Promising Models for Private Sector Engagement in STEM

Testimony to the U.S. House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Research and Technology Hearing:
"Private Sector Initiatives that Engage Students in STEM"

Kemi Jona, Ph.D.
Professor, Learning Sciences and Computer Science
Director, Office of STEM Education Partnerships
Northwestern University

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Good morning members of the committee. My name is Kemi Jona. I am a Professor of Learning Sciences and Computer Science at Northwestern University and serve as the Director of the University's Office of STEM Education Partnerships. I am honored to be here, and I would like to thank both Ranking Member Dan Lipinski and Chairman Larry Bucshon for inviting me to testify today.

The mission of the Office of STEM Education Partnerships (OSEP) is to connect K-12 teachers and students to the world-class science, technology, engineering, and math resources of Northwestern University and beyond. Since I founded OSEP in 2006, we have grown to a staff of 13 including scientists, education researchers, curriculum development specialists, software engineers, and experienced K-12 educators. In that time, we have developed valuable insights and promising models for working with scientists and engineers (in both academia and industry) to engage students in the excitement of STEM fields. Further, I hope to share some of our lessons learned in how to do this in a way that is effective and efficient for these busy STEM professionals.

My testimony today will focus on three university, school, industry, and community partnership models we have found successful in engaging industry partners in STEM education initiatives and that bring the excitement of real world STEM fields to K-12 teachers and students, both in and out of the classroom. I begin my testimony with a brief background on OSEP and conclude with some lessons learned and recommendations for the committee consideration regarding strengthening the broader impacts policy at NSF.

As you will see from the examples presented, my key message to the committee is that what has been missing from the recent discussions about the proper role of federal STEM policy and funding is a recognition of the importance of creating robust dissemination mechanisms that support the scalability and sustainability of those high quality STEM education programs developed with federal or private sector support. One reason that we have seen such an explosion in the number of apps available on our smartphones is that the Apple and Android app stores are such powerful yet easy to use distribution platforms. To really engage students with high quality STEM education, we need the leadership and support of both the federal

government and the private sector to create the distribution platform for STEM education resources. We have begun this work in my home state of Illinois, as I will share with you next.

The Office of STEM Education Partnerships at Northwestern University

Founded in 2006, the Office of STEM Education Partnership's (OSEP, osep.northwestern.edu) mission is to connect K-12 students and teachers to the STEM resources of Northwestern University and beyond. Our goal is to develop university, school, industry, and community partnerships that advance K-12 STEM education. In order to achieve this goal, OSEP serves as a bridge between these diverse stakeholders to help leverage, maximize, and effectively utilize resources and expertise, build capacity, and catalyze cooperation. Through this work we are able to develop and implement innovative teaching and learning programs and technologies that close the gap between authentic STEM research and practice and K-12 STEM education.

Housed within the School of Education and Social Policy at Northwestern University, OSEP consists of 13 full-time staff including scientists, education researchers, curriculum development specialists, software developers, and experienced K-12 educators. We engage Northwestern University faculty from across the university in our work and partner with them to develop scalable and sustainable 'broader impacts' plans and activities as part of their federal grants from the National Science Foundation (NSF). This work helps to integrate current, cutting-edge STEM research and practice and K-12 education while deepening Northwestern University's connections with Chicagoland communities.

Internal, baseline funding for OSEP is provided by Northwestern University's Vice President for Research and the Dean of SESP while external funding comes from diverse federal, private foundation, and corporate grants.

In 2013, 37% of OSEP's funding came from federal grants, 28% from corporate grants and gifts, 26% from private foundations, and 9% from internal university support.

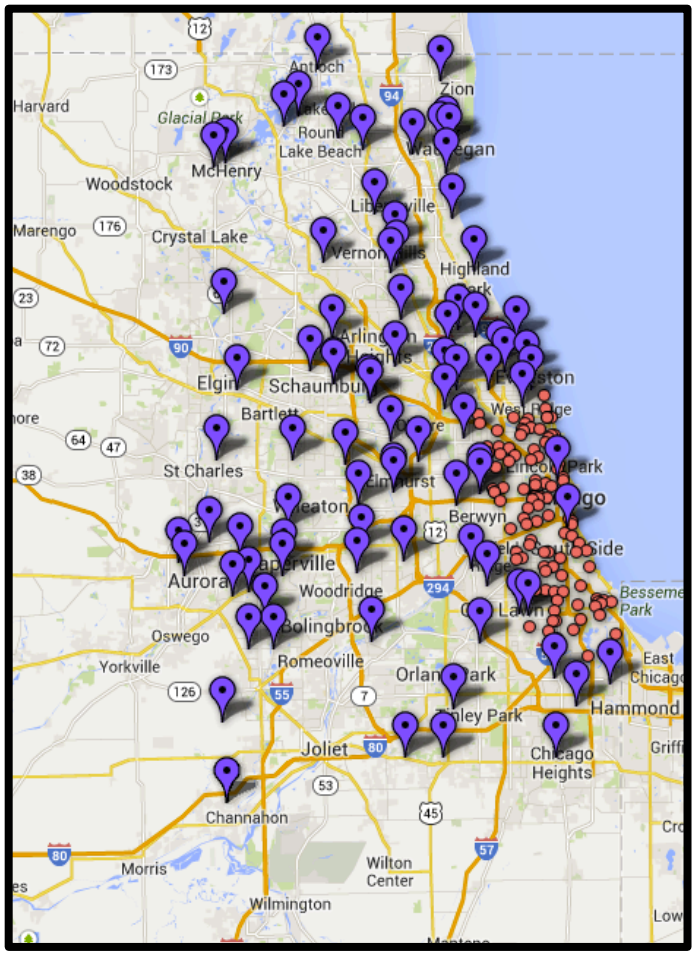
External funders include:
Federal: NSF, National Institutes of Health (NIH)
Corporate: Baxter International Inc., The Boeing Company, Google, Hewlett Packard's Catalyst Initiative, IBM, Motorola Mobility, Motorola Solutions, and Siemens Industry Inc.
Private Foundations: John D. and Catherine T. MacArthur Foundation and Jaquelin Hume Foundation

OSEP Network of Schools

- **A growing network of over 200 Chicago-area schools**
  - » 600+ teachers
  - » Approximately 48,000 students

- **110 Chicago Public Schools**

(Shown in red on map)
  - » 300+ teachers
  - » Approximately 25,000 students



OSEP Programs

OSEP's **11 different programs** focus on teacher professional development (PD); STEM curriculum development; out-of-school time STEM learning; and the design and integration of learning technologies in the K-12 classroom. Our work focuses not only on the development, implementation, and evaluation of STEM education programming but also learning sciences research that helps to advance the understanding and practice of STEM teaching and learning.

OSEP's work is largely focused on the Chicagoland area however some of our programs, including the NSF-funded iLabs Network that provides online access to real laboratory equipment housed at Northwestern and other universities globally, are serving teachers and students all over the U.S. and around the world.

One of OSEP's signature programs is the **Institute for STEM Teaching and Research at Northwestern University (iSTAR@NU)**. This PD institute for middle and high school teachers provides STEM curricula, learning technologies, lab equipment and computer loaner programs, and in-classroom coaching and online resources to teachers throughout Illinois. OSEP works with numerous Northwestern faculty and industry partners to develop content and programs for iSTAR@NU and fund its operation. iSTAR@NU corporate sponsors include Baxter International Inc., The Boeing Company, Google, Hewlett Packard's Catalyst Initiative, Motorola Solutions, and Siemens Industry Inc.

In 2013 OSEP offered 13 different PD opportunities in a variety of different STEM content areas including environmental and earth sciences; computer science and engineering; biotechnology; and science communication. PD opportunities for teachers through iSTAR@NU include research and job shadowing experiences; workshops on new STEM curricula and technologies; symposia; and online courses. The demand for teacher PD continues to be high.

Participation in iSTAR@NU more than doubled from 155 to 320 between 2012 and 2013. These teachers are reaching an estimated 25,000 students.

iSTAR@NU is unique as it provides PD **plus** the support and resources needed to successfully implement innovative, research-based STEM education materials and most importantly, inspire and excite students. OSEP has an established track record of bringing innovation from university research and industry labs to the classroom in a way that other PD providers do not, thus helping teachers build content knowledge and keep current on modern STEM practices. The PD and in-class coaching and online resources also help teachers enhance their pedagogical skills and connect with and learn from other educators. The Next Generation Science Standards have a particular emphasis on incorporating authentic scientific practices and engineering design as cohesive strands through all science content courses. Importantly, iSTAR@NU works towards these goals in integrating cutting-edge research, content, and practices into everyday science learning. OSEP experience and current research on PD has shown that sustaining innovation in STEM classrooms requires all of the components provided by iSTAR@NU.

OSEP Partnerships

Partnerships are central to OSEP's work. Partnerships with Northwestern faculty, industry, schools, and community organizations enhance OSEP programs and provide real-world learning experiences in STEM for teachers and students. OSEP staff specializes in merging research and workplace-based STEM content knowledge and practices with the pedagogical expertise related to best practices in STEM teaching and learning.

The goals of our partnership initiatives vary. However, all of our work seeks to:

- Strengthen the collaboration between university, industry, and K-12 for STEM (science, technology, engineering, and math) education
- Enrich the current scope and impact of STEM at the middle and high school levels
- Increase student and teacher access and reach into STEM research and practice
- Firmly anchor education efforts in STEM in the best practices of teaching and learning
- Increase student awareness of and enthusiasm for STEM careers in both industry and academia.
- Illustrate through local examples of industry work in Illinois and university research at Northwestern, the diverse STEM career options available.
- Increase equity in STEM education, being mindful of both the achievement gap and barriers to careers in science.

How OSEP's Experience Can Inform Private Sector STEM Education Initiatives: Three Models

Working with diverse partners has led to the development of innovative program models that are invigorating teachers and exciting students about STEM. Below are some examples that showcase this partnership work at OSEP.

Model #1: Catalyzing Industry Partnerships with Schools for Scalable and Sustainable Impact on K-12 STEM Education

OSEP is currently working with 8 different industry partners in the Chicago area including Baxter International Inc., The Boeing Company, Google, Hewlett Packard's Catalyst Initiative, IBM, Motorola Mobility, Motorola Solutions, and Siemens Industry Inc. OSEP is also supporting Mayor Rahm Emanuel's 5 new Early College STEM Schools (ECSS) in Chicago Public Schools (CPS) by providing program and curriculum development support and expertise, mentoring programs, and teacher professional development opportunities to ECSS administrators, faculty, and students.

A leading example of our industry partnership activity is our work with **Baxter International Inc.** to support the **Biotechnology Center of Excellence (BCoE)** at Lindblom Math and Science Academy (LMSA), within CPS and located on the southwest side of the city. **While the BCoE is located at LMSA, it provides PD to teachers district-wide. The BCoE works to build capacity and a community of practice and provide lab equipment and teaching and learning resources focused on biotechnology education across CPS.**

The partnership's signature program, the *Biotechnology Professional Development Series,* provides biotechnology curriculum, lab equipment, research experiences, and a Biotechnology Symposium to teachers and connects them to world-class research scientists from Northwestern University and Baxter International. **This series launched in 2012 and 52 teachers from 28 different schools participated that year. Participation soared in 2013, more than doubling to 116 teachers from 87 schools. These teachers are reaching over 13,000 students.**

The Biotechnology Series includes 4 PD opportunities for teachers.

1. **Biotechnology Launch Symposium.** This daylong event, held at Northwestern University, kicks off the series. Teachers have the opportunity to listen and learn from acclaimed scientists from Baxter and Northwestern as they discuss their cutting-edge, biotech-focused research; tour state-of-the-art research facilities at the university; and experience hands-on biotechnology curriculum models led by experienced educators.

Teachers also receive lab equipment for their classrooms at the symposium. In 2013 **Baxter Chairman and Chief Executive Officer, Mr. Robert L. Parkinson, Jr., was the keynote speaker** (see photo at right). Parkinson was instrumental in establishing Baxter's Science@Work: Expanding Minds with Real-World Science education initiative that supports teacher training and student development in healthcare and biotechnology.

When asked to evaluate and comment on the Biotechnology Symposium, one teacher responded: "*Thank you for putting together today's Biotechnology Symposium. It definitely was a breath of fresh air to be out of the classroom to gain knowledge and experience all the while learning new tweaks to keep my students enticed and inspired in the world of STEM. I look forward to the summer trainings at Northwestern University with Baxter.*"

2. **Survey of Biotechnology**. Teachers engage in hands-on PD that incorporates biotech lab skills, recombinant DNA, forensics, proteins, and bioinformatics.

3. **NUBIO** (Northwestern University Biology Investigations in Oncofertility). Teachers learn 6 lab modules that bring cutting-edge cancer biology research from the bench to their classroom.

   *****Both Survey of Biotech and NUBIO provide teachers with lab equipment and resources to support classroom implementation of the lab modules.

   Teachers have made following comments when asked about the value of both Survey and NUBIO to their teaching and professional development:
   "I increased both my knowledge and skill base. Getting a jump-start by having supplies to take back to the classroom helps to avoid budget as a reason not to do a lab is awesome! Also, now I have such a great group of people to work with and count on for support during the school year."

   "I acquired confidence in skills and equipment that I haven't used in a long time and knowledge about research being done right now. I am excited to have my students use these skills!"

4. **Research Lab Experiences**. Teachers are immersed in research lab experiences that connect them with both Baxter and Northwestern University biotechnology research. In addition, teachers collaborate with scientists to write curriculum materials based on their lab experiences. This unique opportunity focuses on helping teachers to bridge bench research and their classroom teaching.

   From one teacher who attended multiple offerings through the Series: "*Thank you so much for the great enrichment experiences you made possible for us. I learned so much, and during the next several months my students will benefit tremendously from all of this learning and the resources you made available for us.*"

Importantly, NUBIO was developed in partnership with Dr. Teresa Woodruff from Northwestern's Fienberg School of Medicine and funding was provided by NIH Administrative Core (UL1RR024925, Administrative Core, Woodruff, P.I.) and R25 grants (RL5CA133836, R25, Jona P.I.) and 3RL5CA133836-02S1, R25 Administrative Supplement Grant, Jona P.I.).

NUBIO was conceived at the intersection of authentic scientific research and the high school classroom. NUBIO's purpose is to create lab-driven discovery of core biology content through the context of Dr. Woodruff's research on oncofertility. Oncofertility, a term in which Dr. Woodruff coined, translates reproductive biology, biotechnology, and biomedical engineering research to the clinical care of preserving fertility for cancer patients undergoing treatment.

OSEP's partnership with Dr. Woodruff and her team of scientists has also created a sophisticated web platform for students and teachers who are using NUBIO in their classrooms. The site includes videos and other resources that support the labs and student learning. Students can also connect with scientists who research oncofertility, find out more about topics and concepts they are studying, and find tips to help with the biotech techniques in the lab. (nubio.ci.northwestern.edu). The NUBIO lab modules have been developed into a full high school biology course that is being implemented at Lakes High School in Antioch, Illinois and Lindblom Math and Science Academy.

Model #2: Illinois Pathways: A Platform for Aggregating and Disseminating Statewide STEM Education Resources and Industry Engagement

Illinois Pathways (http://www.ilpathways.com), funded through Race to the Top, is a new and innovative State of Illinois-led STEM education initiative designed to support college and career readiness for all students. Supported by a partnership between the State of Illinois' education and economic development agencies, Illinois Pathways supports new statewide, public-private partnerships known as STEM Learning Exchanges. Each of the nine STEM Learning Exchanges is developing a network of statewide partnerships (between schools, industry, state government, and non-profits) that better coordinate investments, resources, and planning in STEM industry sectors that are crucial to economic development in Illinois and better utilize industry and public resources. The Exchanges are focused on delivering resources and supports for local pathway systems, to help local schools make clearer and more comprehensive connections with e-Learning and curriculum resources, lab space and equipment, teacher development, and student organizations that foster engagement between schools and the workplace. To that end, the Exchanges are simultaneously focused on expanding work-based learning opportunities for students and communities, to facilitate more job-shadowing and internship opportunities, as well as industry sponsored challenges which directly engage students with industry leaders.

The Illinois Business Roundtable, an organization made up of CEOs and other senior leadership from over 60 of the top businesses in the State, has been a key driver of Illinois Pathways. Each Exchange has active engagement from a broad array of industry partners, which includes sponsoring student competitions, providing student internships, and participating in curriculum development. This initiative has been instrumental in bringing together previously uncoordinated industry, university, and school participation in STEM and the Learning Exchanges are focused on both consolidating and broadly disseminating the partnership work. The Learning Exchanges were launched with $2.3 million in Race to the Top funds, and that was used to leverage $8.5 million in public and private matching funds. See the appendix for supplemental material on Illinois Pathways.

In 2012 OSEP joined the Illinois Science and Technology Institute (ISTI) in their efforts to improve and expand student STEM research opportunities through the Research and Development Learning Exchange (RDLE). The RDLE is a true public-private partnership. More than forty private businesses, not-for-profits and civic institutions collaborated to support the development of an organization that received a seven-year grant of $950,000 ($430,000 guaranteed, $520,000 subject to additional federal funding) from the Illinois State Board of Education (funded via Illinois' Race to the Top grant). To support this grant, ISTI committed to match $100,000 in cash to seed the RDLE, and private partners have committed an additional $117,000 in matching funds in just the first year of operation of the RDLE. In addition, coalition partners have committed programs, support and staff time worth in excess of $1,000,000 to the RDLE.

RDLE coalition partners include private industry partners like Comcast, AT&T, Astellas, Abbvie, Abbott Labs, Baxter, Eaton, Kraft Foods, Takeda, GTL Resources, Northrop Grumman, Google, Motorola Solutions, Willdan Energy Solutions, and Wrigley. Not-for-profits and civic institutional partners include the Shedd Aquarium, Chicago Zoological Society, Brookfield Zoo, iBio Institute, ISTI, and Chicago Coalition for Science and Technology, as well as the State's two National Research Laboratories, Argonne National Lab and Fermi Lab. University partners include major research universities like Northwestern University, University of Chicago, IIT, University of Illinois, Loyola University, and Northern Illinois University.

The RDLE is in its first year of "beta-test" operation, with programs in place with fourteen schools (a map of all Illinois school districts involved across all the STEM Exchanges is provided in the appendix). The RDLE is currently providing three core services, which will include running six science challenges (which will touch more than 400 students at all fourteen schools), building a repository for regional R&D opportunities (available at www.stemlearningexchange.org), and building and hosting the Mentor Matching Engine (MME), an online resource designed to pair students and private industry mentors to conduct independent student-driven research in STEM fields.

As key partner in the RDLE, OSEP provides professional development for teachers and opportunities for high school students to showcase their research projects and network with undergraduates and graduate students at Northwestern. To date, and with funding from the Motorola Solutions Foundation, OSEP has provided over 60 teachers with the STEM Student Research Facilitation Course. Through this course teachers learn about in-school and out-of-school models for student research programs and acquire tools for implementing student research at their schools. These teachers are reaching over 5,000 students in Illinois.

Through research programs, students are able to experience the real world practice of science for themselves. They can develop their own research questions; design the project; conduct investigations and experiments; analyze data; write up and present the results to diverse audiences. Teachers are facilitators, guiding and supporting the student experiences, but the projects are student-driven. These programs offer many students their first opportunity to fully engage in inquiry-based experimental design, research methods, design thinking, and analyses of STEM research and practice. Through these research programs, they improve their understanding of the nature of science and develop important skills, such as critical thinking, problem solving, communication, collaboration, and creativity. Often referred to as 21st Century skills, these are essential to both college and career readiness and success and broader STEM literacy. When asked about the most important things she learned through a research program at her school one student responded:

> *"One of the best things this (research) experience provided me with is **grit**. Learning how to solve problems and figure things out, ask good questions, and keep going and trying…this grit is what will help to make me successful in college and in a job. It also taught me how to work with others on a team and how to talk about what I learned and why it is important."* (2013 STEM Summit, Stevenson High School, Student Panel)

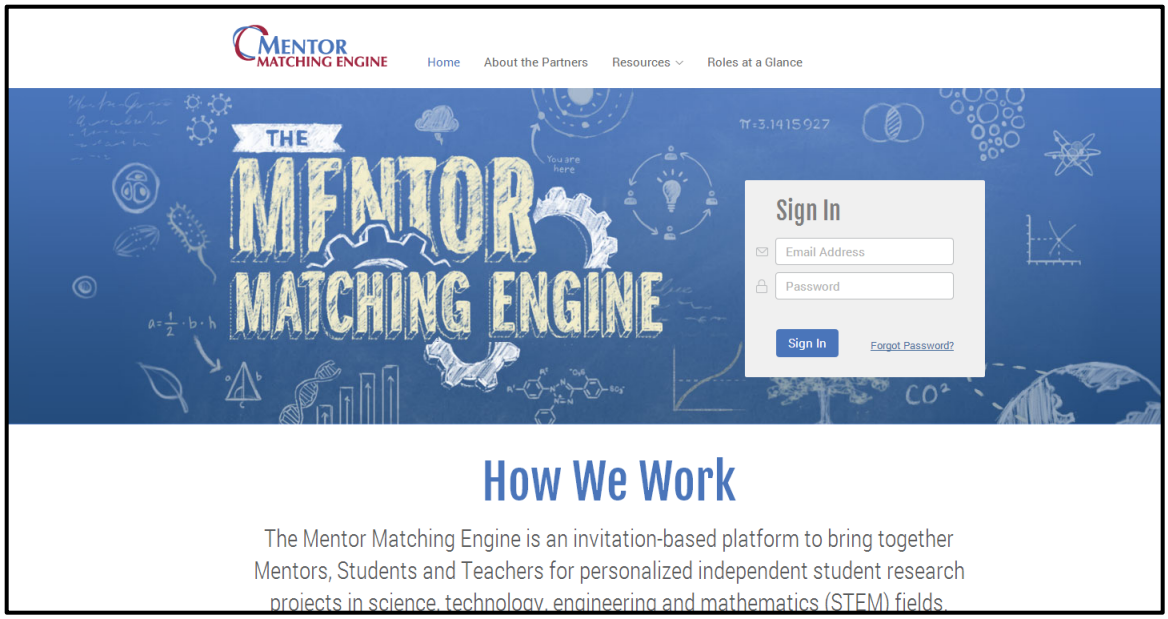
Through research programs students are also guided and supported by STEM professionals. These mentor relationships are essential to successful research projects, as STEM professionals serve as the subject matter experts. These professionals also provide students with ongoing relationships that further support a desire to learn, investigate, discover, and innovate. They create a real-world connection to what a practicing scientist or engineer does every day and the many career paths in STEM. Importantly, research has shown that students who have the opportunity to engage in hands-on scientific research in conjunction with real-world scientists and engineers are significantly more likely to enter and maintain a career in science when compared to students who did not have those opportunities (Roberts and Wassersug, 2009).

When asked about his research experience, another student responded:

> *"I learned more from doing my project and this program than I have ever learned in any of my other classes. It made engineering come to life for me. Every student should have this opportunity." (2013 STEM Summit, Stevenson High School, Student Panel)*

Finally, student research programs directly align with and support the new Next Generation Science Standards (NGSS) and its focus on practices. To quote the NGSS framework, "scientific practices are the behaviors that scientists engage in as they investigate and build models and theories about the natural world. They also include practices of engineering, which are the behaviors that engineers engage in as they apply science and mathematics to design solutions to problems." A focus on practices clarifies for students the relevance of the four STEM fields to everyday life, and engaging in these practices helps students become successful analytical thinkers who prepared for college and careers. High school research programs not only provide opportunities for students to learn these practices, but also to actively engage in the range of cognitive, social, and physical practices that true "inquiry" requires.

In order to support the ongoing development and growth of research programs for students in Illinois, OSEP and the RDLE, along with Illinois Mathematics and Science Academy, are working together to design and test the MME mentioned above. The MME is an online, invitation-based platform that brings together mentors, students, and teachers to collaborate on student research projects focused on the STEM fields. By connecting mentors and students online, the MME offers high quality mentoring experiences for students and mentors alike in a safe and secure environment. It also helps to level the playing field by eliminating geographic and



resource barriers and facilitating access for all students from any school to mentors from diverse STEM fields in industry and academia. The MME also provides industry and their professionals with a low barrier, high impact way to engage in STEM education. The MME is currently being piloted in 14 schools.

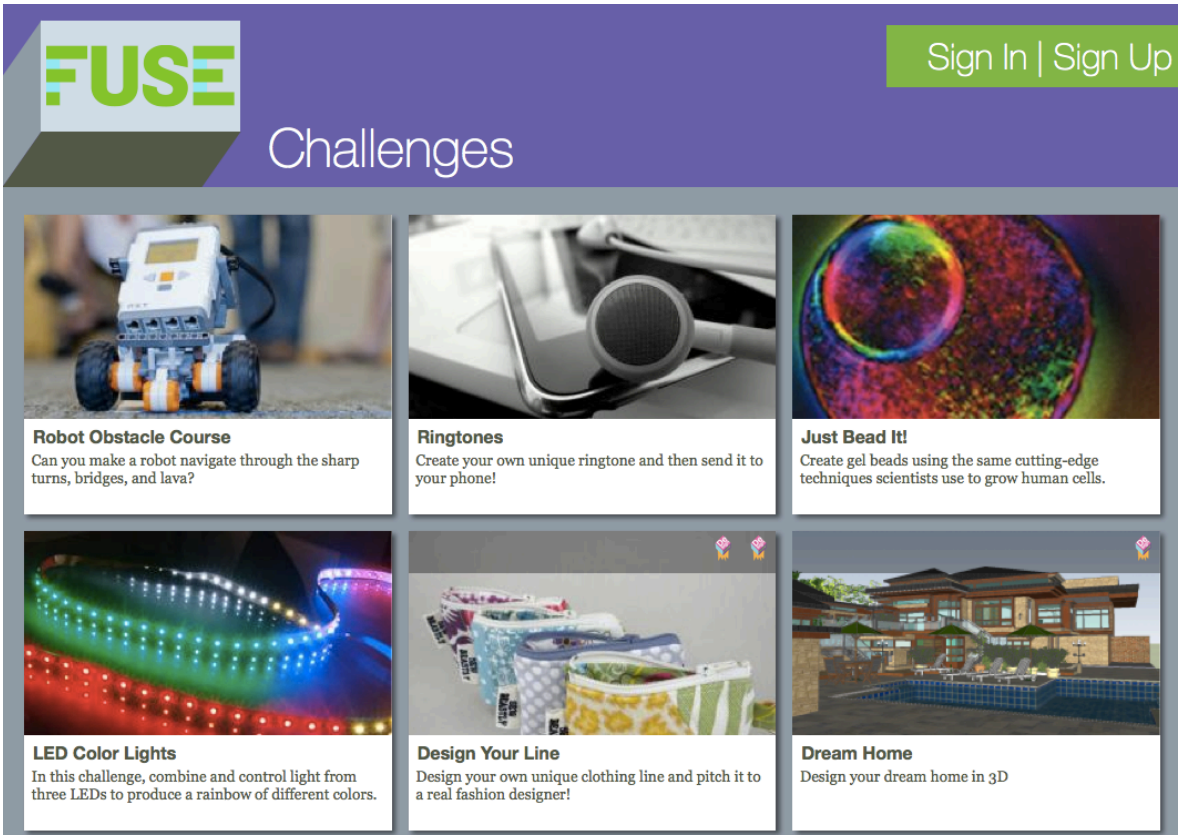
Model #3: FUSE: A modular platform for industry involvement in STEAM education

FUSE is a new kind of interest-driven learning experience being developed by researchers at Northwestern University with the goal of engaging pre-teens and teens in science, technology, engineering, arts/design, and mathematics (STEAM) topics while fostering the development of important 21st century skills including adaptive problem solving, creativity, self-directed learning, persistence, and grit. In particular, FUSE seeks to engage youth who may not yet have developed interests in STEAM fields, or are not already performing at a high level in STEAM, and to do so in more youth-accessible locations—like libraries, community centers, and schools.

FUSE Studios are located at 17 sites around the Chicago metro area in city and suburban public schools and public libraries (see map) and the program is focused on out-of-school time learning. FUSE will reach over 1600 youth in the 2013-4 academic year. There are an additional 23 schools and libraries on our waitlist and new studios will be added as capacity permits.

Challenges are the core activity at FUSE Studios. Each FUSE challenge sequence uses a leveling up model from gaming and is carefully designed to engage teens in different STEAM topics and skills sets. FUSE currently has 20 challenge sequences in areas such as robotics, electronics, biotechnology, graphic design, Android app development, fashion design and 3D printing. New challenges are always in development. See screen shot of FUSE Challenge gallery below.

FUSE is currently working on developing challenges with industry partners. "Challenge-izing" the professional practices of leading industries provides teens with real-world applications of STEAM knowledge and skills. FUSE has built a model for working in partnership with industry on challenge development. In 2012, FUSE collaborated with Motorola Mobility designers to create the Motorola Graphic Design challenge. A partnership with Christopher Duquet Fine Jewelry in Evanston, IL resulted in a very popular Jewelry Design challenge that uses 3D Computer Assisted Design (CAD) tools and 3D printers – exactly the skills needed in engineering design fields. In 2013, the FUSE team designed the Solar Roller Challenge with Siemens' Building Technologies Division and the Northwestern-Argonne Solar Energy Research Center. With the ultimate goal of "mastering the racetrack by getting a solar powered car through tunnels, distance tests, and more," the Solar Roller challenge stimulates youth engagement in and learning about solar energy, energy storage, and electronics. These concepts span physics, mathematics, and engineering and design.



Industry challenges provide teens with a new way to discover and pursue their interests in STEAM fields and to establish a pathway toward STEAM-related activity and study in the future. Industry challenges expose students to the diverse array of career opportunities in STEAM and connect them to real-world problems that scientists and engineers are working to develop solutions for everyday.

FUSE offers industry partners an outreach opportunity that is innovative, creative, and fun. For our industry partners, the modular challenge development format and focus on out-of-school time learning is low-barrier and more productive than focusing on in-school curriculum development that is slow moving and bureaucratic. Industry challenges also provide companies with a unique way to enhance their brand with respect to their corporate citizenship work and FUSE provides the dissemination network as the challenges are offered to schools, libraries, and other partner organizations throughout the city. The goal of FUSE is to engage a diverse body of teens across Chicago, the suburbs, and ultimately the U.S., in challenge-based STEAM engagement and learning.

Lessons Learned: How OSEP's experience can benefit both university and private sector STEM education initiatives

OSEP as a Platform

More than just a collection of individual programs, OSEP provides a *platform* that is built on staff expertise, a growing network of partnerships, and best practice models for STEM teaching and learning. This platform lowers barriers to faculty and industry participation in STEM education and creates new opportunities for engagement and collaboration in STEM education for diverse stakeholders including schools, industry, and universities. OSEP delivers efficiency, increased capability and capacity, and enables greater scalability and sustainability of both new and existing STEM programs. This capacity was initially built to serve internal university stakeholders, but we have seen that it can serve the needs of the private sector equally well.

The OSEP model is built on partnerships for greater impact, sustainability, and scalability in STEM education. As a bridge builder, convener, translator, and catalyst for and between diverse stakeholders, we are able to effectively align efforts and interests, maximize resources and expertise, leverage existing assets and mobilize additional support, and utilize and further grow existing networks and partnerships.

While well intentioned, the diverse stakeholders OSEP serves, especially university faculty and industry, face many challenges to engagement in K-12 STEM education. These challenges include:

- Lack of K-12 experience and expertise
- Broad cultural divide between K-12, industry, and higher education
- Industry and university scientists and engineers are experts in their disciplines, not education, program design & delivery, and evaluation
- Lack of capability, efficiency—enthusiasm for outreach does not equate to capability
- Significant differences in time, financial resources, and organizational capacity
- Schools and school districts are very large, complex organizations—difficult to navigate as an outsider and build effective partnerships
- Partner relationship building is extremely time intensive
- Sustainability and scalability

OSEP has developed the expertise to overcome these challenges and contribute to partnership and program development that can enhance both university and industry involvement in K-12 STEM education. Below is a summary of OSEP's assets and capabilities as developed from our experience in developing partnerships to improve K-12 STEM teaching and learning.

- OSEP has particular expertise on its team of educators, researchers, and software developers in **translating authentic, "bench" science research into high quality curricula for middle and high school STEM education**. OSEP is focused on making the cutting-edge science accessible and relevant to teachers and students. OSEP staff has the capability to merge the science content knowledge with the pedagogical expertise related to best practices in science teaching and learning and brings direct connections to academic and industry research scientists to teachers and students. Furthermore, OSEP has the experience and capability to evaluate the

impact of its work and collaborations through data collection and analysis of the effects on teachers and students.

- OSEP has built a **model to effectively partner with and maximize the expertise and resources of both Northwestern faculty and industry partners**. OSEP can leverage and has access to tremendous resources at Northwestern University. These resources include expertise in teaching and learning within the SESP; over 2,500 STEM faculty across the Weinberg College of Arts and Sciences, McCormick School of Engineering and Applied Science, and Feinberg School of Medicine; state-of-the-art facilities; and the buying power of a top university with respect to scientific equipment, technologies, and materials. OSEP also has in-depth experience in working with a growing network of different industry partners. OSEP serves as a bridge to connect very different groups—teachers, Northwestern faculty, and industry—who have little experience working together to build authentic STEM teaching and learning programs and materials.

- OSEP has **an extensive, and constantly growing, network of teachers and schools.** This network is key to not only recruiting teachers to participate in our professional development programs but also to help us understand and meet the needs of teachers and students as we refine current programs and develop new ones. This network also facilitates easy distribution of programs and materials and supports scalability to many more teachers and students

- OSEP has **in-depth experience in program development, implementation**, **and evaluation** with over 11 STEM teaching and learning programs currently being implemented across the Chicago area, Illinois, and around the world. OSEP programs include those that focus on the development of new curricula and learning technologies to out-of-school time projects that seek to engage and educate youth who have not yet developed interests in STEM.

  OSEP is constantly working to identify, understand, and meet the needs of teachers and students. For example, our *STEM Student Research* program was developed alongside teachers who requested a PD program on how to implement independent student research in high schools. OSEP sought funding, developed the course, and is now offering the PD each summer and fall. It is this effort that is informing the Illinois Pathways' RDLE mentioned above.

- **OSEP focuses on and contributes to current research and state and national policies and efforts in STEM education.** Our staff publishes, presents, and disseminates our work and best practices in scholarly journals, at academic and K-12 education conferences, and to diverse audiences including educators, researchers, policy makers, and foundation and industry leaders.

- OSEP has a **growing number of federal, corporate, and private foundation** supporters that endorse our work and help us build programs and the infrastructure to support them. We are continually seeking new partnerships to help grow, improve,

build resources, and disseminate our programs, technologies, and materials to teachers and students.

- With OSEP, we have created **a platform for STEM outreach**, not just a set of individual programs. Just as in IT, a good platform supports ease of building on top of it and delivers more capability, more efficiently than building from scratch each time.

Strengthening and Expanding the NSF Broader Impacts Model

Every NSF grant recipient must demonstrate the broader impacts[1] of their research. OSEP provides institutional support to researchers in the design, development, implementation, and evaluation of their broader impacts K-12 education and outreach efforts in the Chicagoland community and across the state of Illinois.

Many of OSEP's current and most impactful programs have been developed through broader impacts partnerships with Northwestern faculty, including the NUBIO project mentioned above that was developed in partnership with Dr. Teresa Woodruff and from NIH funding.

Under the current model at OSEP and similar offices around the country, funding for researchers to do broader impacts activities is part of the grant and it's the responsibility of the individual principal investigator (PI) to do the work. OSEP, when asked to participate, only gets a very small portion of each PI's grant, which is typically not sufficient to implement an evidence-based broader impacts program that is sustainable beyond the life of the grant. Furthermore, the STEM faculty members that conduct NSF sponsored research and are expected to be the point person for implementing the broader impacts component of their awards are not usually experts in K-12 education.

While OSEP has been successful in sustaining many of its programs beyond federal funding and providing the necessary support and expertise for effective program development and implementation for broader impacts, this is not the case at most institutions. In recent conversations with subcommittee members' staff, OSEP has offered the following suggestions for improving the impact and effectiveness of the broader impacts policy.

The current America COMPETES Act includes language that encourages institutions of higher education to establish offices like OSEP to provide PIs with assistance in setting up evidenced based broader impacts programs. While this language is a move in the right direction, NSF could significantly strengthen the impact of their research by restructuring how broader impacts

[1] In 2013, NSF clarified the function of the broader impacts (BI) criterion and provided eight exemplar focus areas for BI including: fostering full participation of women, persons with disabilities, and underrepresented minorities in STEM; improved STEM education and educator development; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce, increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

work is funded. This is also an opportunity to improve the incentives for implementing high quality broader impacts programs, and for better tracking and accountability of the investments in broader impacts across NSF. Although outside the purview of the committee, it is recommended that other federal agencies with STEM missions including NIH, the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Environmental Protection Agency (EPA), and the U.S. Geological Survey (USGS) might adopt a similar model.

The essence of our proposal is to shift the responsibility and funding for broader impacts from individual PIs to a shared responsibility between the PI and institutionally-supported broader impacts and outreach offices like OSEP that have the expertise to do this type of work. This shift might be accomplished in a number of ways:

- **Supplemental Awards**. Allow institutional programs with expertise in K-12 education, like OSEP, to apply for a supplemental grant in coordination with a PI to implement their broader impacts program (much as Research Experiences for Undergrads – REU – supplements are currently awarded). Funding would go directly to the institutional program but the PI would be required to take part in the development and implementation of the program. This would help ensure that broader programs are developed by K-12 STEM education experts and allow NSF to better to track the impact of funding allocated to broader impacts work through the institutional program. This approach would also ameliorate the marginalization of funding for broader impacts work that currently occurs when PIs must trade off broader impacts dollars against dollars for research activities to fit under the grant budget limit.

- **Matching Awards**. For every dollar in the main award budget spent by the PI on broader impacts in coordination with an institutional center like OSEP, NSF could provide additional matching funds (up to some specified cap) over and above the main award budget limit for broader impacts activities. Both the original and matching broader impacts funding would flow directly to the institutional center, like OSEP, who would implement the broader impacts activities. This would incentivize institutions to set up offices like OSEP and encourage researchers to take advantage of their services. It would also help mitigate the zero-sum-game budgeting constraint currently preventing PIs from investing more in broader impacts work.

The shift from a PI-based to a shared PI and institutional-based broader impacts funding strategy would also benefit from direct investment by NSF in start-up funding to help establish offices like OSEP at universities across the country and ongoing funding to these programs to conduct systemic evaluations of the efficacy of broader impacts activities at their institutions.

If done well and communicated appropriately these policy changes could be a big win for investigators and institutional broader impacts and outreach centers. Further, NSF will likely see better broader impacts results as a result of empowering K-12 STEM education experts to conduct the work along with PIs. From an agency perspective, NSF would achieve greater transparency and accountability for their investment in broader impacts by rolling up results

from a much smaller number of institutional offices rather than thousands of individual PIs.

NSF's model for broader impacts is widely seen to be among the most effective and successful among all federal agencies. To continue to strengthen our nation's future STEM workforce and science-savvy citizenry, other agencies (NIH, NOAA, NASA, etc.) should be encouraged to adopt similar models to encourage the scientists whose work is funded by those agencies to share their expertise and passion for STEM with the next generation. We need the best and brightest scientists and engineers, working in partnership with STEM education experts, to be active participants in broadening and deepening our students' engagement with the excitement of STEM disciplines and careers.