

I-STEM

EDUCATION INITIATIVE

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

I-STEM EDUCATION INITIATIVE ANNUAL REPORT

January–December, 2017



From the Desk of the I-STEM Director:

In 2017, the participation of I-STEM in the development of multiple STEM programs, units, and research efforts at Illinois continued to be essential for their success. I-STEM has also played a critical role in the achievement of numerous STEM-related activities across Illinois, including numerous grant applications that require an independent evaluation of STEM-related research and education programs.

The 2017 annual report highlights I-STEM involvement in the following activities:

- **Fostering and participating in dialogue among key campus and external stakeholders;**
- **Working with campus units to plan, develop, and submit external funding proposals for STEM education;**
- **Helping to improve campus STEM education programs by performing summative and formative evaluations;**
- **Enabling networking among STEM educators about effective pedagogy and program components;**
- **Disseminating information about campus STEM education programs and funding opportunities;**
- **Promoting university K–12 Outreach Activities.**



I-STEM aims to play a more central role in multiple aspects of STEM education at Illinois 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 reconfiguring many of the existent collaborations in a stronger 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. In 2017, connecting more than 50 STEM faculty and graduate students at Illinois from 10 different departments and STEM units, I-STEM launched a pilot of such a partnership: the I-STEM Multidisciplinary Summer Program.

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 2018!

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

Luisa-Maria Rosu
Interim Director

Front cover: Electrical and Computer Engineering Ph.D. student Lonna Edwards (left) works with an Urbana High School student who is soldering a circuit during ECE Day of I-STEM's Summer Camp.

Back cover: An Urbana High School student proudly exhibits the glowing LED light he produced during an I-STEM Summer Camp ECE Day hands-on activity.

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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 Ed. (MSTE)
- Osher Lifelong Learning Institute (OLLI)
- University of Illinois Extension—4H

EXTERNAL PARTNERS

- American Chemical Society
- American Physical Society
- American Society of Materials
- American Association of Universities (AAU)
- 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

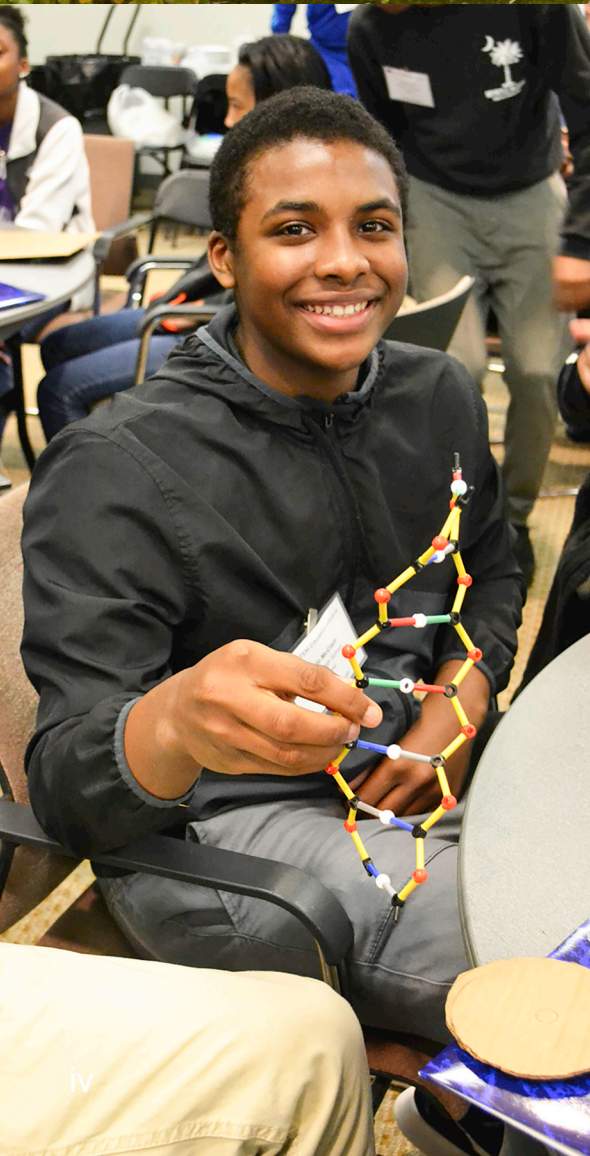
LOCAL PARTNERS

- 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
- Next Generation School
- University Laboratory High School
- University Primary School
- Urbana School District 116





I-STEM ADVISORY BODIES



CAMPUS COUNCIL OF DEANS

- Kimberlee Kae Kidwell, Dean, Agricultural, Consumer, and Environmental Sciences
- Cheryl Hanley-Maxwell, Dean, Applied Health Sciences
- Jeffrey Brown, Dean, Business
- James D. Anderson, Interim Dean, Education
- Andreas Cangellaris, Dean, Engineering
- Kathleen Harleman, Acting Dean, Fine and Applied Arts
- Fritz Drasgow, Interim Dean, Labor & Employment Relations
- Vikram David Amar, Dean, Law
- Feng Sheng Hu, Dean, Liberal Arts and Sciences
- Allen Renear, Dean, Library and Information Science
- Wojtek Chodzko Zajko, Dean, Media
- King Li, Dean, Medicine
- Wynne Korr, Dean, Social Work
- Peter Constable, Dean, Veterinary Medicine

CAMPUS ADMINISTRATION

- Timothy L. Kileen, President of the University of Illinois
- Robert J. Jones, Vice President and Chancellor
- John P. Wilkin, Provost & Vice-Chancellor for Academic Affairs
- Susan Martinis, Vice-Chancellor for Research
- Danita Brown Young, Vice Chancellor for Student Affairs
- Barry Benson, Interim Vice Chancellor for Institutional Advancement
- Wojtek Chodzko Zajko, Associate Provost & Dean, Graduate College



CAMPUS INTERDISCIPLINARY UNITS

- Jeffrey S. Moore, Interim Director, Beckman Institute
- Gene Robinson, Director, Institute for Genomic Biology and Swanlund Chair of Entomology
- Evan DeLucia, Director, Institute for Sustainability, Energy, and Environment
- Neal Cohen, Director, Interdisciplinary Health Sciences Initiative
- Brian T. Cunningham, Director, Micro and Nanotechnology Lab
- Bill Gropp, Director, National Center for Supercomputing Applications
- Mark R. Ryan, Executive Director, Prairie Research Institute

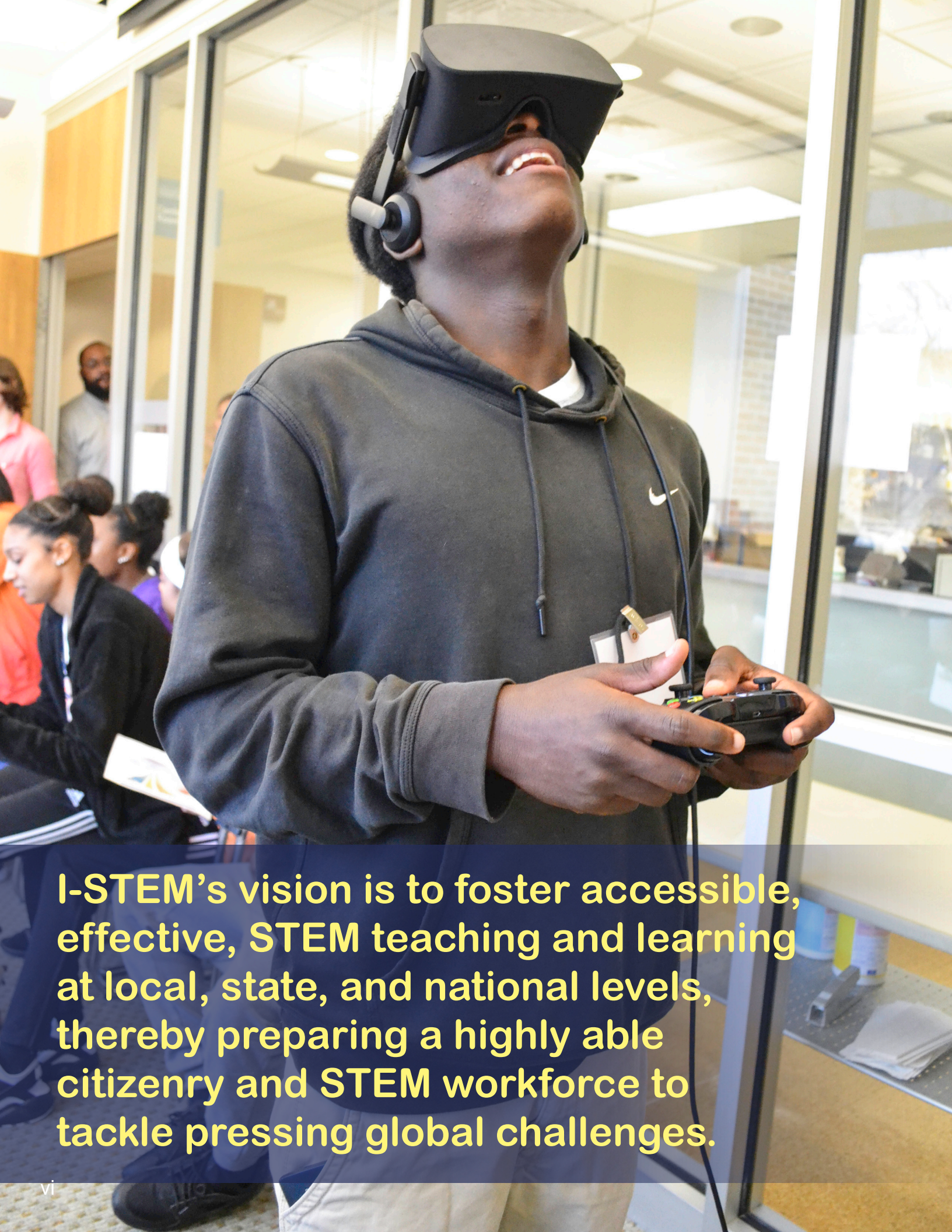
I-STEM EXTERNAL ADVISORY BOARD

- José M. Torres, President, Illinois Mathematics and Science Academy
- Susan Zola, Superintendent, Champaign Unit 4 School District
- Donald Owen, Superintendent, Urbana School District 116
- Evangeline Pianfetti, Chair, Champaign-Urbana Schools Foundation

I-STEM CORPORATE ADVISORY BOARD

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





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

I-STEM's Mission and Goals

I-STEM (the *Illinois* Science, Technology, Engineering, and Mathematics Education Initiative) will complete its ninth full year of operation in January 2018. I-STEM partners with STEM (science, technology, engineering, and mathematics) academic, research, and outreach units at the University of Illinois at Urbana-Champaign (*Illinois*), as well as a number of partners locally and 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: I-STEM campers get a chance to see the access panels beneath the room where the Blue Waters Supercomputer is housed.

Opposite (page vi): A UHS student enjoys virtual reality while looking at a honey bee's brain during I-STEM's DNA and Health Day.

I-STEM seeks to improve the access, quality, and efficiency of STEM education activities at Illinois and in the state and the nation.

Communication Resources

■ I-STEM Website

url: istem.illinois.edu/index.html.

→ **Top Stories:** Web articles are organized in descending order, chronologically.

url: <http://www.istem.illinois.edu/news/topstories.html>

→ **STEM Education News Story Archives:** Web articles are organized by category.

url: <http://www.istem.illinois.edu/news/archives.html>

→ **Directory of Externally Funded STEM Education Projects:** This directory is organized by target audience.

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>

→ **STEM Education External Funding Opportunities, by Upcoming Deadlines (by Month):** url: <http://www.istem.illinois.edu/funding/upcomingdeadlines.html>;

■ **I-STEM-News Listserv.** url: <https://lists.illinois.edu/lists/info/i-stem-news>

■ **I-STEM Print/Electronic Resources.** In addition to this Annual Report, I-STEM is producing its annual magazine, a compilation of all of the 2017 web articles, *STEM Education at Illinois in 2017*, which will be released early in 2018 both in hard copy as well as online (url: istem.illinois.edu/resources/resources.html#2017magazine). I-STEM also produced a magazine commemorating its new summer camp: the I-STEM 2017 Summer Camp magazine, which is currently available both in hard copy as well as online (url: <http://istem.illinois.edu/resources/resources.html#summercampmag>).

OVERVIEW OF I-STEM ACTIVITIES

During its ninth 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 it locally, in the state, the nation, as well as internationally. Major I-STEM activities in 2017 included:

1. **Fostering and participating in dialogue among key campus and external stakeholders.** Key stakeholders discussed 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's Director, Luisa Maria Rosu, who has significant expertise in both education and evaluation of educational programs, was key in the development of evaluation components for numerous proposals. I-STEM will evaluate 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.** I-STEM fosters discourse 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.** I-STEM's website highlights effective, on- and off-campus STEM Education outreach activities, courses, and programs, such as research opportunities for various groups. STEM Education news stories are organized chronologically on the HomePage and in Top Stories, while the News Story Archives organizes them by category, including by various age groups, by discipline, by year, etc. The ISTEM-News Listserv informs its members about current STEM-education news and upcoming events.
6. **Disseminating information about campus and external funding opportunities.** The website also reports on upcoming funding opportunities that promote, foster, and improve STEM education for I-STEM's target groups, organized both by funder and by month. I-STEM's Listserv also informs members about upcoming funding opportunities (see communication resources to the left).
7. **Promoting/Organizing K–12 Outreach Activities.** I-STEM has developed an extensive network of STEM outreach projects and organizations and helped to recruit volunteers for several K–12 outreach activities during 2017, including two I-STEM-organized outreach activities, DNA and Health Day, on February 22nd, and the 2017 I-STEM Summer Camp, a multidisciplinary, two-week day camp from August 7–18. Both of these outreach events targeted scholar-athletes from Urbana High School.

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 & Health Day and the I-STEM Summer Camp: A Multidisciplinary Program.

★ **Funding Opportunities.** I-STEM's website offers resources regarding upcoming STEM education funding opportunities involving our target groups: Upcoming Funding Deadlines¹ lists impending deadlines by date; STEM Education Funding Opportunities² organizes data by funder. The I-STEM-News listserv apprises subscribers of upcoming funding opportunities. I-STEM staff routinely research funding sites and perform maintenance of I-STEM's resources to catalog and make available current information.

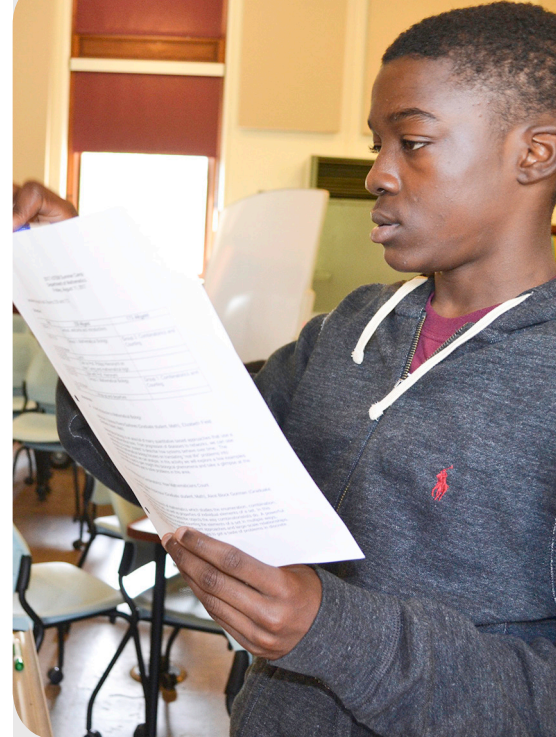
★ **Provide Education/Evaluation Expertise.** I-STEM serves in an advisory capacity to faculty, researchers, or units, and assists in writing education, outreach, and/or evaluation components for their proposals and/or research grants/projects. I-STEM evaluates the impact of various programs' outreach 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. Most of I-STEM's evaluation reports, annual reports, magazines, STEM education outreach flyer, and posters are available electronically, while some are also available in printed form.

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

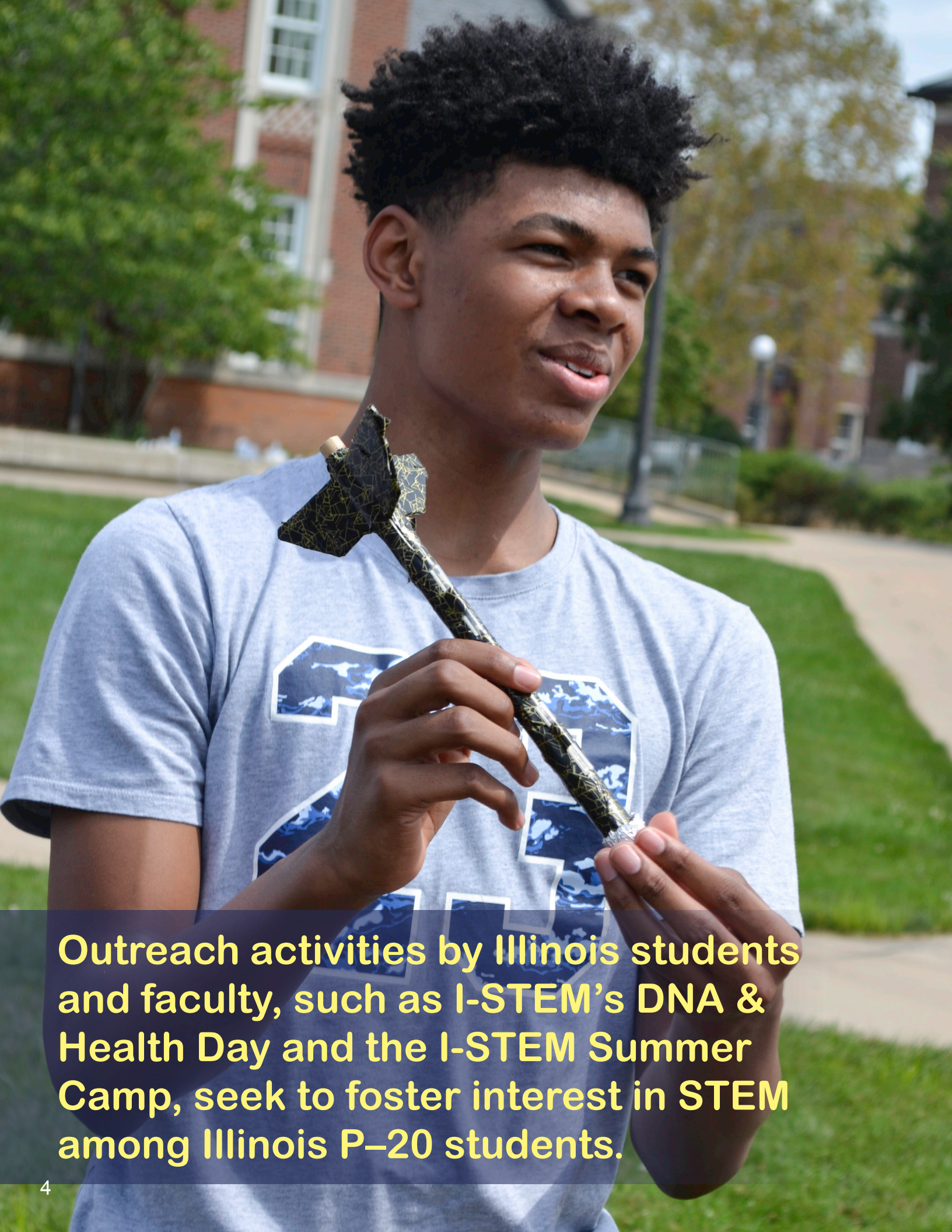
²<http://www.istem.illinois.edu/funding/fundingopps.html>



Above: A UHS student works through a problem during I-STEM Summer Camp's Math Day.

Glossary of Terms

- AAU: American Association of Universities
- CPS: Chicago Public Schools
- DNA: Deoxyribonucleic Acid
- GLAM: Girls Learn About Materials
- IGB: Institute for Genomic Biology
- IGL: Illinois Geometry Lab
- 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 Systems
- RET: Research Experiences for Teachers
- REU: Research Experience for Undergraduates
- RSO: Registered Student Organization
- STEM: Science, Technology, Engineering and Mathematics
- TOPRS: Transdisciplinary Obesity Prevention Research Sciences
- UHS: Urbana High School
- URM: Underrepresented minorities



Outreach activities by Illinois students and faculty, such as I-STEM's DNA & Health Day and the I-STEM Summer Camp, 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 2017, 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 2017, I-STEM identified and prominently displayed information about these activities via its website, listserv, and in printed or electronic materials, including its annual magazine, *STEM Education at Illinois in 2017*, which features 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 Stories³ 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 24–31). In 2017, I-STEM continued to develop a webpage listing outstanding STEM education outreach groups/programs⁸, many of which I-STEM evaluated, collaborated with, and/or featured on its website in 2017.

◆ 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 Mathematics and Science Academy* (see page 26).

◆ 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 2017.)

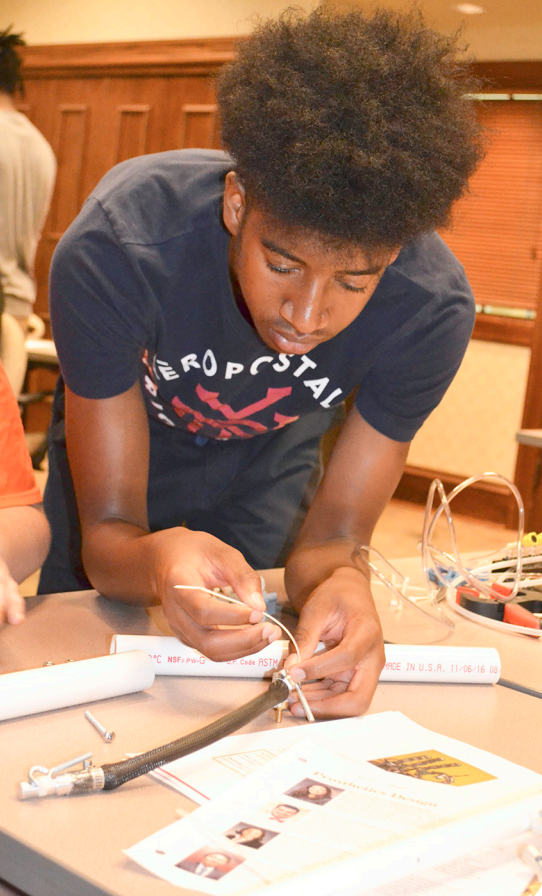


Above: An I-STEM camper, demonstrates proper lab safety equipment: a tie-dye lab coat and neon orange safety goggles.

Opposite page (page 4): An I-STEM camper hopes his rocket will fly the highest on Bardeen Quad during Aerospace Day.

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 Ed Outreach Groups**
⁸<http://www.istem.illinois.edu/resources/stem-ed-outreach.html>



Above: A UHS student athlete works on his team's prosthetic during MechSE Day at I-STEM's summer camp..

Below: Arunita Kar, an ECE grad student, helps a UHS student doing a hands-on activity during the I-STEM camp's ECE Day.



**Table 1: Selected P–20 Outreach Programs
I-STEM Evaluated in 2017**

Program	PI/CoPI/Program Director(s)
Centrality of Advanced Digitally ENabled Science (CADENS)	Donna Cox, PI, Director AVL, NCSA
GLAM Evaluation	Jessica Krogstad, PI, MatSE Professor
Mathways	Matt Ando, Head, Mathematics Department

◆ Work with campus STEM Education sites/outreach groups.

I-STEM works with campus STEM Education 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. I-STEM partnered with the Urbana School District's Urbana High School in 2017 order to expose its students to STEM education activities through our two outreach events, DNA and Health Day, and the new I-STEM Summer Camp: A Multidisciplinary Program.

- In 2017, I-STEM continued to develop its informal network of campus outreach groups, plus served as a liaison to apprise them of outreach opportunities via email and its list-serv. I-STEM called upon many of these to help with our DNA and Health Day, and our new I-STEM Summer Camp: A Multidisciplinary Program.
- I-STEM continued to develop 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 performs/sponsors. This database may found at <http://www.istem.illinois.edu/resources/stem-ed-outreach.html>.
- I-STEM worked directly with campus groups seeking to engage in STEM education outreach activities. Several student groups, I-STEM staff recruited for outreach events included the MCBees, an MCB graduate student organization, Chemistry's REACT, and Illini Aerospace Outreach. I-STEM will continue to partner with these groups and others in 2018 to link them with schools seeking outreach or other service opportunities, such as I-STEM's DNA & Health Day (see page 11) and Summer Camp (see pages 12–21).



◆ **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–20 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) as well as other STEM education organizations. In addition, in an effort to target underrepresented population groups locally, I-STEM specifically targeted students at Urbana High School in its two outreach activities in 2017 (DNA and Health Day and the I-STEM Summer Camp). I-STEM also obliquely addresses this emphasis through its evaluation of a number of STEM education programs with similar goals. For example, one program I-STEM evaluated in 2017 was the GLAM GAMES camp, which targets high school young women, who are underrepresented in STEM fields.

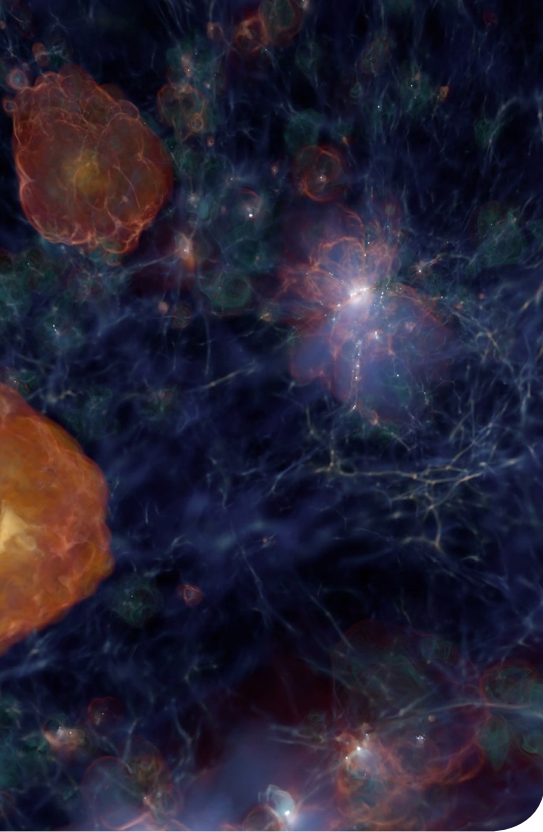
◆ **Increase external funding for P–20 STEM education and outreach.**

To establish an adequate, sustainable campus funding base for P–20 STEM education and outreach, in 2017, I-STEM contributed to the evaluation portion of around 30 proposals, including NSF CAREER grants, with potential impact of about \$30 million external funding at *Illinois* in the following 3–5 years.

Above: MCB PhD student Katie Frye works with a group of UHS students doing a hands-on activity during the I-STEM Summer Camp's MCB Day.

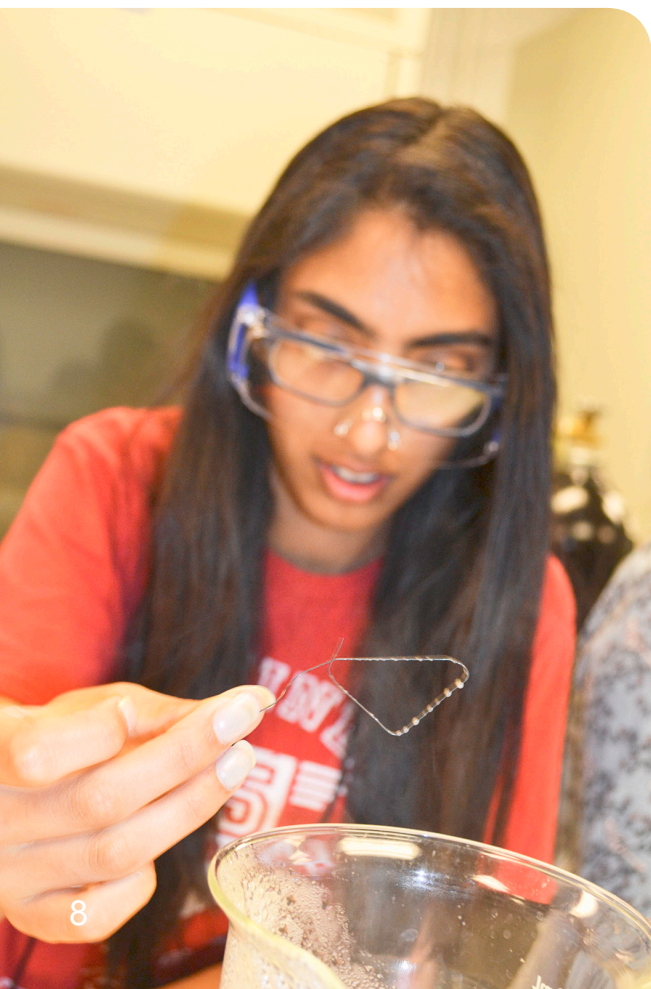
Below: A UHS student does calculations for a hands-on activity during the I-STEM Summer Camp's CEE Day.





Above: A visualization the AVL made for its “Seeing the Beginning of Time” documentary (image courtesy of AVL website: http://www.ncsa.illinois.edu/enabling/vis/cadens/documentary/beginning_of_time).

Below: A high school student experiments with memory metal during GLAM 2017.



P–20 STEM EDUCATION OUTREACH PROGRAMS

★ **CADENS (Centrality of Advanced Digitally ENabled Science).** In collaboration with Lizanne DeStefano at Georgia Tech, in 2017, I-STEM evaluated 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 materials 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. Other shows and documentaries produced include *Seeing the Beginning of Time* and *Birth of Planet Earth*. The project also 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 assessed the accessibility of the visualizations and the clarity of the accompanying script and supplementary materials, both during development and after the films were released. The goal was 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.

★ **Girls Learning about Materials (GLAM).** GLAM is one of eight, week-long summer camps for high school girls operating under the umbrella of the University of Illinois Women in Engineering G.A.M.E.S (Girls Adventures in Math, Engineering and Science) program. The camp is structured to introduce young women to a wide range of concepts core to the field of materials science ranging from phase evolution (in chocolate) to advanced characterization techniques such as small-angle x-ray scattering (SAXS) to band gap theory applied towards building a solar-powered phone charging station. Traditionally, the camp has been structured as a lecture to introduce a new topic or concept followed by a hands-on lab activity, and this approach has proven successful. However, given the overarching goal of not only introducing young women to the field but also encouraging them to actually enter the discipline upon matriculation, GLAM has developed a plan to restructure the program to improve retention by enhancing camper engagement and improving concept integration through an ICME-inspired design project. Having already run the camp in its traditional form, the plan is based not only on experience but also on evidence-based teaching methods shown to enhance long-term learning outcomes in students.

Changes to the camp will be implemented gradually over five years, starting with the introduction of basic tools such as iClickers, concept mapping, and small-group worksheets to the camp's lecture components. Even a simple tool like the iClicker can result in meaningful changes to the lecture if used properly. Prior experience using the devices in undergraduate lectures will be applied to restructure lectures to include smaller group work and promote higher-level critical thinking. These changes will also engage more visual and active learners. In the second and third years of the program, materials traditionally provided to the campers via lecture will be directly integrated into lab activities, requiring students to actively make connections with concepts through hands-on reasoning. The ultimate goal of these progressive changes is to develop an integrated project that incorporates lessons from many smaller activities throughout the week-long camp.

I-STEM's evaluation will provide formative information on the effectiveness of GLAM to Jessica Krogstad, PI of the NSF-funded CAREER grant funding this study, as well as perform a quasi-experimental study (pre- and post-surveys) to analyze satisfaction regarding the development of the program and to assess the impact of other critical components of GLAM's new initiatives on summer camp participants' perceptions of pursuing a STEM college major and career.

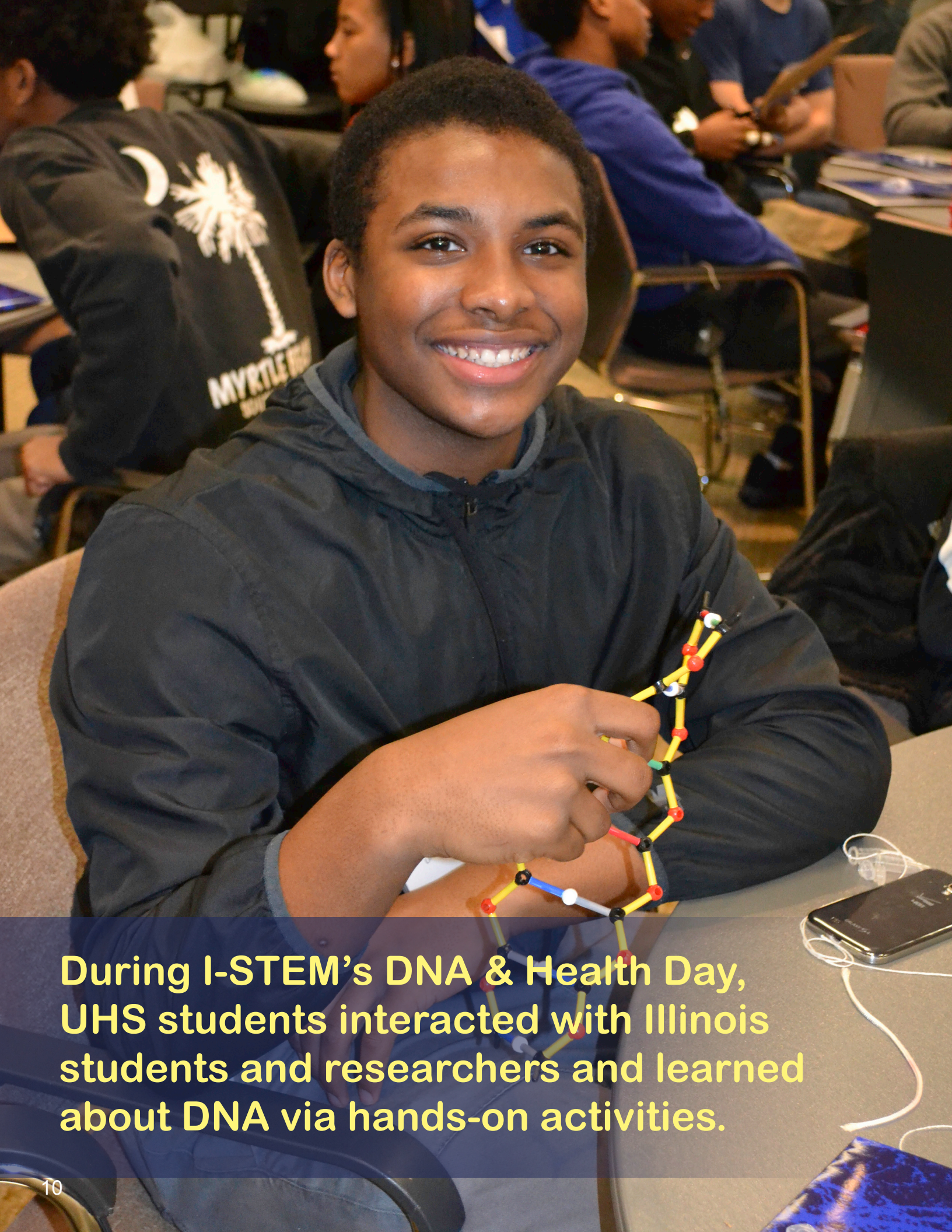
Year one evaluation findings showed that post-survey responses for GLAM participants were higher than both their own pre-survey responses and the pre and post-survey responses of the control group regarding whether they would expect engineering to be an enjoyable career, as well as their confidence in the engineering design process.

★ **Mathways.** Mathways is an NSF-funded program that strives to create a pathway that encourages URM students to participate in collaborative mathematics research, mentoring, and instruction. This is achieved by recruiting *Illinois* students in the Merit program, which provides supplemental services to underrepresented students in STEM fields, to the *Illinois* Geometry Lab, a math research lab. Mathways students are provided with opportunities to conduct and present research, as well as attend summer camps and other outreach programs. The Mathways evaluation is currently in progress and focuses on the program's implementation, effectiveness, impact and sustainability.

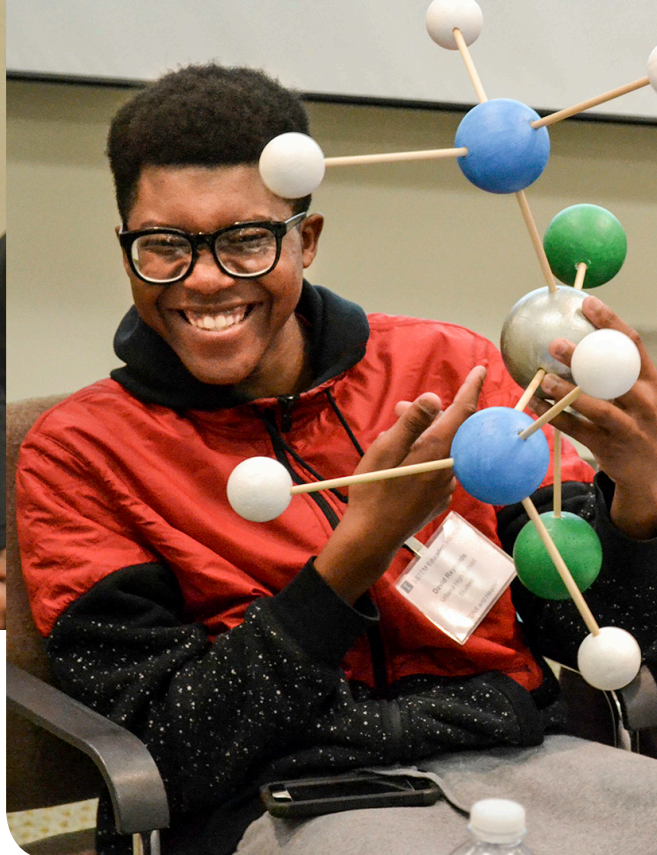


Above and below: 2017 GLAM GAMES campers enjoying the materials science hands-on activities.





During I-STEM's DNA & Health Day, UHS students interacted with Illinois students and researchers and learned about DNA via hands-on activities.



I-STEM OUTREACH PROGRAMS

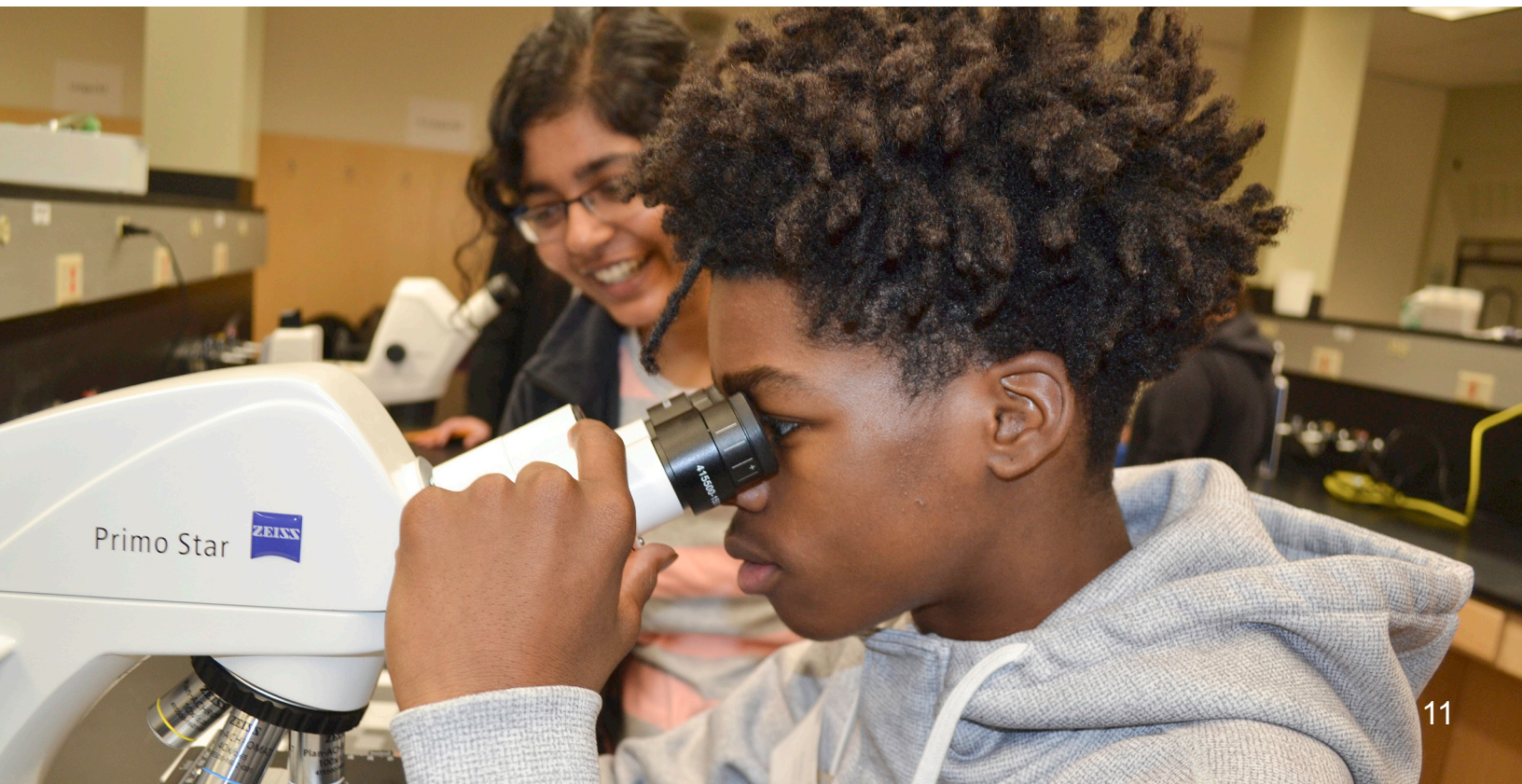
I-STEM DNA and Health Day

On February 22, 2017, I-STEM's DNA & Health Day hosted 63 scholar-athletes, mostly underrepresented students, from Urbana High School, who visited the Institute for Genomic Biology (IGB) to learn about DNA and health via a number of hands-on activities. Plus, students got to interact with *Illinois* researchers, such as Bruce Fouke. During an IGB tour, they got their hands on state-of-the-art microscopes and cutting-edge technology and, over lunch, folks from several campus offices shared about resources available should students matriculate to *Illinois*. Plus, participants interacted with *Illinois* students: the MCBees, MCB's graduate student RSO; chemistry undergrads; and members of Chemistry's REACT student organization. It is hoped that participants took away the notion that exploring the world of "Omics" is intriguing and fun and that they too can become scientists if they so choose.

Top left: An Urbana High School student shows off the DNA he extracted from strawberries during one of the DNA & Health Day hands-on activities.

Above: A UHS student holds a model of a molecule, which he then recreated using gum drops and toothpick.

Below: During DNA & Health Day, a UHS student examines a sample through a microscope in IGB's Training Lab.





Above: A student prepares to launch the glider he built in the halls of Talbot Lab.



Top right: An MCB grad student (center) teaches two UHS students how to use a pipette.

Bottom left: MCB grad student, Jeremiah Heredia, works with a UHS student who is learning how to use a pipette in order to do the DNA hands-on activity.

Below: During Chemistry Day, a camper pours the soap he made into a container.

I-STEM Summer Camp: A Multidisciplinary Program

From August 7–18, twenty-seven Urbana High School (UHS) athletes, mostly underrepresented minorities, participated in the first-ever I-STEM Summer Camp. The goals of this multidisciplinary summer program were to 1) expose participants to various STEM fields so they know what their options are when choosing their career/college path; 2) to build teamwork and lab skills in different STEM disciplines; and 3) to allow students to experience what STEM research is about. Ten different STEM departments and units on campus were each responsible for one day of activities during the two-week camp.

According to I-STEM Interim Director Luisa Rosu, the program's long-term goal was to build a foundation for a stronger STEM partnership between the campus and local schools that particularly emphasizes groups underrepresented in STEM and has the potential to support the pipeline for future research capacity in participating departments.

Rosu shares why programs like I-STEM's camp are important: "Students, high school students in particular, are looking for college experiences. They need this kind of experience, to come on our campus, to see what it means to be a student, to see what it means to stay in a class for a longer time—not just for a couple of hours, not just for a lab visit, but an entire college day experience over two weeks."



Multi-Disciplinary STEM Activities

Each day of the camp addressed a different STEM discipline. Faculty, students, and other personnel from ten different *Illinois* departments, units, or groups participated in the camp. Following are key personnel who presented, plus a brief description of the types of instruction and/or hands-on activities to which they exposed the students:

MCB Day. On Monday, August 7th, members of the MCB (School of Molecular and Cellular Biology) graduate student organization used a fun scenario, a crime scene involving a “dead graduate student,” to structure their activities. For the “Whodunit?” students were to discover which of two suspects did it: an undergrad who wanted the grad student’s spot and/or funding, or the professor who was upset with the grad student because he wasn’t working hard in the lab.

The job of the high schoolers was to take DNA samples from the crime scene, extract DNA from the cells found there, then perform a Polymerase Chain Reaction to amplify the part of the DNA that they were interested in, producing millions of copies of that DNA. Then they were to take that DNA and separate it on a gel, a thick jello-like substance that they could run the DNA through. Based on size, a different pattern would appear, that they would then need to match to the pattern found on the murder weapon.

The reason the MCBees chose this experiment, explains MCBees Outreach Coordinator Mara Livezey, is because it was a real research experience. “It’s like a real, start-to-finish experiment, and a lot of the techniques we use today are things that I use in lab every day.”

“I think something like this where we can make a fun scenario for the kids to follow along with is more interesting. It can grab their excitement a little bit more and motivate them to maybe consider science in their future. I want them to have a real experience, like this is really what we do every day in lab. And if they can understand that, then maybe they’ll be interested.”



Above, below, and to the bottom left: During the I-STEM Camp’s MCB Day, UHS students participate in hands-on activities with DNA.

***“It’s like a real, start-to-finish experiment, and a lot of the techniques we use today are things that I use in lab every day.”
– Mara Livezey***





ECE Assistant Professor Ange-Therese Akono teaches the UHS students about materials' microstructure composition and fracture resistance.

Top right: Dr. Mark McCollum explains to the UHS students why cleanrooms are important to research going on at MNTL

Below: A UHS student looks at a specimen to see if it's been polished enough to perform an indentation test.



MNTL/Nano@IL RET. On Tuesday, August 8, MNTL Day, I-STEM campers visited MNTL (the Micro and Nanotechnology Lab), for “A Primer on Semiconductors.” In preparation for creating their own poster about their I-STEM camp experience, students listened to nano@illinois RET teachers’ poster presentations about their research this past summer. In addition, students used a rubric to evaluate each teacher’s presentation according to the following four criteria: organization, use of graphics, effectiveness, and responsiveness, giving each a grade from 1 to 3. In the afternoon, Dr. Mark McCollum led students on a tour of MNTL’s cleanroom laboratory.

One nano@illinois RET participant, J. D. Graham, who teaches grades 9–12 biological sciences at Sullivan High School in Sullivan, Illinois, shares why the camp was a good experience for the UHS students.

“It’s just exposure,” Graham acknowledges. “It’s like learning another language; it’s like going to another country. You can hear that those things exist, but to actually see somebody speak a language, it takes the mystery away that it’s not something somebody else does, it’s something you can do.”

Civil and Environmental Engineering (CEE). CEE Assistant Professor Ange-Therese Akono, along with some students in her lab, exposed the high-schoolers to a nanomechanics workshop on Wednesday, August 9.

According to Akono, events like this help high school students “just get excited about science!”

“They get to discover an aspect of science they wouldn’t have thought about,” she continues. “In this case, we’re looking at civil engineering. They get to understand what it is to be a civil engineer, what kind of questions we’re asking, and how this is both exciting but also applicable in real life.” Akono asserts that students experience civil engineering every day, “but maybe they’ve never thought about all the people actually designing it.” She says their other goal was “to inspire them so that later, they would select these careers and be the future engineers that we need for this country.”



Electrical and Computer Engineering (ECE). On Thursday, August 10, ECE Day, Professor Lynford Goddard and his students taught the campers about how to design research experiments, how to solder, and then had them build circuits.

One of the graduate students from Goddard's lab, Lonna Edwards (who was involved in four camps this past summer) indicates that she participates in outreach events like I-STEM's camp because it's something she didn't have access to at that age.

"I love doing outreach. It's something I wish that I'd had when I was younger. I wasn't aware. I didn't know what an engineer was until I was starting college, and I learned about what they do, so I just picked it as a major, not really knowing much about it. It was a struggle in the sense that I had to maintain a certain GPA, so I was stressed out a lot of the time. But I made it, so I made it a goal to expose people earlier."

Edwards says it's a good idea to bring high school kids into a lab early. "The earlier the better," she says. "But kids who get to experience this are at an advantage, because they're learning about things I didn't learn until I got to college. I tell them not to feel bad if they feel like they're not getting something; I tell them that they're still ahead of the game."

"The earlier you get exposed, the better you'll be at it," she adds, "because it won't be as stressful, and because it's something you've seen before. You'll be able to learn it and be confident. So I wanted to reach out to kids who are younger so they get that exposure, especially kids that are underrepresented in the field."



Top left: A UHS student solders a circuit.

Above: An I-STEM camper gets his LED to light up during an ECE Day hands-on activity.

Below: A UHS student works on soldering a circuit during ECE Day at I-STEM camp.

Bottom left: An I-STEM camper does a hands-on activity with an LED during an ECE Day hands-on activity.

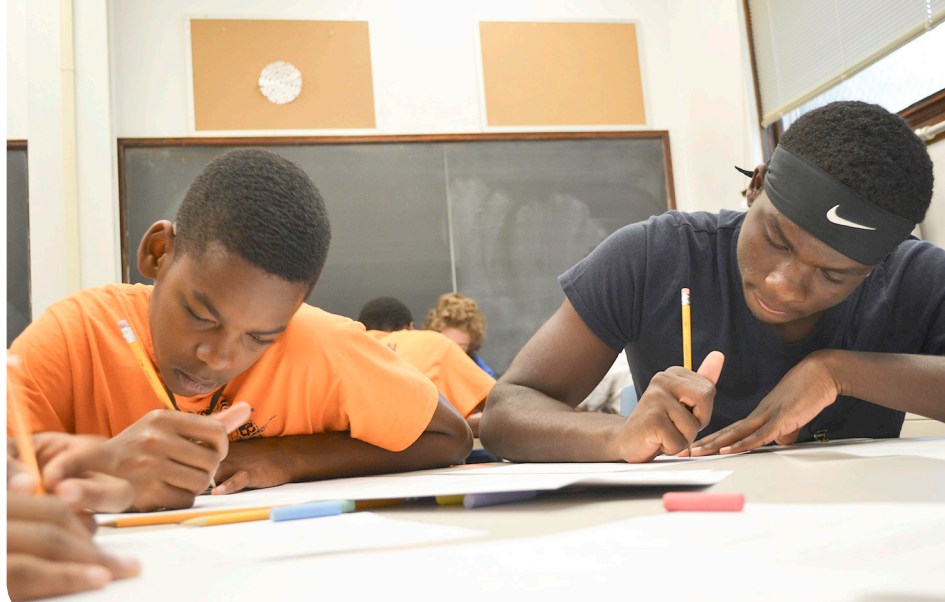




Above: Math grad student Elizabeth Field helps a UHS student.

Top right: Two UHS students do a Mathematics Day activity.

Below: Professor Phillip Hieronymi introduces students to mathematical logic.



Mathematics. On Friday, August 11, Mathematics Department Head, Matt Ando, welcomed the students and discussed the importance of math. Later, Assistant Professor Phillip Hieronymi introduced students to mathematical logic via a “brain teaser” about Alan Turing. In addition, several math Ph.D. students, Alexi Taylor Block Gorman, Colleen Elizabeth Robichaux, Elizabeth Field, and Vanessa Rivera-Quinones, did hands-on activities related to their math research with the students.

For instance, Vanessa Rivera-Quinones, a fifth year math Ph.D. student, did an event with the students related to disease modeling. In her research, she uses mathematical models to try to understand how disease spreads, in particular in a lake ecosystem.

Rivera-Quinones participated in I-STEM’s camp because she believes **“math should be painted in a fun light.”** While she says the math in school is interesting, she admits, **“It doesn’t tell you the complete picture. I always want try to motivate other students to see how math is used in non-traditional settings or how the math in high school could be pushed to explain some real-life phenomenon.”**

So, she gave the students an exciting exercise related to real life and to her work in epidemiology (the spread of infectious diseases). In a website game called VAX, students were given a limited number of “quarantines” (breaking a link from one person to another) to try to stop a disease from spreading. Once the disease got started, however, it spread rapidly from person to person. The students were quite engaged as they scrambled to try stop the spread of the disease—with varying degrees of success.

Regarding the impact I-STEM’s camp had on the students, Rivera-Quinones reports, **“Since this program is trying to paint a picture of what a researcher looks like, hopefully they can see that it’s not just one picture; across different disciplines, we do different types of things, and all of them are research.”**

According to Rivera-Quinones, her main goal was for the students to gain confidence: “My hope for them is that they understand that there’s not one definition of being a mathematician,” she explains. “They can also be mathematicians even though they’re not pursuing a PhD in math. As long as they have interest in how things work and how patterns are formed, they can also be mathematicians.”

Aerospace Engineering. On Monday, August 14, I-STEM campers learned a bit about the engineering and physics behind how airplanes and rockets fly courtesy of Illini Aerospace Outreach, Aerospace Engineering's RSO, who organized the event. Campers learned about flight mechanics and jet engines; got a demonstration of the wind tunnel; learned rocketry basics; then designed, built, and launched balsa wood gliders and model rockets.

Elle Wroblewski, an Aerospace Ph.D. student who helped with the camp, shares why events like the camp are important for high school students.

"When I was in high school," she explains, "my impression of engineering was only based off of what older people would tell me; I didn't have any first-hand experiences as to what that meant. An event like this shows students more in depth and gives them a better grasp as to what engineering is and shows them a practical application in math and science, whereas beforehand, I feel like it's a little more theoretical, or it's a bit more science-fiction based."

In fact, Wroblewski says that much of what kids believe about space flight is based on what they've seen in movies and on TV and "not so much on the technical details," she admits. **"An event like this makes it more realistic, so that when they're thinking about careers, they have a better grasp as to what it actually is."**

Wroblewski says it's even more important to show them they have what it takes to be engineers, refuting **"pre-conceived notions like 'I can't do that because I'm not smart enough,' because they've experienced that they are smart enough to do it. It's exciting and fun that they can achieve something as opposed to not knowing whether or not they could."**



Above: A UHS student waits to fly his rocket on Bardeen Quad.

Below: During a tour, campers view a Rolls Royce rocket engine in the basement of Talbot Lab.





Above: I-STEM campers observe chemiluminescence in action.

Top right: A UHS student (center) completes one of the steps of a Chemistry Day hands-on activity.

Bottom right: Tina Huang (right) helps a UHS student doing a hands-on activity.

Below: An I-STEM camper stirs his concoction during the soap-making hands-on activity



Chemistry. On Tuesday, August 15, Chemistry's Tina Huang, and her lab assistant, Stephanie Legare, helped campers discover chemistry via several hands-on activities. After learning about lab safety, students suited up in lab coats, goggles, and gloves, then did activities in saponification (making soap), forensic chemistry (extracting pen ink and candy dye using chromatography), and how temperature can change the physical and chemical properties of matter.

According to Huang, activities like I-STEM camp's Chemistry Day are important to help students overcome their fear of certain STEM subjects:

"We hear from the students that in order for them to get interested, they need to start as early as possible," Huang explains. "Many students have a fear of STEM. Even though they want to major in it, they're sometimes afraid when they get to the college level. They view certain topics as really hard and difficult to master. I think if we give them something fun that they can do, that they'll know it's not impossible, but that learning also takes time. So then, they'll have the attitude when they get to college that it's going to be hard, but not impossible."



Computer Science (CS). On Wednesday, August 16, students learned about computer science and coding. After a presentation by I-STEM camp mentor and ECE major Kushal Goenka about what it means to code, students visited a CS computer lab and made Scratch (an online program for programming stories, games, and animations) projects of their own. Students also heard from a CS PhD student, Everett Hildenbrandt, about CS formal methods, did a Magnet/Copper activity, and learned that computer science is everywhere.

Mechanical Science and Engineering (MechSE). On Thursday, August 17, a team of professors and students from MechSE, including Elif Ertekin, Mariana Kersh, Kazem Alidoost, Jason Kim, and John Shanley, exposed campers to some current research in their field. The hands-on activity they led involved making a prosthetic device: an arm for an amputee that would operate using pressurized air from an air tank and include a hand with fingers that could pick up a pair of sunglasses.

According to Associate Professor Elif Ertekin, one of their goals was to help the high school students see themselves doing engineering.

“A lot of the modern research shows that in order to be able to choose a certain career path, you have to be able to envision yourself being that person and doing that job in the future. So right now, by trying to give the young people hands-on experience, working directly with graduate student researchers and faculty, I think that really helps them imagine themselves doing this as a part of their careers in the future.”

MechSE’s Assistant Professor Mariana Kersh says events like the camp are important to high school students to “provide that light at the end of the tunnel” to help them “learn that there is this bigger picture.”

While high school students “may know that they’re good in math or that they like science...they don’t really know where that’s going to take them.” She envisions the event as helping to show them the possible routes early and to help keep them on track. She admits that students need to have a vision. “It’s not about the degree per se; it’s about what you’re going to do with it in order to help,” she explains. This can help them get through distractions such as getting discouraged when they don’t do well on a test, because they’ve learned that “there’s this bigger picture that I really learned about and that’s what is driving me.”



Above: An I-STEM campers enjoys using Scratch on Computer Science Day.

Below: I-STEM campers build a prosthetic device during MechSE Day.

Bottom left: A UHS athlete shows off his team’s completed prosthetic device.





Above: Students view the AVL's 3D presentations.

Below: A UHS student-athlete inspects a sample Blue Waters cable

Bottom Left: Three UHS students enjoy a tour of Blue Waters.



National Center for Super-computing Applications (NCSA).

On Friday, August 18, campers learned about research at NCSA, including a peek at some of the Advanced Visualization Laboratory's (AVL's) high-resolution, cinematic-quality data visualizations for public outreach. Students also attended a panel featuring AVL research programmer Kalina Borkiewicz; Eliu Huerta, a Physics and Astronomy Research Scientist in the Relativity Group; Dan Lapine from the Scientific Computing Services Group; and Adam Slagell of NCSA's Cybersecurity Group. Finally, students toured the National Petascale Computing Facility, home of the Blue Waters Super Computer.

Barbara Jewett, a managing editor at NCSA, shares why events like I-STEM's camp are important: "Because you never know what is going to change someone's life. And it is very important that we encourage young people to explore careers and the other opportunities that are available to them in the areas of math and science. And by exposing them to what is available on campus, we can stimulate their interest."

As an example, Jewett shares an anecdote about her daughter, a chemistry Ph.D. student. "She got her interest in chemistry from freshman chemistry the very first day," Jewett explains, "when the instructor poured two solutions together, and they turned pink!"

"You just never know," she continues. "There are so many opportunities and things you can do with science. Plus, let's face it, science affects our daily lives. All the food we eat; all the products we use; the air we breathe; the science that grows things. So science is in everything. So just the exposure to it and getting people involved in science is really important."

Learning Opportunities for Developing Soft Skills

Besides exposing under-represented minority HS student-athletes to various STEM research experiences and helping them to make informed decisions when choosing their career/college path, this pioneering multidisciplinary program also offered learning opportunities for developing soft skills, like teamwork, communication, assertiveness, and adaptability.

UHS students worked in groups, under ISTEM mentors' supervision, to incorporate their two-week experience into a poster. Students were given the assignment to make the connection between the best experience they had during the camp and their current career choice. As a final culminating event, UHS was to hold a poster event where students could present about their ISTEM summer experiences to UHS colleagues and teachers.

Mentors. In addition to exposure to more than 100 *Illinois* faculty, students and other personnel from participating departments, units, or organizations, I-STEM incorporated an additional component: *Illinois* students served as mentors who not only helped to guide and motivate the high schoolers during activities, but provided the opportunity for relationship-building with *Illinois* students. The idea was that the campers might more easily identify with *Illinois* undergrads because they were closer in age to the high school students, plus they had recently been through the college/career decision-making process themselves.

Regarding the camp's impact on the participants, mentor Amber Shields, a junior in Human Development and Family Studies, reports, "My group has been very engaged...Someone wants to be an engineer, so he's asking a lot of questions...I like the experience they're getting. I like to see their happy faces; I like to see them engaged, asking me questions."

Shield's mentees weren't the only ones benefitting from the camp. In addition to mentoring students, Shields was jumping in with both feet during the various multi-disciplinary activities. "I'd like to thank you for me," says Shields, "because I learned a lot of things throughout this camp. I learned new buildings that I've never seen before, never gone inside before because some buildings are restricted. You have to be an engineer or a STEM student to get inside them. It's a very new experience, and it's very appreciated. I learned something new."

Mentor leader Kadeem Fuller got involved with the camp in order to get to know kids. "Having the time to engage with students that are younger than me, people that only a couple years ago, I was in their shoes," he admits. "So anytime I can give them a type of guidance or something to do other than just sitting at home during the summer time."

Kadeem also hoped to discover the kids' dreams and encourage them to pursue them, to "get to know their passion, so we can kind of push them in the direction that they want to do and what they want to be."

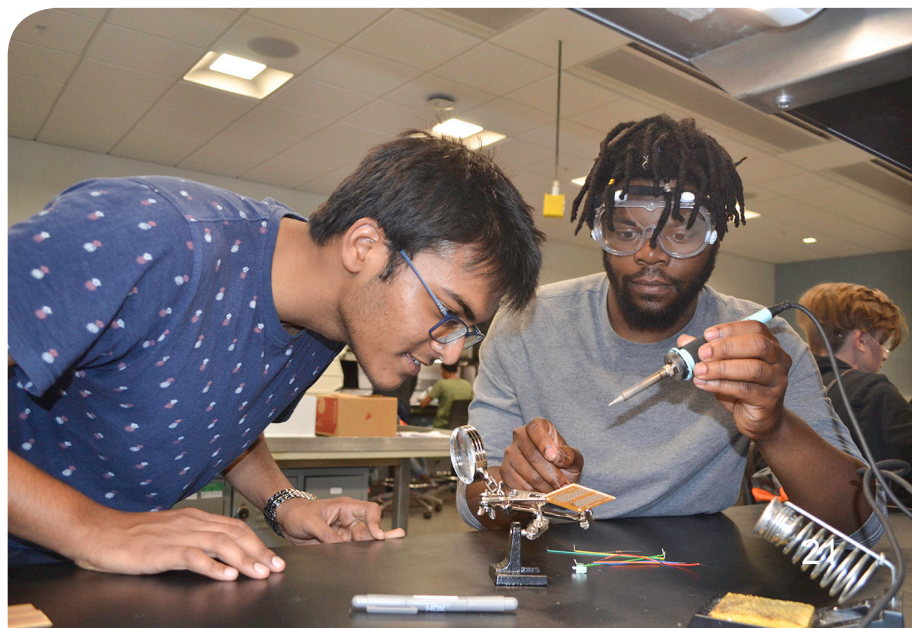
I-STEM Interim Director Luisa Rosu believes the camp had just such an impact on the students: it gave them confidence to consider a career in STEM: **"I would say the biggest impact is that students became aware of their potential. Most of the students attended our Health Day in spring. I remember that first hour when they entered the IGB conference room, you could see in their eyes: 'This is not my place. Why am I here? Why did they bring me here? What's this about?' And during that day in spring, they started to feel more comfortable. So the first day of our summer camp program, we started with the MCBees, a familiar experience and familiar faces, and it clearly gave students this comfortable feeling. 'I can be a college student. I have this potential; it's just up to me what I choose.' And I think this is the best thing about that first day of their summer experience; there was a shift from just being comfortable with college to starting to think, 'Which STEM discipline do I like the most?'"**



Top Right: An I-STEM mentor (center) works with her students on MechSE Day.

Above: I-STEM Mentor Amber Shields.

Bottom Right: I-STEM mentor Kushal Goenka examines mentor leader Kadeem Fuller's work as he solders a circuit.





I-STEM partners with campus projects, such as POETS' RET, which provides research experiences and fosters curriculum development for teachers.

Goal 2: Improve STEM Teacher Training and Professional Development Quality

STEM TEACHER TRAINING/PROFESSIONAL DEVELOPMENT IMPROVEMENT

◆ Increase external funding for teacher preparation and professional development.

In 2017, 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.

◆ Evaluate STEM teacher training and professional development projects.

In 2017, I-STEM evaluated two NSF-funded STEM teacher training and professional development projects operating at *Illinois*, the Nano@*Illinois* RET and the POETS RET. 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.

◆ Disseminate information about STEM teacher professional development and research experiences.

I-STEM works to disseminate information about current campus STEM teacher professional development programs that offer workshops and training and work to improve STEM teacher retention, reduce out-of-field teaching, and increase student performance. These programs provide a variety of resources, including induction and mentoring; graduate disciplinary coursework and degree options; leadership development; and research experiences.

I-STEM posts web articles reporting on these programs' past activities in its STEM Education News section; for STEM educators seeking to participate in these types of activities, I-STEM posts information about upcoming STEM teacher PD and research experience opportunities in its resources section. Information about all of I-STEM's different web articles plus upcoming PD and research opportunities are also sent to interested stakeholders via I-STEM's listserv. (See page 2 for communication resources.)



Above: A nano@illinois teacher discusses his research during the nano@illinois end-of-the-summer poster session.

On the opposite page, (page 22): Uni High chemistry teacher David Bergandine shows off some of the equipment his students used and heat pipes they tested while researching heat pipes. The research projects were a part of the curriculum he developed for POETS' RET.

I-STEM encourages K–12 school districts to take advantage of campus PD resources. In addition, I-STEM recommends that projects/labs offer Research Experiences for Teachers.



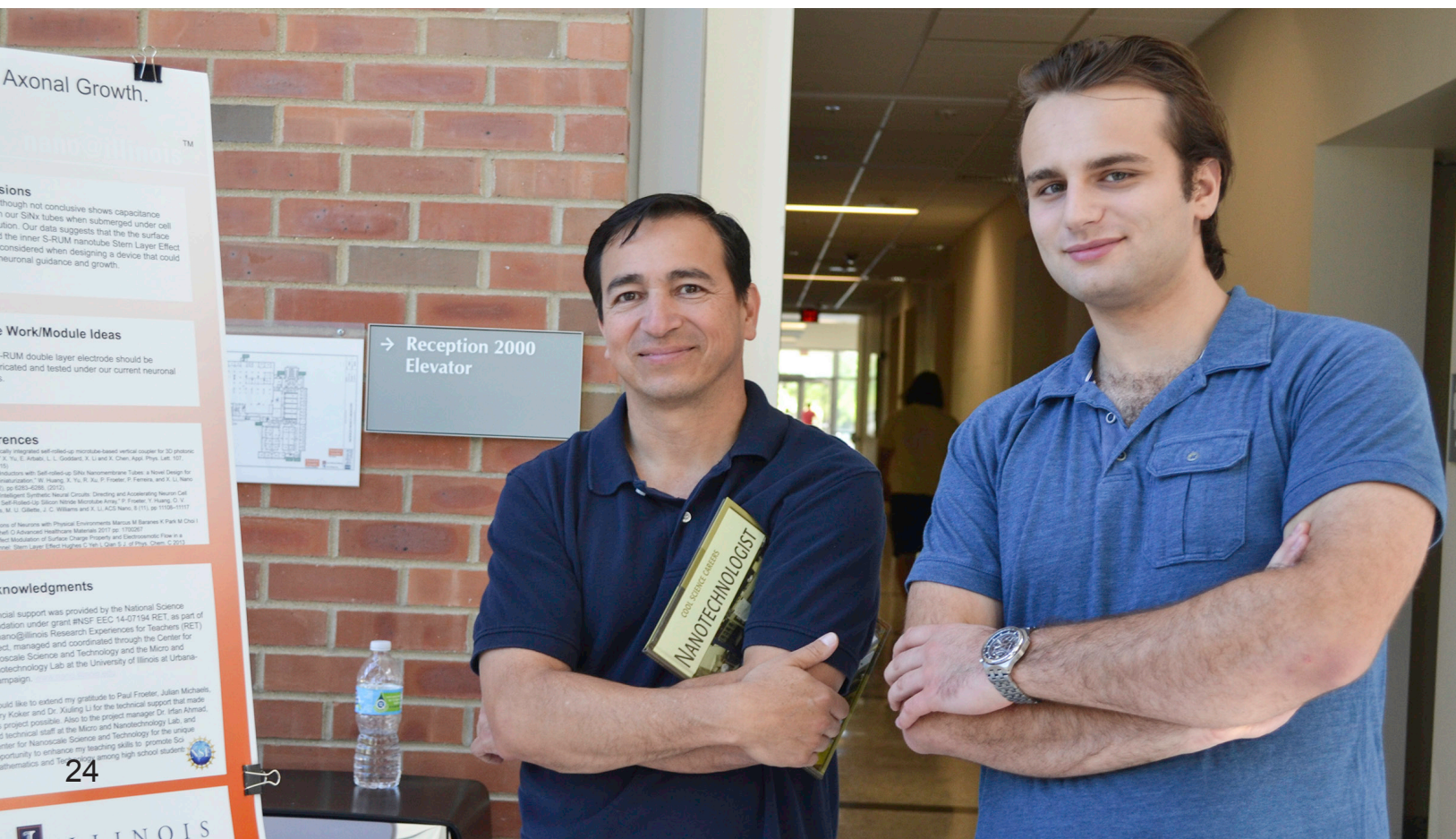
Above: nano@illinois teacher, J. D. Graham, and his poster

Below: Antonio Gamboa (left) and his Ph.D student mentor by his poster at nano@illinois' poster session.

◆ 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 fostering commitment to outreach and possibly even increasing the number of teacher education candidates in those disciplines. In 2017, *Illinois* staff and students volunteered in numerous programs targeting P–12 students, including camps, open houses, and outreach in schools. As part of its mandate to disseminate information about STEM education activities, I-STEM published web articles about many of these student groups/outreach activities.

Plus, in 2017, I-STEM continued to develop its 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 2017. I-STEM staff also continued to update its STEM Education Outreach webpage. (For a list of these organizations/projects and outreach activities, see <http://www.istem.illinois.edu/resources/stem-ed-outreach.html>.)





STEM EDUCATION TEACHER TRAINING/ PROFESSIONAL DEVELOPMENT PROGRAMS

★ **Cyberinfrastructure Program (CIP).** I-STEM evaluates NCSA's Cyberinfrastructure Program (CIP), whose aim is to address the issue of the shortage of a workforce with specialized skills needed to support advanced Cyberinfrastructure (CI) operations. The goal of this internship program is to provide motivated individuals the opportunity to obtain real-world CI operational experience through a short, full-time program in an area already supported by NCSA for its own operations. Over the three years of this project, the program will train 30 interns to enter the workforce as CI system engineers and system administrators. In the long-term, the program will result in study materials and best practices that can be transferred to other institutions interested in establishing similar internship programs for CI professionals. This evaluation study will collect and analyze data and report to the program coordinators and NSF. Key components of the program (interns and mentors training, seminars, visits and interactions with industry partners in the Research Park) will be evaluated to see if they are operating effectively and how and to what extent they may be improved. Furthermore, to explore the impact and value added of participating in the CIP activities, the evaluation will survey all interns after participation in the program.



Top left: Fall 2017 CIP intern, Yogesh Bhandari, who worked with ISDA (Innovation Software and Data Analysis).

Above: CIP PI Daniel Lapine explains about Blue Waters during a recent tour.

Below: Fall 2017 CIP intern Vikram Mudaliar, who worked with NCSA's Incident Response and Security group.

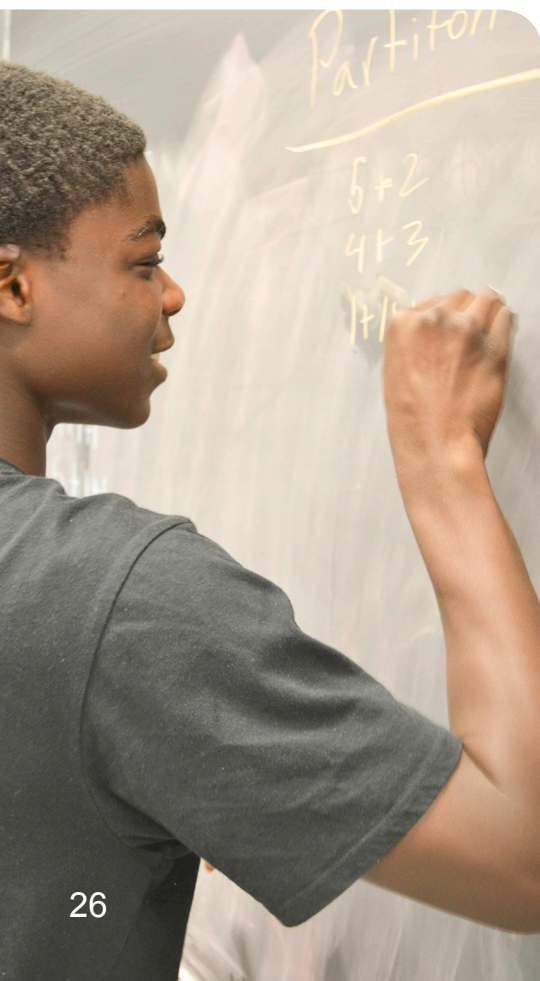
Bottom left: Pranav Baitule, a Fall 2017 CIP intern who worked with NCSA's Incident Response and Security group.





Above and below: UHS students do math activities during Math Day at I-STEM's summer camp.

Bottom right: Geometric shapes being used to express mathematics principles.

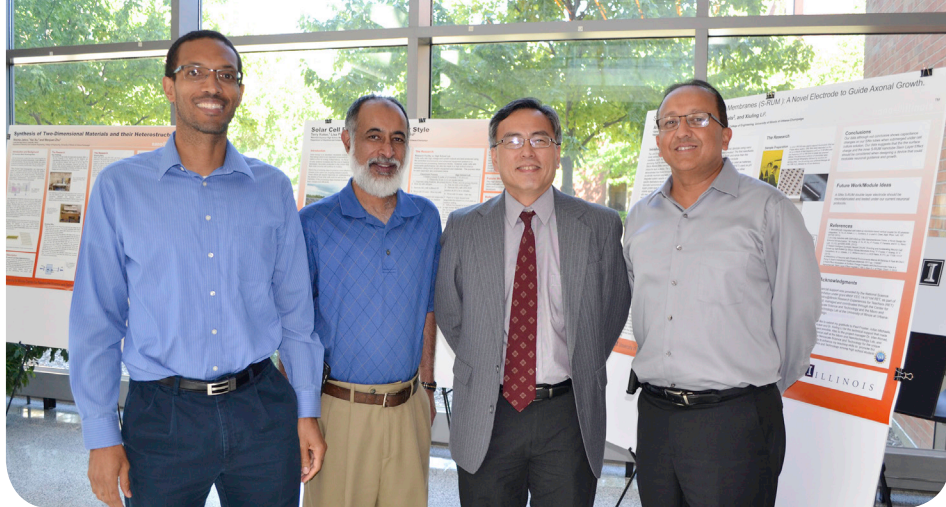


★ Illinois Mathematics and Science Academy (IMSA)

Fusion. I-STEM is evaluating IMSA's Fusion project, a teacher professional development and student STEM enrichment program for Illinois grade 4–8 students who are talented in, interested in, and motivated by mathematics and science. Fusion places a special emphasis on students historically underrepresented in those areas. The 2017 evaluation activities consisted of a review of curriculum documentation, securing IRB approval for the study, and visits to observe professional development (PD) at IMSA. By design, the IMSA Fusion curriculum is inquiry based, problem centered, and integrative. Learning experiences focus on helping students “learn how to learn” and emphasize logic, mathematical thinking, and experimental scientific thinking. Topics relate to students' lives, thereby arousing their curiosity and increasing their motivation to learn in mathematics and science. Teachers from each participating school are supported with on-going professional development for the delivery of the curriculum and use of appropriate pedagogy. This evaluation study is designed to provide the FUSION PD program's management and IMSA Office of Professional Field Services leadership with valid, useful information to guide improvement and assess effectiveness and impact of the FUSION interventions on teachers' practices. Key components of the program (teacher training, interactions with professional development leaders, new curriculum activities implementation, and instructional practices) will be evaluated to see if they are operating effectively and how and to what extent they may be improved. Furthermore, to explore the impact and value added of participating in FUSION activities, the evaluation will survey teachers, mentors, and trainers after participation in the program.

The significance of the study results from identifying quality teaching practices and the ways teachers develop instructional activities, pedagogical strategies, and curriculum to encourage URM students (underrepresented minorities) to pursue STEM careers. Overall, the evaluation will contribute to the development of quality teacher professional training in STEM disciplines. During the first year of the study, a multi-case evaluation study of 6 to 10 schools/sites is being considered to describe and understand the essentials of each school and, in particular, how the implementation adheres to the objectives of the PD program.





★ **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 2017 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.

★ **POETS Research Experience for Teachers (RET).** POETS' RET program brings STEM middle school and high school teachers to the POETS partner universities, where they focus on either research, curriculum development, or a combination, with the goal of impacting students vicariously through their teachers. At partners where teachers focus solely on curricular development, teachers are being introduced to POETS and its research, then focus on developing a product. Other programs offer more traditional RETs: embedded into a research lab, teachers are trained in laboratory safety, do experiments, analyze data, then give a poster presentation summarizing their research. I-STEM evaluates the POETS RET programs at the participating POETS partner universities.



Top left: (left to right): nano@illinois RET co-PI Lynford Goddard, ECE; Irfan Ahmad, the Executive Director of the Center for Nanoscale Science and Technology and nano@illinois RET Program Manager; nano@illinois RET PI Xiuling Li, ECE; Rashid Bashir, Head of the Department of Bioengineering.

Above: A Uni High student works on a solar car design during a test run of a POETS RET curriculum module.

Below and bottom left: Uni High students presents their teams' research during a poster session as part of the heat pipes curriculum that Uni High chemistry teacher David Bergandine developed for his nano@illinois RET project.



Wick Structures in Heat Pipes
Testing wicks made of cloth, aluminum

Design and Testing

- Variable: wick inside of the heat pipe
- 2 "control" pipes:
 - Only air
 - Water without a wick
- 3 kinds of pipe with wick:
 - Copper mesh
 - Aluminum
 - Cheesecloth
- Tried testing in sand first to combat steam
- Didn't work so we used water with a covering against steam

Measurement

- Each pipe 24cm long
- Filled each pipe with 120g of water
- Wick sizes:
 - Aluminum & copper: .7cm x 24cm
 - Cheesecloth: 1cm x 24cm
- Measured temp. with temp probes attached to top of pipe


Explanation

- Thermal energy is absorbed at hot end
- This energy is used to heat water

Table:

Pipe Length	Ethanol (mL)	Temp. v. Fake Pipe
10 cm	0.44	Same
20 cm	0.88	~ 14°C
30 cm	1.31	~ 3°C
40 cm	1.75	~ 40°C
50 cm	2.19	N/A

Conclusion: The longer the heat pipe, the more water it can hold, and the more water the pipe will hold, the shorter heat pipes, when water condenses.

A young woman with brown hair tied back, wearing clear safety goggles and a maroon zip-up lab coat, is smiling at the camera. She is holding two small, clear plastic vials with white caps. The vial in her left hand contains an orange liquid, and the vial in her right hand contains a yellow liquid. The background is a laboratory setting with shelves and equipment.

I-STEM is working to foster accessible and effective undergraduate and graduate STEM programs and engaging research experiences that promote student success in STEM fields.

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 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 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. In 2017, I-STEM completed a CPLC Climate Study begun in 2016, and also assessed student satisfaction with a large Biology course, IB 150 (see page 34). I-STEM also met with decision makers from several units to plan future climate studies.

✦ 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 (see page 36) and Research Experiences for Undergraduates (see pages 30–41) have used to increase student support.

Table 2: Selected Undergraduate/ Graduate STEM Education Programs I-STEM Evaluated in 2017

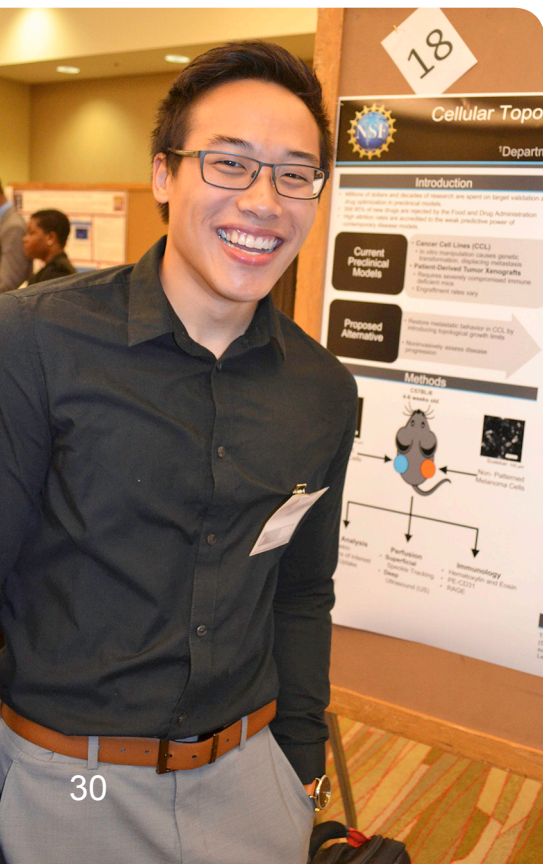
Project	PIs
Bioimaging REU	Marina Marjanovic
IDEAS	Ripan Malhi
Inclusion REU	Daniel Katz
Integrative Biology 150	
Merit Fellows Scholarship Program (S-STEM)	Jennifer McNeilly
Network for Computational Nanotechnology– NanoBIO Node	Umberto Ravaioli
NIH R-25 Suretox	Rowana Nowak
POETS: Center for Power Optimization of Electro-Thermal System	Andrew Alleyne
nano@illinois REU	Cathy Murphy
PIRE	Narayan Aluru
Sustained-Petascale In Action: Blue Waters Enabling Transformative Science And Engineering: Blue Waters Community Education	Bill Kramer
T-35 SRTP: (Summer Research Training Program), NIH	Lois Hoyer
Toxicology	Sue Schantz
USDA ELI REEU: WE CAN REU	Paul Davidson



Above: 2017 Bioimaging REU undergrad, Janee Phillips, by her poster at the Illinois Summer Research Symposium.

Bottom right: Bioimaging REU participant Than Huynh (right) and his grad student mentor, Jamila Hedhli.

Below: Bioimaging REU participant Than Huynh by his poster at the Symposium.



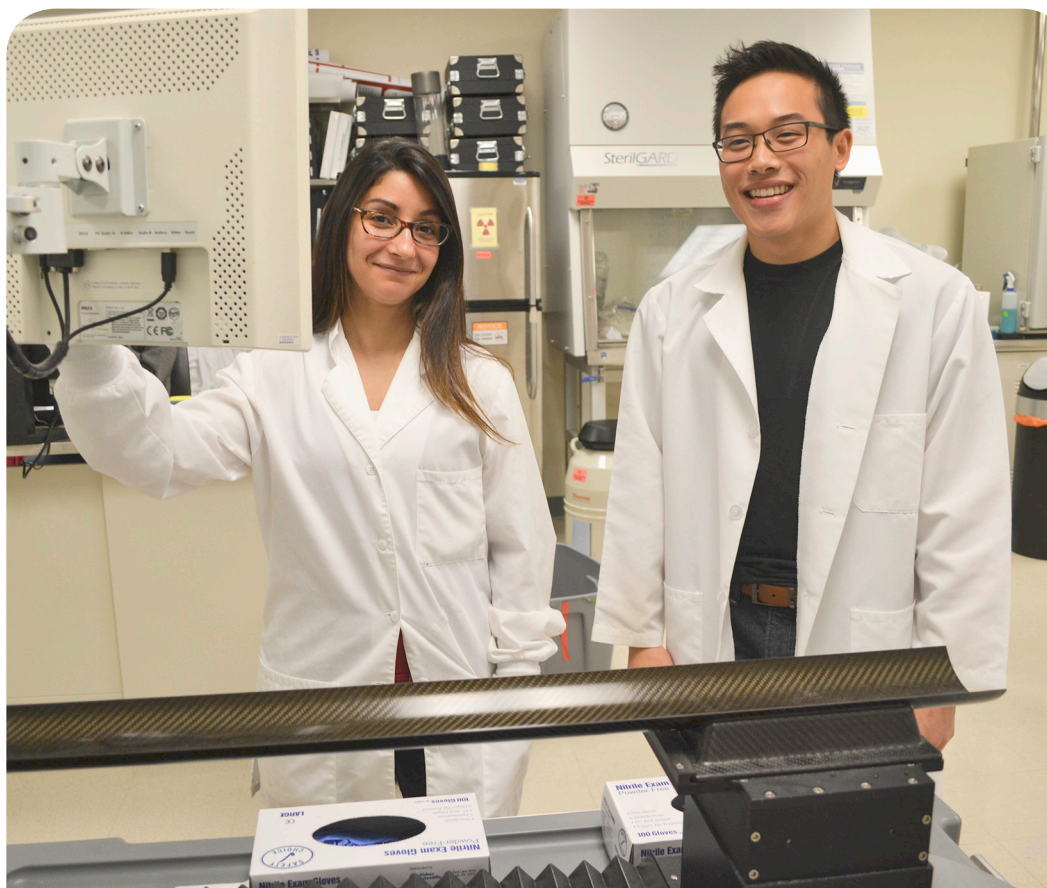
◆ Evaluate and analyze undergraduate and graduate STEM education reform projects.

I-STEM identifies strengths and gaps in campus STEM academic programs to assist in developing effective, scalable, and sustainable STEM education models. STEM departments have implemented both campus- and externally-funded reform projects. In 2017, I-STEM conducted evaluations of several of these, including several REUs.

Research Experiences for Undergraduates. Research Experiences for Undergraduates (REUs) have been found to increase the number of students choosing STEM careers. I-STEM evaluated six summer research experience programs for undergraduate students in 2017. Three were official REU sites funded through the National Science Foundation's REU (Research Experiences for Undergraduates) program and engaged a number of students in research. These included the Bioimaging REU, the Nano@Illinois REU, and NCSA's Inclusion REU. I-STEM also evaluated an NIH-funded research experience, SURE Tox, and a USDA-funded ELI REEU. POETS, an Engineering Research Center, also offered an REU as one of its STEM education components. I-STEM also began an evaluation of I-MRSEC in 2017, which will offer a Materials Science REU in 2018.

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

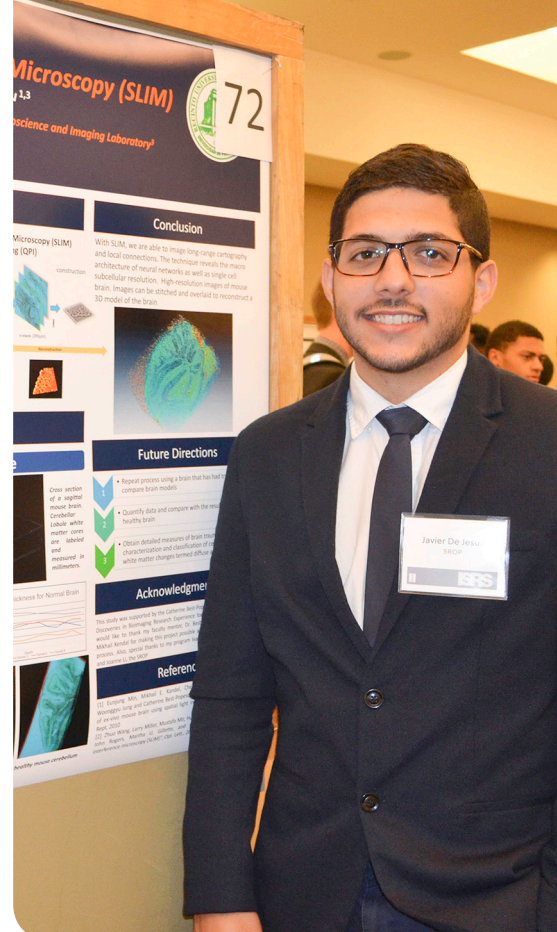
To ensure adequate funding to support undergraduate and graduate STEM education reform for consistent, sustained, high-impact programming, I-STEM encourages units to apply for educational improvement resources from major external funders. In 2017, I-STEM was involved in several grant submissions seeking to improve undergraduate and graduate STEM education (see page 7). I-STEM also supports faculty via a variety of mechanisms (see page 2).



UNDERGRADUATE/GRADUATE STEM EDUCATION PROGRAMS/INITIATIVES

★ **AAPA Increasing Diversity in Evolutionary Anthropological Sciences (IDEAS).** The IDEAS NSF-funded project proposes to improve diversity in Anthropological Sciences through targeted mentoring and outreach to minority communities. One of the main IDEAS workshop objectives is to match undergraduate and graduate students with faculty mentors of similar interests and to include professionalization modules and networking activities throughout the meeting that will allow the participants to meet a variety of researchers at the conference in an engaging manner. These mentoring groups serve as the formal unit of support structure for the IDEAS program. In 2017 all participants (students and faculty) indicated that they would recommend the IDEAS workshop to other students and will remain 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, developed a better understanding of biological anthropology, and that “speed mentoring” groups offered more opportunities to obtain responses to relevant career questions.

★ **Bioimaging REU.** Discoveries in Bioimaging Research Experience for Undergraduates (REU) is a 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 2017 evaluation found that the program components with which participants were most satisfied included their research projects, professional development/ supplemental programs, and networking opportunities.



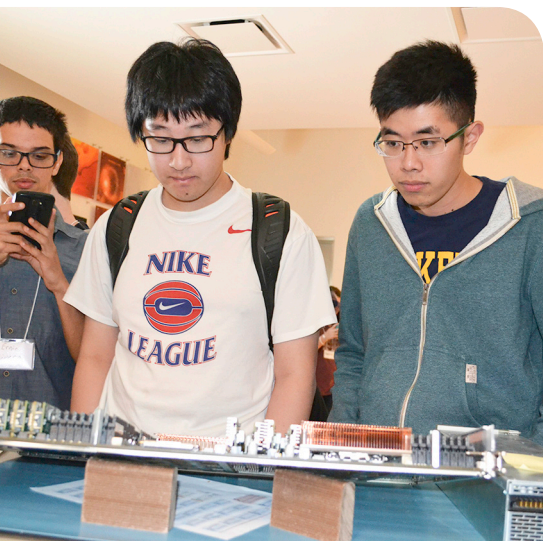
Above and below: Bioimaging REU participants present their research at the Illinois Summer Research Symposium.

Bottom left: Bioimaging REU participant Carolyn Quiles exhibits some of the work she did in Professor Rohit Bhargava's lab.





Above and below: 2017 Blue Waters interns learn about the Supercomputer during a tour of the Petascale Institute.



Below: Blue Waters Interns learn about HPC during the Blue Waters Symposium.

★ **Blue Waters.** In 2017, I-STEM evaluated the Community Engagement programs for *Illinois'* Blue Waters Supercomputer. Using surveys, interviews, and focus groups, I-STEM assessed the quality of Blue Waters' education outreach components and also collected data from PIs, symposium, and workshop participants. Following are the 2017 evaluation results:

- **Internship Program.** The 18 new Blue Waters interns participated in the 2-week Blue Waters institute at NCSA in June 2017, providing feedback via daily surveys regarding communication with instructors and level/quality of the content. During a focus group, interns expressed high satisfaction with the content, research opportunities, and program benefits, and appreciated their exposure to NCSA professionals, instructors, and hands-on lectures. Four 2016 interns who presented their research in poster sessions at the 2017 Blue Waters symposium agreed that their research experiences and the practical, hands-on time with their faculty advisors during the past year had been very valuable. They appreciated the year-long internship compared to a summer internship because it had allowed them to work on larger projects. They suggested more communication with Shodor instructors and sharing their progress with other interns during the year.
- **Fellows Program.** I-STEM evaluators held a focus group with the 2016 fellows during the 2017 Blue Waters symposium to find out about program impacts on their research/career plans, expected support from the program, and their experiences as Blue Waters fellows. The fellows said the opportunity had added other fields/perspectives to their degrees and allowed them to demonstrate their work well, regardless of where they were in their degree programs. All agreed that attending the symposium was useful and had enabled them to network with some key people.



- **Point-of-Contact Focus Group.** I-STEM evaluators held focus groups with eight points of contact (POC). POCs reported that their role is providing support for technical problems, that working effectively with the fellows requires cooperation between the team members, and observed that the Blue Waters fellows are uniquely motivated and talented. Regarding the program's impact on the fellows, POCs reported that this opportunity would be a great booster for fellows' future careers and their research progress and that having a face-to-face meeting with fellows at the beginning of the program was very helpful for both them and the fellows to understand the project and plan the year together.
- **PI Interviews.** Evaluation staff conducted phone interviews with about 37 PIs in order to assess satisfaction with Blue Waters' impact on research/education and glean suggestions for improvement. Respondents uniformly expressed high satisfaction with Blue Waters' services and cited significant positive impact on productivity and research quality. Respondents described Blue Waters as "a revolutionary concept in "user-focused design and support." Across all disciplines, PIs also reported that access to Blue Waters had "greatly accelerated" their science. In no case was Blue Waters engagement cited as negative, plus 85% of PIs believe that Blue Waters is necessary to their research.
- **User Survey.** Evaluators surveyed about 650 active Blue Waters users regarding their satisfaction with Blue Waters services (system usability, functionality, system features, etc.) Users could also submit suggestions regarding using Blue Waters.
- **Virtual School.** In February of 2017, I-STEM evaluators reported results of a focus group held with nine faculty who had taught Blue Waters' Virtual School courses in 2016. Faculty indicated that courses had been positive learning experiences for students, had enabled locations with limited resources to offer higher-level classes without extensive development efforts; had helped students applying to graduate school; and reported that aspects of the courses were easy to implement and that they had received quick updates and feedback from core faculty. Faculty suggested improvements, such as TA grading support, increasing the capability of their training account, and clarifying course prerequisites. Additional suggestions included adding a community-building component, building in more flexibility in courses, offering the courses in a two-year cycle, and making course information more easily accessible.
- **2017 Blue Waters Symposium.** The external evaluation team conducted post event surveys at the Symposium to evaluate the experiences of participants, who were very highly satisfied with their overall experience, responding that the symposium was well organized and that their goals for attending the symposium had been achieved. They noted that "collaboration opportunities" and "Engaging with Blue Waters staff" were the most important resources offered, and suggested future improvements: inviting more diverse participants and having more bi-directional discussion time



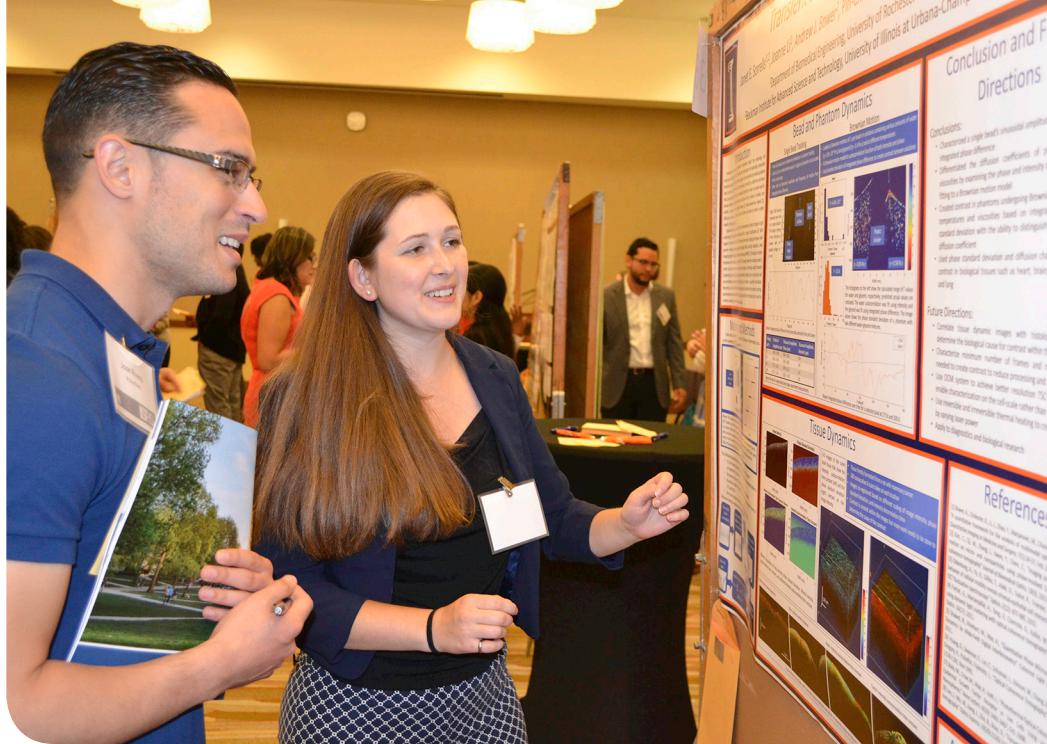
Above: Blue Waters Intern Monet Alberts from Boise State University during the Blue Waters Institute.

Below: A Blue Waters intern examines a sample of cable used for the Blue Waters supercomputer.





Above: An INCLUSION REU participant presents her research at the Illinois Summer Research Symposium.



Above right: A Bioimaging REU participant explains her research to an Illinois Summer Research Symposium visitor

Below: Andrew Smith, co-PI of the Bioimaging REU.



over presentations.

★ **Biology Climate Study.** In 2017, 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. 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.

★ **BRIDGE Seed Fund:** A collaborative, inter-institutional, multidisciplinary project. The expanded availability of computer-aided mathematics and the development of proof assistants was aimed to represent a paradigm shift in learning and doing research in mathematics. However, computer-aided mathematics almost exclusively means computer algebra software which adds to instruction and small research experiments but does not cover proofs, thus exposing learners to mathematical techniques without access to deeper understanding that comes with proving theorems. Building upon complementary expertise, BRIDGE “Interactive Theorem Provers Assessments: Bridging Research and Instruction Practices in Mathematics Formalization” project brings together research teams in Computer Science (Grigore Rosu, Illinois), Mathematics (Corneliu Hoffman, Birmingham University), and Education (Luisa-Maria Rosu, I-STEM, Illinois) to bridge the existent gap by developing common strategies and tools in mathematics formalization.

Project goals are twofold: 1) to introduce proof assistants to mathematical instruction and help develop automated assessments for more sophisticated mathematics courses beyond mere computer algebra, and 2) to bring together mathematicians and computer scientists with the aim of using automated theorem provers directly in mathematical research. The project aims to establish a multidisciplinary partnership that will evaluate current methods of automated reasoning in software engineering and theoretical

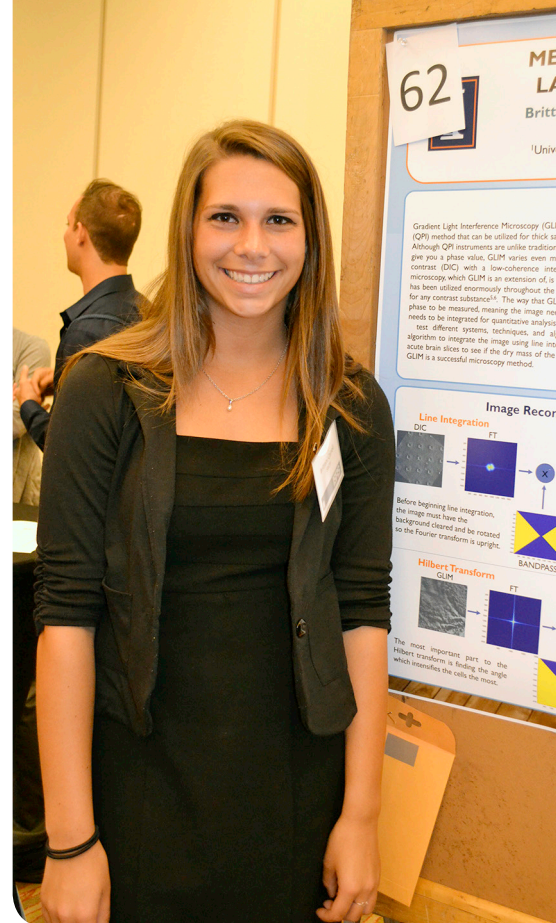


computer science and advance the use of interactive theorem provers in mathematics research and instruction.

★ **The Center for the Physics of Living Cells (CPLC) Climate Study.** CPLC, an NSF Physics Frontiers Center, aspires to make transformational advances at a genuine scientific frontier. I-STEM's evaluation study sought to inform CPLC leadership and administration about the Center's climate and necessary education programming changes. Evaluators administered a survey to assess CPLC members' perceptions of experiences and satisfaction. Members reported that affiliation groups and the reputations of faculty were the main factors influencing their participation in CPLC. Members had gained increased confidence in their abilities and understanding since working with CPLC and had benefitted from CPLC's symposiums, seminars, outreach instruction, and teaching for K-12. Members perceived the Center's climate to be very positive; a majority had never heard insensitive or disparaging comments about specific groups. Overall, postdocs, research associates, scientists, and graduate students rated their research advisor(s) highly, and those who had taught in CPLC's Summer School met or exceeded expectations of themselves, their students, and CPLC faculty. Faculty reported being satisfied with their experiences in the CPLC.

★ **Illinois Materials Research Science and Engineering Center (I-MRSEC).** I-MRSEC's mission is to perform fundamental, innovative research on understanding the dynamic properties of materials, with applications to societal needs, and to support interdisciplinary education and training of students in materials design, understanding, and application, particularly targeting students from underserved and underrepresented communities. The scope of the proposed research and education goals and the associated challenges require the multidisciplinary, collaborative effort of a Center whose vision is to be a world leader in multidisciplinary materials research that has broad scientific impact across many fields and to serve as a Midwestern hub of excellence in materials research, innovation, education and outreach. The science of the Center will form the basis for new technologies in electronics, information storage, photonics, and biomaterials.

- MRSEC's Education, Human Resource Development, and Diversity (EHRD) program will be integrated with research and partnership activities to increase interest, knowledge, and skills for



Above left: CPLC Postdoc Caitlin Davis shows an Urbana High student how diffraction works during I-STEM's 2016 DNA Day event.

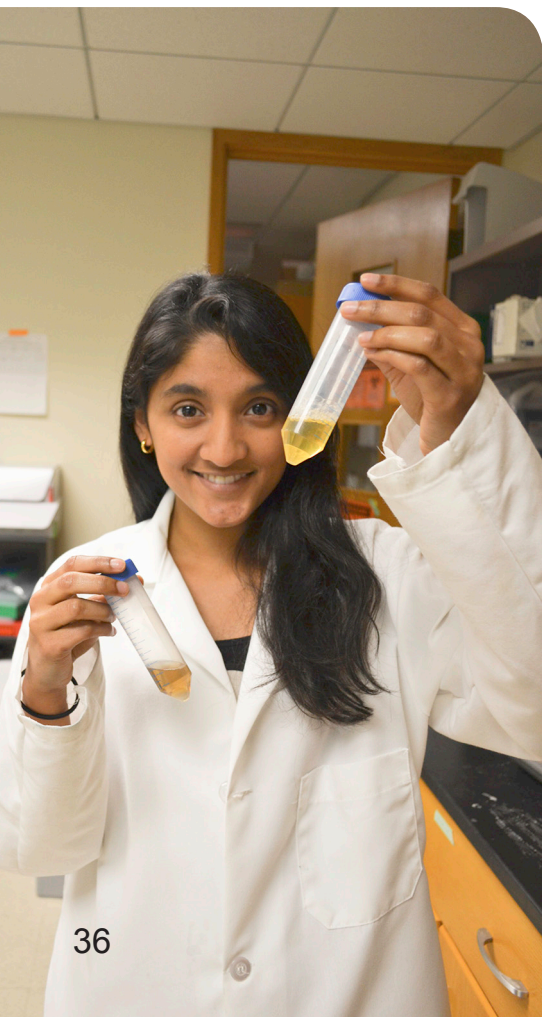
Above: Brittani Carroll by her poster at the 2017 Illinois Summer Research Symposium.

Below: Mechanical Science and Engineering Assistant Professor Sungwoo Nam, a member of the I-MRSEC interdisciplinary team seeking active interfaces between highly deformable nanomaterials.





Above and below: Two undergraduate students who got to experience research in *Illinois* labs over the three years of the Nano@*Illinois* project.



students at many levels, particularly targeting students traditionally underrepresented in STEM. I-MRSEC will provide opportunities for teachers and students in rural and underserved schools to participate in materials science research and interact with Center PIs and students. I-MRSEC will include materials science activities in Science Olympiad for the first time to stimulate interest in the field among students nationwide. The REU program will seek to transition undergraduates to STEM graduate programs or high-tech industrial jobs. An annual Materials Science Boot Camp will enhance connections between academia, industry, and national labs. I-MRSEC will train graduate students and postdocs in both research and professional development to produce scientists with the skill and knowledge to push the boundaries of materials science research in industrial and academic environments.

- I-STEM's evaluation of MRSEC's EHRD activities will include evaluation planning, data collection, and analysis and will seek to provide both formative information to guide program improvement and a summative assessment of its effectiveness and impact.

★ **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. In 2017, I-STEM evaluators revised the evaluation instruments and submitted an IRB amendment.

★ **Nano@*Illinois* REU.** I-STEM evaluated this REU, which sought to provide a highly effective, interdisciplinary research experience for undergraduates in nanotechnology. In its third and final year, this NSF-funded REU provided undergraduate students a 10-week summer program of team-based, research-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. Through surveys, observations, focus groups, and interviews, I-STEM assessed whether the REU had achieved its goal of providing exciting, nanotechnology-related research and educational experiences across a range of disciplines and applications that address many grand challenges facing our world.

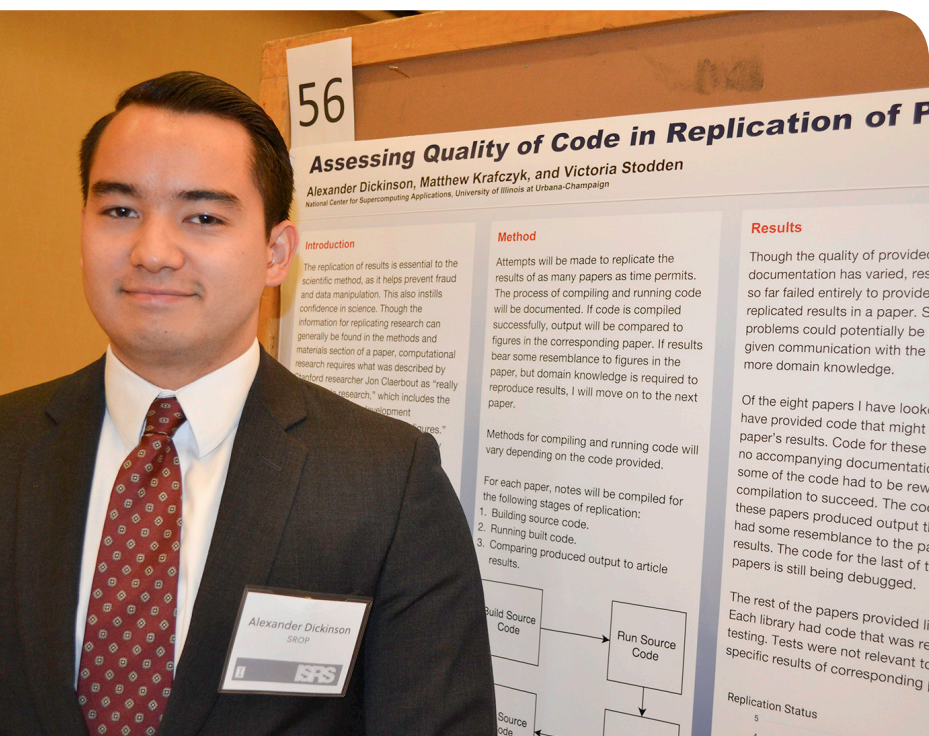
★ **NanoBIO Node.** The NSF-funded NanoBIO Node is a resource for graduate students, postdocs, faculty, and people in industry with research areas related to nanotechnology and bioengineering. A collaboration between *Illinois* and the University of California at Merced, NanoBIO Node offers simulations, web tutorials, webinars, workshops, and other information for nanotechnology and bioengineering researchers. It aims to create a community of researchers and students who use nanoscale tools and methods to drive progress and research in biotechnology, bridge engineering, and biology through strategic partnerships and outreach activities.

I-STEM staff developed a survey assessing the impact on graduate students, post-docs, and faculty members of nanoBIO node's 2-day, Light Matter Interactions Workshop. On average, attendees gave favorable assessments of Day One presentations, with neutral to



Above: INCLUSION REU undergrads who just finished presenting at the 2017 Illinois Summer Research Symposium.

Below: An INCLUSION REU participant, Alex Dickinson, presents his research at the 2017 Illinois Summer Research Symposium.



favorable ratings of those on Day Two. I-STEM evaluators also created a yet-to-be administered NanoBIO Node Community Survey.

★ **INCLUSION REU.** I-STEM evaluates this 3-year, NSF-funded Research Experience for Undergraduates (REU): INCLUSION (Incubating a New Community of Leaders Using Software, Inclusion, Innovation, Interdisciplinary and Open-Science), which trains pairs of students in software skills, leveraging and building upon state-of-the-art lessons. Students work with pairs of mentors on interdisciplinary research projects that develop and use open source software across a wide variety of STEM fields. Their work can lead to research advances, and their project contributes open source tools to the larger scientific community, leading to additional advances. INCLUSION provides interdisciplinary training for undergraduate researchers, facilitating students' professional growth, and preparing them for the STEM workplace, while increasing diversity in the STEM pipeline through engagement in research. I-STEM evaluation activities included an end-of program survey, mid-program focus program, as well



as interviews with participants to capture the impact of the program activities and its effectiveness in creating both formal and informal mentoring relationships.

★ **SURE Tox.** I-STEM evaluates the College of Veterinary Medicine's NIH-funded Summer Undergraduate Research Experience in Toxicology (SURE Tox) for PIs Romana Nowak and Jodi Flaws. SURE Tox provides a 10-week, authentic research experience for seven undergraduate students, also exposing them to advanced degree options and careers in the toxicology fields, with the ultimate goal of increasing the number of students, especially those from underrepresented groups, who pursue graduate school in toxicology-related fields. During the summer of 2017, I-STEM conducted a pre-survey, post-survey, and focus group with the seven students in order to explore participant perceptions of the benefits of SURE Tox regarding a number of areas, such as SURE Tox research topics, conducting research, working in a research team, presenting research, and professional development for budding scientists.

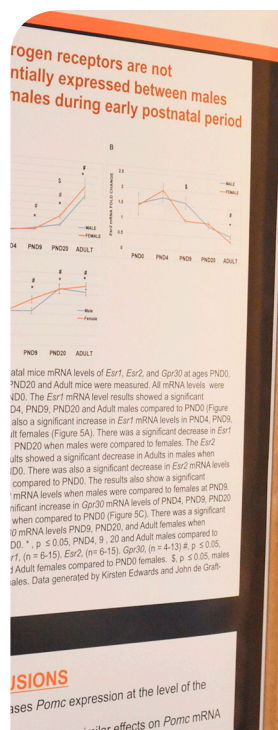
Evaluation findings indicate that SURE Tox allowed participants to gain valuable laboratory skills, learn what graduate school would be like, and develop meaningful professional relationships with faculty, graduate student, and postdoctoral mentors, as well as with one another. Participants attained substantial research skills and were given the ability to explore numerous options scientists have in conducting research. Participants also found that lab research opportunities gave them insight into future careers in



Above left: SURE Tox participant Mario Barenas explains his research at the 2017 Illinois Summer Research Symposium.

Above: Tamia Tolson, a summer 2017 SURE Tox participant, by her poster at the 2017 Illinois Summer Research Symposium.

Below: SURE Tox participant John de Graft-Johnson presents his research at the 2017 Illinois Summer Research Symposium.





Above: POETS REU student Adam Castaneda presents his research at the Illinois Summer Research Symposium.

Below: POETS PI Andrew Alleyne teaches a session during the ENG 198 Personal Mobility Course.



research, thus helping them to make informed decisions regarding their research career paths. Most participants agreed that they had gained a better understanding of toxicology as a discipline and also of interdisciplinary concepts related to toxicology.

- ★ **NIH SING.** Summer Internship for Native Americans in Genomics (SING). SING, a one-week workshop about the uses, misuses, and limitations of genomics as a tool for Native American communities, also trains Native Americans in the concepts and methods currently used in genomics. I-STEM's 2017 evaluation included a pre- and post- questionnaire for each day of the workshop to determine the effectiveness of SING's program as well as an end of program survey.
- ★ **PIRE.** I-STEM evaluates this NSF-funded Partnership in International Research and Education (PIRE) energy program between *Illinois*, Berkley, and Northwestern Universities, and Kyushu University in Japan. During the first two years of the program, 12 undergraduates from *Illinois*, Berkley, and Northwestern visited Kyushu and participated in experimentally-based projects responding to the challenge of energy storage. I-STEM administered pre, post, and follow-up surveys to participants and observed major events and activities throughout the last year: the K–12 outreach training of undergraduate students, x-FU(s)ION first cohort experiences before and after the Kyushu visit (who all agreed that the experience was not only unique, but also extremely formative for their future research careers in energy storage); a visit to *Illinois* by a Kyushu graduate student (who remarked that the most valuable part of his experience was being exposed to the culture of learning in the U.S.); and the PIRE all-hands meeting). Also, I-STEM monitored recruitment of x-FU(s)ION second year cohort of students. Monthly interactions among research groups included not only WebEx meetings, but also were reported as regular research communication exchanges between members of collaborating groups.

Outcomes: Regarding the goal of developing a robust PIRE community interested in research of energy storage, several events attracted additional undergraduate students and researchers besides members of the program and direct participants. Plus, the second year of the x-FU(s)ION undergraduate initiative has been already integrated within the International Programs in Engineering at *Illinois*, thus supporting the institutionalization of program initiatives.

- ★ **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 give freshmen a chance to discover what it's like to be an engineer early on.

Working as part of interdisciplinary teams, they learn 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.

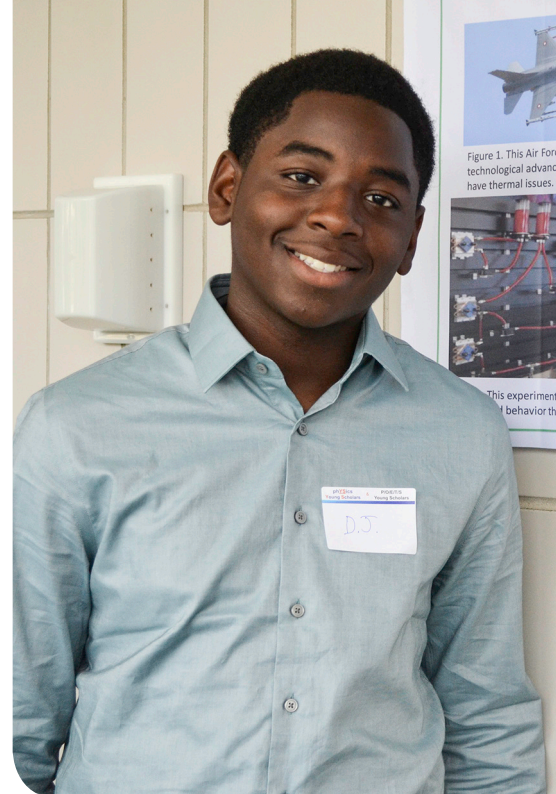
Young Scholars Program (YSP). A summer research program for high school students, YSP was piloted at *Illinois* in the summer of 2017. The program aimed to introduce students to scientific research and promote career opportunities in the field, plus help them gain knowledge in a variety of science applications as well as an understanding of science and its local and global impact. Students indicated that they enrolled in the program to learn about college and because their teachers encouraged them to do so. Students were satisfied or very satisfied with the campus, interactions with their research mentors, and the amount of guidance given. All students found activities about applying to college, whether college might be possible, and the poster session workshop to be useful or very useful.

★ **T35 SRTP: Summer Training in Translational Biomedical Research:** I-STEM evaluated this 10-week, NIH-funded, Summer Research Training Program (SRTP), which seeks to foster *Illinois* veterinary medicine students' interest in research. Project PI Lois Hoyer matched 20 students with faculty mentors who share similar research interests. With their faculty member's help, students planned and conducted research projects and participated in weekly seminars to explore available careers and be trained in research ethics and compliance and scientific writing. Students contributed to an end-of-the-program poster session at *Illinois*; many also presented at the NIH Veterinary Scholars Symposium.

★ **Transdisciplinary Obesity Prevention Research Sciences (TOPRS).**

TOPRS sought to develop and implement a transdisciplinary curriculum for undergraduate students that focused on the causes and consequences of childhood obesity. The curriculum's "flip-the-classroom" format had 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 indicated 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



Above: POETS Young Scholar Darius Jackson presents his research at the Young Scholars Poster Session on July 28, 2017.

Bottom right: A Veterinary Medicine student who participated in the SRTP program presents her research at an end-of-summer poster session.



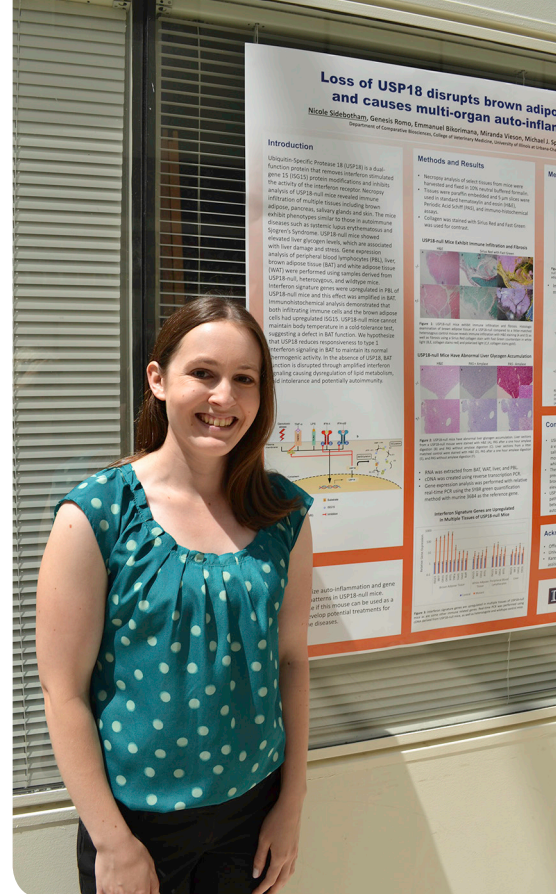
while taking the course did not necessarily influence them to change their major, it did impact how they viewed and thought about obesity; demonstrated significant gains in content knowledge throughout and at the end of the course semesters; and were satisfied with what they learned throughout the course.

★ **Toxicology.** I-STEM conducted an online survey with former CMBB Environmental Toxicology Traineeship participants who had completed the program at least one year prior in order to learn about former trainees's current occupations plus obtain their reflections on the traineeship. Over one third of respondents currently work as assistant or associate professors. Survey respondents were either satisfied or very satisfied with the toxicology traineeship, and indicated that the traineeship had provided them with: 1) opportunities to present and publish research, 2) networking opportunities that led to future employment, 3) collaborations with researchers at *Illinois* and other research and academic institutions, 4) learning skills for effective communication of their research, and 5) the training to identify important concepts and research questions that would be the most pertinent within toxicology.

★ **USDA ELI RE EU: WE CAN REU.** The goal of the 3-year USDA ELI RE EU fellowship program, WE CAN REU, is to cultivate leaders in agriculture by providing undergraduate students with unique, multi-disciplinary skills bridging global food security, agri-ecosystems, and technology via an immersive, two-year experience. Scientific research often lacks interdisciplinary collaboration; engineers and biologists are typically isolated and work in "silos," resulting in a gap. This program aims to bridge this gap and break down cross-discipline communication barriers by bringing together undergraduates from diverse backgrounds via a 2-phase internship. Summer I will provide undergrads with initial exposure and training in co-management of natural resource conservation and agricultural engineering. Summer II fellows will participate in SRORP, *Illinois*' Summer Research Opportunities Program, where their individual interests and skills will be channeled into independent research mentored by *Illinois* faculty, with students networking with USDA personnel through seminars.

I-STEM's evaluation seeks to provide the grant's PIs valid, useful information to guide improvement and assess program effectiveness and impact. Evaluators administered online pre and post student surveys, plus held focus groups for students, faculty/mentors, volunteers, and staff in order to understand baseline participation; retention rates; perceptions; and the experiences of all participants.

According to Year 1 evaluation findings, participants found the program organization and structure to be effective; however, some were dissatisfied with receiving their first stipend late. Participant satisfaction with



Above: Nicole Sidebotham, a third Year Vet Med student who says she was able to gain a better understanding of how she can make research part of her career through SRTP.

Below: A grad student tests his team's solar oven during a STEM outreach visit at POETS' 2017 NSF Site Visit.

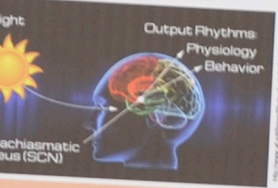


Impacts Impulsivity and Attention: Neural Mechanisms in Long-Evans Rats

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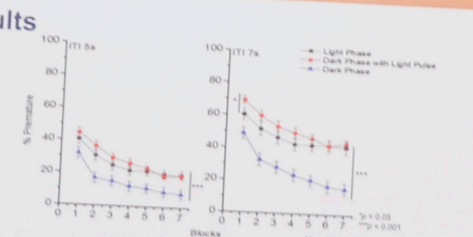
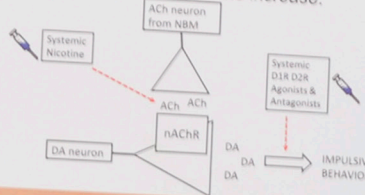
and circadian rhythms (via SCN), while the basal ganglia (NBM) modulates cholinergic input to the SCN and provides cholinergic input to other brain regions (including the PFC). Studies show that there may be a bidirectional relationship between ACh and DA.⁵ In the PFC, the NBM binds to nicotinic subtypes of receptors (nAChRs), stimulating DA neurons to release DA.⁴ Therefore, we hypothesized that resulting from circadian disruption is an ACh-DA interaction.



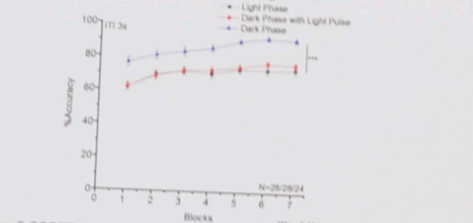
Aims

1. Study the effects of 2 forms of circadian disruption on attention and impulsive behavior
 - Hypothesis: Both forms of circadian disruption will cause decreased attention and increased impulsivity.
2. Use pharmacological challenges to study the interactions between cholinergic and dopaminergic neurotransmitters and their effect on attention and impulsive behavior
 - Hypothesis: Nicotine will increase impulsive behavior and SCH 23390 will attenuate the increase.

Interactions in prefrontal cortex:



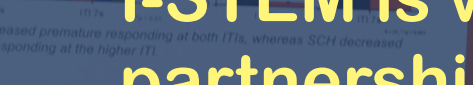
are responding on 5-CSRTT for the 3 models of circadian disruption. Dark control rats had significantly lower premature responses. The dark phase with light showed the poorest performance at the longest ITI.



on 5-CSRTT for the 3 models of circadian disruption. The control condition showed significantly greater accuracy. Same results for ITI 5 and 7s.



Increased premature responding at both ITIs, whereas SCH decreased responding at the higher ITI.



and with nicotine, SCH attenuated the effect of nicotine on impulsivity.

Conclusions

- Both models of circadian disruption showed poor attention and increased impulsive behavior when compared to the control. The light-at-night model showed greater impulsivity than the shift work model. This suggests that artificial light-at-night may be more harmful to cognition than overnight shift work.
- Pharmacological challenges with a nAChR agonist and a D1R antagonist helped us understand how circadian disruption affects impulsive behavior. Nicotine, which increases DA release, caused an increase in premature responding, while the antagonist SCH 23390 reduced impulsive behavior. When combined with nicotine, SCH attenuated the effect of nicotine on impulsive behavior. These results suggest that D1Rs have a role in impulsivity and that cholinergic signaling interacts with the DA system to influence impulsive behavior.
- The next step in this investigation will be to perform pharmacological challenges under all three light conditions to see if there is a differential effect of light condition on impulsivity and drug response. If so, this will provide additional evidence that the proposed mechanism explains how the cholinergic manipulation of circadian disruption affects attention and impulsivity.

Acknowledgments

- National Institutes of Health (NIH) Grant R01DA016191
- University of Illinois Research Board RB16191
- Arlene Ow and Eubig lab undergraduates

References

1. Siegel, A., et al. *Prog Brain Research*, 190, 119-133 (2010)
2. Siegel, A., et al. *Learning & Memory*, 16(3), 126-141 (2013)
3. Chellappa, et al. *Prog Brain Research*, 190, 119-133 (2010)

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 STEM Education Policy and Advocate for Support

STEM EDUCATION POLICY AND ADVOCACY ACTIVITIES

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

In 2017, I-STEM staff members continued to network at the local, state, national, and international levels to promote STEM education and advocate for STEM education programs and resources.

On the local level...

I-STEM staff regularly met with campus administration and researchers from various colleges or departments and presented at unit-level meetings.

On the state, national, and international levels...

- ★ **AAU DC Washington: Undergraduate STEM Education Network Conference.** I-STEM Interim Director Luisa Rosu participated in this conference held in Washington, DC on October 2–3, 2017, which convened approximately 125 faculty members and administrators from AAU institutions who are involved in efforts on their campuses to improve undergraduate teaching and learning. Attendees had the opportunity to showcase their efforts and learn about the work of others, discuss common themes and challenges, and build relationships across institutions. One conference session provided attendees with the opportunity to learn strategies to effectively communicate the impact and importance of their work to policy makers and the public. On Tuesday, October 3rd, faculty members and university leaders from institutions participating in the conference met with congressional staff and/or members in order to discuss the value and impact of efforts to improve the effectiveness and quality of introductory STEM courses occurring on the various campuses. It was also an opportunity to highlight STEM efforts and to report the national need to address future STEM workforce needs by attracting and retaining more STEM majors.

◆ 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 worked with the Association of American Universities (AAU; see above), to address STEM workforce needs and how American universities can address those, as well as the Illinois Mathematics and Science Academy, evaluating IMSA's Fusion STEM enrichment program (see page 26).



Above: A UHS student learns to use a pipette during a hands-on activity during the I-STEM Summer Camp's MCB Day.

Below: A UHS student enjoying MCB Day during I-STEM's Summer Camp.

Opposite (page 28): Bridget Clancy, second year Vet Med student.





Above: MCB Ph.D. student Mara Livezey (right) watches a student perform a Polymerase Chain Reaction (PCR).

Top right: SURE Tox participant John de Graft-Johnson presents his research at the 2017 Illinois Summer Research Symposium.

Bottom right: A UHS student uses a microscope to view some samples in the IGB's training lab.

Below: Arunita Kar, an ECE grad student, helps a UHS student doing a hands-on activity during the I-STEM Summer Camp's ECE Day.



◆ 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.

◆ 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, 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 (see page 2). 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 page 2).



STEM EDUCATION POLICY/ADVOCACY PARTNERS, PROJECTS, AND EVENTS

★ **University of Bucharest Conference.** Dr. Luisa-Maria Rosu spoke at the University of Bucharest Conference, “Education for Future: Scenarios and Resources” on Friday, May 12, 2017. The keynote speaker, she presented “The Role of Evaluation in Promoting Diversity in STEM Educational Programs in the USA.” The conference is a forum for professionals in the field of education to exchange ideas about contemporary issues in education and stimulate students and their academic interests, and is meant to be a platform for communication and sharing as a basis for future professional communities in the field of education. The collaboration between the University of Bucharest and the University of Illinois will continue to foster students and professionals sharing study and research interests.

★ **National Conference of Community Science Education.** Dr. Luisa-Maria Rosu was the keynote speaker at the 2nd edition of this conference held in Bucharest, Romania in November 2017, which sought to promote “the integration of research results into practice.”

Under the Office of the President of Romania, the meeting gathered education experts, renowned professors in STEM disciplines, and members of several EU research institutes, policy decision makers in schools and at the government level, as well as non-governmental EU organizations such as: European Institute of Innovation and Technology, Research & Development, ORT Israel, and European Training Foundation. The meeting included key speakers, round tables, workshops, and visits to the National Institute for Laser, Plasma, & Radiation Physics. The scope of the 2017 event was to discuss the integration of research experiences in both sciences and education with current instructional and teaching practices.

I-STEM Interim Director, Luisa-Maria Rosu, was one of the keynote speakers. Her presentation was intended to introduce inspiring information about approaches and experiences related to the development of STEM education to the audience of educators, students, and decision makers in education policy as she presented the development of the summer pilot outreach research multidisciplinary program as a model of the integration of STEM research into K–12 education.



Above: I-STEM Interim Director, Luisa-Maria Rosu presents presents “The Role of Evaluation in Rromoting Diversity in STEM Educational Programs in the USA.”



Above, below, and bottom left: I-STEM Interim Director, Luisa-Maria Rosu presents her keynote address at the National Conference of Community Science Education in Bucharest, Romania.





I-STEM RESOURCES

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

Below: I-STEM Summer Camp Director, Joe Cross, prepares to fly his rocket.



I-STEM STAFF

- Luisa-Maria Rosu, I-STEM Interim Director. Projects: PIRE, IDEAS, R25, Mathways, POETS
- Dominic Coombs, Graduate Research Assistant. Projects: Nano@Illinois RET, CPLC Physics of Life Experience (POLE)
- Joseph Cross: I-STEM PostDoctoral Researcher: Project: I-STEM Summer Camp Director
- Gabriela Garcia, Graduate Research Assistant. Project: Transdisciplinary Obesity Prevention Research Sciences (TOPRS).
- Elizabeth Innes, Communications Specialist. Projects: I-STEM website, I-STEM Magazine, I-STEM Annual Report; edit, format, and publish all evaluation reports.
- Emily Loveland, Graduate Research Assistant. Project: Mathways.
- Marlon Mitchell, Graduate Research Assistant. Projects: POETS REU, POETS Learning Community, Bioimaging REU, Nano@Illinois REU
- Youngshil Paek, Research Scientist. Projects: CPLC, POETS, Transdisciplinary Obesity Prevention Research Sciences (TOPRS).
- Leah Peoples, Graduate Research Assistant. Projects: Mathways, SRTP
- Maggie Phan, Graduate Research Assistant. Project: NanoBio Node
- Debby Ann Reynolds, Office Support Specialist
- Christine Shenouda, Research Specialist. Project: CADENS
- Jung Sung, Visiting Research Specialist. Projects: Blue Waters, IB150
- Ron Threadgill, Graduate Research Assistant. Projects: Nano@Illinois RET.

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.

- Kristina Allen (fall 2017). A junior in Anthropology with a concentration in Human Evolutionary Biology and a minor in Integrative Biology, upon graduation, Kristina plans to attend graduate school and do research.
- Megha Bamola (summer 2017).
- Ashley Chung (summer 2017).
- Ericka Victoria Hamm-Gordils (spring 2017).
- Sanjay Kalidindi (spring 2017). Sanjay graduated in May 2017 with a degree in Electrical Engineering and a minor in Statistics.
- Myungjin (Jenny) Kim (spring, summer, and fall 2017). A senior in Statistics, Myungjin would like to work in the field of data analytics or statistical consulting.
- Payal Malik (spring and fall 2017). A senior in Economics, Finance, her career goal is to be the chief economist of some small, open economy (top right).
- Nick O'Connell (fall 2017). A sophomore in mechanical engineering with a minor in computer science, after Nick completes his Bachelor's degree, he plans to work for in the R&D department of a big technology company.
- Patrick Pavilonis (fall 2017). A junior studying Middle Grades Education with concentrations in both math and science, Patrick hopes to teach either math or science at the middle school level in the Chicagoland area following graduation.
- Alexandria Peltier (spring and summer, 2017). A May 2017 graduate, Alexandria majored in Statistics with a minor in Informatics.
- Quin Ramirez (summer 2017).
- Preeti Veena Subramaniyan (summer 2017).
- Megan Sullivan (spring, summer, and fall 2017). A Mathematics major (bottom right), Sullivan graduated in December of 2017 and will work on the data science team at a digital transformation agency in Chicago in 2018.
- Baicheng Wang (summer 2017).

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 2017; some were funded externally, such as by NSF and NIH, which requires evaluations for its projects. Climate studies, such that done for the Center for the Physics of Living Cells, were funded internally by the units themselves. Additionally, I-STEM completed several pro bono projects in hopes that these might become a source of revenue in the future.



Above: I-STEM undergraduate student worker, Payal Malik.

Below (Left to Right): I-STEM undergraduate student workers Kristina Allen and Meghan Sullivan.





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