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Inspiring Innovation. Advancing Research. Enhancing Education.

Assessing Research Community Health and Vitality

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NASA's science vision:

Using the vantage point of space to achieve with the science community and our partners a deep scientific understanding of our planet, other planets and solar system bodies, the interplanetary environment, the Sun and its effects on the solar system, and the universe beyond. In so doing, we lay the intellectual foundation for the robotic and human expeditions of the future while meeting today's needs for scientific information to address national concerns, such as climate change and space weather. At every step we share the journey of scientific exploration with the public and partner with others to substantially improve science, technology, engineering and mathematics (STEM) education nationwide.

Foci Derived from Vision:

- Advancement of understanding
- Basis for future research and research tools
- Link to National priorities (taken from OSTP)
  - COVID-19
  - Health Care
  - Climate
  - Racial Equity
  - Immigration
  - Economic Development
  - Global Standing
- Enhance public understanding
- Improve STEM education

$\left.\begin{array}{l}\text{COVID-19}\\ \text{Health Care}\end{array}\right\}$ Improved Human Health

$\left.\begin{array}{l}\text{Racial Equity}\\ \text{Immigration}\end{array}\right\}$ Human Resource Development

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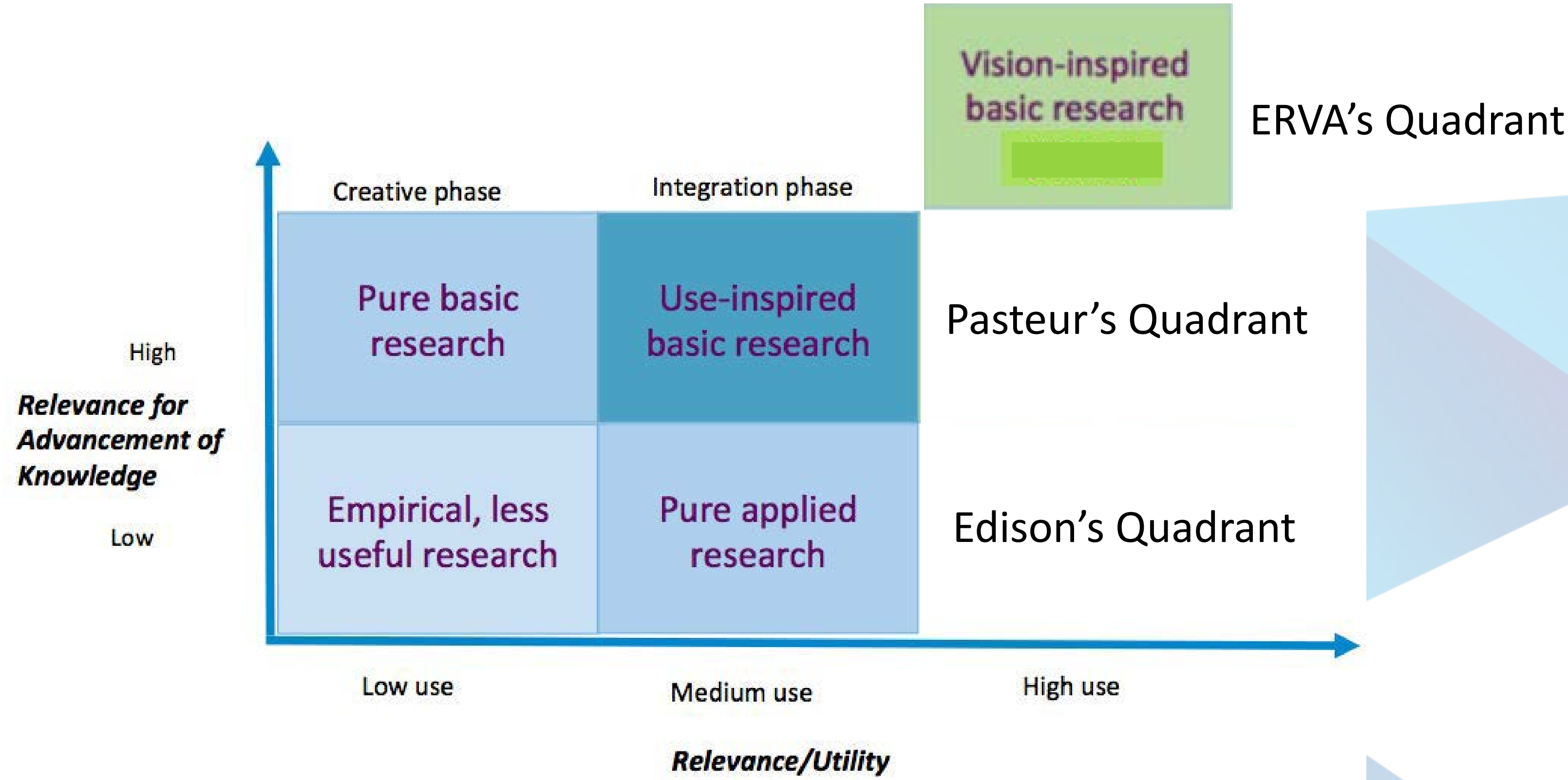
RESEARCH PRODUCTS: Advancement of Understanding & Basis for Future Research and Research Tools

(METRIC: What is the distribution of the portfolio?)



Collateral Outputs of Research

- Health care applications and tools
- Enhanced understanding of climate dynamics and mitigation strategies for climate change
- Economic development spinoffs

METRICS: How many, how extensive, how robust?

Collateral Outcomes of Research

- Purposeful Changes to Human Resource Base
  - Immigration
  - Racial Equity
- Improved Public Understanding
  - Events with explanations
- Improved STEM Education
  - Opportunities for “sparks” of engagement
  - Curricular and laboratory materials
  - Expanded student/teacher/faculty research opportunities
  - Improved content knowledge and examples

Globally Desired Characteristics: Are for Engineers Able to

- Straddle uncertainty, disciplines, diverse cultures, evolving technologies, etc.
- Define as well as solve problems
- Create, manage, lead in technology and policy
- Drive economic growth & enhance standards of living
- Blend theory and practice
- Blend technical and professional skills
- Exhibit global awareness and intercultural competence (national, ethnic, religious, etc.)

Desired Characteristics:

Engineers have to be more agile and facile

- Across engineering, physical science AND social science fields,
- Working with non-engineering professionals, and
- Communicating with the general public.

Engineers and IT workers are increasingly socially active (e.g., workers at Amazon, Facebook, Google, and Microsoft)

Desired Characteristics: Facts, not assumptions

- An increasingly technical world needs people with engineering knowledge even if they do not practice as engineers
- Diverse thought improves engineering design and production
- In order to adequately serve humanity, engineers must understand human needs
- Failure to engage women or ethnic/religious minorities violates the above facts and does not make economic or technical sense.
- Attention to diversity should be integral to overall effort to enhance engineering education

Assessing the Status of the Human Resource Base

METRICS

- Who (organizations and individuals) is engaged?
  - Academe
  - Industry
  - NGOs
- How are they engaged?
- What is the extent of their engagement (money, time, control/autonomy)?

Purposeful Changes to the Human Resource Base

- Engaging Underserved Populations and Institutions
  - Institutional research infrastructure and capacity building
  - Development of faculty research skills, teaching skills, and professional connections
  - Curricular and laboratory Enhancements
  - Student internships, fellowships, competitions, and challenges.
  - Authentic partnerships and sustainability

Background

Project Goals: Develop metrics to assess participation in NSF-supported activities by

- Individuals from populations underrepresented in Science, Technology, Engineering, and Math (STEM) fields
  - Women,
  - Underrepresented minorities,
  - Persons with disabilities
- Individuals from institutions underrepresented as NSF-grantees
  - Baccalaureate colleges,
  - Community colleges
  - Minority-serving institutions, etc.

NSF Grant (REC-0643048)

Organization of Metrics and Data

	Individually-held Data	Institutionally-held Data
Research and Education Activities within an Institution	*Metrics related to the S&E workforce preparation, utilization and advancement of individuals from underrepresented populations or underparticipating institutions. – research, teaching, service at all levels.*	
Research and Education Activities across Institutions		

NSF Grant (REC-0643048)

Underrepresented Populations

Characterize efforts to identify, attract, engage, prepare, support, retain, sustain, utilize and advance, a diverse science and engineering workforce.

- Faculty/Teachers
- Students
- Administrators
- Staff

NSF Grant (REC-0643048)

Underrepresented Populations

Sample Metrics

- Comparisons of recruitment, retention, and promotion activities, numbers and rates for faculty/teachers by gender and ethnicity over time [Data is generally held by institutions]

- Numbers and rates of participation of students in research activities, publications, presentations, etc. [Data is generally held by individuals]

NSF Grant (REC-0643048)

Underrepresented Populations

We suggest juxtaposing institutionally-held diversity data with the publicly available data on NSF funding received by institutions in order to display the human resource return on the NSF investment.

As a practical matter, we believe this would (minimally) result in an augmentation of the current “Award Summary: Top 200 Institutions” <http://dellweb.bfa.nsf.gov/Top50Inst2/default.asp> to include that section of the three most recent affirmative action plans for the awardee institution that indicates whether and to what degree it has met its utilization goals for women and minorities.

NSF Grant (REC-0643048)

Underparticipating Institutions

Characterize efforts to engage and collaborate with individuals from community colleges, baccalaureate institutions, minority serving institutions, etc. in ways that build self-sustaining capacity

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NSF Grant (REC-0643048)

Underparticipating Institutions

Sample Metrics (numbers and rates)

- Project participation and leadership
- Project management and share of funds
- Facilities access and use
- Development of capacity and experience in grant management

Data is variously held by institutions and individuals

NSF Grant (REC-0643048)

Underparticipating Institutions

We suggest juxtaposing institutionally-held data with the publicly available data on NSF funding received by institutions in order to display the institutional diversity return on the NSF investment.

As a practical matter, we believe this would (minimally) result in an augmentation of the current "Award Summary: Top 200 Institutions" <http://dellweb.bfa.nsf.gov/Top50Inst2/default.asp> to include data on the identified metrics and tracking overtime of metrics of the UI's participation in NSF activities.

Improved Public Understanding

- Measures of Public Understanding
  - Factual Knowledge – what facts they can recall
  - Perceived Knowledge – what they think they know
  - Structural Knowledge - The nature of connections among different pieces of information in memory

- Which “publics”?
- Under what circumstances?

Improved STEM Education

- Opportunities for "sparks" of engagement
- Curricular and laboratory materials
- Expanded student/teacher/faculty research opportunities
- Improved student/teacher/faculty content knowledge and examples

METRICS

- Materials produced, distributed, and used
- Workshops/Seminars held, # of attendees, extent of follow-up (no "one and done")
- Deeper versions of Public Understanding Metrics

Comments on Questions (rec'vd 11 Oct)

- Dynamics of attrition?
  - Preparation
  - Support
  - Climate
- Dynamics associated with increasing the number and success of graduate degree recipients in engineering and science drawn from underrepresented minority populations?
  - See above dynamics of attrition
  - Quality of Mentorship – what do you automatically do for your "best" students?
- General characteristics of a healthy and vital research community? Role of diversity?
  - Broad engagement
  - Diverse representation (racial-ethnic/gender/geographic) to stimulate diverse thinking

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Comments on Questions (rec'vd 11 Oct)

- Pipeline or pathway considerations, both entering and supportive as well as those that stifle and limit? What role or responsibility can or should grant awarding organizations have in have in graduate or undergraduate education? Hiring organizations? Roles in K-12 pipeline?
  - Pathways not pipelines
  - Coordinated (or at least aligned efforts along the pathways)
  - Need to support proven practices as well as innovation
  - Understand the academic reward system
- What elements of partnership between government, industry and academia are critical?
  - Trust
  - Transparency
  - Mutual benefit
- Roles of government agencies that are both supportive and limiting
  - Limited grant duration
  - Limited grant scope – need to address totality of required effort
  - Overly restrictive clearance requirements
- Successful policy initiatives?
  - NSF Systemic Initiatives – totality of effort

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Comments on Questions (rec'vd 11 Oct)

- What would your ideal preparation for a technical workforce look like and how could it be made more accessible and equitable to all?
  - Coordinated, comprehensive, and pervasive spanning exposure, engagement, enrichment, and reinforcement
  - Make what is made available to G&T is made available to all

- What are the most significant barriers that are hindering the achievement of a diverse STEM workforce and what suggestions do you have to mitigate those barriers?
  - Misunderstanding of the difference between "qualified" and "qualifiable"
  - Systemic mentorship

- How could STEM mentoring be made more systemic within the period of workforce preparation and do you envision a more intentional role that industry/NASA could play in mentoring?
  - Make mentoring "standard" rather than "extra".
  - Have explicit academic expectations for work-based (and other) experiential learning opportunities. Better link technical and professional skills.

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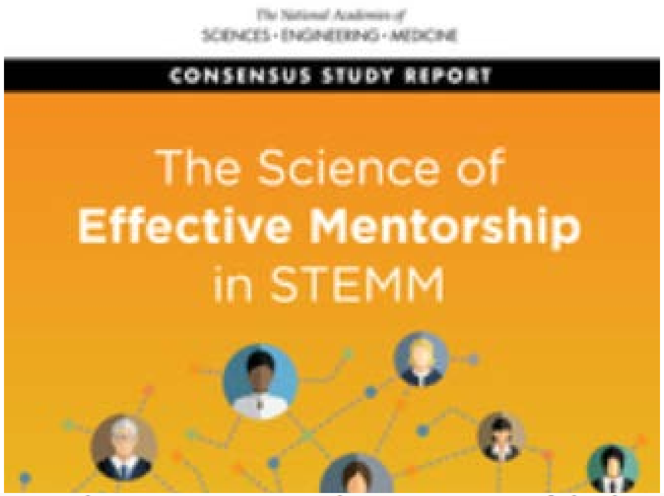
Science of Effective Mentorship in STEMM (NAP 2019)

https://www.nationalacademies.org/our-work/the-science-of-effective-mentoring-in-stemm



The Science of Effective Mentorship in STEMM

Mentorship is a catalyst capable of unleashing one's potential for discovery, curiosity, and participation in STEMM and subsequently improving the training environment in which that STEMM potential is fostered. Mentoring relationships provide developmental spaces in which students' STEMM skills are honed and pathways into STEMM fields can be discovered. Because mentorship can be so influential in shaping the future STEMM workforce, its occurrence should not be left to chance or idiosyncratic implementation. There is a gap between what we know about effective mentoring and how it is practiced in higher education.

RESOURCES

- Press Release
- Report Highlights
- The Science of Effective Mentorship in STEMM: Online Guide V1.0
- The Science of Mentorship: A STEMM Podcast
- The Science of Effective Mentorship

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Comments on Questions (rec'vd 11 Oct)

- What are the key critical points (classes, experiences, etc) for retention of individuals paths through their higher education and early career? Are there noticeable differences in the actual critical points or the magnitude of importance for URM students/early career? Are there key differences between scientists and engineers?
  - Key transition points are elementary to middle school, middle to high school, high school to college, 2-yr to 4-yr, undergrad to grad, grad to doc, academic to workforce (including academic workforce), pre-tenure to tenure (and industry equivalent).
  - Theodore von Kármán (1881-1963) – "Scientists study the world as it is, **engineers create the world that never has been**."

- Development of self-efficacy of STEM students and professionals has been noted as a key intervention. Do you have any insights into how to measure self-efficacy or properties which might indicate strength in moving forward for a student/early-career scientist – measure of specific actions? Attitudinal responses?
  - 2336 papers (since 1996) - https://peer.asee.org/?q=measuring+self-efficacy

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Best Undergrad Retention Practices:

- ASEE 2012 report:
  - Background for NSF initiative
- Focus on Student Learning Through Tutoring/Mentoring
- Student Programs and Financial Aid
- Student Academic Enrichment Programs
- Student Research/Work Experience
- Curriculum and Class Enhancements
- Institutional/Educational Research
- Change in Institutional/Departmental Policy

From a 2016 presentation:

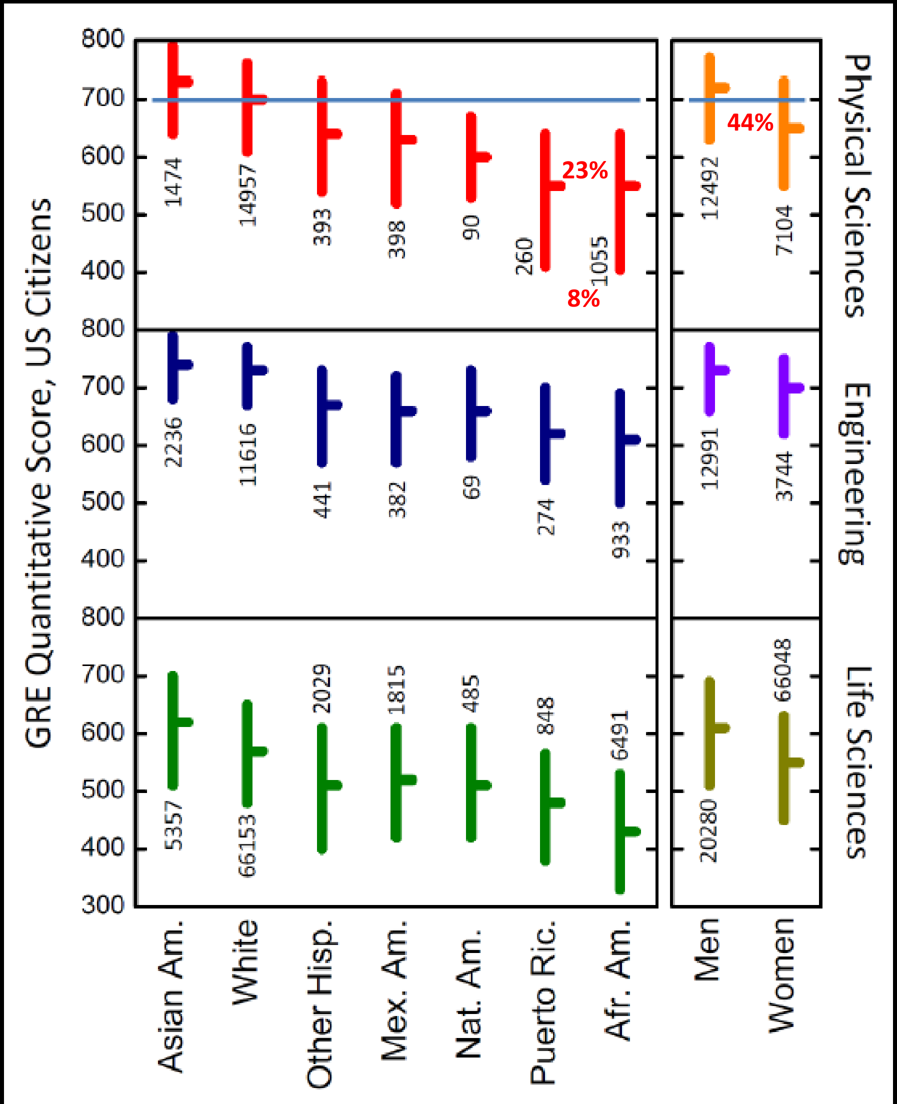
Excellence, Diversity, and the Quest for Other Worlds:

Lessons from the Fisk-Vanderbilt Bridge Program

Keivan Guadalupe Stassun

Professor of Physics & Astronomy, Vanderbilt University
Adjunct Professor of Physics, Fisk University
Director, Vanderbilt Initiative in Data-Intensive Astrophysics (VIDA)
Founding Director, Fisk-Vanderbilt Masters-to-PhD Bridge Program

How GRE suppresses diversity



Miller & Stassun (2014, *Nature*)

Identifying Students With the Right Stuff

What roles are we looking for?	What qualities predict success?
* Commitment and academic potential * Productive, creative, entrepreneurial researchers * Effective teachers and mentors * Transformational leadership	* Passion, “fire in the belly” * Ability to succeed in relevant courses * Ability in the laboratory * Persistence in the face of hardship (the “P” in PhD) * Entrepreneurial spirit

Two most important elements in admissions: (1) basic academic preparation, (2) grit

“performance character”, “successful intelligence”

Measuring grit and growth mindset

	Score		
Attribute	**High**	**Medium**	**Low**
Positive Self-Concept	Expresses confidence they can complete challenging goals, makes positive statements about abilities	Shows confidence and independence but may be unsure about adequacy or skills	Is unsure they can complete the program, exhibits low self-esteem
Realistic Self-Appraisal	Can clearly and realistically delineate strengths and weaknesses, works on self devlopment	Has trouble identifying strengths and weakness but appreciates/seeks both positive and negative feedback	Over or understates abilities, does little to no self-assesment, does not appear to have learned from experiences
Preference for Long vs. Short Term Goals	Clearly communicates long-range goals beyond the PhD	Primary goal is PhD completion	Is vague about long-term goals, or goals are short term such as coursework
Support Person Availability	Can define a professional support network including mentors	Expresses support from one individual, or family or community	Expresses little or no support from family or institution for goals
Leadership/Community Involvement	Demonstrates involvement and leadership ability in either academics, family, community, religious group,	Demonstrates involvement in groups in academia or extramurals but has not shown leadership	Not involved in institutional or community group, no demonstated leadership
Knowledge in a Field/Non-Traditional Learning	Has engaged in, and learned from, experiences outside the classroom, i.e. performed independent research, extramural activies, self-taught skills	Shows some evidence of non-traditional learning experience	Has not engaged in or indicated learning from experiences outside the classroom
Perserverance	Can descibe a time they failed or encountered an obstacle and successfully coped.	Can identify a time they hit an obstacle but has trouble defining how they overcame the challenge.	Has little experience with failure/obstacles. Cannot provide an examole or describe response

Stassun et al (2011, Am. Journ. Phys.)

fisk-vanderbilt-bridge.org

Applicant Interview Protocol

College Experience:

- High points
  - Describe the high points of your college experience.
  - What went well for you? / What are you most proud of?
  - Describe a time when you have faced a difficult academic challenge or hurdle that you successfully navigated. What was the challenge and how did you handle it?
  - What are you most proud of accomplishing?
- Low points
  - Were there any personal or academic obstacles or challenges that had a significant impact on your college experience?
  - Describe the low points./What didn't go well and why?
  - What failures did you have (a time also to probe for issues with the transcript)? How did you handle them?
  - What mistakes did you make?
  - What would you do differently?

Research Experience (in class, lab or other)

- Tell us about your most successful or interesting research experience, either in class, in the lab or at work?
- What was most challenging about it?
- How did you figure out what to do?
- What did you learn most from this experience?
- Who did you work with, and describe the working relationships.

Stassun et al (2011, Am. Journ. Phys.)