I-STEM

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

I-STEM EDUCATION INITIATIVE ANNUAL REPORT

January–December, 2016

ILLINOIS

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From the Desk of the I-STEM Director:

In 2016, the participation of I-STEM continued to be essential in the success of multiple STEM programs, units, and research efforts at Illinois. I-STEM has played a critical role in the achievement of numerous STEM-related activities across our campus, including the numerous grant applications that require an independent evaluation of STEM-related research and education programs. The 2016 annual report highlights I-STEM involvement in the following activities: (1) Fostering and participating in dialogue among key campus and external stakeholders; (2) Working with campus units to plan, develop, and submit external funding proposals for STEM education; (3) Helping to improve campus STEM education programs by performing summative and formative evaluations; (4) Enabling discourse and networking among STEM educators about effective pedagogy and program components; (5) Disseminating information about campus STEM education programs and funding opportunities; (6) Promoting university K-12 Outreach Activities.

I-STEM aims to play a more central role in multiple aspects of STEM education and to be better known across campus and serve as a locus of activity and as a clearinghouse for all STEM education research, evaluation, and outreach activities in the following years. In particular, for a larger impact, I-STEM is also developing a new approach to reconfigure many of the existent collaborations in a strong partnership among the involved stakeholders in STEM education: local schools and communities; the Chancellor's Office; the Colleges of ACES (Agricultural, Consumer, and Environmental Sciences), Engineering, Education, LAS (Liberal Arts and Sciences), and Veterinary Medicine; and industry partners, corporations and foundations.

We hope you will recognize the benefits of the powerful STEM initiatives in this report and of the increased collaboration and entrepreneurship in STEM education on our campus. We are hopeful that the energy and impact of these STEM initiatives will continue to grow in 2017!

Luisa-Maria Rosu
Interim Director

Front cover: Left to right: A local middle school student uses a laser pointer as he learns about DNA from CPLC Postdoc Caitlin Davis during I-STEM's DNA Day.
Back cover: Ph.D. student Javier Suárez (left) and Bioimaging REU participant Denise Medina (right) in Stephen Boppart's Biophotonics Imaging lab.

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I-STEM PARTNERS

COLLEGES AND SCHOOLS

- College of Agricultural, Consumer, & 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 Materials
- Association of Public Land-Grant Universities (APLU)
- Caterpillar Foundation

EXTERNAL PARTNERS (CONTINUED)

- Chicago Community Trust (CCT)
- Chicago Public Schools (CPS)
- Department of Commerce & Economic Opportunity (DCEO)
- DREAM-Up
- 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
- University Primary School
- Urbana School District 116
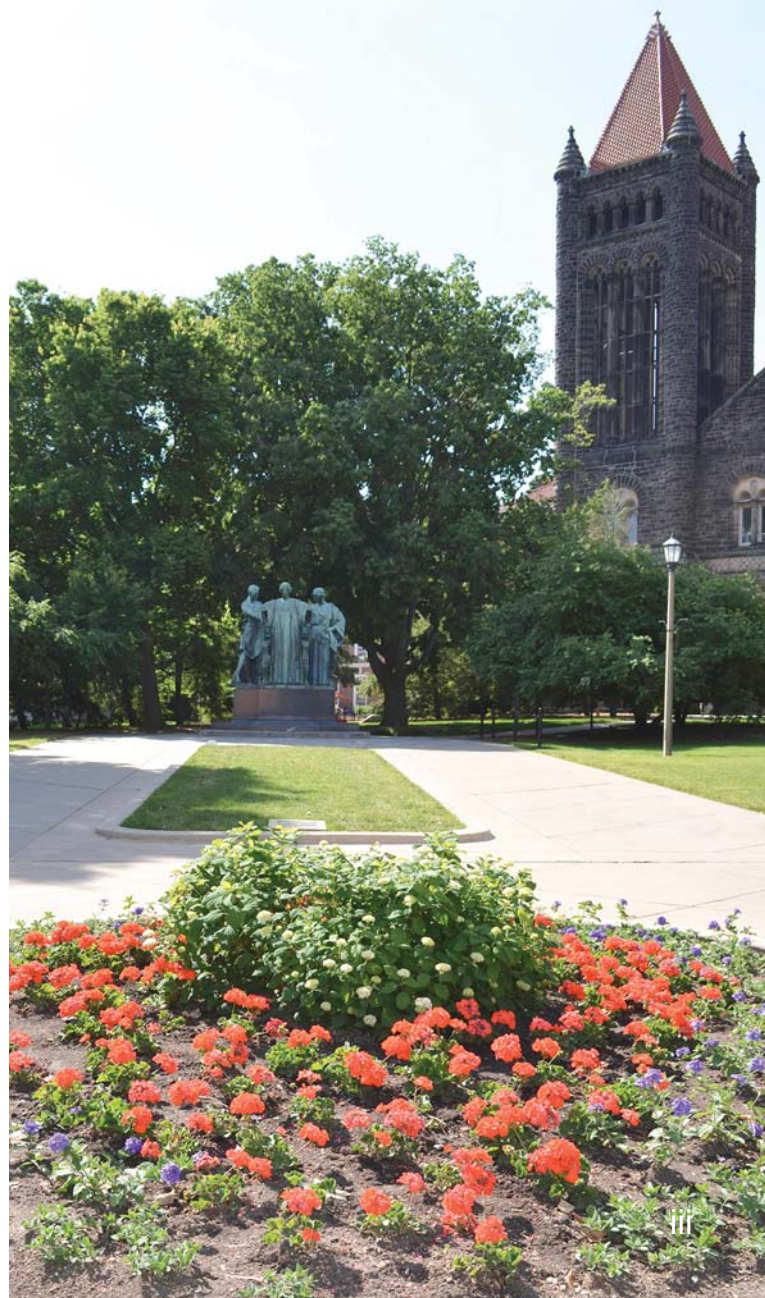
I-STEM ADVISORY BODIES
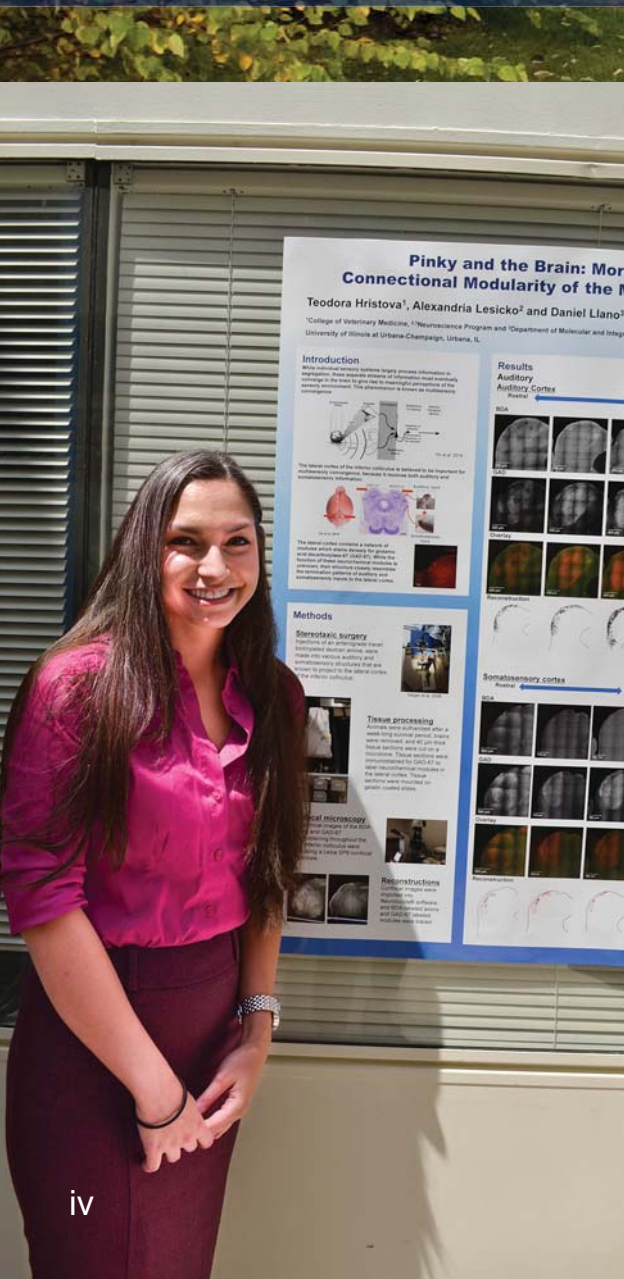
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- Donald Owen, Superintendent, Urbana School District 116
- C. Pius Weibel, Chair, Champaign-Urbana Schools Foundation

I-STEM CORPORATE ADVISORY BOARD

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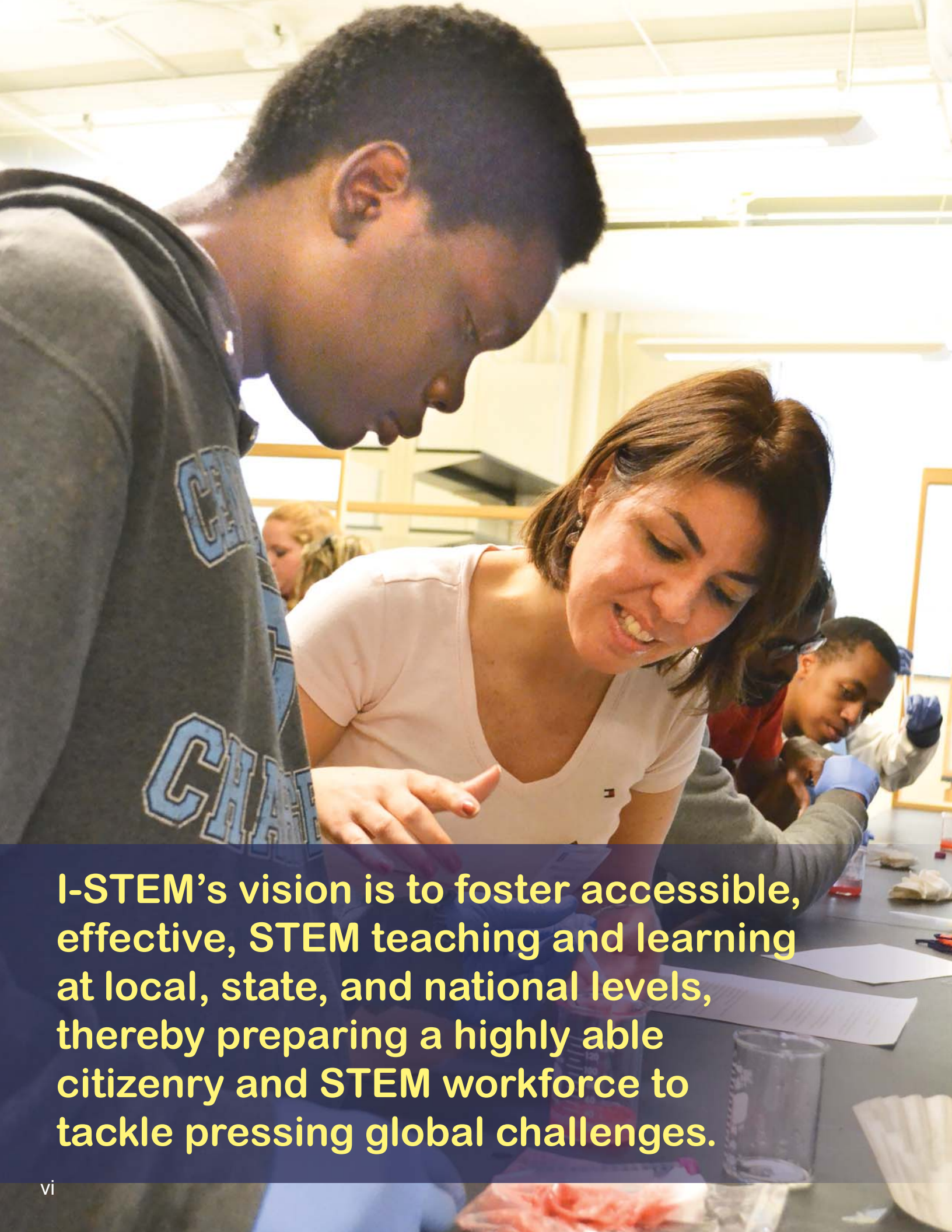
I-STEM's vision is to foster accessible, effective, STEM teaching and learning at local, state, and national levels, thereby preparing a highly able citizenry and STEM workforce to tackle pressing global challenges.

I-STEM's Mission and Goals

I-STEM (the *Illinois* Science, Technology, Engineering, and Mathematics Education Initiative) completed its eighth full year of operation in January 2017. I-STEM partnered with STEM (science, technology, engineering, and mathematics) academic and research units at the University of Illinois at Urbana-Champaign (*Illinois*), as well as a number of partners locally, as well as across the state and nation. I-STEM seeks to improve the access, quality, and efficiency of STEM education activities at *Illinois* and 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, involving 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 the nation.

Above: A member of the MCBees, a student group which partners with I-STEM on outreach activities, at work in her lab.

Opposite (page vi): A participant in I-STEM's DNA Day extracts DNA from strawberries, supervised by an *Illinois* grad student and member of the MCBees (center).

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

Above and bottom right: Students in the Blue Waters Internship program, which I-STEM evaluates, learn about HPC (high-performance computing) during the 2016 Petascale Institute.

Communication Resources

- **I-STEM Website.** Incorporates information about campus STEM education outreach activities and upcoming funding opportunities for both internal and external audiences. STEM Education news stories are organized chronologically, the Directory of Externally-Funded Projects is organized by target audience. Funding Opportunities are organized both chronolocigally and by funder. urls: istem.illinois. edu/index.html; istem.illinois. edu/funding/upcomingdeadlines. html; istem.illinois.edu/funding/ fundingopps.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: *STEM Education at Illinois in 2016.* url: istem.illinois.edu/ resources/resources.html

OVERVIEW OF I-STEM ACTIVITIES

During its eighth 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 2016 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 to the left).

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 target groups (see communication resources to the left and on page 29).

6. **Promoting K–12 Outreach Activities.** I-STEM has developed an extensive network of STEM outreach projects and organizations and played a significant role in recruiting volunteers for a variety of K–12 outreach activities during 2016, including I-STEM's DNA Day, which fostered a visit to campus by several Illinois schools.

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**. 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 and helps organize outreach events, such as I-STEM's DNA Day.

★ **Funding Opportunities.** I-STEM's website offers resources regarding upcoming STEM education funding opportunities involving our target groups: Upcoming Funding Deadlines[1] lists impending deadlines by date; STEM Education Funding Opportunities[2] 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 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
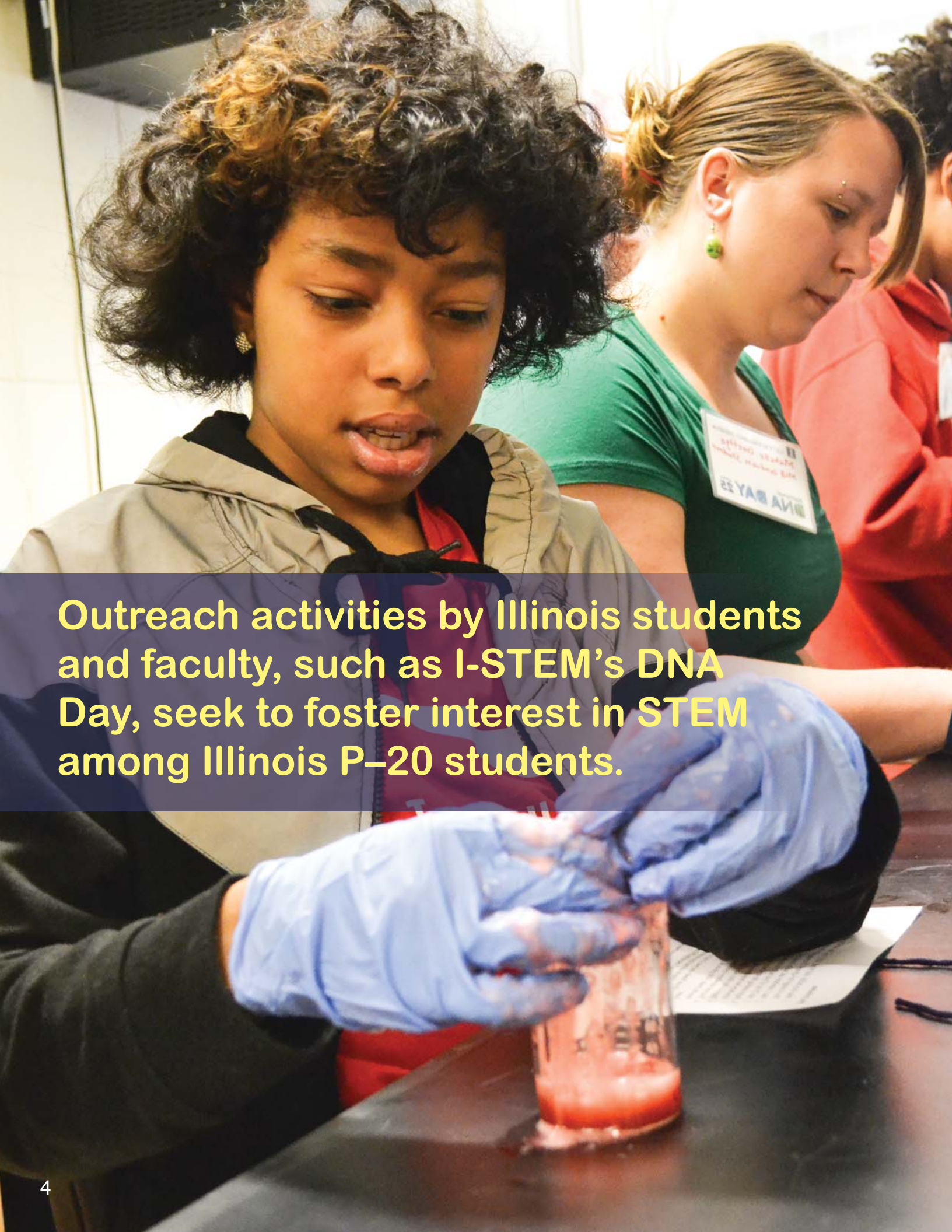
Above: An ENG 198 student works on his team's foldable longboard.

Glossary of Terms

- AAP: Access and Achievement Program
- AEA: American Evaluation Association
- CPLC: Center for the Physics of Living Cells
- CPS: Chicago Public Schools
- IGERT: Integrative Graduate Education & Research Traineeship
- NIH: National Institutes of Health
- NCSA: National Center for Supercomputing Applications
- NSF: National Science Foundation
- PD: Professional Development
- POETS: Center for Power OPtimization of Electro-Thermal System
- RET: Research Experiences for Teachers
- REU: Research Experiences for Undergraduates
- RISE: Readying Illinois Students for Excellence
- RSO: Registered Student Organization
- STEM: Science, Technology, Engineering and Mathematics
- TOPRS: Transdiciplinary Obesity Prevention Research Sciences
- XSEDE: eXtreme Science and Engineering Discovery Environment

Outreach activities by Illinois students and faculty, such as I-STEM's DNA Day, 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 2016, including partners or projects with whom staff collaborated or disseminated information about.

✦ **Identify and disseminate information about campus STEM P–20 outreach activities.**

Illinois faculty, units, colleges, and student organizations host numerous STEM Education P–20 outreach activities. In 2016, I-STEM identified and prominently displayed information about these activities via its website, listserv, and in printed or electronic materials, including its new annual magazine. *2016, The Year in STEM Education,* featured many of the articles published on I-STEM's website throughout the year about STEM education activities by *Illinois* researchers, staff, and students. Website news articles are published under Top Stories[3] and Archives.[4] Information for those seeking to participate in outreach activities is organized by stakeholder groups: *P–20 teachers*[5] who seek professional development or to reinforce classroom instruction with additional activities, and parents and/or students seeking STEM education opportunities via *summer camps*[6] or *academic year activities.*[7]

I-STEM has also identified programs which serve as examples of highly effective STEM education P–20 programs, such as Research Experiences for Undergraduates (see pages 18–24). In 2016, I-STEM also developed a new webpage listing outstanding STEM education outreach groups/programs[8], many of which I-STEM evaluated, collaborated with, and/or featured on it website in 2016.

✦ **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, especially those from underrepresented groups, I-STEM partnered with state and national STEM P–20 organizations/initiatives, such as the Illinois Science & Technology Institute (see page 7).

✦ **Evaluate P–20 STEM outreach activities.**

To improve the impact of *Illinois*' STEM P–20 outreach activities, I-STEM assesses programs to systematically collect data on participant and school demographics, satisfaction, and impact on STEM interest and content knowledge. Aggregated, these data represent campus-level impact and the degree to which STEM outreach activities are easily accessed by families and educators, extend across all grade levels, align with school needs, and attract demographically diverse participants. (See Table 1 which follows for several P–20 outreach programs I-STEM evaluated in 2016.)

During I-STEM's DNA Day, an *Illinois* grad student (left) works with a local teen on a hands-on activity about folding DNA.

I-STEM Website's P–20 STEM Education Resources

- **STEM Education Top Stories**
  [3]http://www.istem.illinois.edu/news/topstories.html

- **STEM Education Story Archives**
  [4]http://www.istem.illinois.edu/news/archives.html

- **Resources for P-20 Teachers**
  [5]http://www.istem.illinois.edu/resources/goal2resources.html#teacherdevelop

- **Resources for P-20 Students**
  [6]http://www.istem.illinois.edu/resources/goal1resources.2.html#summercamps

  [7]http://www.istem.illinois.edu/resources/goal1resources.2.html#acadyear

- **STEM Education Outreach Groups**
  [8]http://www.istem.illinois.edu/resources/stem-ed-outreach.html

Above: MechSE grad students Matt Milner and Ashley Armstrong, creators of the ENVISION MechSE grad student outreach group.

Below: Maryam Khademian, an MCB Ph.D. student and president of the MCBees.

Table 1: Selected P–20 Outreach Programs I-STEM Evaluated in 2016

Program	PI/CoPI/Program Director(s)
Centrality of Advanced Digitally ENabled Science (CADENS)	Donna Cox, PI
MakerGirl	Julia Haried, Co-Founder
Mathways	Matt Ando, Head, Mathematics Department
Research & Development STEM Learning Exchange (RDLE)	Mark Harris, President & CEO, Allie Barwise & Emily Cooper, Program Managers

✦ **Work with campus STEM demonstration sites and outreach groups.**

I-STEM works with campus STEM demonstration sites to ensure that STEM outreach activities, both campus visits and/or off-site activities, span all age ranges (elementary, middle, and secondary school students) and demographic groups. I-STEM works with campus groups and local schools, often serving as a liaison, to increase recruitment of schools not engaged with STEM outreach and to boost outreach activities, especially for primary and middle school students.

– In 2016, I-STEM developed an informal network of campus outreach groups and served as a liaison to apprise them of outreach opportunities via a list-serv.

– I-STEM is compiling a list of *Illinois* student groups, researchers/research groups, and grant projects that conduct P-20 STEM education outreach activities, with the goal of creating a complete listing that both university and off-campus groups can access in order to engage groups to perform STEM outreach activities. Types of outreach events employed include after-school programs, Saturday events, mentoring, one-day or weekend campus visits, summer camps, research experiences, and internships. While this database is by no means comprehensive, I-STEM staff regularly add groups to the database, which contains the group's name (and acronym), url, contact information, targeted age groups, plus the different kinds of outreach programs/activities each sponsors. This database may found at http://www.istem.illinois.edu/resources/stem-ed-outreach.html. In addition, I-STEM is incorporating these data into a promotional flyer, to be released in 2017.

– I-STEM worked directly with campus groups seeking to engage in STEM education outreach activities. I-STEM staff met with, promoted, and/or helped organize outreach events for newly organized student groups, such as ENViSION, a Mechanical Engineering graduate student outreach group; and the MCBees, an MCB graduate student organization. Staff met with ECE's Eta Kappa Nu (HKN), an established group seeking to add an outreach component. I-STEM will continue to partner with these student groups in 2017 to link them with schools seeking outreach or other service opportunities, such as I-STEM's DNA Day (see page 8).

✦ Increase the number of underrepresented students who enter the STEM pipeline/graduate from *Illinois* in STEM.

Implicit in I-STEM's vision of preparing a diverse STEM workforce is an emphasis which has increasingly gained importance over the last several years—the need to increase the number of students from underrepresented groups who enter the STEM pipeline. Thus, I-STEM collaborates with both campus and other, off-campus programs which specifically seek to engage talented P–12th grade students in order to increase the number of underrepresented students who both enter the STEM pipeline and eventually graduate from *Illinois* in STEM fields. These groups target schools (both local and throughout the state, including Chicago Public Schools [CPS]) as well as other STEM education organizations. Some programs which target underrepresented population groups include the Research & Development STEM Learning Exchange (RDLE), which I-STEM evaluated in 2016, and I-STEM's DNA Day. In addition, I-STEM obliquely addresses this emphasis through its evaluation of a number of STEM education programs with similar goals.

✦ 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 40 external funding proposals in 2016. 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 29–31 for I-STEM's analysis of STEM education funding on campus).

Top left and above: Local students use lasers to simulate DNA diffraction during DNA Day workshop sessions.

Below: A local student works to extract DNA from strawberries during a DNA Day hands-on activity.

P–20 STEM EDUCATION OUTREACH PROGRAMS

✳ **CADENS (Centrality of Advanced Digitally ENabled Science).** In collaboration with Lizanne DeStefano at Georgia Tech, I-STEM evaluates this three-year, NSF-funded project led by Donna Cox from the Advanced Visualization Lab (AVL) at Illinois' NCSA. CADENS works on using visualization of computational data to develop high-resolution dome shows, high-definition documentary programs, and supplementary educational material for the general public. For instance, the project has produced Solar Superstorms, a dome show narrated by Benedict Cumberbatch, that visualizes the inner workings of the sun, which is shown at planetariums across the country and has been translated to ten languages and awarded three international awards. It has also been shown on Capitol Hill in Washington, DC as part of raising awareness about the importance of funding for space weather research. Flat-screen versions of Solar Superstorms are also available to the public through YouTube. Another flat-screen documentary, SuperTornado: Anatomy of a Megadisaster, visualizes data explaining how the Joplin, Missouri tornado unfolded in 2011. Several other shows and documentaries are in the works, including Seeing the Beginning of Time and Birth of Planet Earth. The project recently received a supplementary award through NSF to create short "Making Of" clips that go into more depth with scientists and visualization experts about the process of creating these shows. The evaluation team assesses the accessibility of the visualizations and the clarity of the accompanying script and supplementary materials, both during development and after the films are released. The goal is to assess the impact of these films on children's and adults' understanding of and interest in the scientific material and importance of computational data and visualization.

Above: A DNA Day participant extracts DNA from strawberries as an Illinois graduate student watches nearby.

Below: An MCB graduate student works with a local student during I-STEM's DNA Day.

✳ **I-STEM DNA Day.** In 2016, I-STEM hosted a campus DNA Day, "DNA Applications: Interdisciplinary Perspectives for STEM Careers," as part of the National Institutes of Health's National DNA Day activities. A group of 29 mostly underrepresented students from Urbana High School, plus several Champaign middle and high schools visited campus, participating in hands-on activities and tours which introduced students to DNA, DNA research on campus, and careers that deal with DNA. Students were also encouraged to go to college and apprised of several resources available to help them achieve that goal. Several campus groups/units participated: the Center for the Physics of Living Cells (CPLC); the MCBees, an MCB graduate student group; the Institute for Genomic Biology (IGB), and representatives from several campus offices.

Above: An Illinois Engineering student helps a young MakerGirl with her design.

Top left: A sophomore in Material Science and Engineering student watches as a girl from a local girl scout troop uses Tinker CAD to make a 3D design.

Below: MakerGirl co-founder Julia Haried (left) helps a young MakerGirl with her 3D design during the "Gears" session.

✦ **MakerGirl.** I-STEM is evaluating this after-school program begun and run by female *Illinois* students with the goal of piquing girls' interest in STEM fields. Held in the MakerLab of *Illinois'* Business Instructional Facility, the program offers 3D printing sessions to local 7–10-year-old girls. Themed one-hour sessions introduce young girls to the science behind 3D printing. Following a short presentation, the girls use Tinker CAD (a free, web-based software program for kids) to make 3D designs, which they then fabricate via 3D printers. To extend this program to girls across the country, the MakerGirl team went on a ten-week road trip in summer 2016 offering 3-D printing sessions to over 1000 girls in twenty states.

The goal of this pro bono evaluation conducted by I-STEM is to gauge the effectiveness of the sessions in terms of delivering content and fostering long-term interest in STEM fields. The evaluation surveys girls who participate in the sessions as well as their parents to get a better understanding of their impressions of the sessions and how the sessions improve their spatial skills and increase their interest in STEM fields.

★ **Mathways.** The main goal of Mathways (an NSF-funded program) is to create a pipeline that encourages underrepresented students to participate in collaborative mathematics research and instruction. This is achieved by recruiting Merit students at the University of Illinois at Urbana-Champaign, a program that provides supplemental services to underrepresented students in STEM fields, to the Illinois Geometry Lab, a math research lab. Additionally, Mathways provides other opportunities to connect underrepresent students to math research and instruction through summer math camps and outreach programs. The Mathways evaluation is in progress and focuses on building a program theory, developing a monitoring plan, and understanding the experiences of participants in the various Mathways programs.

Above: An Evanston student whose team participated in the R&D STEM Challenge.

Below: A team of students from Lindblom Math and Science Adacemy in Chicago present about their research project in RDLE's STEM Challenge Student Showcase.

★ **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 Repository. Funded by the Illinois Science & Technology Institute, I-STEM's evaluation, which seeks to provide program managers useful information to guide program improvement, effectiveness, and suitability, found that:

— RDLE gave students the confidence to solve real-world problems, engage/make connections with STEM field professionals, and make an impact in the world. Students, collaborated throughout the program, learning the importance of teamwork. They experienced research, how to formulate a research question, and how scientific knowledge is built. They also learned the nature of a STEM researcher's job and how to present in front of others.

— Teachers saw industry mentors as resources and as possible connections for their students. Students enjoyed working with industry partners/mentors, and enjoyed industry site visits.

— The Mentor-Matching Engine was found to be in need of minor refinement; teachers made suggestions to increase its effectiveness.

— Teachers saw real value in exposing their students to professionals in STEM fields and would like to participate in RDLE next year. RDLE motivated teachers to continue to use Problem-Based Learning (PBL) in their classrooms.

Above: A team of students from Evanston, Illinois, who participated in the R&D STEM Challenge. Bottom left: A team of students from Lindblom Math and Science Academy show off the certificates they received during RDLE's STEM Challenge Student Showcase at Motorola's Chicago offices. Bottom right: Two industry mentors on hand at the Student Showcase to watch their teams present.
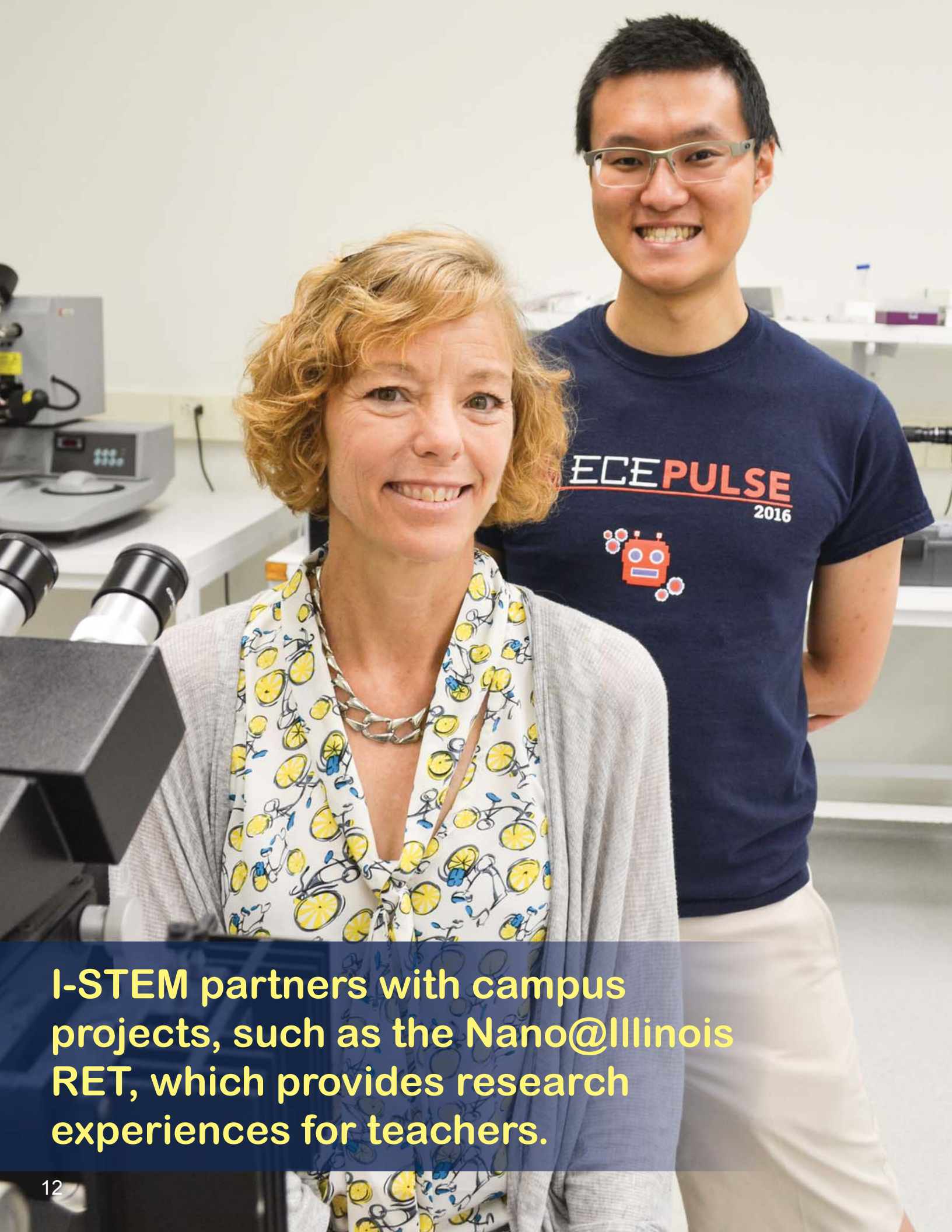
I-STEM partners with campus projects, such as the Nano@Illinois RET, which provides research experiences for teachers.

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 and campus units which share this same goal.

✦ **Evaluate STEM teacher training and professional development projects.**

In 2016, I-STEM evaluated a couple of NSF-funded STEM teacher training and professional development projects operating at *Illinois*, including the The Center for the Physics of Living Cells (CPLC) Physics of Life Experience (POLE), which exposed Illinois science teachers to research within the CPLC network, 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 Diana Rodriguez explains her research to the RET's co-PI, Lynford Goddard.

On opposite page, (page 12): A 2016 RET participant Kelly Jolley and her graduate student mentor at work in an MNTL lab.

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

Table 2: Selected Teacher Development Programs I-STEM Evaluated in 2016

Program	Principal Investigator(s)/Directors
Center for the Physics of Living Cells (CPLC) Physics of Life Experience (POLE)	Jaya G. Yodh, Ph.D. Director of Education and Outreach & Katie J. Molohon Hess, Ph.D. CPLC K-12 Education & Outreach Coordinator
nano@illinois Research Experience for Teachers (RET)	Xiuling Li, Chemistry Lynford Goddard, ECE

Above: Elementary school teacher Beth Koplinkski presenting her research at the nano@illinois RET final poster session.

Bottom right: At the end-of-the-summer poster session, a 2016 Nano@Illinois RET participant, Tatiana Stine, points to the image of Gene the Graphene on her poster. Stine created Gene the Graphene as a tool kids could relate to when teaching them about graphene.

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 29 for communication resources.)

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

In 2016, 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 (see Table 3 to the left). In 2016, twelve campus projects offered research opportunities for teachers.

✦ **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 2016, *Illinois* staff and students volunteered in numerous programs targeting P–12 students, including camps, open houses, and outreach in schools.

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
2016–2017	12

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In 2016, 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 2016. (For a list of these organizations/projects and outreach activities, see http://www.istem.illinois.edu/resources/stem-ed-outreach.html.) 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.

STEM EDUCATION TEACHER TRAINING/ PROFESSIONAL DEVELOPMENT PROGRAMS

★ **The CPLC Physics of Life Experience for Teachers, 2016 (POLE).** The Center for the Physics of Living Cells (CPLC) is a University of Illinois at Urbana-Champaign, National Science Foundation Physics Frontiers Center that aspires to make transformational advances at a genuine scientific frontier. From June 1st–June 10, 2016, CPLC hosted an eight-day workshop, the Physics of Life Experience for Teachers, 2016, which I-STEM evaluated. CPLC's goal was to provide an environment for seven Central Illinois high school physics, biology, and chemistry teachers to learn about the latest research within the CPLC, network with fellow teachers, and work with graduate students and postdoctoral researchers to develop lessons applicable to classrooms. Developed and designed by post-doc Katie Molohan, the workshop culminated in presentations by participants, where faculty and researchers provided feedback to the participants regarding their lessons.

I-STEM's evaluation showed that all participants believed that they gained knowledge, education, and awareness of new technology, research, and theories, and, more specifically, deveoped lesson plans that they can take back and use in their classrooms.

★ **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 science, technology, engineering, and mathematics (STEM) teachers and community college faculty from across the nation to cutting-edge research in nanotechnology. Teachers conduct research and attend professional development at the University of Illinois at Urbana-Champaign over six weeks during the summer, with four follow-up sessions during the academic school year.

According to the 2016 evaluation report, program participants strongly believed that the program helped to increase their knowledge capacity. Participants also strongly believed that the research projects would influence how they will develop and design lesson plans as well as teach STEM programming in their classrooms.

Above: 2016 Nano@IL RET teacher Tatiana Stine suited up to enter the clean room (photo courtesy of Tatiana Stine).

Below: 2016 Nano@IL RET participants at work in their labs.

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Introduction

Endometriosis is a painful, chronic disease in which endom
pelvic pain, dysmenorrhea, and dyspareunia, while also res
accepted mechanism of endometriosis, stating that blood a
peritoneal cavity. The purpose of this preliminary experime
mimics the process of retrograde menstruation found in hur

Hypothesis

As endometriotic lesions develop on the
peritoneal wall, cell proliferation will increase, the
number of smooth muscle cells will increase, the
number of mesothelial cells will decrease, and
evidence of angiogenesis will be present.

Objectives

- To investigate the morphology of peritoneal
lesions from a mouse model of endometriosis.
- To analyze changes in expression of protein
markers for proliferation, epithelium,
endothelium, smooth muscle, and mesothelium
in peritoneal lesions at different intervals post
transplantation.

Methods

Figure 1. Ovariectomies of
CD-1 recipient mice were
performed via dorsal
midline incision.

- Peritoneal endometriotic lesions were
analyzed at day 4, day 8, and day 16 post
uterine tissue transplantation using
immunohistochemistry (IHC).
- A NanoZoomer slide scanner was used to
count cell proliferation.

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.
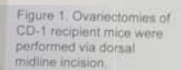
Goal 3: Foster Undergraduate and Graduate STEM Education Reform

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 2016, I-STEM performed a Chemistry Climate Study and assessed student satisfaction with a large course for Biology, IB 150 (see page 21).

✦ **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 18).

Table 4: Selected Undergraduate/ Graduate STEM Education Programs I-STEM Evaluated in 2016

AAP (Access and Achievement Program) STEM Initiative

Bioimaging Research Experience for Undergraduates

Chemistry Climate Study

Digital Forensics Initiative (DFI, NSF)

Illinois Cyber Security Scholars Program (ICSSP)

IDEAS (Increasing Diversity in Evolutionary Anthropological Sciences) Workshop

Integrative Biology 150

IOLab: Interactive Online Lab

Merit Fellows Scholarship Program (S-STEM)

Network for Computational Nanotechnology - NanoBIO Node

POETS: Center for Power Optimization of Electro-Thermal System

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

T-35 SRTP: (Summer Research Training Program), NIH

VINTG (Vertically Integrated Training with Genomics) IGERT

XSEDE: eXtreme Science and Engineering Discovery Environment
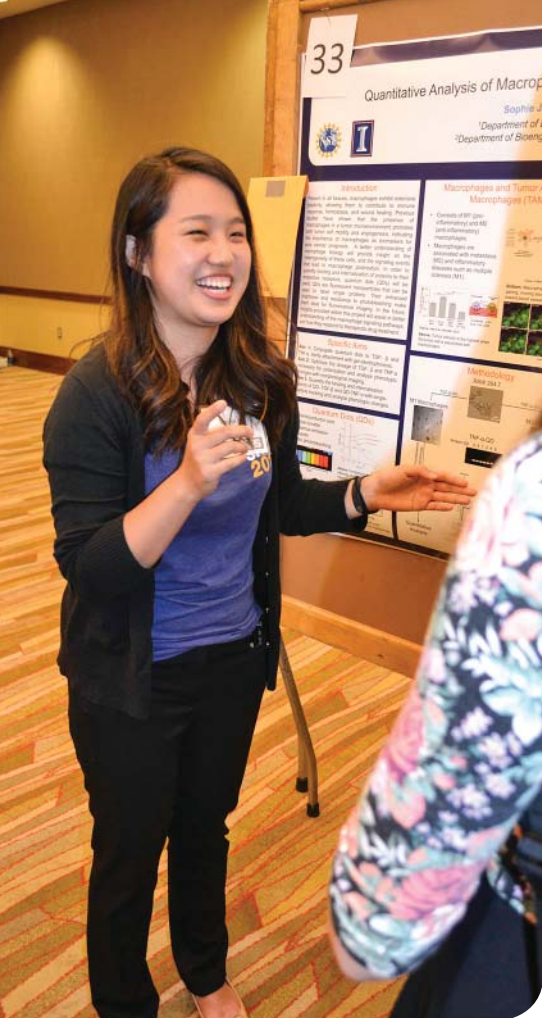
Above: 2016 Bioimaging REU participant Sophie Xie, a rising junior at Vanderbilt University, explains her research to a visitor during the Illinois Summer Research Symposium.

Below: 2016 Bioimaging REU participant Matthew Kavanaugh.
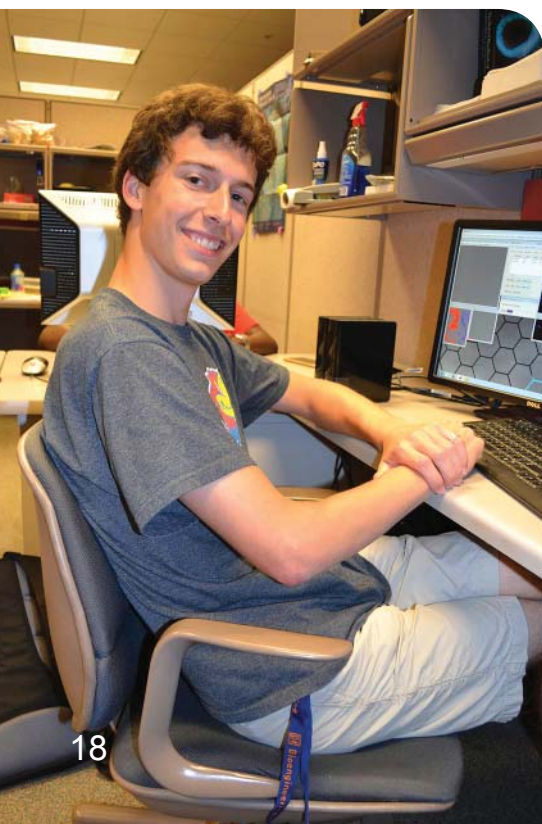
✦ **Evaluate and analyze undergraduate and graduate STEM education reform projects.**

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 using 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 2016, I-STEM conducted evaluations of several of these (see Table 4 on page 17), including an IGERT and several REUs.

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 2016, I-STEM evaluated the VINTG IGERT, 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 2016, like in 2015, at least 248 campus projects offered research experiences for undergraduates (see Figure 1 below). Some, official REU sites funded through NSF's REU (Research Experiences for Undergraduates) program, engaged a number of students in research. In addition, many campus projects, both NSF-funded and non-NSF-funded, offered research experiences for one or more undergraduates.

I-STEM evaluated five NSF REU sites in 2016: the Bioimaging, Chemistry, Nano@Illinois, and Systems Biology Laboratory REUs, as well as one for a larger center, POETS, which offered a REU component as one of its STEM education emphases.

Figure 1: Research Experiences for Undergraduates, 2005–2016

Year	05	06	07	08	09	10	11	12	13	14	15	16
Value	14	18	31	44	75	124	167	206	264	240	248	248
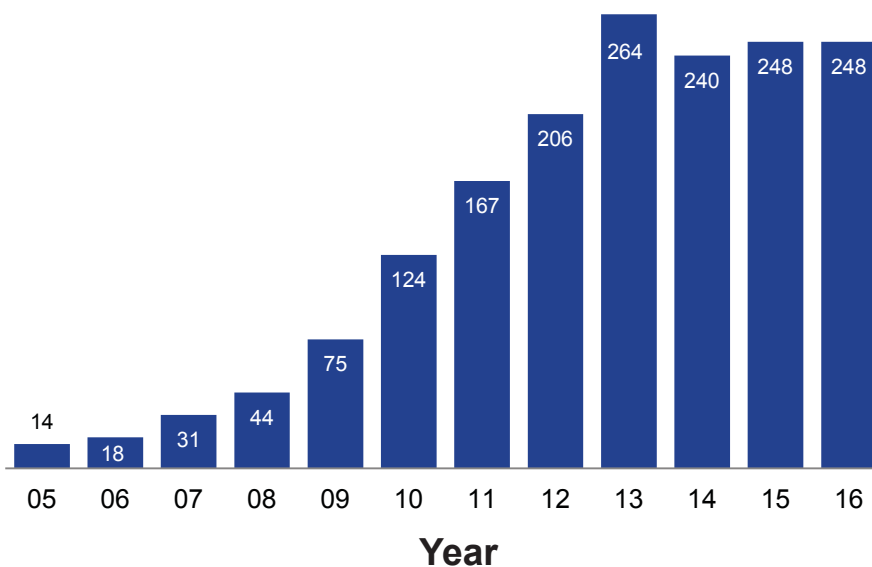
✦ Increase external funding to improve undergraduate and graduate STEM education.

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 2016, 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 29).

UNDERGRADUATE/GRADUATE STEM EDUCATION PROGRAMS/INITIATIVES

★ **AAP STEM Initiative.** The Access and Achievement Program (AAP), a student-centered academic program within *Illinois'* College of Liberal Arts & Sciences, 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 were used to conduct the assessment. A preliminary report was submitted to AAP administrators and department representatives in spring 2016.

★ **Bioimaging REU.** Discoveries in Bioimaging Research Experience for Undergraduates (REU) is 10-week summer program of team-based research which integrates social and professional activities to supply a multi-tiered mentoring strategy. Participants are encouraged to develop a network of role models, mentors, and peers to support and encourage their transition to graduate school. This REU's objective is to exploit the unifying link between bioscience, discovery, and bioimaging, which is an inspirational centerpiece for the *Illinois* campus. This program targets undergraduate students from underrepresented populations. I-STEM's 2016 evaluation found that REU participants believed the lab experience to be useful and relevant and gained a strong sense of their ability to read, interpret, and use research information. Participants showed growth in their abilities/skills over time and developed and/or increased their research, presentation, and interpersonal skills.

★ **Blue Waters.** I-STEM evaluates the Community Engagement programs for Illinois' Blue Waters, one of the world's most powerful supercomputers. Using surveys, interviews, and focus groups, I-STEM assessed the quality of the program's community engagement educational outreach programs: an internship program for undergraduate students, fellowship program for graduate students, plus virtual school courses for students across the country. I-STEM also collected data from symposium and workshop participants. NSF has reviewed the assessments to date and concurred that the assessment process was sound and the findings were informative and substantive. Following are the Blue Waters education outreach components I-STEM evaluated in 2016:

Above: Students at work in an *Illinois* lab.

Below: A 2016 Bioimaging REU participant conducting her summer summer research in Stephen Boppart's Biophotonics Imaging lab.

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Above and below: Blue Waters interns tour *Illinois'* Petascale Facility, home of Blue Waters.

Bottom right: Interns learn about HPC.

– **Fellowship Program.** This Blue Waters program enables select graduate students from across the country to immerse themselves in a year of focused, high-performance-computing research. The fellowship empowers these talented students to accelerate their research and advance their HPC knowledge. In 2016, I-STEM evaluated the experiences of the 2015–2016 cohort of six graduate fellows (from August 2015–August 2016). I-STEM's evaluation found that the program enhanced the Fellows' research progress by utilizing the unique power of Blue Waters. The Fellows pointed out that the strengths of this program were the diversity of the science and the research independence.

– **Internship Program.** The Blue Waters' Internship Program seeks to help prepare the next generation of supercomputing researchers. This program offers paid internships to about 22 undergraduate students from across the country every year. The internship lasts from May through April the following year. Thus in 2016, I-STEM evaluated the internship program experiences of the 2015-2016 cohort of interns (May 2015–April 2016) as well as the 2016–2017 cohort (May 2016–April 2017). The Internship Program provided undergraduate interns with hands-on research experiences which allowed them to have a strong HPC background and practical skills. The two-week institute was very effective at providing overall concepts and knowledge for interns.

– **Virtual School.** Courses Blue Waters offered in its Virtual School program in 2016 included: "Designing and Building Applications for Extreme Scale Systems" (Spring 2016); "Introduction to High-Performance Computing" (Fall 2016); and "Algorithmic Techniques for Scalable Many-Core Computing" (Fall 2016). (Virtual School evaluation data were not available as of the printing of this report.)

– **Symposium.** I-STEM evaluators conducted an evaluation of the 2016 Blue Waters Symposium held held from June 13–15, 2016. 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. According to I-STEM's evaluation, participants found the symposium had very valuable and useful resources & informative individual sessions (mean = 4.15, std.dev = 0.7). In addition, participants expressed high satisfaction on the overall experience (mean = 4.57, std.dev = 0.51) and achived their goals for attending the Symposium (mean = 4.52, std.dev = 0.56). Participants indicated that the the strengths of the symposium were the diversity of topics (30%) and high quality of presentations (21%).

– **Workshops.** I-STEM evaluated Blue Waters' Advanced User Workshop, held March 16–18, 2016. Results of the evaluation showed that participants were highly satisfied with the workshop.

★ **Chemistry Research Experience for Undergraduates.**
The Chemistry REU, funded by NSF and the 3M Foundation, is
for undergraduate students not from *Illinois* who are interested in
graduate study in chemistry or medical school. It seeks to provide
these undergraduate students with research experiences and prepare
them for graduate study in chemistry. I-STEM's evaluation found
that most students who participated in the REU reported that their
experience was useful and helped them decide whether to pursue an
advanced degree in chemistry and how to prepare for that.

★ **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 2016 or planned for 2017.

— **Biology Climate Study.** In 2016, as part of the Biology climate
study, a pro bono evaluation I-STEM is conducting, a survey was
conducted of students who took the Integrative Biology 150 course.
In Spring 2016, about 500 students registered for the course, and
in Fall 2016, about 650 students registered. The purpose of the
survey was to obtain their perceptions of course quality, aspects
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 2016,
I-STEM conducted a study exploring 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.

— **Center for the Physics of the Living Cells (CPLC)**.
I-STEM also participated in planning meetings in 2016 for a climate
study addressing satisfaction of graduate students in the Center for
the Physics of the Living Cells (CPLC) in Physics.

★ **Digital Forensics Initiative (DFI).** Funded by NSF, DFI
developed an interdisciplinary undergraduate educational curriculum
that focused on the recovery and investigation of data found in digital
devices. Unlike most digital forensics programs, which mainly focus
on computer science, DFI incorporated aspects of law, sociology,
accounting, and psychology. Once the curriculum was developed, DFI
began working towards its acceptance as the national digital forensics
standard. I-STEM's 2016 evaluation, also the last year of the grant,
found that students enjoyed the course, viewed its interdisciplinarity
as a strength, were satisfied with material covered, and provided
insights into potential areas for improvement.

★ **Discovering the Nanoworld.** This NSF-funded project
developed teaching modules about molecules and bonding in general
chemistry. A cohort of 200 students took the new post-Chem102
course in spring 2016, which I-STEM evaluated.

Above: An undergraduate student
presents at the Chemistry REU's end-of-
summer poster session in the Illini Union.

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

An *Illinois* student shares her expertise in Computer Science with another student.

★ **IDEAS: (Increasing Diversity in Evolutionary Anthropological Sciences) Workshop.** The IDEAS NSF-funded project proposed to improve diversity in Anthropological Sciences through targeted mentoring and outreach to minority communities. IDEAS Workshop Objectives were to match undergraduate and graduate students with faculty mentors of similar interests; these mentoring groups would serve as the formal unit of support structure for the IDEAS program, which would also to include professionalization modules and networking activities throughout the meeting to allow participants to meet a variety of researchers at the conference in an engaging manner.

All participants indicated that they would recommend the IDEAS workshop to other students and hoped to stay in contact with the IDEAS community. Most indicated that they had learned more about the diversity of research topics than they would have through a typical research community, that they they developed a better understanding of biological anthropology through the workshop, and that working in groups helped integrate within the IDEAS community and offered more opportunities to obtain responses to relevant career questions.

★ **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.

★ **Interactive Online Lab (IOLab).** The Physics Education Research (PER) Group at *Illinois* developed an approach that integrates hardware, software, and curricular materials in an inexpensive, web- and PC/Mac-based learning environment. The aim is to provide students with online lesson plans and inexpensive equipment so they can engage in short, hands-on lab activities at the time, location, and pace that best supports their learning. This evaluation focused on the Interactive Online Lab (IOLab), a wireless data acquisition system that serves as the hardware and software component of the developed approach. Some evaluation findings, based on interviews conducted with IOLab users, concluded that:

■ The size of the IOLab device is practically efficient because it is wireless, portable, and the "simplicity of it is brilliant."

■ IOLab allows for flexibility and creativity in physics instruction and for the exploration of new and different kinds of physics experiments because it is a portable and manageable device.

■ Utilizing the IOLab in physics instruction helps connect conceptual material with everyday experience because experiments can be done outside of the laboratory setting. As a result, this helps foster curiosity and creativity among students because it encourages student-led experiments.

Images of the IOLab (courtesy of Mats Selen).

* **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) is a 10-week summer program of team-based, research-integrated social and professional activities that supplied a multi-tiered mentoring strategy. Undergraduate participants were encouraged to develop a network of role models, mentors, and peers to support and encourage their transition to graduate school. The premise of the REU is that nanotechnology provides an exciting possibility to integrate research and educational experiences across a range of disciplines and applications to address many grand challenges facing our world. The goal is to implement, evaluate, and disseminate a highly effective, interdisciplinary research experience for undergraduates in nanotechnology.

* **NanoBIO Node.** The NSF-funded NanoBIO Node is a resource for graduate students, postdocs, faculty, and people in industry whose areas of research are related to nanotechnology and bioengineering. This collaboration between *Illinois* and the University of California at Merced, seeks to provide a resource that offers simulations, web tutorials, webinars, workshops, and other information for people in nanotechnology and bioengineering research. 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.

* **NIH R-25 Sure TOX.** Veterinary Medicine's SURE Tox Summer Experience provided research experiences for seven undergraduate students in summer 2016. I-STEM performed a focus group interview with the seven program participants at the end of the summer 2016, to discover participant perceptions regarding SURE Tox research topics, research team work, and benefits of participation in the SURE Tox program. Evaluation findings indicate that the lab research opportunities were extremely useful, in particular helping students to make informed decisions regarding their research career paths. In addition, most of the student participants agreed that they had developed a better understanding of toxicology as a discipline and also of interdisciplinary concepts related to toxicology (for example with female reproductive system and hematology).

* **PIRE.** I-STEM evaluates this NSF-funded Partnership in International Research and Education (PIRE) energy program between University of Illinois and Kyushu University, Japan. In 2016, six undergraduates from UIUC visited Kyushu and participated in experimental-based projects trying to respond the challenge of energy storage.

Above: A nano@illinois REU participant, a rising sophomore in chemical engineering at the University of Buffalo, who spent the summer researching nanotechnology in Arend van der Zande's lab.

Below: A junior studying bio engineering at the University of Maryland who participated in the nano@illinois REU during summer 2016.

Above: An ENG 198 student at work on her team's personal mobility project.

Top right: A student tackles automatic bike gear shifting on a bike.

Below: An ENG 198 student uses a drill press as she works on her team's personal mobility project: a foldable longboard.

✦ **Center for Power Optimization of Electro-Thermal System (POETS).** The goal of this NSF-funded Engineering Research Center is to increase the power density of current mobile electrified systems by 10–100 times over current state-of-the-art systems. I-STEM evaluates POETS' educational programs.

– **Research Experience for Undergraduates (REU).** This 10-week summer program for undergraduate students provided team-based research and integrated social and professional activities to supply a multi-tiered mentoring strategy. Participants were encouraged to develop a network of role models, mentors, and peers to support and encourage their transition to graduate school.

– **ENG 198 Mobility Course.** This course's goal is to teach freshmen the engineering process and teamwork while doing personal mobility projects that let them experience having contributed to society. I-STEM performed observations of a number of the course sessions.

– **Structured Learning Community.** I-STEM staff developed a survey to obtain general information/feedback (research interest, active projects, best practices, etc.) from POETS' partnering campuses in an effort to build collaborations and learning communities.

✦ **Readying Illinois Students for Excellence (RISE).** In 2016, 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. In order to guide program activities for future participants, I-STEM is tracking RISE participants throughout their freshman year in order to document their experience.

✦ **Sytems Biology Laboratory REU.** This 10-week summer program of team-based research for undergraduate students in the area of systems biology integrated social and professional activities that supplied a multi-tiered mentoring strategy. Participants were encouraged to develop a network of role models, mentors, and peers to support and encourage their transition to graduate school.

✦ **Summer Training in Translational Biomedical Research.** I-STEM evaluated this NIH-funded, 10-week Summer Research Training Program is to identify and train veterinary students who have the ability and motivation to become research scientists. Ten students were matched with faculty mentors who share similar research interests. Each trainee formulated a hypothesis, designed experiments, collected and analyzed data, and reported the conclusions via an abstract submitted to a national meeting, a poster presentation, and a short manuscript to a scientific journal. Instruction in research included orientation week activities and a seminar series on veterinary career opportunities and scientific writing. Trainees presented their work at an in-house poster session and at NIH's Veterinary Scholars Symposium.

✦ **Transdiciplinary Obesity Prevention Research Sciences (TOPRS).** The aim of TOPRS, which was implemented between 2014 and 2016, was to develop and implement a transdiciplinary curriculum for undergraduate students that focused on the causes and consequences of childhood obesity. The curriculum's "flip-the-classroom" format consisted of students viewing video lectures prior to attending class then spending class time on interactive group activities. The evaluation was designed to contribute to the quality and implementation of TOPRS.

Evaluation findings indicate that the majority of participants:

— Agreed that the videos contributed to their learning, helped them understand the material better, and enriched the course material presented;

— Shared that while taking the course did not necessarily influence them to change their major, it did impact how they viewed and thought about obesity;

— Demonstrated significant gains in content knowledge throughout and at the end of the course semesters; and

— Were satisfied with what they learned throughout the 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 2016 external evaluation for XSEDE's Training, Education, and Outreach Services included:

— 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.

— To allow more proactive decision making and strategic planning, the development and implementation of an interactive, live dashboard allows program managers and coordinators to view and track their program's success at the click of a button.

Above and below: Veterinary Medicine students present posters about the research they performed during the 2016 Summer Research Training Program.

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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 2016, I-STEM staff members continued to network at the local, state, and national 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 from various colleges or departments and presented at unit-level meetings. In June, I-STEM Research associates Leah Peoples and Dominic Combs presented a workshop on Culturally Responsive Pedagogy at the CPLC's POLE workshop, and for the Nano@Illinois Research Experience for Teachers.

- **YWCA Science, Technology, Engineering & Mathematics Leadership Award.** In March 2016, I-STEM Interim Director Luisa-Maria Rosu received this YWCA Award for her extraordinary commitment to the quality of teaching and the evaluation of STEM programs in higher education.

On the state and national level...

- **American Evaluation Association 2016.** I-STEM Research Associates Marlon Mitchell, Dominic Combs, and Leah Peoples gave a poster presentation at AEA 2016 entitled, "An Exploration of the National Science Foundation's Broadening Participation Agenda: Identifying Inherent Challenges Using a Mixed-Evaluation Approach."

  Combs, Mitchell, and Peoples also presented, "Lessons Learned Using a Values-Engaged, Educative Approach to Evaluate a Research Experiences for Teachers (RET) Program," which highlighted how effective the Values-Engaged, Educative Evaluation Approach has been in measuring the implementation, impact, effectiveness, and sustainability of the NSF-funded Nano@Illinois Research Experience for Teachers, as well as the value and quality of I-STEM's work on the NSF-funded Research Experiences for Undergraduates programs on the *Illinois* campus.

- **ASME IDETC/DEC Conference 2016.** Marlon Mitchell gave a presentation entitled, "Integrated Model-Based Design and Physical Design Evaluation for Improved Design Education."

- **Clemson University's "Who's Not at the Table?" Conference.** Marlon Mitchell gave a presentation entitled, "Adding to the Broadening Participation Discussion.

Above: I-STEM Interim Director receives a YWCA STEM Leadership Award.

Opposite (page 26): Key contributors to I-STEM's DNA Day (top left to bottom right): Curtis Blanden, Office of Minority Student Affairs; Courtney Cox, IGB Outreach Manager; Luisa Rosu, I-STEM Director; Alejandra Stenger, MCB Merit Program Director; and Daniel Wong, Associate Director of the Educational Equity Programs office.

In 2016, I-STEM staff members continued to network at the local, state, and national, levels to promote STEM education and advocate for STEM education programs and resources.

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Above: During I-STEM's DNA Day, an IGB postdoc explains to some local middle school students how communicable diseases are spread by touch.

Below: MCBees Outreach Director Mara Livesey at work in her lab.

- **Frontiers in Education (FIE) 2016.** Marlon Mitchell gave a presentation entitled, "Culturally Responsive practices in K–16 Engineering Education."

✦ **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. For example, I-STEM continued its work with the Illinois Pathways Initiative's R&D STEM Learning Exchange and Mentor-Matching Engine (see page 10 and below).

✦ **Evaluate and analyze STEM policies.**

One of I-STEM's roles is to examine broad policy initiatives affecting STEM education at all levels, and often includes formal evaluations, like the Danielson Framework Validation Study (see below).

✦ **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 25–27). I-STEM reports on many of these in the Current STEM Ed Highlights of I-STEM's home page, the News section, and STEM Ed Projects section of I-STEM's website[10]. 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 29).

STEM EDUCATION POLICY/ADVOCACY PARTNERS, PROJECTS, AND EVENTS

✶ **Danielson Framework Validation Study.** I-STEM evaluated this project for the Illinois State University's Center for the Study of Education Policy from 2014 to 2016. This study examined the effectiveness and appropriateness of the Charlotte Danielson Framework in accurately describing and measuring PreK–3 teacher effectiveness and providing a structured framework whereby principals and teachers can use feedback from the Framework to support teacher growth. The evaluation found that the framework is applicable and practical for the pre-K to 3rd grade span, and that participants believe the framework promotes a shared language of teaching and learning, supports consistent communication, provides clear expectations, and encourages self-reflection.

✶ **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 2016, I-STEM staff helped recruit Illinois students to the Mentor-Matching Engine[12] program, which connects STEM graduate students and professionals to serve as mentors for the students.
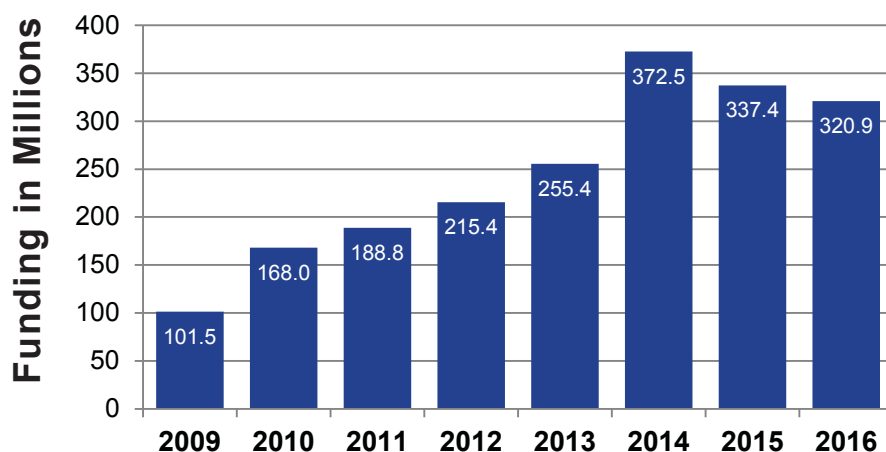
STEM EDUCATION EXTERNAL FUNDING AT ILLINOIS

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 30 and 31, respectively.

Figure 2 below presents estimated STEM Education funding at *Illinois* from 2009 through 2016. 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 2016, the estimated total of $320.9 million in active STEM education investments by funding sources (see Figure 3 on page 30) spans federal agencies (i.e., the National Science Foundation, the U.S. Department of Education, and National Institutes of Health), state of Illinois agencies (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 31). 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.

**Figure 2: STEM Education Funding at Illinois, 2009–2016**

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, we research available campus databases, as well as funders' electronic databases.

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 2016, by Funder
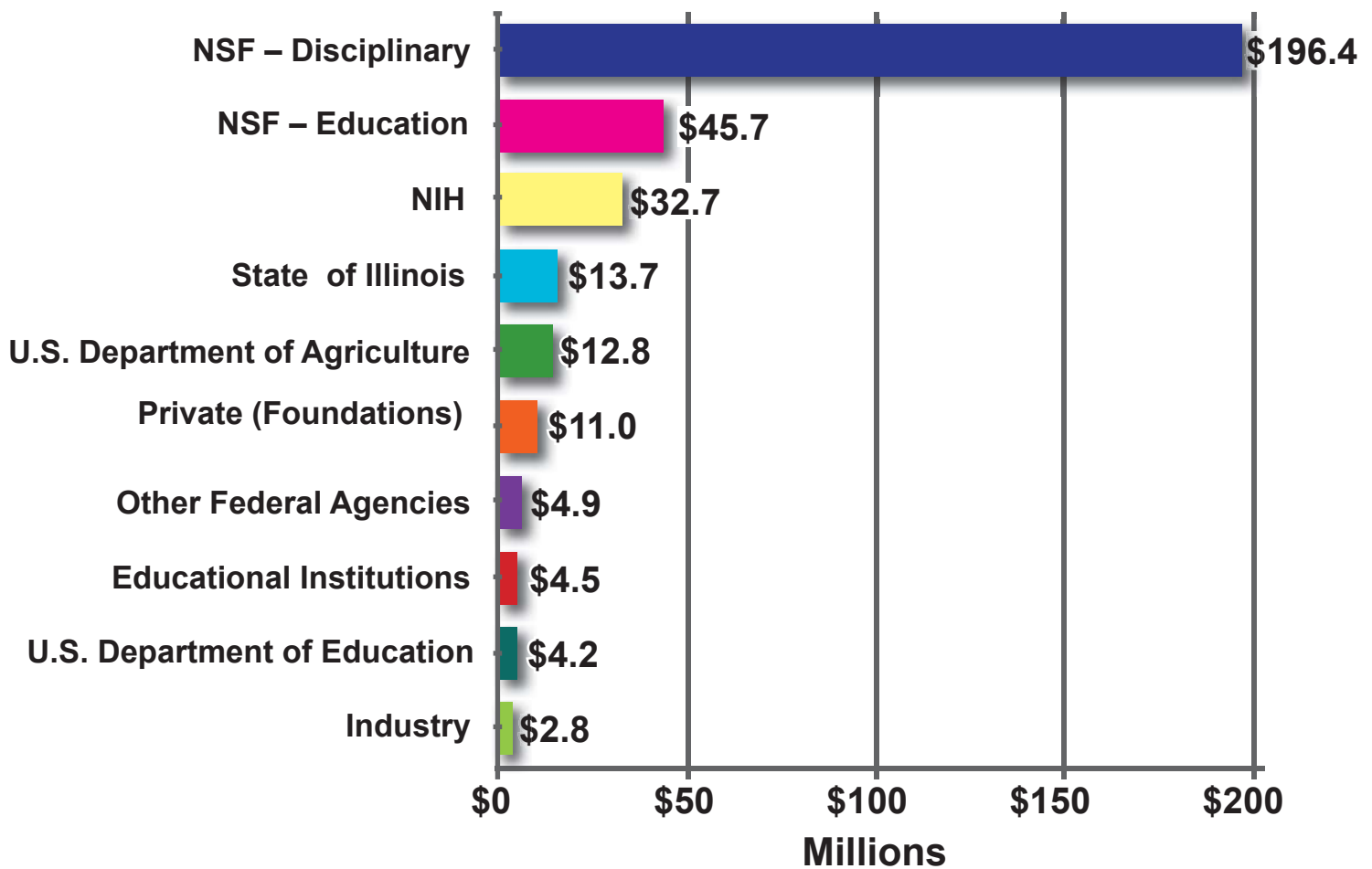

FUNDER	INVESTMENT
National Science Foundation—Disciplinary Directorates/Other Offices (NSF–Disciplinary)	$194,483,579
National Science Foundation—Education & Human Resources Directorate (NSF–EHR)	$42,796,167
National Institutes of Health (NIH)	$29,938,058
State of Illinois Agencies (State of Illinois)	$13,685,176
U.S. Department of Agriculture (USDA)	$12,815,109
Private (Foundations, Associations)⁺	$11,024,124
Industry⁺	$4,901,546
Educational Institutions	$4,539,315
Other Federal Agencies (Army, DoD, DoE, DoL, DoT, EPA, NASA, Nuclear Reg. Comm.)	$4,242,334
U.S. Department of Education (DoED)	$2,522,352
Total	**$320,947,759**

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 29).

⁺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; Dreyfus Foundation; Howard Hughes Medical Institution; National 4H Council; National Academy for Nuclear Training; Neilsen Foundation; and the Sloan Foundation. Corporate/industry support includes companies such as Abbott Laboratories, AbbVie, Eli Lilly & Company, Intel, John Deere & Company, and Microsoft.

Figure 4: Active External Investment in STEM Education at *Illinois* for 2016, by Campus Unit
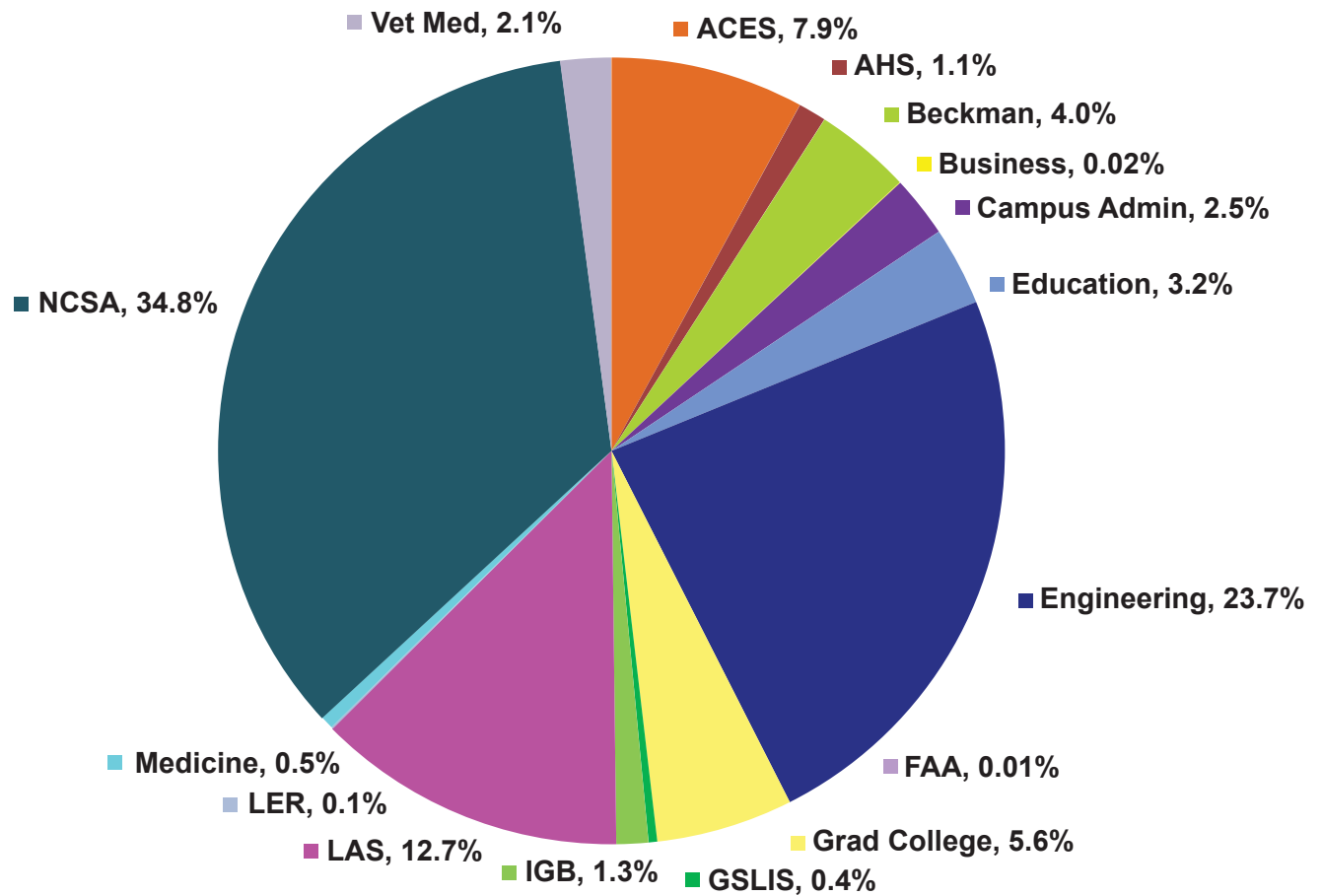
CAMPUS UNIT	INVESTMENT
Agricultural, Consumer and Environmental Sciences (ACES)	25,487,815
Applied Health Sciences (AHS)	3,687,427
Beckman Institute	12,765,779
Business	76,755
Campus/University Administration	8,091,412
Education	10,318,119
Engineering	76,091,663
Fine and Applied Arts (FAA)	24,991
Graduate College	18,006,844
Graduate School of Library and Information Sciences (GSLIS)	1,131,209
Institute for Genomic Biology (IGB)	4,190,113
Labor and Employment Relations (LER)	40,852,674
Liberal Arts and Sciences (LAS)	40,852,674
Medicine	240,000
National Center for Supercomputing Applications (NCSA)	111,555,856
Veterinary Medicine (Vet Med)	6,696,425
Total	**$320,947,759**

Above: Several members of I-STEM's staff in Spring of 2016: front row, left to right: Maggie Phan, Luisa-Maria Rosu, Christine Shenouda, Sarai Coba, Lorna Rivera,Jung Sung. Back row, left to right: Domic Combs, Sergio Contreras, Marlon Mitchell, Derrick Houston.

Below: I-STEM staff members, left to right: Marlon Mitchell, Christine Shenouda, and Jung Sung.

I-STEM STAFF AND STUDENTS

I-STEM DIRECTOR

- Luisa-Maria Rosu, I-STEM Interim Director. Projects: PIRE, IDEAS, R25, Mathways, RDLE, McCormick Danielson Framework Validation Study

I-STEM RESEARCHERS

- Sarai Coba-Rodriguez, Graduate Research Assistant. Projects: Research and Development Learning Exchanges (RDLE), Danielson Framework Validation Study

- Dominic Darrell Combs, Graduate Research Assistant. Projects: Nano@ Illinois RET, Center for the Physics of Living Cells Physics of Life Experience (POLE)

- Sergio Andres Contreras Pinto, Graduate Research Assistant. Project: XSEDE.

- Gabriela Garcia, Graduate Research Assistant. Projects: COTC, Danielson Framework Validation Study, Digital Forensics Initiative (DFI), Illinois Cyber Security Scholars Program (ICSSP), Interactive Online Lab (IOLab), Merit Fellows Scholarship Program, Transdiciplinary Obesity Prevention Research Sciences (TOPRS).

- Derek Houston, Graduate Research Assistant. Projects: P-20 Council Study; AAP STEM Initiative; Engineering James Scholar Program

- Marlon Mitchell, Graduate Research Assistant. Projects: POETS REU, POETS Learning Community, Systems Biology Laboratory REU, Bioimaging REU, Nano@Illinois REU

- Youngshil Paek, Research Scientist. Projects:CPLC, POETS, Transdiciplinary Obesity Prevention Research Sciences (TOPRS).

Above: I-STEM Director Luisa Rosu (right), watches as local students learn about DNA.

Below: I-STEM Research Assistant, Gabriela Garcia.

Clockwise from above: Leah Peoples, an I-STEM Graduate Research Assistant.

To;p right: I-STEM Graduate Research Assistant Marlon Mitchell chats with Professor Andrew Alleyne about the new ENG 198 course Alleyne helped create.

Bottom right: I-STEM Research Assocates Christine Shenouda and Jung Sung.

Below: Lorna Rivera and Jung Sung at a 2016 tour of the Blue Waters Petascale Institute.

- Leah Peoples, Graduate Research Assistant. Projects: Mathways, SRTP
- Maggie Phan, Graduate Research Assistant. Projects: NanoBio Node, Chemistry REU
- Lorna Rivera, Senior Research Specialist. Projects: XSEDE, RISE
- Christine Shenouda, Research Specialist. Projects: CADENS, MakerGirl
- Rebecca Teasdale, Graduate Research Assistant. Projects: Research and Development Learning Exchanges (RDLE)
- Jung Sung, Visiting Research Specialist. Projects: Blue Waters, IB150

I-STEM SUPPORT STAFF

- Elizabeth Innes, Communications Specialist. Projects: Disseminate information: I-STEM website, I-STEM Magazine, I-STEM Annual Report; edit, format, and publish all evalution reports.
- Debby Ann Reynolds, Office Support Specialist

I-STEM UNDERGRADUATE STUDENTS

Undergraduate students assisted I-STEM staff with data entry and interview transcriptions, as well as website maintenance and publication development. Students learned professionalism in a workplace setting; new skills, such as html/CSS coding; and proficiency with new software, such as SPSS, Adobe Dreamweaver, InDesign, and/or Photoshop.

- Emily Alameda (spring 2016). An undeclared freshman who hopes to be a Chemistry professor.
- Cherie Chin (spring 2016). A senior in ACES majoring in Finance in Agribusiness, minor in Business. Cherie, who hoped to be an analyst in a financial technology company, graduated in May 2016.
- Morgan Doggett (summer and fall 2016). A junior majoring in Agriculture Consumer Economics and Agriculture Leadership Education.
- Derrick Domi (spring 2016). A senior in Technical Systems Management, with a minor in Business. Derrick is continuing his studies, currently working on a Master's in Technology Management at *Illinois.*
- Valentina Gill (spring 2016). A senior in Speech and Hearing Science with a minor in Spanish Linguistics, Gill graduated in May 2016, and is currently attending graduate school in Communication Disorders.
- Ericka Hamm-Gordils (summer and fall 2016).
- Sanjay Kalidindi (spring, summer, and fall 2016). An Electrical Engineering junior with a focus on Power and Energy, and a minor in Statistics. A huge tennis fan, Sanjay also enjoys traveling. Passionate about the environment and sustainability, he hopes to work for a renewable energy firm (top right).
- Payal Malik (spring, summer, and fall 2016). A junior in Economics, Finance, her career goal is to be the chief economist of some small, open economy (right).
- Alexandria Peltier (summer and fall 2016). Alexandria is majoring in Statistics with a minor in Informatics minor. She wants to work with big data in marketing or research (second from the bottom on the right).
- Megan Sullivan (spring, summer, and fall 2016). A mathematics major (bottom right).
- Nicoletta Wagner (spring 2016). A Psychology major, Nicoletta graduated in May 2016 and is currently an HR intern at BWAY Corporation in Chicago, Illinois.
- Chelsea Wilson (spring 2016). A senior in Earth, Society & Environmental Sustainability Chelsea graduated in May 2016 and is currently working as a geospatial analyst at Northrop Grumman Corporation in Oswego, Illinois.

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 a comprehensive list of evaluation projects I-STEM worked on in 2016; some were funded externally, such as by NSF and NIH, which requires evaluations for its projects. Climate studies, such as the Chemistry study, were funded internally by the stunits themselves. Additionally, I-STEM completed several pro bono projects in hopes that these might become a source of revenue in the future.