Statement of Gerald C. Blazey
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Northern Illinois University
before the
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National Science Foundation: Advancing Research for the Future of U.S. Innovation Part II

The Role of Emerging Research Institutions in Research and Research Opportunity Equity

Introduction and Greetings

Good morning, Chairwoman Stevens, Ranking Member Waltz, and members of the subcommittee. Thank you for allowing me to address you today. My name is Gerald Blazey, I am the vice president for research and innovation partnerships at Northern Illinois University. I also hold a full professorship in physics.

About NIU

Located 65 miles west of Chicago, Northern Illinois University (NIU) is a student-centered, nationally recognized public research university, with expertise that benefits our region and spans the globe in a wide variety of fields, including the sciences, engineering, health, business, education, the humanities, and the arts. NIU is a Carnegie classified R2 Doctoral University with high research activity.

We believe a life-changing education should be within reach of everyone and seek to be an engine for innovation to advance social mobility; to promote personal, professional, and intellectual growth; and to transform the world through research, artistry, teaching and outreach. We offer high-quality academic programs spanning more than 100 areas of study that lead to successful careers.

NIU has a diverse campus community of about 17,000 students. Collectively, students from underserved populations comprise about 75% of NIU's student body: 53% are undergraduate students of color, 43% undergraduate are Pell grant recipients, and 52% are first-generation college students. The vast majority of NIU students hail from the state of Illinois and 46% of undergraduates transfer to NIU from local community colleges. Most of our alumni remain in Illinois.

Research at NIU and the Benefits of NSF Support

Northern Illinois University has a robust and extremely efficient research enterprise. Over the last three fiscal years, the institution received a yearly average of $34M for externally sponsored programs of which a yearly average of $13M was for research. About one third of the research funding is provided by the NSF with every Directorate contributing. NSF is consistently one of our top research sponsors. NIU's degree production with respect to the level of external funding is extraordinary: in 2019 the institution awarded 117 doctoral degrees, ranking 157th out of all U.S. research institutions. In a 2017 report, NIU was recognized by the Brookings Institution to be among a select group of the nation's public universities cited for simultaneously producing important research while also extending social-mobility opportunities to students from low-income households. We believe research serves society in multiple ways.

With respect to efficiency, a 2020 report titled *The Innovation Impact of U.S. Universities* ranked NIU third nationally for "innovation impact productivity"—or in more colloquial terms, "the bang for the buck per research dollar spent." That report was released by the George W. Bush Institute and the Opus Faveo Innovation Development consulting firm. While large universities dominated the category of "overall innovation impact," the top tier of universities with a smaller research footprint, which included NIU, accounted for the study's highest innovation impact productivity scores. I am extremely proud of our faculty scholarship. To be sure, universities with small-to-mid-sized research footprints play a vital role in ensuring U.S. leadership in the areas of science, technology and innovation.

The 21st century is facing unprecedented, rapid change. Accordingly, the overall research vision of NIU is to "prepare northern Illinois for a century of change" with an emphasis on environmental, technological, and demographic change. These changes require rapid and sustained response, and the support NSF provides helps us to meet those changes by solving complex problems in our region and beyond, informing policy decisions, and training the next generation of scientists, engineers, and entrepreneurs.

National Science Foundation funding is vital to NIU's mission to empower students and faculty through educational excellence and experiential learning, pursue new knowledge through research, and engage communities and partners for the benefit of our region, state, nation, and world. Comprehensive institutions like NIU, with a broad set of programs designed to meet the varied needs of their regions, greatly benefit from the broad portfolio supported by NSF. The resulting infusion of science into society and our curriculum has lasting impact. Some of our research areas include COVID-19; climate change; environmental protection, restoration and sustainability; alternative energy sources; nanomaterials; investigations into the building blocks of our universe; accelerator physics and technology; drug development; neuroscience; and increasing science, technology, engineering, and mathematics (STEM) participation among underrepresented students.

Our planned Northern Illinois Center for Community Sustainability (NICCS) continues to gain momentum and offers a tremendous opportunity to address societal challenges. The Center is part of the Illinois Innovation Network (IIN) comprised of research and innovation centers at all state universities in Illinois. The mission of IIN is to drive economic growth in Illinois and address critical global issues. The center, once constructed and fully running, will be a venue for not only research, but for student education and public-private partnerships all addressing the most pressing issues of our time - sustainability in a rapidly changing physical, technical, and demographic environment. Indeed, faculty affiliates of the center are already conducting important collaborative research in numerous areas, including an NSF-funded study of prairie restoration and a separate study into the interactions of plant roots with soil microbes.

As our demographics suggest, NIU's classrooms are an ideal laboratory for investigating the mechanisms of learning and persistence for a diverse, STEM workforce. For example, the National Science Foundation's Scholarships in STEM (S-STEM) program has invested $1M in our students, many of whom are first-generation college students and transfer to NIU from our regional, minority-serving community colleges. NIU's role serving students historically under-represented in STEM enables us to investigate the mechanisms of student persistence and sense of belonging in STEM. Our findings can contribute to the understanding of why our current U.S. STEM workforce does not reflect the demographics of our country.

NSF's investment in STEM education and research at NIU impacts more than the diverse students involved in these programs. The researchers who connect with students through these programs are also changed. One example is NIU's International Research Experiences for Students project to study climate dynamics in the Baltic Region. Unlike most undergraduate research experiences, this project was designed to engage community college students with little formal training in field- and lab-based research. While the students gained practical field skills, the lead investigator trained at a large research institution and gained powerful insights into the lived experiences of non-traditional and under-represented students. This has changed his approach to mentoring students.

Institutions with smaller research footprints face numerous challenges building and sustaining research programs and centers, all of which are addressed by NSF sponsorship. External funding facilitates initiation of research programs at all institutions but is particularly important for smaller institutions with limited resources. Once a program is established, funding stability is especially important for smaller research portfolios because institutional resources may not be available to bridge funding gaps. External funding is particularly important for the establishment of research centers at institutions with smaller footprints because facilities and infrastructure may be limited.

Another vexing challenge is limited infrastructure and the inability to purchase and operate up-to-date instrumentation and equipment. This lessens the competitiveness of proposals and attractiveness of science programs to potential students and faculty. NSF has programs such as the Major Research Instrumentation program (MRI) to support equipment purchases but the program is oversubscribed. Beyond acquisitions, because of limited research intensity,

institutions that are not conducting research at scale are unable to support an array of instruments and equipment with personnel or materials. An unfortunate cycle develops, as institutions that do not conduct research at scale have difficulty hosting or operating the equipment necessary to build out their research programs and centers.

In many of these regards, the NIU research portfolio benefits from partnerships with neighboring institutions. Collaboration with the two nearby Department of Energy-supported national laboratories Fermi National Accelerator Laboratory and Argonne National Laboratory amplifies the impact of our research program through the availability of expertise and world leading facilities. Likewise, the partnership with our sister state institutions through the Illinois Innovation Network broadens our impact and builds capacity. Partnerships serve as a model for improving research opportunity for the "missing millions." The National Science Board's (NSB) report Vision 2030 describes the "missing millions" as the "number of women must nearly double, Black or African Americans must more than double, and Hispanic or Latinos must triple the number that are in the 2020 U.S. science and engineering (S&E) workforce" if the S&E workforce is to be representative of the U.S. population in 2030.

Opportunities for NSF to Increase Support

As today's testimony demonstrates, a variety of research universities have significant roles in the national science and technology portfolio. Unfortunately, for some, the impact is blunted by a longstanding structural impediment to the success of our students. Historically, most federal research funding has been distributed to a small fraction of our nation's research universities. The concentration of funding adds to the "missing millions" described in the NSB Vision 2030 report. Fortunately, *The NSF for the Future Act* offers a remedy for what I would describe as the 'missing millions in the middle' by promoting partnerships between established and emerging research institutions. These partnerships will simultaneously serve the national need for research excellence and broadened opportunity.

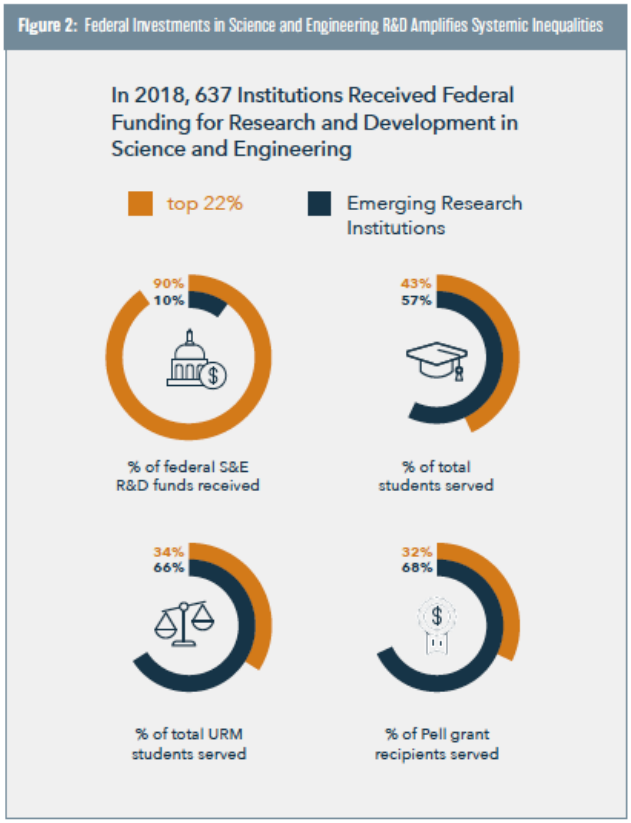
Taken together, data from two separate sources show that federal research support is concentrated at a fraction of the nation's research universities. The concentration presents a structural impediment to diversification. The Higher Education Research and Development (HERD)[1] survey collected and maintained by the NSF's own National Center for Science and Engineering Statistics (NCSES) provides comprehensive information on national and institution investments in science and engineering. The Carnegie Classification of Institutions of Higher Education[2] recognizes *very high research doctoral universities* and *high research doctoral universities*. The classification utilizes data from NCSES and the Integrated Postsecondary Education Data System (IPEDS)[3] from the U.S. Department of Education. Traditionally, and commonly, the two doctoral university classifications are referred to as R1 and R2 universities; all other universities with research programs are traditionally designated R3 universities.

[1] https://ncsesdata.nsf.gov/herd/2018/

[2] https://carnegieclassifications.iu.edu/index.php

[3] https://nces.ed.gov/ipeds/

The American Physical Society's report *Building America's STEM Workforce: Eliminating Barriers and Unlocking Advantages* includes an analysis of the distribution of federal research funding using HERD survey and IPEDS data.[4] As illustrated below in the figure extracted from the report, the data shows that 637 institutions received federal funding for science and engineering research and development in 2018. The top 22% of institutions, comprised of 139 predominantly R1 institutions, received 90% ($36.6 billion) of federal science and engineering research and development dollars. However, those same institutions serve only one third (34%) of the underrepresented minority (URM) college students, and 43% of all college students, served by the 637 institutions involved in federally funded STEM research. Said another way, **two-thirds of our nation's students of color attending STEM research-active institutions see only about 10% ($4.1 billion) of federal research dollars on their campus**. This leaves the other nearly 500 predominately R2 and R3 institutions with limited research funding and opportunities. The situation is nearly identical for students who are Pell grant recipients.



Uneven geographic distribution is also evident, with 96% of the top 22% of institutions located in urban or suburban areas while 20% of the remaining institutions are in town and rural areas.

[4] American Physical Society (2021). *Building America's STEM Workforce: Eliminating Barriers and Unlocking Advantages.* https://www.aps.org/policy/analysis/upload/Building-America-STEM-workforce.pdf.

As a result, students in more rural settings also see less research opportunity. These structural characteristics of federal funding distribution have been evident for decades; in fact, a recent article on the history of NSF by Dr. Emily Gibson indicates that concern about the distribution of research funding was expressed at the inception of the agency.

Participation in research is extremely effective for the retention of students and the diversification of STEM fields as attested by recommendations from The National Academies of Sciences, Engineering and Medicine[5,6,7,8] and National Academy of Engineering[9] and findings from the National Survey of Student Engagement[10]. Participation in research prepares students to think critically, communicate their ideas, and apply their knowledge in their field[11] and is identified as a high-impact practice by the Association of American Colleges and Universities (AAC&U)[12]. Undergraduate research experiences increase student engagement and interest, foster a sense of belonging and self-efficacy, and lead to higher graduation rates[13,14]. Those demographically underrepresented students go on to innovate at higher rates than majority students; said another way, diversity breeds innovation[15].

These findings are borne out at NIU; for example, our 'Research Rookies' program matches first year students with faculty research mentors. Student retention for those involved is excellent. I can personally attest to the power of research experience for these students and the impact of the research experience on their skills and confidence.

Any proposal for new structures to foster innovation must maintain the excellence of the R1s while leveraging the strength of the R2s and R3s to broaden opportunity and build research capacity nationwide. Both aims can be achieved by requiring R1 institutions that are hosting new initiatives, research centers, and other large grants to build meaningful partnerships with non-R1 institutions. The *NSF for the Future Act* offers an important first remedy for the research funding inequity through a five-year pilot program to promote partnerships between very high

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[5] National Academies of Sciences, Engineering, and Medicine (2016). Quality in the Undergraduate Experience: What Is It? How Is It Measured? Who Decides? Summary of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/23514.

[6] National Academies of Sciences, Engineering, and Medicine (2018). How People Learn II: Learners, Contexts, and Cultures. Washington, DC: The National Academies Press. https://doi.org/10.17226/24783.

[7] National Academies of Sciences, Engineering, and Medicine, (2019). The Science of Effective Mentorship in STEM. Washington, DC: The National Academies Press. https://doi.org/10.17226/25568.

[8] National Academies of Science, Engineering, and Medicine (2019). Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce. Washington, DC: The National Academies Press. https://www.nap.edu/catalog/25257/minority-serving-institutions-americas-underutilized-resource-for-strengthening-the-stem.

[9] National Academy of Engineering, (2018). Understanding the Educational and Career Pathways of Engineers. Washington, DC: The National Academies Press. https://doi.org/10.17226/25284.

[10] National Survey of Student Engagement. (2016). Retrieved from https://nsse.indiana.edu/html/engagement_indicators.cfm.

[11] National Academies of Sciences, Engineering, and Medicine (2016). Quality in the Undergraduate Experience: What Is It? How Is It Measured? Who Decides? Summary of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/23514.

[12] Kuh, G. D. (2008). Excerpt from high-impact educational practices: What they are, who has access to them, and why they matter. Association of American Colleges and Universities, 14(3), 28-29. https://secure.aacu.org/imis/ItemDetail?iProductCode=E-HIGHIMP&Category=.

[13] National Academies of Sciences, Engineering, and Medicine (2017). Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities. Washington, DC: The National Academies Press. https://doi.org/10.17226/24622.

[14] National Academies of Sciences, Engineering, and Medicine (2018). Indicators for Monitoring Undergraduate STEM Education. Washington, DC: The National Academies Press. https://doi.org/10.17226/24943.

[15] Hofstra et al. (2020). The Diversity–Innovation Paradox in Science. www.pnas.org/cgi/doi/10.1073/pnas.1915378117.

research institutions and emerging research institutions. The pilot requires direction of at least 25% of any award over $1,000,000 to an emerging research institution to build research capacity. The legislation also includes important review and assessment of the program. As discussed earlier, the power of partnerships for building capacity is evident in NIU's close collaboration with the two nearby federal laboratories and the Illinois Innovation Network.

To fully benefit the nation and broaden participation, these partnerships must ensure that expertise is shared and sustained at the emerging institutions. As an example, a quantum information sciences or artificial intelligence center established at a large university could provide fellowships for faculty from their emerging partners. Upon return to their home universities these fellows could continue their research and engage students with the support of the large university center. Creating paid, full-academic-year research opportunities for undergraduate students at partnering emerging institutions serves as another example. Paid research positions have been shown to increase retention rates in STEM for students[16], help students develop a sense of scientific identity[17,18] and provide students needed financial support[19]. Creating research opportunities at the emerging research institution accommodates students with myriad life circumstances (e.g., caregiving responsibilities, employment) that prevent them from relocating away from their home institution for weeks or months at a time. Additionally, these full-academic-year research experiences more effectively impact the emerging research community than limited summer research experiences by creating accessible peer role models for students and fostering a STEM research community on campus. Other examples of successful diffusion of expertise include shared postdoctoral scholars and graduate research internships.

I fully endorse this important first step to reach the "missing millions in the middle". I stress that this is a first step and further actions must be taken to ensure equity of research opportunity. I applaud NSF for the focus on the "missing millions" and urge the agency and Congress to continue to consider additional programs to promote equity in research opportunity.

Risk and Benefits of New NSF Directorate

The proposed increased funding for NSF in the *NSF for the Future Act* and the related *Endless Frontier Act* represents a heartening acknowledgement of the tremendous importance of science to our Nation. As has been frequently discussed elsewhere, many excellent, positively reviewed research proposals and programs cannot be funded with the limited budgets of the

[16] National Academies of Science, Engineering, and Medicine (2019). Minority Serving Institutions: America's Underutilized Resource for Strengthening the STEM Workforce. Washington, DC: The National Academies Press. https://www.nap.edu/catalog/25257/minority-serving-institutions-americas-underutilized-resource-for-strengthening-the-stem.

[17] National Academies of Sciences, Engineering, and Medicine (2017). Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities. Washington, DC: The National Academies Press. https://doi.org/10.17226/24622.

[18] American Institute of Physics (2020). The Time Is Now: Systemic Changes to Increase African Americans with Bachelor's Degrees in Physics and Astronomy https://www.aip.org/sites/default/files/aipcorp/files/teamup-full-report.pdf

[19] Ibid.

past. Additional funds will significantly strengthen and expand fundamental research, the wellspring of innovation and our ability to respond to societal issues.

New structures and programs are essential to support the translational research necessary to address the issues facing the nation and competition from directed economies. The proposed new Directorate for Science and Engineering Solutions represents a tremendous opportunity to help ensure basic research fostered and supported by NSF effectively addresses societal and national challenges. Research equity must be a founding principle of the new directorate. Because of the interdisciplinary and transdisciplinary nature of complicated problems facing society and our economy, the new directorate should be cross cutting in organization and funding. The mission of the new directorate calls for reformulation or expansion of the Graduate Research Fellowship Program to support innovation activities as well as research. For example, Fellows should receive cross-disciplinary training in subjects such as project management, formal safety analysis, and team building. The new directorate would also provide a fresh opportunity to integrate efforts with other agencies, institutions, and initiatives such as the American Innovation Investment Fund proposed by the Council on Competitiveness.

There are attendant risks to a new directorate focused on translation. First, there is the potential to broaden the equity gap in research opportunity. Institutions with significant research footprints already have a deep portfolio of fundamental research from which to draw new ideas for translation. With their running start, other institutions may be left further behind. Second, many of the problems facing society are so-called "wicked problems," which require protracted, deliberate effort, and timescales not always commensurate with the more rapid timescales of translational research. Any "fast-fail" approach will discriminate against institutions with limited resources.

Finally, there is a risk to the basic research mission of NSF. There can be no doubt that the peer-reviewed NSF model and the resulting magnificent intellectual portfolio is the envy of the world – other countries emulate the NSF. We must vigilantly guard our investment in long-term curiosity-driven research, or we risk losing out on the development of technologies of the future. Two wonderous examples demonstrate the importance of long-term NSF funded curiosity-driven research: the study of communications between bees that led to the 'bee algorithm' used widely in computer science and the study of microbes in the Yellowstone thermal pools that led to tests for COVID-19. The annual Golden Goose Awards offer many other examples.

I am grateful for the opportunity to offer this testimony today and share my thoughts on the *NSF for the Future Act* and how to support institutions with a smaller research footprint that are key to broadening research opportunity for the "missing millions in the middle." I thank you and look forward to your questions.

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Short Biography
Gerald C. Blazey

Gerald (Jerry) C. Blazey graduated from South Dakota State University in 1979 with degrees in mathematics and physics and received his doctoral degree in experimental particle physics from the University of Minnesota in 1986. He is an author of over 500 papers and is a Fellow of the American Physical Society. Since joining Northern Illinois University in 1996 he has been appointed a Distinguished Research Professor and Director of the Northern Illinois Center for Accelerator and Detector Development and has been a principle investigator for federally funded grants from the National Science Foundation, the Department of Energy, the Department of Education, and the Department of Defense.

Dr. Blazey has extensive experience in scientific administration and policy. While participating in the Fermi National Accelerator Laboratory collider program, he served from 2002 to 2006 as co-Spokesperson of the DZero collaboration comprised of more than 600 physicists from over 20 countries. From 2007 to 2010 he was the Program Manager for the International Linear Collider in the Office of High Energy Physics at the Department of Energy. More recently, from 2011 to 2014, he was the Assistant Director for Physical Sciences in the Office of Science and Technology Policy in the Executive Office of the President of the United States where he worked on numerous issues including helium supply, space weather resiliency, exascale computing, and quantum science. Since 2015 he has served as the Vice President for Research and Innovative Partnerships at Northern Illinois University.