid Bashir, Electrical & Computer Engineering; Ann Nardulli, Molecular & Integrative Physiology
NASA Astrobiology Institute (NAI)	Bruce Fouke, Geology, Institute for Genomic Biology
Research Experiences for Undergraduates (REU) for 1) CSN, 2) Chemistry, and 3) EBICS.	1) Robert Hamers, Chemistry, UW-Madison 2) Alexander Scheeline, Chemistry 3) Rashid Bashir, Engineering
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* attain its goal of reaching 100% of local elementary, middle, and secondary school students annually through campus STEM outreach—and to ensure that activities span all age ranges and demographic groups—campus STEM demonstration sites are working to increase recruitment of local schools not engaged with STEM outreach and boosting outreach activities for primary and middle school students. In 2013, more than 5,800 local school students engaged with STEM researchers either during visits to the *Illinois* campus or off-site activities. I-STEM continued to identify and promote *Illinois*' numerous P–20 STEM outreach activities, featuring a number on its website.

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

This campus strives to repeatedly engage talented 7th through 12th grade Chicago Public School (CPS) students via after-school programs, summer camps, mentors, internships, and campus visits through programs like the Urban Schools Initiative and the campus visits I-STEM orchestrates in order to increase the number of CPS students graduating from *Illinois* in STEM fields.

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

To establish an adequate, sustainable campus funding base of \$2 million for P–20 STEM education and outreach, I-STEM participated in the submission of 60+ external funding proposals totaling approximately \$84 million in requested funds in 2013. 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 page 37 for I-STEM funding resources).



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

Below: A CPS student on a campus tour enjoys a Chemistry presentation.

Bottom left: *Illinois* graduates celebrate during commencement in 2013.

This campus strives to repeatedly engage talented 7th through 12th grade CPS students via after-school programs, summer camps, mentors, internships, & campus visits.





Clockwise from above: A Betabrain contestant stirs milk during the “Say Cheese” challenge.



Top right: Betabrain contestants test their design during the “Battle Chip” challenge.

Bottom right: A student does an experiment during a REACT outreach at Barkstall Elementary during spring 2013.

Bottom left: Betabrain contestants prepare their Cartesian Diver for the “Sink It” challenge.



P–20 STEM EDUCATION OUTREACH PROGRAMS

Betabrain. On March 8, 2013, I-STEM staff, along with other *Illinois* educators, participated in this science competition involving hands-on, problem-solving challenges, which served around 400 McClean County middle school and high school students. In its second year, the competition changed its emphasis from solely IT/engineering to include biology, chemistry, and physics. Betabrain began as a result of local educators’ participation in the EnLiST project (see page 21).

Chemistry Outreach. Personnel from *Illinois*’ Chemistry Department regularly provide chemistry outreach activities for hundreds of visitors to campus each year. In 2013, their demonstrations were one of the highlights during a number of campus visits by high schools. Also popular is its festive, year-end **Holiday Magic Chemistry Demonstration Show**. In addition, Chemistry students who participate in **REACT** (Reaching and Educating America’s Chemists of Tomorrow) participated in numerous in-school demonstrations, including in 45 local third grade classrooms, to help teach youngsters about chemistry.





Discover Architecture. The 68 young people who came to one of Discover Architecture's two, two-week sessions in summer 2013 had hands-on opportunities to use software to design a structure, build a model, and present it at a poster session; learned about careers in architecture; and discovered what studying architecture at *Illinois* is like.

EBICS. As part of the evaluation for EBICS, I-STEM staff visited two predominantly African-American high schools in Atlanta, Georgia in which EBICS does outreach: the all-male Business, Engineering, Science, and Technology (B.E.S.T.) Academy, and Coretta Scott King Young Womens' Leadership Academy, which is all female students.

G.A.M.E.S. In 2013, G.A.M.E.S. (Girls' Adventures in Mathematics, Engineering, and Science) camp helped 167 middle-school girls explore nine engineering disciplines via demonstrations, classroom presentations, hands-on activities, and contacts with women in these fields. According to data, participating in G.A.M.E.S. increases girls' engineering content knowledge and changes their attitudes about women in engineering, what engineers are, and what they and do.

GEMS. In the summer of 2013, GEMS (Girls Engaged in Math and Science) camp shifted its focus from an emphasis on math and science in general to computer science. Its two, one-week sessions gave 50 local middle school girls the opportunity to learn how to create Android apps and to discover what careers in computer science would be like.

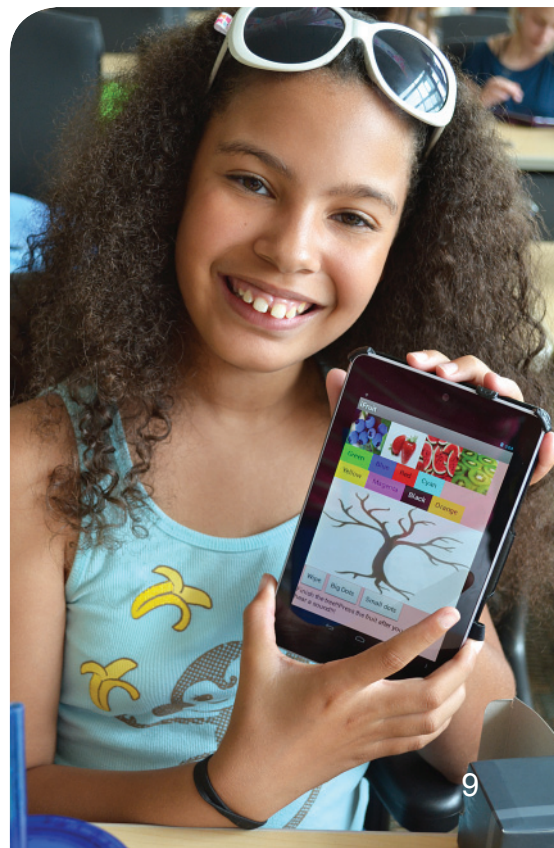


Clockwise from top left: Two participants in the 2013 Environmental Engineering G.A.M.E.S. camp learn about water purity.

Above: Two Bioengineering G.A.M.E.S. campers perform a hands-on activity during the "Glowing Bacteria" session.

Below: A GEMS camper proudly displays the Android app she created.

Bottom left: A local student works on an experiment during a REACT outreach at Barkstall Elementary during spring 2013.





Above: A local youngster and an *Illinois* graduate student stand in front of a green screen to see themselves “dance with plants” at Genome Day.

Below: A young visitor to Genome Day chronicles his experience using a ProScope to magnify rocks and coral.



Above: An *Illinois* student helps a local youngster with a hands-on activity about genetics during Genome Day 2013.

Below: Two *Illinois* graduate students man an exhibit at Genome Day in fall 2013.

Genome Day. The Institute for Genomic Biology’s Genome Day on November 2, 2013, gave visitors the opportunity to learn about genomic research, including genes, human or plant genomes, DNA, and evolution, plus skills/instruments scientists use in research. Sharing their love of science with local youngsters and their families were 100+ *Illinois* volunteers, including undergrads, grads, post-docs and fellows, faculty, and staff, including one I-STEM staff member.

Illinois P–20 Council. The P–20 Council⁶ guides education policy and seeks to develop an integrated P–20 system in Illinois. As its Coordinator, Dr. DeStefano serves on all P–20 committees, including the Coordinating Committee, Implementation Review, JELC (Joint Education Leadership), Postsecondary & Workforce Readiness (PWR), Teacher & Leader Effectiveness, and Research & Development STEM Coalition Steering Committee (see pages 36 and 37 for more Council activities).

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

⁷<http://stemlearningexchange.org/>





Two Illinois Science Olympiad contestants prepare to test the glider they designed.

Illinois Science Olympiad Competition. *Illinois* hosted the Illinois Science Olympiad (ISO) State Tournament in April 2013, with 1800+ student participants representing all regions of the state. I-STEM staff were involved in planning meetings for the event and also volunteered in a number of capacities during the competition, including photography, hospitality, and the closing awards ceremony.

iRISE. In 2013, iRISE (Illinois Researchers in Partnership with K–12 Science Educators) graduate students developed then taught lessons to Edison Middle School students (see more about iRISE on pages 19, 21, and 29).

iRobotics. iRobotics, a registered student organization, does robotics-related outreach locally, including demonstrations in schools; helping start, mentor, or prepare 4H or FIRST robotics teams for competition; and serving as judges in both local and statewide competitions.

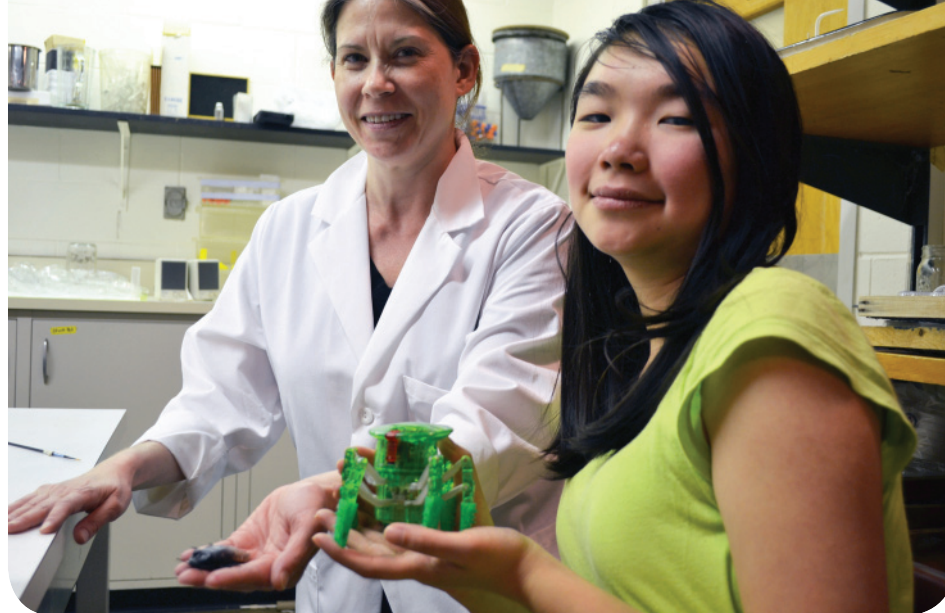


Clockwise from above: An Edison Middle School student designs a knee replacement during an iRISE lesson.

Below: An iRobotics member (left) chats with several members of a local team during a practice competition iRobotics held in November 2013.

Bottom left: Edison Middle School students display the knee replacement design and prototype they built as part of the iRISE partnership.





Clockwise from left: Visitors to the Naturally Illinois Expo examine the “Creatures That Are Not Afraid of the Dark” display.

Above: An I-STEM high school researcher (right) holds a hexabot modeled after the Madagascar Hissing Cockroach researcher Marianne Alleyne (left) is holding.

Below: An I-STEM high school researcher performs tests on the navel orangeworm.

Bottom left: Dr. Felipe Soto-Adames (top) supervises an I-STEM high school researcher (bottom) as he examines springtails through a microscope.

Through I-STEM’s 2013 High School Summer Research Experience, 24 students received an authentic research experience and were mentored by some of the premier researchers in their fields.

I-STEM High School Summer Research Experience. In 2013, 24 students from University Laboratory High School participated in summer research. Chosen on the basis of their performance in STEM and an essay on their interest in a STEM career, students received an authentic research experience in *Illinois’* labs, mentored by some of the premier researchers in their fields. Says one student participant: “I now know what it is like to conduct actual research, perform tests on subjects...I gained authentic experience from the I-STEM program that definitely made me even more eager to pursue a scientific profession.”

Mississippi River Transportation Distribution and Logistic Consortium. I-STEM evaluates this project seeking to advance economic development in the Mississippi River region by training and placing workers in jobs in the transportation, distribution, and logistics-related industry.





Two young visitors to the Naturally Illinois Expo examine an exhibit explaining how water can flow through concrete.

NASA Astrobiology Institute (NAI). In collaboration with the National Park Service, NAI's education/public outreach plan involves K–12 formal education with middle school teachers and students, informal education via a web-based video series for middle school classrooms, and community outreach via two new astrobiology courses.

Naturally Illinois Expo. Sponsored by the Prairie Research Institute, the Expo in March 2013 attracted 1900+ visitors to campus, including around 1100 students, teachers, and chaperones from 12 schools and 40 classrooms. Emphasizing hands-on activities, the Expo's 48 exhibits and more than 200 exhibitors and volunteers provided learning experiences about a broad range of scientific disciplines and topics Institute researchers study every day, including dinosaurs, mosquitoes, ground water, earthquakes, bones, pollination, glaciers, and how to produce zero waste, to name a few.



Above: A Naturally Illinois Expo visitor learns about minerals in Illinois water.

Below: Using an infrared thermometer, a NASA Astrobiology Institute graduate student helps a Genome Day visitor measure the temperature of a Yellowstone hot-spring simulation.

Bottom left: Researcher Christine Hedman and an I-STEM high school researcher examine teeth retrieved from an archaeological excavation site.





Above: A PRI camper (left) takes readings as Illinois State Water Survey's Walt Kelly (right) explains how to analyze well water.

Below: PRI campers watch Illinois State Geological Survey researchers gather data using a rig and core samples.



Above: The Physics Van and the 2013 Physics Van program coordinators.

Below: Illinois Sustainable Technology Center researchers (right) help a PRI camper test drive a go-cart fueled by biodiesel made from campus waste cooking oil.

OneGoal Campus Visit. I-STEM helped make arrangements for a campus visit by 51 juniors from Chicago Public Schools high schools who were part of the OneGoal (formerly US Empowered) program.

Physics Van. Completely run by *Illinois* Physics students, Physics Van is an engaging way for local youngsters to learn science. Though kids can only learn so much science in an hour-long show, not only will they never forget the physics principles introduced during the Van's entertaining hybrid of slap-stick comedy and scientific wizardry, but they'll discover that Physics can be fun.

Prairie Research Institute Science Camp. In 2013, I-STEM evaluated the Prairie Research Institute's (PRI) first ever Science Camp the week of July 15–19. While showcasing research that takes place in the five state scientific surveys that comprise the PRI, the Institute's enthusiastic researchers were delighted to show students what they do and expose them to the kinds of careers possible in the natural sciences.





Above: A Physics Van trainee performs a demo placing a balloon in liquid nitrogen; the balloon shrivels as the air in it contracts, then regains its shape as the air expands.

Below: A PRI camp counselor holds a just-banded female cardinal.

UIC College Prep Campus Visits. I-STEM arranged two campus visits in 2013 for students from UIC College Preparatory High School in Chicago, during which students learned about the application process at *Illinois* and toured campus. On May 16th, 80 juniors experienced demonstrations by Food Science and Human Nutrition and Chemistry instructors. During the November 20th visit, 70 students experienced first-hand what college is like. “It was incredibly powerful for them to have the opportunity to visit classes, learn from our alumni about their experiences, and see the campus,” says principal Tressie McDonough, who reports seeing “a noticeable difference in motivation for those scholars. Kids came back from the visit engaged and excited to improve their GPAs and to work toward this vision of college.”

Urban Schools Initiative. I-STEM partners with the Urban Schools Initiative (USI) to establish and retain Science Olympiad teams in Illinois urban schools. USI included 30 CPS middle and high schools (around 450 students) in the 2013–2014 school year. I-STEM hosted a visit by ten USI high school and middle school teams (a total of 164 students), who experienced campus as VIP guests of the University the day before competing in the 2013 Illinois Science Olympiad state tournament.



Above: A female cardinal who was just banded during the PRI Science Camp.

Below: UIC College Prep students experience a class session during a fall 2013 visit to campus.





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

Goal 2: Improve STEM Teacher Training and Professional Development Quality

STEM EDUCATION TEACHER TRAINING/PROFESSIONAL DEVELOPMENT IMPROVEMENT ACTIVITIES

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

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, such as SMTI, and campus projects, such as EnLiST (both described on page 20), which share this same goal.

✦ Evaluate STEM teacher training and professional development projects.

In 2013, I-STEM evaluated several NSF-funded STEM teacher training and professional development projects operating at *Illinois*, including EnLiST, an NSF Math and Science Partnership which provided teacher leadership training, and Nano-CEMMS, which also provided professional development for STEM teachers (see Table 2 below). 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.

✦ Coordinate and strengthen campus STEM teacher professional development.

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

**Table 2: Selected Teacher Development Programs
I-STEM Evaluated in 2013**

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-CEMMS: Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems: Teacher Institutes	Placid Ferreira, Engineering John Rogers, Engineering
Robert Noyce Master Teaching Fellowship Program	Thomas Dunning, Chemistry & NCSA



Above and below: *Illinois* K–12 science teachers participate in EnLiST summer 2013 professional development at *Illinois*.

On the opposite page (p. 14): an iRISE student presents her Water Filtration lesson to teachers during a workshop.

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





Above: An *Illinois* math student plays Abalone with a youngster at iMATHS after-school club.

Bottom right: A grad student supervises a Genome Day visitor using a ProScope.

Below: A MechSE student works with a BTW Technology Club student.

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



Because past participants have often reported a 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. I-STEM's database of STEM teacher PD opportunities is continuously updated, posted on the I-STEM website, and sent to campus stakeholders (many of whom are I-STEM Affiliates) via the I-STEM listserv. (See pages 2 and 37 for links to communication resources.)

◆ Increase external funding for teacher preparation and professional development.

In 2013, I-STEM helped units submit STEM teacher development proposals to funding agencies. I-STEM encourages faculty writing new proposals to incorporate existing campus teacher development programs into them as a way to sustain and institutionalize these teacher preparation and professional development programs. Also, K–12 school districts have been encouraged to take advantage of campus professional development resources. In addition, I-STEM recommends that campus projects and labs offer Research Experiences for Teachers (RET), the number of which has steadily increased over the last several years (see Table 3 to the left).

◆ Increase teacher education candidates/student volunteers.

Exposing STEM majors to service learning opportunities in schools and other informal educational settings not only benefits youngsters by exposing them to STEM, but increases the possibility that the STEM majors themselves might choose teaching as a career or continue to perform STEM outreach activities once they graduate. Thus, I-STEM encourages units/projects to increase the number of teacher education candidates and foster commitment to outreach by including components where students perform outreach in the community. In 2013, *Illinois* staff and students volunteered in numerous outreach programs targeting K–12 students, including:



- **Booker T. Washington STEM Academy (BTW).** Several units/ programs provided outreach at BTW in 2013. For instance, Nano-CEMMS/MechSE educator Joe Muskin and six pre-service teachers taught kindergarteners about polymers and manufacturing. At BTW's after-school Technology Club, MechSE students taught engineering via fun, hands-on activities.
- **Genome Day.** *Illinois* undergraduate and graduate students participated in the Institute for Genomic Biology's Genome Day, teaching local youngsters about genomic research (see page 10).
- **Illinois Geometry Lab (IGL).** IGL students performed community outreach to share their love of mathematics—specifically geometry—with local students, such as at Centennial High School's Tap-In after-school program.
- **Illinois Science Olympiad.** A large number of *Illinois* personnel volunteered in the 2013 state tournament held on campus, including current *Illinois* students who had participated in Science Olympiad themselves.
- **iMATHS.** Staffed by Noyce math scholars and held at the Champaign Public Library, iMATHS (Inquiring through Mathematics As Thoughtful HumanS) is a bilingual, after-school club for middle-school and high-school kids.
- **iRISE.** In 2013, iRISE (Illinois Researchers in Partnership with K–12 Science Educators) trained and encouraged K–12 educators, research professionals in STEM fields, and graduate students to conduct effective educational outreach for middle school students. Training included actually conducting outreach programs for middle school students (see more about iRISE on pages 11, 21, and 29).
- **iRobotics.** Comprised of engineering students, iRobotics members seek to share their love of the sport with youngsters and to get them interested in STEM. To prepare members for outreach and working with robotics teams, iRobotics members and their faculty advisor developed a course, ENG 298 LRM (Lego Robotics Mentoring; for more about iRobotics outreach, see page 11.)
- **I-STEM High School Summer Research Experience.** This I-STEM program pairs high school students with research projects in *Illinois* labs, where graduate students help mentor them (see page 12 for more about I-STEM's Summer Research Experience).



Above: An Illinois Geometry Lab math undergrad works with a student at Centennial's Tap-In.

Below: A grad student at the Naturally Illinois Expo exhibits Cecil the Tarantula.

Bottom left: The circus atmosphere at this graduate student's exhibit about river otters in Illinois attracted lots of visitors at the 2013 Naturally Illinois Expo.





Above: Grinning from ear to ear, pit bull Kevin, supervised by a Vet Med student, enjoys a moment with a young visitor to Vet Med Open House, 2013.

Below: A student introduces Snowbird to visitors at Vet Med Open House.



- **Naturally Illinois Expo.** Many of the Expo's 200 exhibitors in 2013 were natural history students or affiliated with the Prairie Research Institute. Exhibitors hoped to not only teach visitors about their research, but possibly influence youngsters to go into their field.
- **Next Generation School Partnerships.** Mechanical Science and Engineering students helped teach a Project-Lead-the-Way unit in which students designed playground equipment using AutoDesk Inventor software to construct 3D images. A highlight of the project was a tour of MechSE's Ford Lab. In addition, *Illinois* researchers and students judged the school's 2013 Science Fair.
- **Physics Van.** This program (see page 14), which provides physics outreach to local schools, exposes physics students to a classroom setting and gives them practice communicating at a level a layperson—or a third grader—can understand.
- **Pollen Power.** Middle school girls who participated in this camp not only learned about pollen and the technology used to study it; female graduate students who taught them served as role models in hopes that the girls will follow in these women's footsteps
- **REACT.** REACT chemistry students visited local schools and other events, such as the Trick or Treat event at the Orpheum Children's Museum, to help teach local youngsters about chemistry via hands-on demonstrations (for more on REACT, see page 8).
- **University Laboratory High School outreach programs.** Not only university students, but Uni High students themselves worked in several K–12 outreach programs, which used high school students as tutors/mentors.
- **Vet Med Open House.** At the fall 2013 Open House, Vet Med students interacted with visitors, both young and old, to show the public what goes on at an animal hospital. Said one student: "Open House gives the public a taste of what it takes to be a veterinarian."

STEM EDUCATION TEACHER TRAINING/PROFESSIONAL DEVELOPMENT IMPROVEMENT PROGRAMS

APLU/SMTI. A member institution of APLU (Association of Public and Land-grant Universities), *Illinois* is committed to its Science and Mathematics Teacher Imperative, a national effort to increase the number and improve the quality/diversity of science and math teachers. Its Mathematics Teacher Education Partnership fosters university-K–12 district collaboration to transform math teacher preparation.

Children's Environmental Health Center. This Center seeks to assess the effects of chemicals in the environment on child development and work with child-care professionals to make them aware of environmental health risks.

DCEO Coal Education Program. In 2013, I-STEM conducted an evaluation of the Department of Commerce and Economic Opportunity's Coal Education Program, which trains K–12 educators about coal.

EnLiST. Entrepreneurial Leadership in STEM Teaching & Learning seeks to develop content mastery and entrepreneurial skills for K–12 science teacher leaders. The I-STEM evaluation found that teacher leaders significantly increased their knowledge in Physics and Chemistry and their skills and commitments to entrepreneurial leadership from participating in summer professional development institutes.



iRISE. In 2013, iRISE (Illinois Researchers in Partnership with K–12 Science Educators) held professional development sessions to train middle school teachers to use the classroom-ready teacher materials iRISE scholars created (see pages 11, 19, and 29 for more about iRISE).

Nano-CEMMS. The Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems offered summer workshops to help teachers learn how scientists and engineers manipulate matter at the molecular level, plus online teaching modules for classroom use (see page 29 for more on Nano-CEMMS).

REMSI: Research and Evaluation of Math and Science Implementation. I-STEM evaluates this University of Chicago grant that measures the use of innovations in mathematics and science education and factors that contribute to and/or inhibit their implementation, spread, and sustainability.

Robert Noyce Teacher Scholarship Program. Noyce provides scholarships to encourage math majors and professionals to work with K–12 students and to teach math in high-needs schools. Scholars are not only exposed to creative math pedagogy, and receive mentoring, but are prepared to effectively teach marginalized minority students.




Clockwise from top left: A graduate student interacts with a middle school student during Pollen Power camp.

Above: A science teacher displays the “airplane” she built during an iRISE PD session on aerospace engineering.

Below and bottom left: Illinois K–12 science teachers participate in EnLiST summer 2013 professional development.



A female student with long blonde hair, wearing a light blue lab coat over a black shirt and clear safety glasses, is focused on her work in a laboratory. She is holding a small black component in her gloved hand. The background is filled with various scientific equipment, including a yellow manifold with multiple valves, several white bottles with blue caps, and a rack of electronic modules. The lighting is bright, highlighting the student's concentration.

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.

♦ 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 2013, I-STEM conducted evaluations of several of these (many of which are listed in Table 4 on page 24).

♦ Perform student satisfaction/climate studies.

Another I-STEM priority is helping units understand student data patterns regarding performance, why students choose/leave STEM majors, and impacts of reform on student performance. I-STEM provides expertise to campus units interested in self-evaluation, such as Chemistry (see page 25) and Engineering (see page 27). A 2014 climate study addressing student satisfaction is planned for Biology, whose courses are offered across various STEM disciplines.



Clockwise from above: Students working in an *Illinois* lab.

Bottom left: Two Math undergraduate students who participate in *Illinois* Geometry Lab's outreach.

Opposite on page 22: A Chemistry REU student in Martin Burke's lab works to synthesize a building block of a larger molecule, Pharmaceutical TWS 119.

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



Above: CEE 398 students discuss their project during the course's final poster presentation.

Below: A Civil Engineering student enrolled in CEE 398 participates in a tour of Abbott Power Plant in Fall 2013.



◆ 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. In addition, 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 incorporate Research Experiences for Undergraduates (see page 30) and to adapt strategies successful *Illinois* programs, such as iFoundry and the *Illinois* Engineering Freshmen Experience (see page 28), use to increase student support.

◆ 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 2013, I-STEM was involved in more than 60 grant submissions, representing seven colleges and 20 departments. To assist faculty, I-STEM provides support via a variety of mechanisms (see pages 2 and 37).

Table 4: Selected Undergraduate/Graduate STEM Education Programs I-STEM Evaluated in 2013

Chemistry CCLI: Discovering the Nanoworld: Module for Teaching About Molecules/Bonding in Chemistry
Chemistry Student Experiences Study
Chemistry REU (Research Experience for Undergraduates)
CMMB (Cellular & Molecular Mechanics & BioNano-technology) IGERT
CSN (Center for Sustainable Nanotechnology)
M-CNTC (Midwest Cancer Nanotechnology Training Center)
Digital Forensics
EBICS (Emergent Behaviors of Integrated Cellular Systems)
Engineering Climate Study
iFoundry/iEFX (Engineering Freshman Experience)
Neuroengineering IGERT
Physics CCLI: Enhancing Student Learning in Physics Through Multimedia Learning Modules
SIIP (Engineering Strategic Instructional Initiatives Program)
S-STEM (Scholarships in Science, Technology, Engineering, and Mathematics): Merit Fellows Scholarship Program
UBM Group: Biomathematics
VINTG (Vertically Integrated Training with Genomics) IGERT
XSEDE: TEOS (Extreme Science and Engineering Discovery Environment: Training, Education, and Outreach Services)

UNDERGRADUATE/GRADUATE STEM EDUCATION PROGRAMS/INITIATIVES

AAU Initiative to Improve Undergraduate STEM Education.

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

Blue Waters. I-STEM evaluates the community outreach program for *Illinois*' Blue Waters, one of the world's most powerful super-computers. This includes internships for undergraduates, fellowships for graduates, faculty professional development, and public engagement activities.

Chemistry Student Experiences Study. Like I-STEM's 2011 climate study, this 2013 follow-up study investigated undergraduate and graduate students' experiences in the Department of Chemistry, 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.

CEE 398: Project-Based Learning. In fall 2013, Civil and Environmental Engineering (CEE) offered this new sustainability course through SIIP (page 31). Ranked #1 nationally both at graduate and undergraduate levels, CEE innovations in teaching and research include major renovations/restructuring in large undergraduate gateway classes. CEE 201 (System Planning and Optimization) and CEE 202 (Probability and Statistics) incorporate problem-solving and critical-thinking activities and pre-lecture reading, videos, and knowledge assessment. CEE 195 (Introduction to CEE) uses out-of-class discovery and in-class case study discussions to expose students to CEE's various disciplines.

CEE 398 bridges CEE195 to upper-level technical courses. To develop students' critical-thinking skills and prepare them for summer internships, its team of multi-disciplinary faculty presented interactive case studies over various CEE concentrations. Student teams' semester-long projects proposed solutions to campus sustainability problems, while field trips to local infrastructure sites enriched students' experiences.



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

Below and bottom left: As part of the CEE 398 course, students took a tour of the University's Abbott Power Plant.





Clockwise from above: G.A.M.E.S. campers recruited to help test a prototype of EBICS' ethics module text responses assessing the material presented.

Top right: Civil and Environmental Engineering students tour the University's Abbott Power Plant as part of the CEE 398 course.

Bottom left: A summer 2013 EBICS REU student (center) with her two graduate student mentors during the end-of-semester poster presentation.



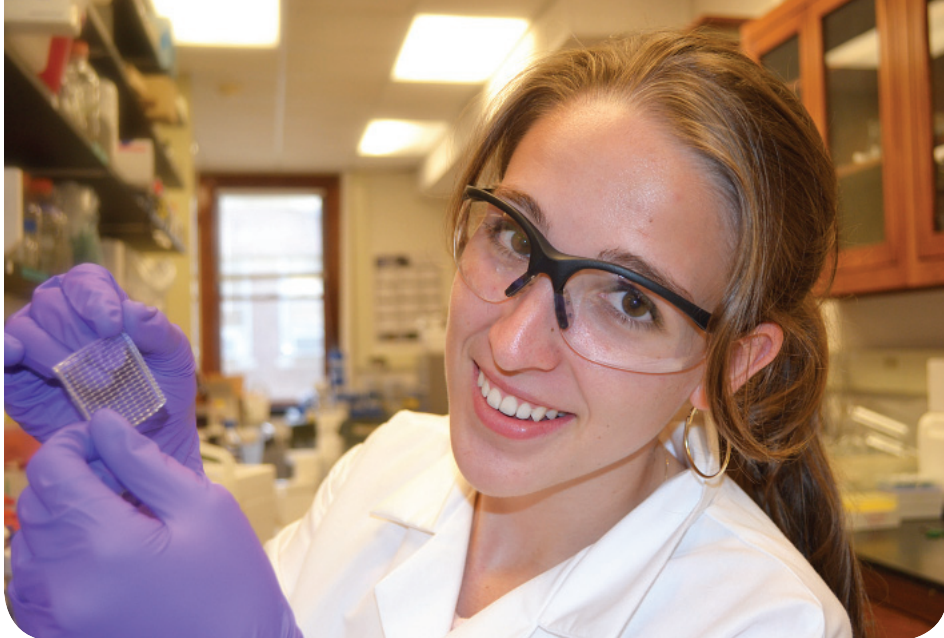
CMOP. Dr. DeStefano serves as a director for the Center for Coastal Margin Observation & Prediction (CMOP), a national center that embraces anticipatory rather than reactive science of coastal margin ecosystems. CMOP seeks to train a STEM-literate coastal margin workforce and foster participation of underrepresented groups.

CSN. The Center for Sustainable Nanotechnology (CSN), a multi-institutional partnership, is devoted to investigating the fundamental molecular mechanisms by which nanoparticles interact with biological systems. Its goal is 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.

Digital Forensics. Funded by NSF, Roy Campbell and colleagues from the Information Trust Institute (ITI) are seeking to develop and implement an educational interdisciplinary curriculum in digital forensics focused on the recovery and investigation of data found in digital devices. The aim is to implement an undergraduate educational curriculum that incorporates aspects of computer science, law, sociology, accounting, and psychology and to work for that curriculum's acceptance as a digital forensics standard.

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

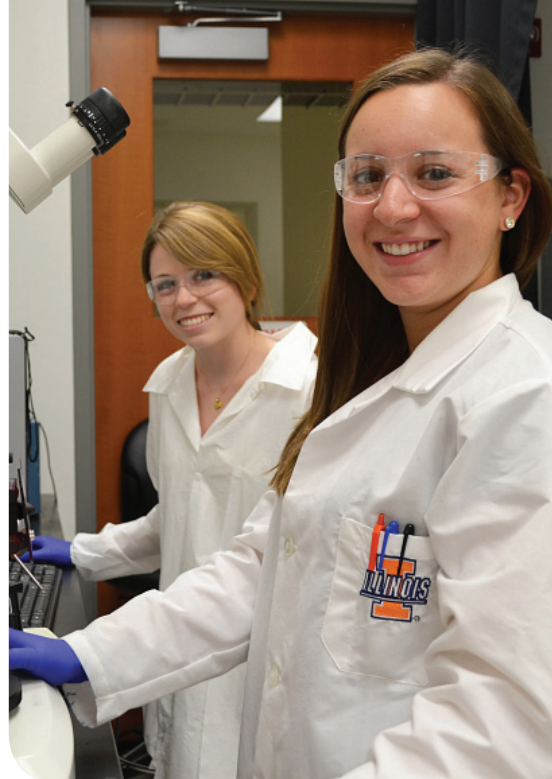




EBICS. Emergent Behaviors of Integrated Cellular Systems (EBICS) is an NSF-funded Center at *Illinois*, MIT, and Georgia Tech to advance research in complex biological systems and develop programs to attract students to STEM fields. I-STEM provides leadership for the education component and evaluates the educational activities.

Engineering Climate Study. In 2013, I-STEM performed a climate study for the College of Engineering looking at undergraduate and graduate students' experiences in the College, plus barriers and opportunities to increasing recruitment and retention. Since I-STEM's initial study in 2009 and the 2011 follow-up, the College and individual departments have considered these data during decision-making, and to determine to what degree policy changes and course reforms implemented over the last five years have impacted students' satisfaction and perceptions of climate.

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



Clockwise from top left: A 2013 EBICS Research Experience for Undergraduates (REU) student displays the work she did studying myogenesis of muscle tissue.

Above: An EBICS REU student (left) is mentored by an EBICS graduate student while working in the lab of *Illinois* researcher Rashid Bashir.

Bottom left: A MechSE senior interacts with a fourth grader during an engineering outreach he arranged and taught at Stratton School.



Since I-STEM's initial Engineering Climate Study in 2009 and the 2011 follow-up, the College and individual departments have considered these data during decision-making, and to determine to what degree policy changes and course reforms implemented over the last five years have impacted students' satisfaction and perceptions of climate.



Clockwise from above: An Engineering graduate student teaches a lesson on Water Filtration during an iRISE workshop.

Bottom left: Two iRISE engineering students work with Edison Middle School students doing a hands-on activity as part of a lesson on knee replacements that they created.

Below: A Mechanical Science and Engineering student who is heavily involved with iRobotics.



IEFX. Birthed out of iFoundry (see below), the Illinois Engineering First-Year Experience (IEFX) interdisciplinary program for all first-year engineering students at *Illinois* became a full-scale program with its own leadership in 2012. It seeks to respect, support, and foster students' aspirations within initiatives that lay a foundation for students' collegiate careers. The beginning-of-semester *Launch* event officially welcomes students to Engineering at *Illinois*. IEFX courses, events, and sub-programs build community and help students gain an engineering identity. In 2013, ISTEM evaluated these new courses: Aspirations to Leadership, IEFX Projects, and Spatial Visualization. The instructional design of IEFX Projects has served as a model for other projects courses on campus, for example CEE398.

iFoundry. The Illinois Foundry for Innovation in Engineering Education (iFoundry) is 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. Several of its initiatives that I-STEM evaluates include:

- **Innovation Certificate (IC).** IC's special courses, coaching opportunities, and community helps develop students' creative and innovative capabilities to address problems that impact our society.
- **Intrinsic Motivation Course Conversion.** It allows students to learn the same material in new, more meaningful ways.
- **James Scholar Quest program.** New in fall 2013, this program seeks to create a new experience for James Scholars.

Engineering Summer Scholars. In 2013, I-STEM evaluated this iEFX summer program designed to reduce attrition among incoming engineering freshmen by creating a small-campus feel. Scholars came to campus during the summer and took courses, including a projects course they took together. The program was designed to help them adjust to life as students, become familiar with campus, and form support groups before the fall influx of students. ISTEM's evaluation found the program may help students (especially international students) adjust to the new culture and learn about professional networks.



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 2013, I-STEM evaluated the following three *Illinois* IGERTs.

- **CMMB (Cellular and Molecular Mechanics and BioNano-technology) IGERT:** This IGERT seeks to train the next generation of leaders in cellular and molecular mechanics and bionanotechnology.
- **Neuroengineering IGERT.** This IGERT trains students, representing a range of disciplines, at the intersection of neuroscience and engineering.
- **VINTG (Vertically Integrated Training with Genomics) IGERT.** The goal of the VINTG IGERT is to train students in the interdisciplinary field of genomics.

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

iRISE. In 2013, iRISE (Illinois Researchers in Partnership with K–12 Science Educators) developed a new course: ECE 598 EO: Community Outreach for Engineering Researchers. *Illinois* graduate students interested in outreach created lessons for middle school students (including classroom-ready teacher materials), piloted them on students, then trained middle school science teachers to use the lessons.

M-CNTC. The Midwest Cancer Nanotechnology Training Center (M-CNTC) is training the next generation of leaders who will define the new frontiers and applications of nanotechnology in cancer research.

ME 199: Interdisciplinary Research and Education in Biology, Engineering, and Health Science. As part of the NSF-funded EBICS Center (see page 27 for a full description), ME 199 is introducing students to interdisciplinary education and preparing them to become future researchers and leaders in the new EBICS discipline, with expertise in both biology and engineering.

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

Nano-CEMMS. In 2013, the education outreach component of the Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems provided professional development opportunities for teachers via programs, such as EnLiST, and also provided hands-on learning opportunities for both campus programs and local schools. As the Education Director and Evaluator, Lizanne DeStefano participated in the design and evaluation of Nano-CEMMS’ education programs.



Above: During a summer 2013 iRISE workshop, an engineering graduate student who took the ECE 598 EO course explains to local science teachers how to use the aeronautical engineering lesson plan he developed.

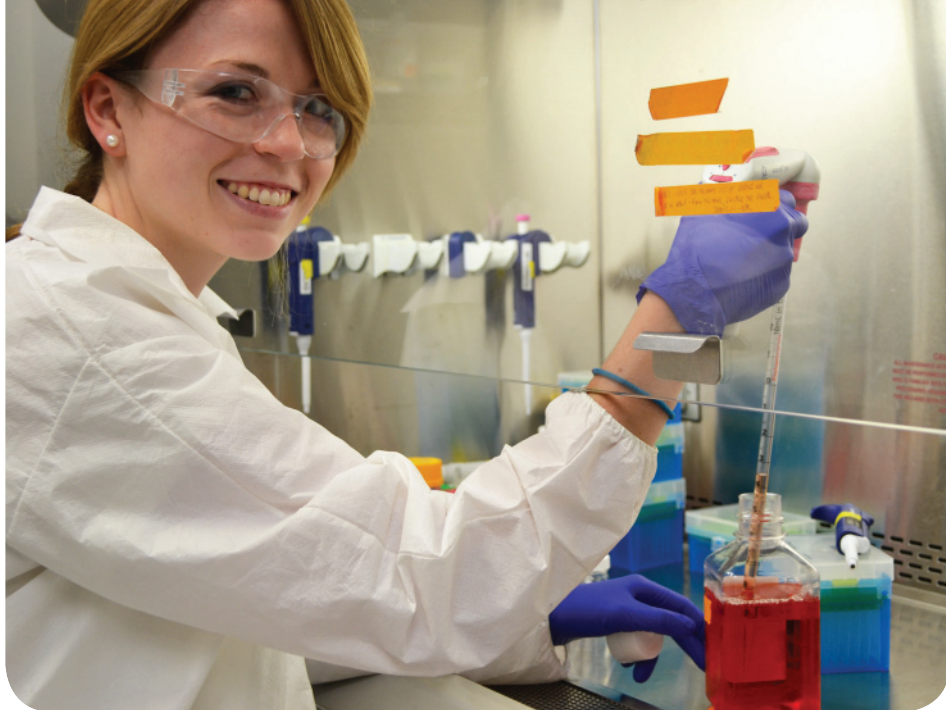
In 2013, I-STEM evaluated the Engineering Summer Scholars program, designed to reduce attrition among incoming engineering freshmen by helping them adjust to life as students, become familiar with campus, and form support groups before the influx of students in the fall.



Clockwise from above: A Chemistry REU undergraduate synthesizing a building block in researcher Martin Burke's lab.

Top right: An undergraduate student in the EBICS REU program works in the lab of *Illinois* researcher Rashid Bashir.

Below: A Chemistry REU participant works with nitrogen-containing compounds in the Hull Lab.



Research Experiences for Undergraduates. I-STEM advocates employing research experiences for undergraduates to increase the number of students choosing careers in STEM fields. In fiscal year 2014, at least 149 campus projects offered research experiences for undergraduates (see Figure 1 below), most funded through NSF's Research Experiences for Undergraduates (REU) program. Five were NSF REU Sites engaging a number of students in research; many were NSF-funded research projects offering research for a few undergraduates. However, some of the undergraduate research experiences offered on campus were through funders other than NSF.

I-STEM evaluates three NSF REU programs which engage a number of students: Chemistry, an NSF-funded program specifically for REUs, plus two programs that offer REU components as one of their STEM education emphases: EBICS (Emergent Behaviors of Integrated Cellular Systems Science and Technology Center) and the Center for Sustainable Nanotechnology (CSN). However, although *Illinois* is one of five CSN universities, no REU students were on campus in 2013.

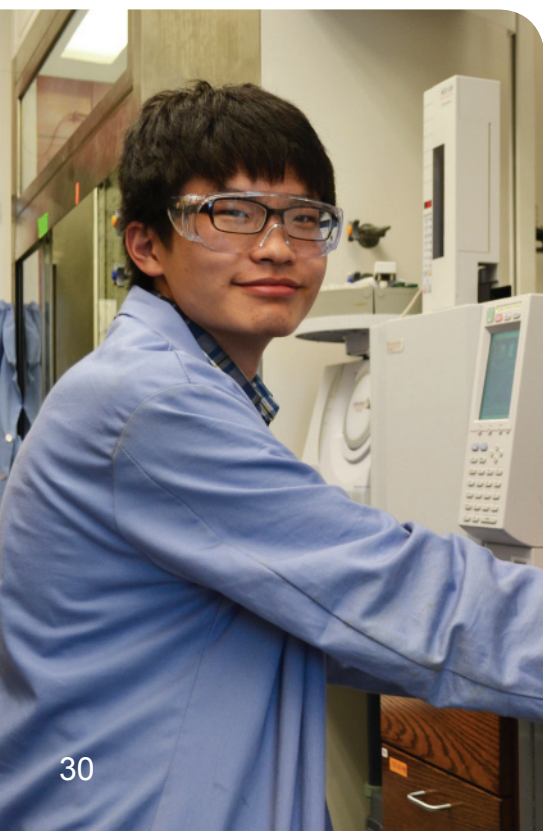
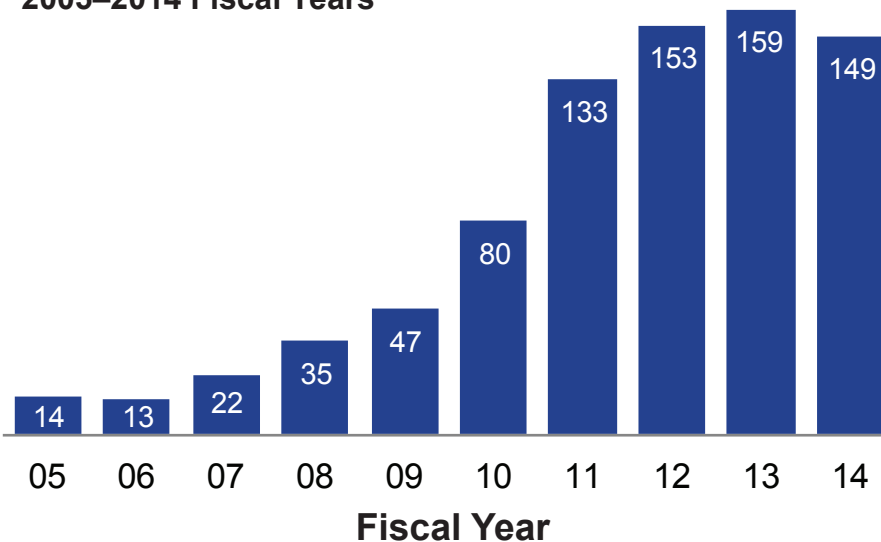
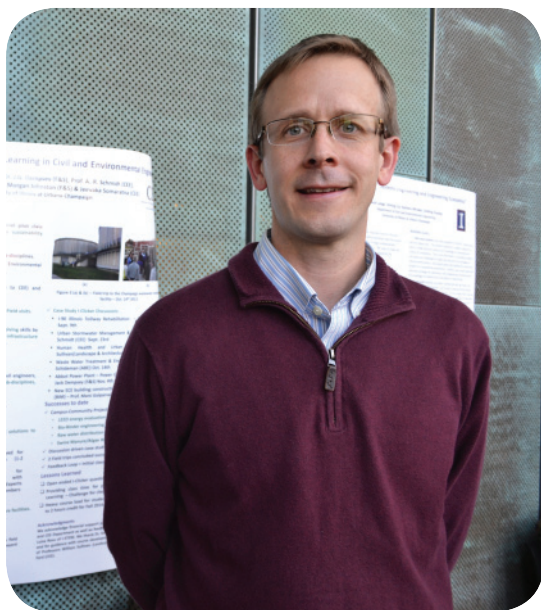


Figure 1: Research Experiences for Undergraduates, 2005–2014 Fiscal Years





SIIP. The College of Engineering Strategic Instructional Initiatives Program (SIIP) strives to improve the pedagogy of targeted large, foundational undergraduate courses in order to improve student engagement and learning outcomes. I-STEM's evaluation found that interacting with student data information during instructional decision making could inform instructors in a timely manner of the effectiveness and impact of instructional initiatives.



XSEDE. Extreme Science and Engineering Discovery Environment (XSEDE), led by Illinois' National Center for Supercomputing Applications (NCSA) and supported by NSF, offers a collection of advanced digital resources and services to a broad range of researchers, allowing scientists nationwide to collaborate remotely on over 16 supercomputers and high-end visualization and data analysis resources across the country. I-STEM is conducting the external evaluation for TEOS (Training, Education, and Outreach Services). Some highlights of the evaluation this year include:

- **International HPC Summer School.** XSEDE partners annually with similar organizations in the European Union (PRACE), Japan (Riken), and most recently, Canada (Compute Canada) to offer a summer school on "HPC Challenges in Computational Science." I-STEM is conducting the external evaluation of the innovative school as part of the TEOS evaluation.
- **Staff Climate Study.** I-STEM conducted the first staff climate study of XSEDE in 2013 to better understand how the over 250 staff members function in a virtual organization funded by NSF. This study is expected to be repeated annually as the program rapidly continues to evolve to meet the needs of its community.



Clockwise from top left: During the SIIP Poster Showcase in fall 2013, ME Professor Sameh Tawfik explains the particulars of ME 370 and 371 to *Illinois* Provost Ilesanmi Adesida.

Above: A Chemistry REU student studies the effects of cholesterol depletion on proteins in researcher Mary Kraft's lab.

Left: Professor Jeff Roesler presents a poster about CEE 398 PBL during the SIIP Poster Showcase in fall 2013.

I-STEM's SIIP evaluation found that interacting with student data information during instructional decision making could inform instructors in a timely manner of the effectiveness and impact of instructional initiatives.

A young woman with reddish-brown hair, wearing a white lab coat, is focused on writing in a notebook. She is in a laboratory setting, with various pieces of scientific equipment visible. In the foreground, there is a blue electronic device with yellow cables. In the background, other students in lab coats are working, and a large piece of laboratory equipment is visible. The text is overlaid on the bottom half of the image.

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 2013, I-STEM staff members continued to network at the local, state, and national levels to promote STEM education and to advocate for STEM education programs and resources.

On the local level... I-STEM staff regularly discussed STEM education with campus administration and researchers. They attended and presented at unit-level meetings, such as with College of Engineering and Chemistry administrators. On the campus level, I-STEM director Dr. Lizanne DeStefano also served on a number of committees, such as the Office of Technology Management Advisory Committee, and attended cross-campus events such as the Faculty Development Brown Bag Series and Advancing the Future of Women Faculty at Illinois. She also served on interdisciplinary focus groups, like the Biology Coordinating Committee, which met regularly in 2013 to plan a Biology Climate Study (see page 23). Research-related activities included Focus on Illinois Education Research Symposium; CRAWG (Campus Research Administrators' Working Group); and presenting grant-writing workshops to units regarding how to submit grants, such as to the NIH.

On the state level... Dr. DeStefano participated in the Illinois State Board of Education's Technical Advisory Committee. As P-20 Council Coordinator, she served on all P-20 committees (see pages 10 and 35) and also attended meetings regarding workforce development (see page 36); Illinois' Race-to-the-Top grant and Longitudinal Data Systems, which the Council oversees; and the Education Legislative Institute, which meets annually to brief educators about important education issues, such as the Institute's 2013 topic: Common Core.

On the national level... I-STEM staff served on several committees and task force groups and advocated for STEM education with policymakers. Dr. DeStefano attended meetings regarding NSF's MSP (Math and Science Partnerships) program and STEM-C Partnerships (increasing teaching of computation in high schools). In addition, several I-STEM staff members presented at the Center for Culturally Responsive Evaluation & Assessment Conference, with Dr. DeStefano chairing the session.



Clockwise from above: A local youngster enjoys a hands-on activity at Genome Day in fall 2013.

Bottom left: An Illinois Engineering student and member of iRobotics serves as a judge at an iRobotics practice competition held in fall 2013.

Opposite (page 32): During the 2013 Illinois Science Olympiad, a contestant competes in an event in an *Illinois* lab.

In 2013, I-STEM staff served on several national STEM education committees and task force groups and advocated for STEM education with policymakers.



Clockwise from above: An exhibitor at the Naturally Illinois Expo holds a stuffed owl in the “Creatures That Are Not Afraid of the Dark” exhibit. Displayed on the table in front of her is an owl wing that visitors were invited to feel.

Top right: An *Illinois* math undergrad (right) affiliated with the IGL works with a Tap-In participant at Centennial High School.

Bottom right: Jesse Miller (left) and company who performed at Chemistry’s Holiday Magic show “pass” a ball of fire down the line as the handful of bubbled methane gas each is holding ignites, demonstrating that chemistry can be fun.



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

As part of I-STEM’s continued involvement in STEM workforce development, Dr. DeStefano attended a meeting with the Chicagoland Chamber of Conference and served on the Entrepreneurship Roundtable Committee. I-STEM also fostered participation in STEM Learning Exchanges. Designed to foster student interest in STEM careers, these programs can strengthen the state’s STEM pipeline and contribute to workforce development.

◆ Evaluate and analyze STEM policies.

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

◆ Identify STEM education reform projects at *Illinois*.

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

I-STEM identifies and catalogs Illinois’ current external funding projects and potential resources and conducts an annual, campus-wide appraisal of external STEM education investments on campus.





STEM EDUCATION POLICY/ADVOCACY PARTNERS, PROJECTS, AND EVENTS

Champaign-Urbana Schools Foundation. Lizanne DeStefano is on the Advisory Board of this local partner committed to facilitating STEM and other educational initiatives in Champaign-Urbana schools.

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

Global Institute for Secondary Educators. In this 6-week program, secondary educators from 23 different countries visited *Illinois*, and other sites nationally, to strengthen their curricula and quality of teaching. I-STEM's evaluation found that participants' understanding of U.S./American culture deepened, and they developed new lessons, activities to use in their home countries.

Illinois P-20 Council. Dr. DeStefano is a member of all P-20 Council's committees, including the Entrepreneurship Roundtable Committee and Illinois Educational Opportunities for Military Children Council (for more P-20 Council activities, see pages 10 and 36).



Clockwise from top left: A local kindergartener experiments with Cartesian divers during a REACT outreach at Orpheum Children's Museum.

Above: A local youngster at the 2013 Holiday Magic Chemistry Demonstration Show appreciates the magic.

Below: IGL Outreach Manager Noel DeJarnett works with a student at Centennial's Tap-In after-school program.

Bottom left: At the fall 2013 Science Night at Danville's South View Middle School, *Illinois* students explained to visitors how seeds are transported.



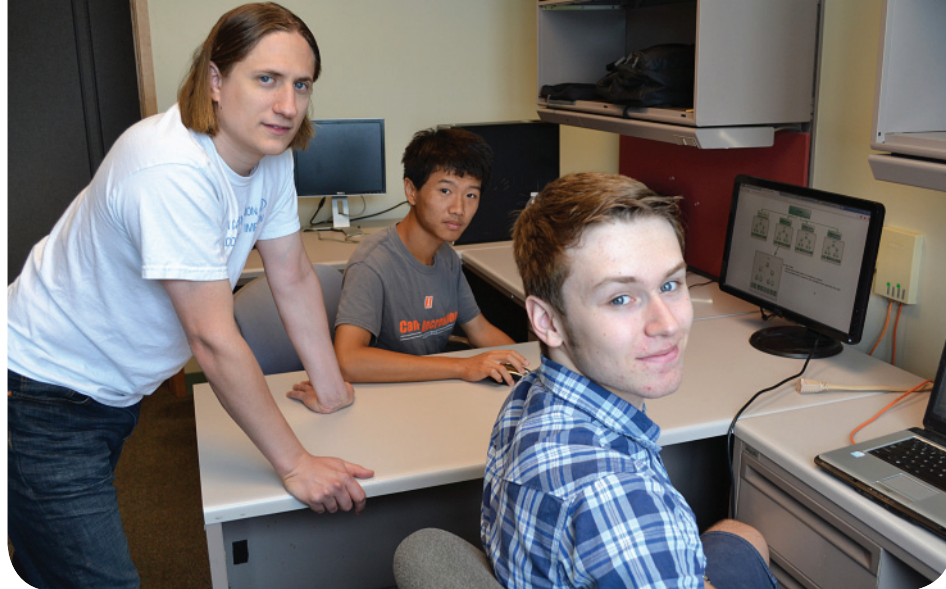


Clockwise from above: A student designs a knee replacement as part of an iRISE lesson taught at Edison Middle School.

Top right: An *Illinois* graduate student (left) mentors two I-STEM high school researchers.

Bottom right: An *Illinois* REACT student (left) explains a chemistry activity to Barkstall students in spring 2013.

Below: Two Marie Murphy students compete in the Illinois Science Olympiad.



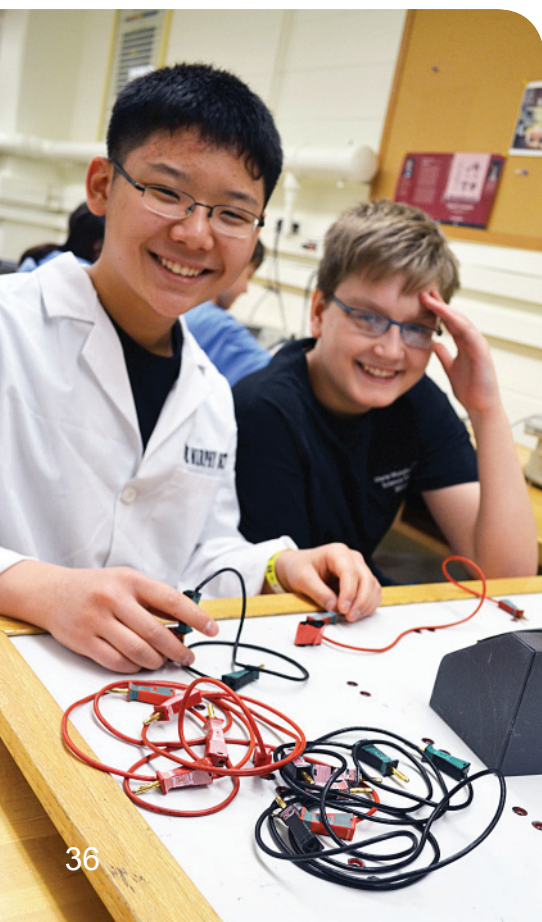
Illinois Pathways Initiative. This program's STEM Learning Exchanges are partnerships to promote collaboration and engagement of K–12 students in real-life scientific problems via web resources, which students may access for career-related educational resources. In 2013, the STEM Research and Development committee developed a STEM Learning Exchange Resource Repository⁷ which enables organizations to provide enhanced learning experiences for students and teachers.

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 2013, 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 Panel, and also presented results of the 2012 project creating accessible blocks that involve special education students and English-language learners on NAEP's Reading assessment. This project built on I-STEM's 2010 work to include accessible blocks to NAEP's Math Assessment.

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

⁷<http://stemlearningexchange.org/>



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, plus 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 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 38 and 39, respectively.

Figure 2 below presents estimated STEM Education funding at *Illinois* from 2009 to 2013. Estimates of STEM education award amounts per year are based on data retrieved by the time each year's annual report was published and are not necessarily inclusive of all grants awarded to the University in the area of STEM education over the five-year period.

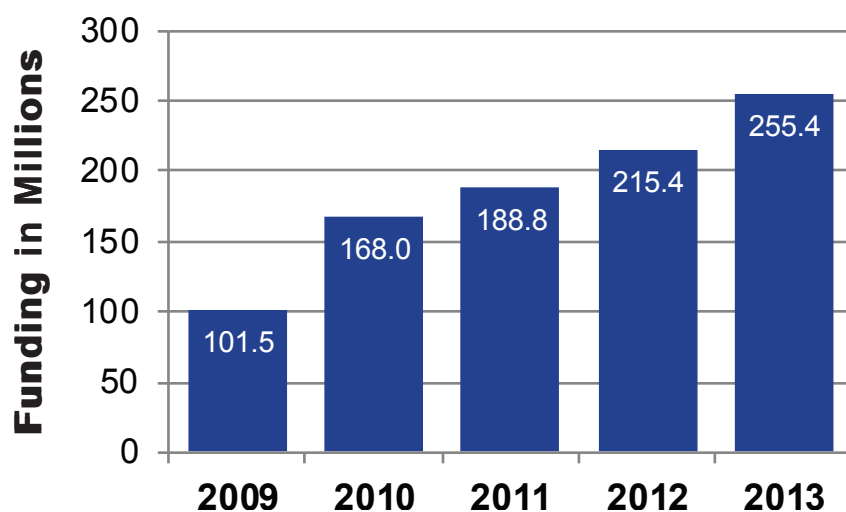
For 2013, the estimated total of \$255.4 million in active STEM education investments by funding sources (see Figure 3 on page 38) spans federal agencies (i.e., the National Science Foundation, the U.S. Department of Education, and National Institutes of Health); the state of Illinois (i.e., the Illinois State Board of Education and Illinois Board of Higher Education); as well as private and corporate support.

This external investment supports STEM education activities across 16 academic, research, and campus-level administration units (see Figure 4 on page 39). 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.



In spring 2013, a student participates in an Illinois Science Olympiad event in one of *Illinois'* labs.

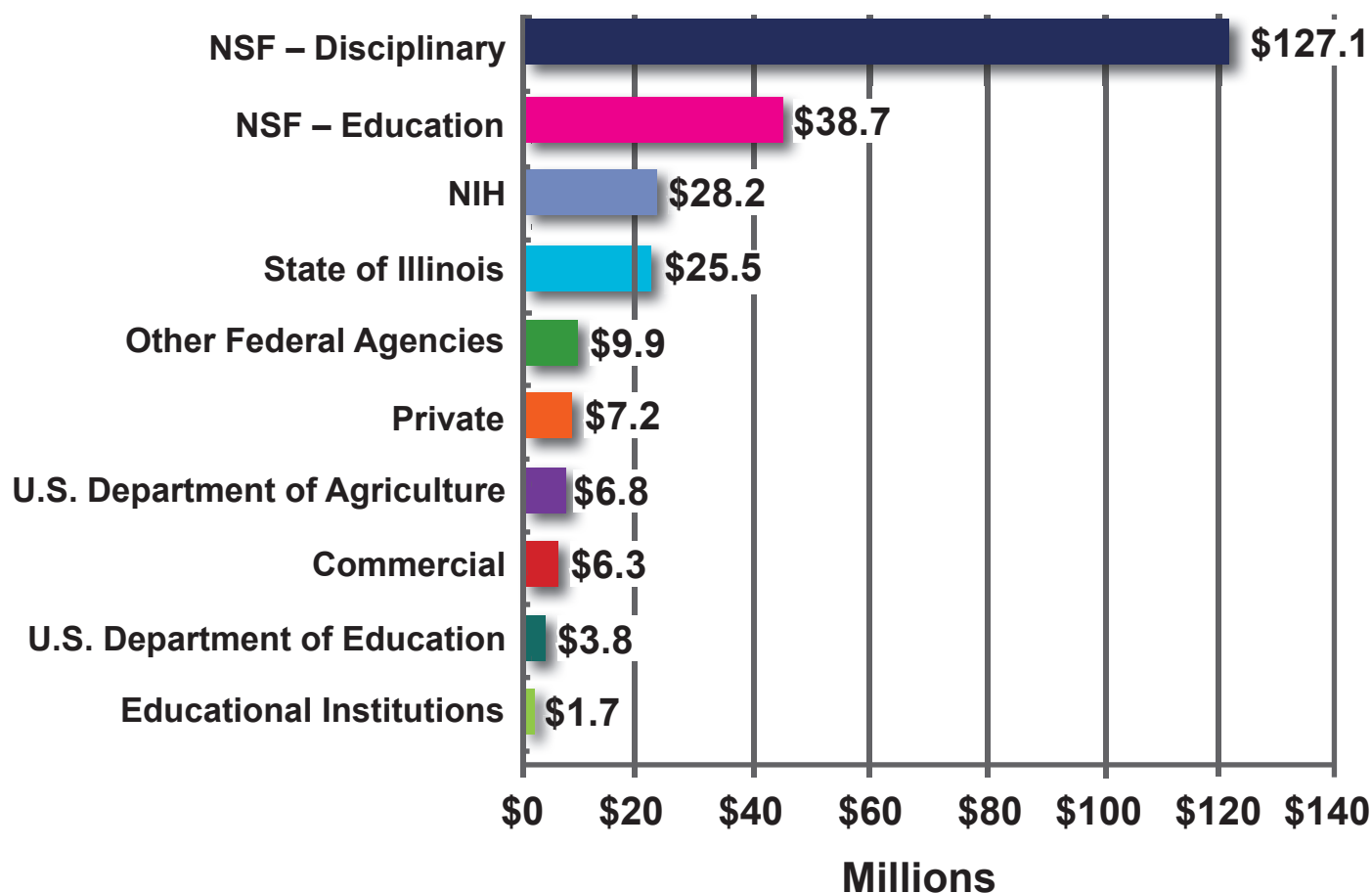
Figure 2: STEM Education Funding at Illinois, 2009–2013



I-STEM Website Externally Funded Projects and Funding Resources

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

Figure 3: Active External Investment in STEM Education at Illinois for 2013, by Funder

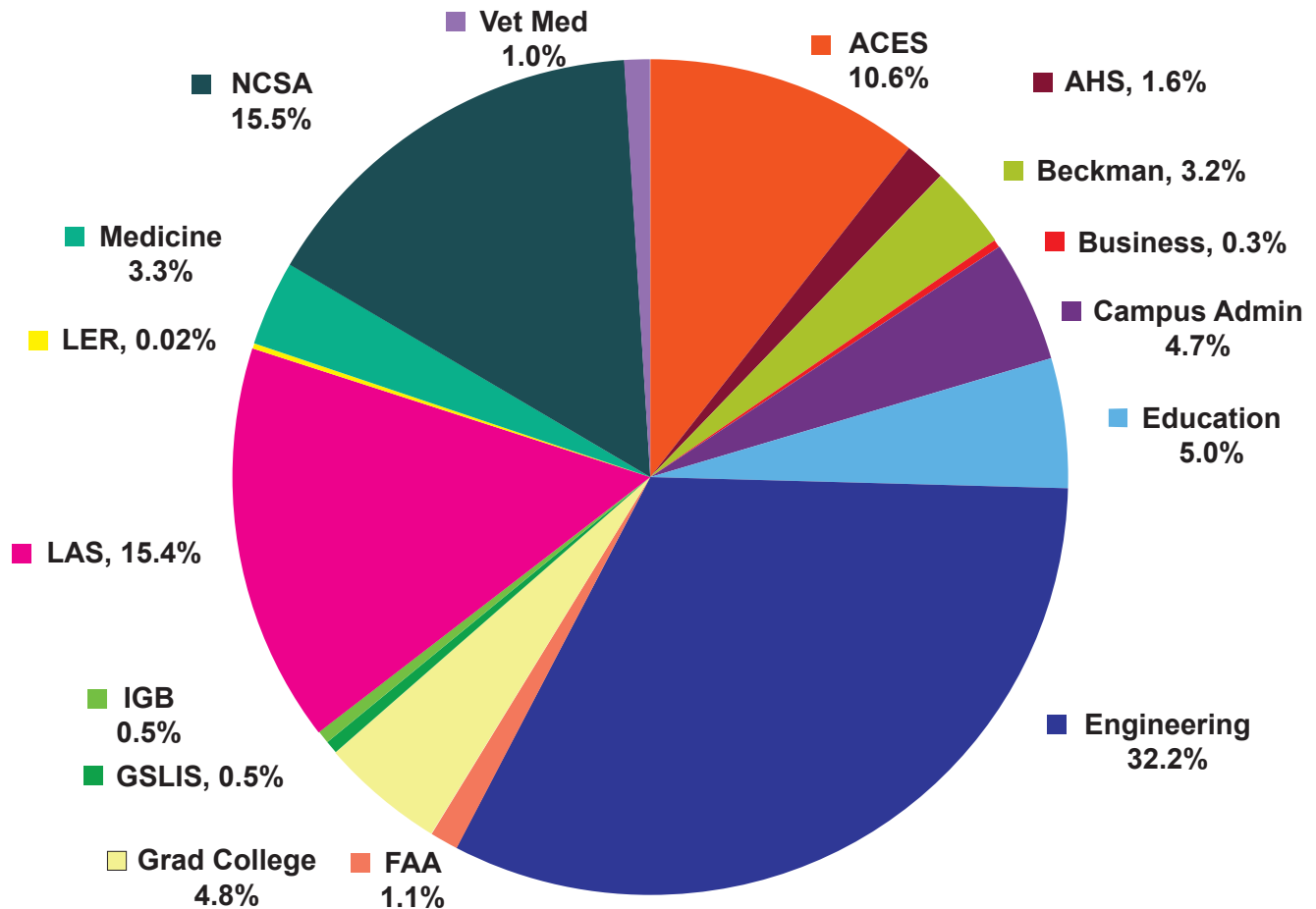


FUNDER	INVESTMENT
National Science Foundation—Disciplinary Directorates/Other Offices (NSF—Disciplinary)	127,115,738
National Science Foundation—Education & Human Resources Directorate (NSF—EHR)	38,747,420
National Institutes of Health (NIH)	28,201,842
State of Illinois Agencies (State of Illinois)	25,522,179
Other Federal Agencies (DoD, DoE, NASA)	9,906,084
Private (Foundations, Associations)*	7,249,328
U.S. Department of Agriculture (USDA)	6,833,703
Commercial*	6,280,162
U.S. Department of Education (DoED)	3,819,800
Educational Institutions	1,741,054
Total	\$255,417,309

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 37).

*Notable private and corporate support for STEM education projects includes Sloan Foundation, Caterpillar Foundation, Hewlett Packard Co., Ford Foundation, the National 4-H Council, Abbott Laboratories, John Deere Foundation, Motorola Foundation, Shell Oil Company, and ExxonMobil, as well as others.

Figure 4: Active External Investment in STEM Education at Illinois for 2013, by Campus Unit



CAMPUS UNIT	INVESTMENT
Agricultural, Consumer and Environmental Sciences (ACES)	26,950,352
Applied Health Sciences (AHS)	4,156,547
Beckman Institute	8,159,668
Business	717,680
Campus/University Administration	11,986,781
Education	12,812,898
Engineering	82,353,304
Fine and Applied Arts (FAA)	2,922,605
Graduate College	12,194,782
Graduate School of Library and Information Sciences (GSLIS)	1,398,436
Institute for Genomic Biology (IGB)	1,336,102
Liberal Arts and Sciences (LAS)	39,431,322
Labor and Employment Relations (LER)	430,529
Medicine	8,341,365
National Center for Supercomputing Applications (NCSA)	39,671,747
Veterinary Medicine (Vet Med)	2,553,192
Total	\$255,417,309



I-STEM Education Initiative
University of Illinois at Urbana-Champaign

704 South Sixth Street
Champaign, Illinois 61820
Phone: 217.333.9625
Fax: 217.244.3949
url: <http://www.istem.illinois.edu>