# Engineering Education & Centers: An Integrative Mission

**Theresa A. Maldonado**
**Division Director**

ENG Advisory Committee Meeting
April 13-14, 2011

# Agenda

- EEC current situation
- External influencers
- Potential future directions

# Directorate for Engineering (ENG)

**Office of the Assistant Director**
**Thomas Peterson, Assistant Director**
**Cheryl Albus, Acting Deputy Assistant Director**

**Emerging Frontiers in Research and Innovation (EFRI)**
Sohi Rastegar

**Senior Advisor for Nanotechnology**
Mihail Roco

**Program Director for Diversity**
Omnia El-Hakim

**Engineering Education and Centers (EEC)**
Theresa Maldonado

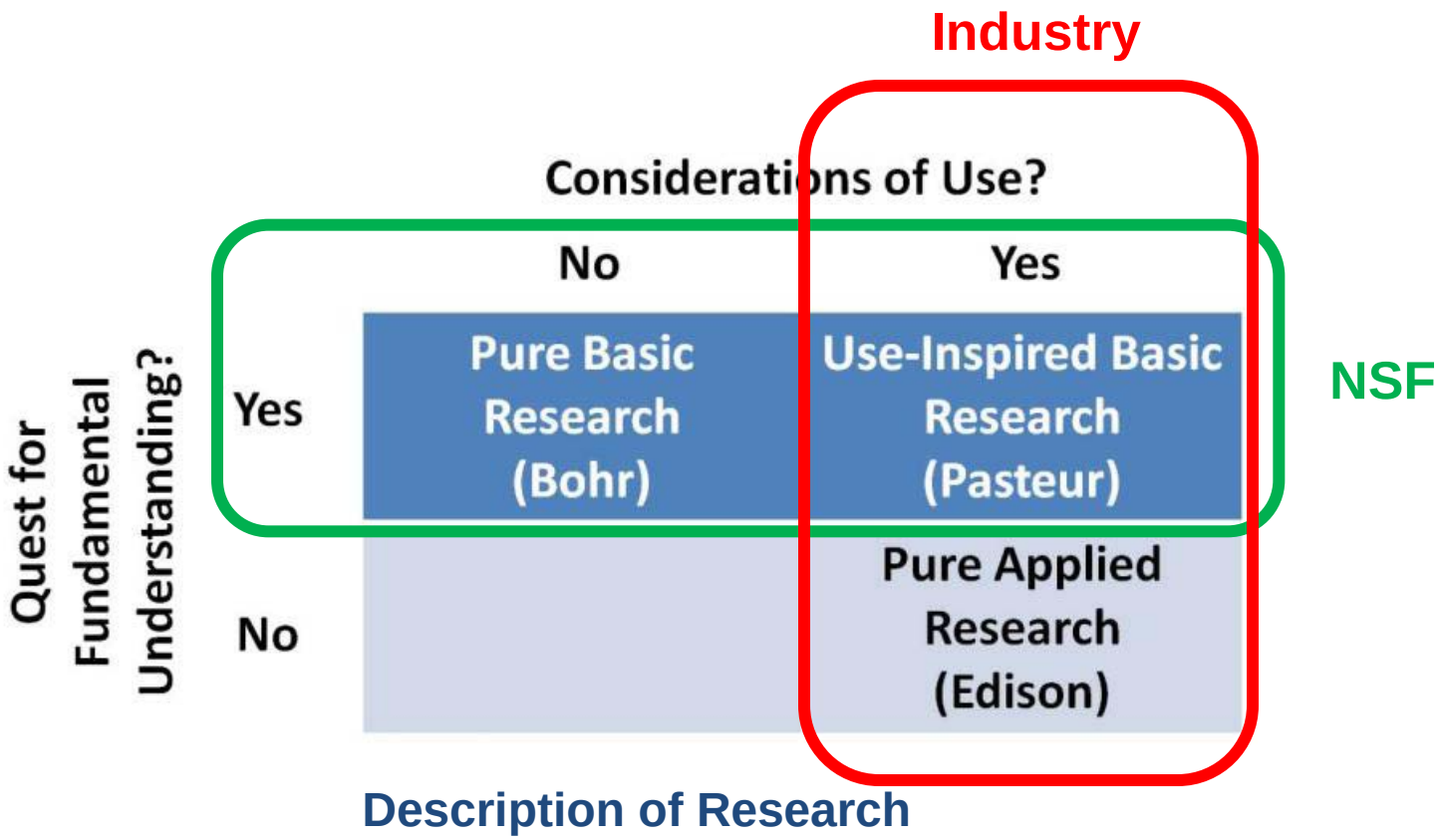
**Chemical, Bioengineering, Environmental, and Transport Systems (CBET)**
John McGrath

**Civil, Mechanical, and Manufacturing Innovation (CMMI)**
Steven McKnight

**Electrical, Communications, and Cyber Systems (ECCS)**
Robert Trew

**Industrial Innovation and Partnerships (IIP)**
Kesh Narayanan

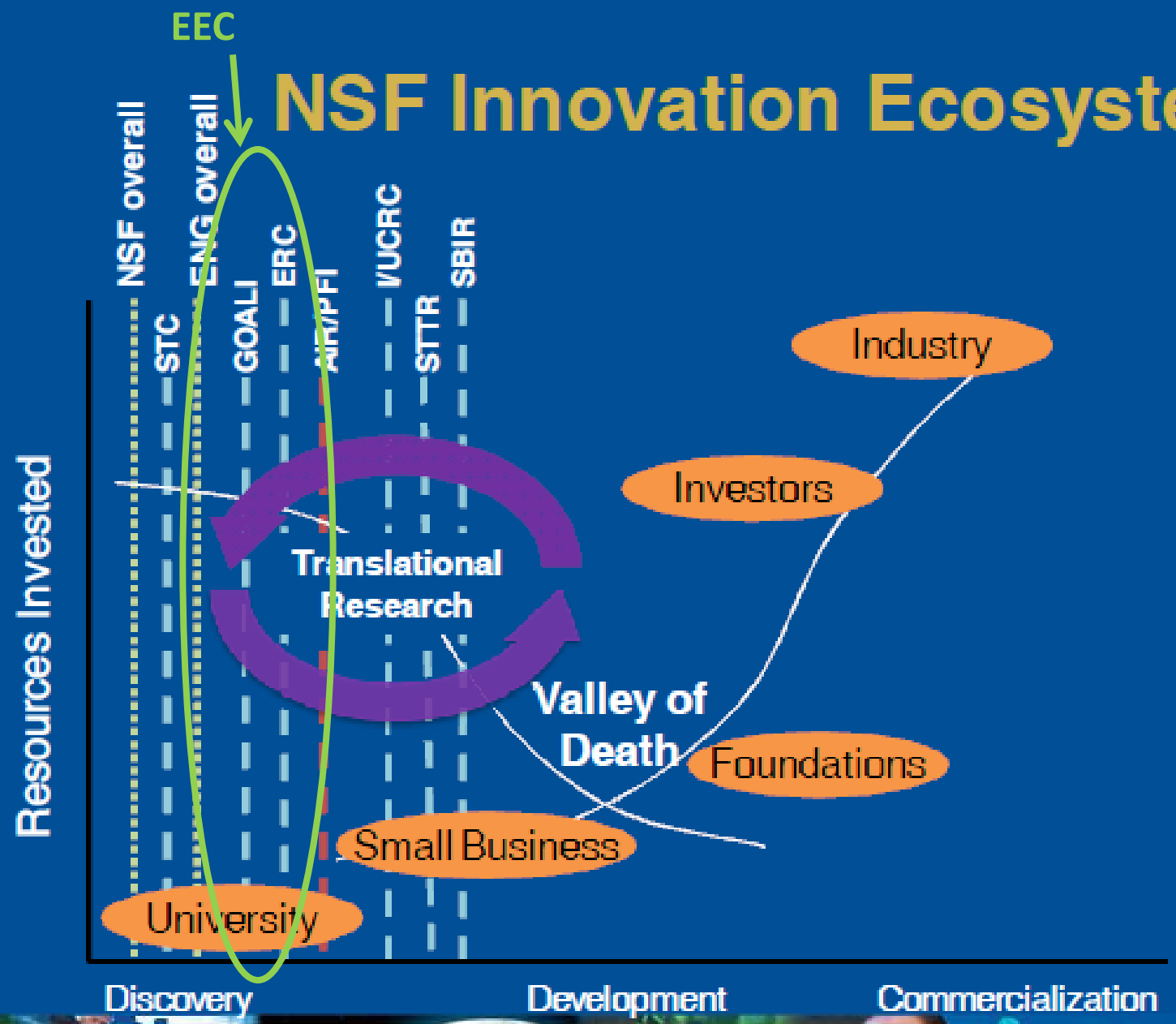
# Pasteur's Quadrant



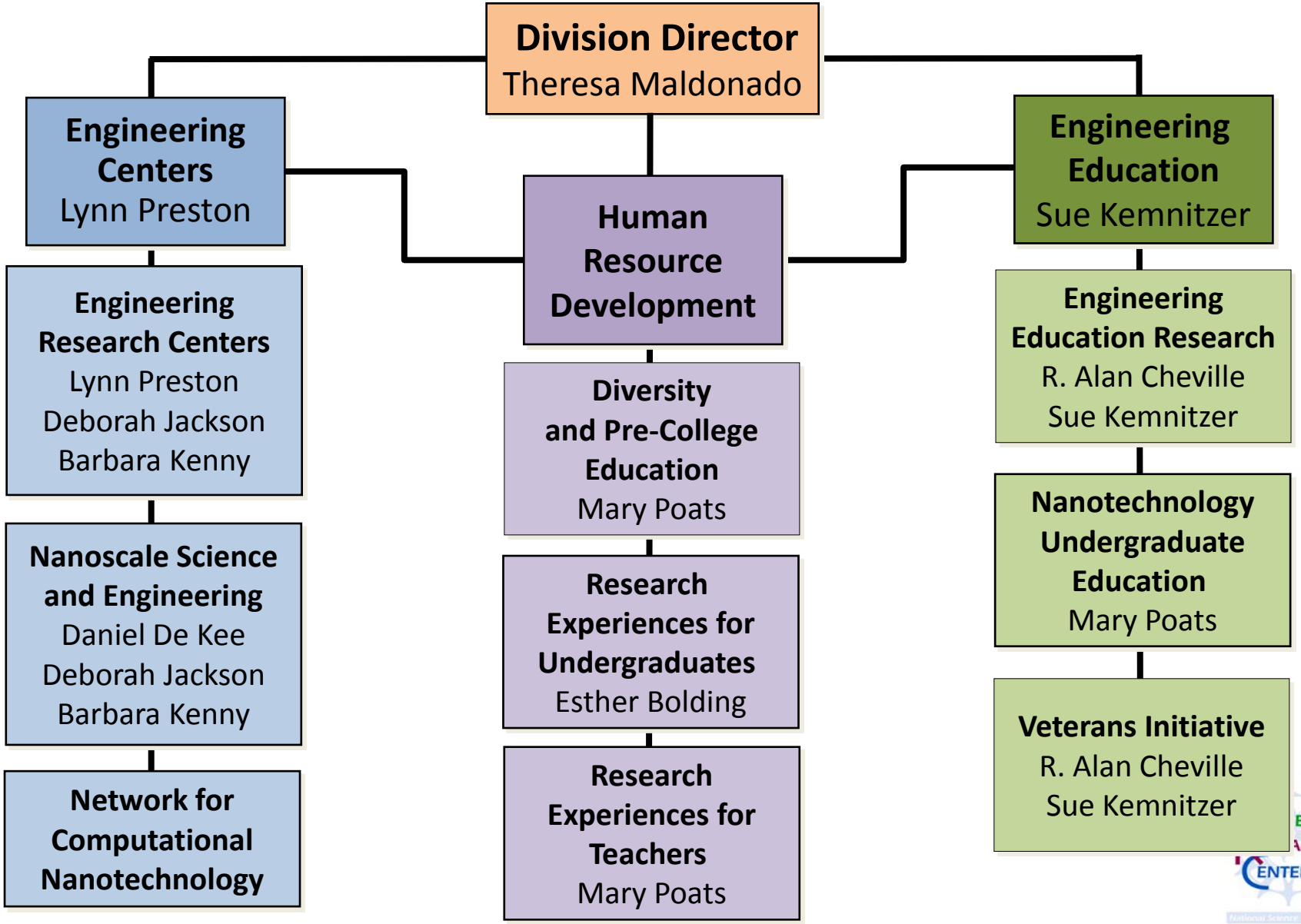

NSF support of Innovation Ecosystem: Translational research integrated with basic research and education

From: D. Stokes, "Pasteur's Quadrant," 1997.

# NSF Innovation Ecosystem



# EEC: Current Situation



# EEC FY12 Budget Request

**EEC Funding**

(Dollars in Millions)

| | FY 2010 Omnibus Actual | FY 2010 ARRA Actual | FY 2010 Enacted/ Annualized FY 2011 CR | FY 2012 Request | Change Over FY 2010 Enacted Amount | Change Over FY 2010 Enacted Percent |
|---|---|---|---|---|---|---|
| **EEC** | **$125.86** | **-** | **$124.11** | **$132.40** | **8.29** | **6.7%** |
| **Research** | **77.12** | | **78.60** | **98.76** | **20.16** | **25.6%** |
| *CAREER* | *0.02* | - | *0.40* | *0.80* | *0.40* | *100.0%* |
| *Centers Funding (total)* | *61.06* | - | *67.11* | *85.99* | *18.88* | *28.1%* |
| *ERC* | *48.60* | - | *54.91* | *81.00* | *26.09* | *47.5%* |
| *Nano Centers* | *10.24* | - | *10.00* | *2.79* | *-7.21* | *-72.1%* |
| *SLC* | *2.22* | | *2.20* | *2.20* | - | - |
| **Education** | **48.74** | **-** | **45.51** | **33.64** | **-11.87** | **-26.1%** |

- Engineering Education Program $11.85M
- NUE $ 1.00M
- REU $10.50M
- RET $ 2.00M
- ENG Emphasis Areas $ 1.20M

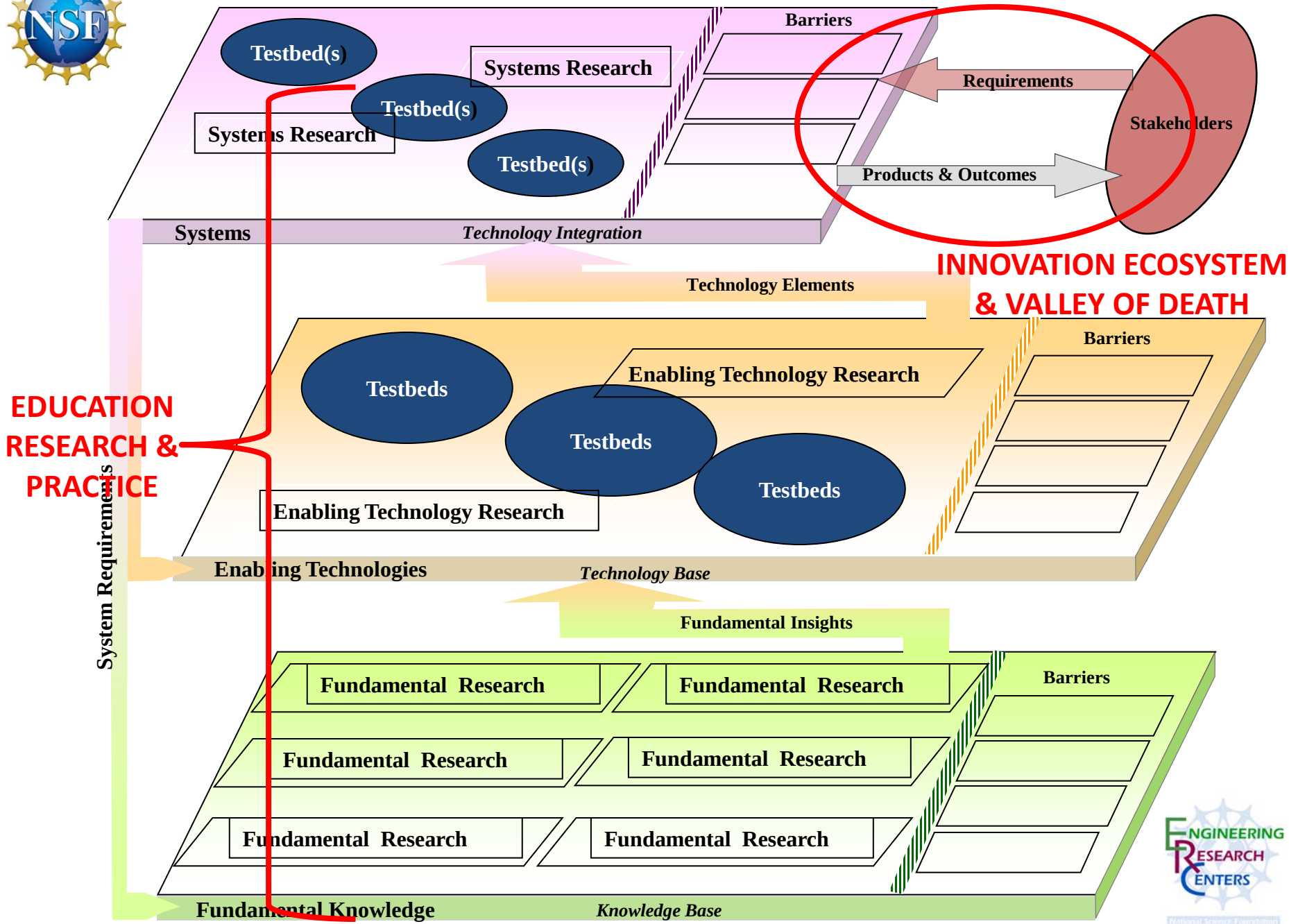
# Current Portfolio

- “Centers”
- “Engineering Education” ?
- “Human Resource Development”

# Centers: An Evolving Machine

- ERC
  - 25th Anniversary
  - Three generations since 1985
  - 50 ERCs since 1985
  - Current competition Gen-3 ERCs
    - Open topic
    - Energy: Partnership with DOE
    - Infrastructure
  - Next competitions
    - NanoSystems ERC – **Just posted: NSF 11-537 (No pre-proposals)**
    - Open topic
- NSEC
  - 19 NSECs since 2001
  - 3 graduated NSECs from FY01 class

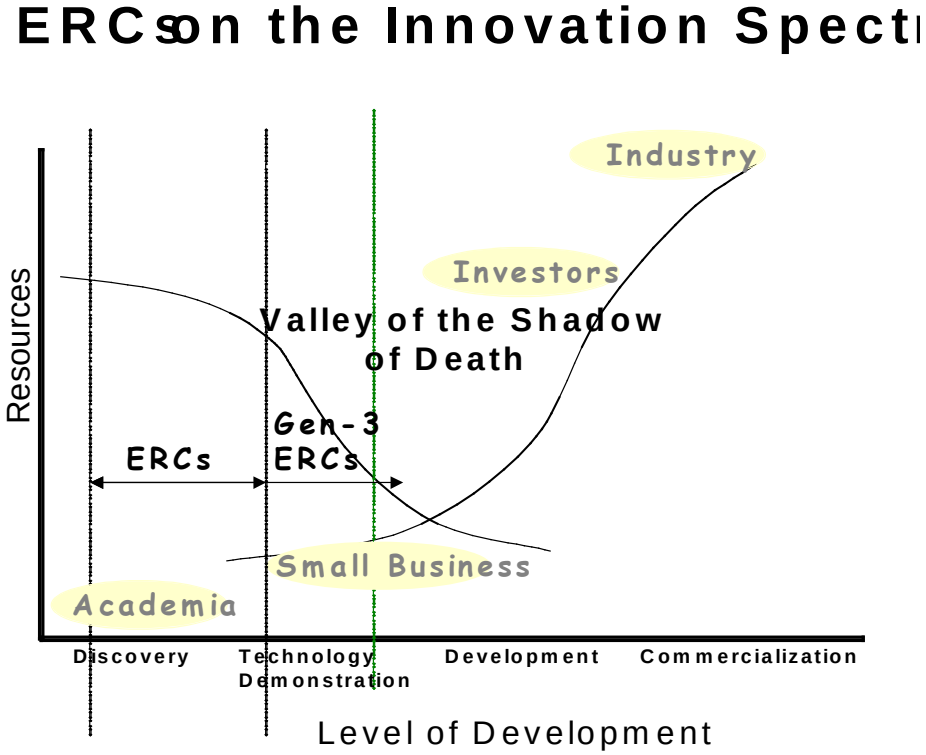
# ERC (Research) Strategic Framework:



# Additional Gen-3 ERC Key Features

Gen-3 ERCs bridge discovery to innovation by expanding the research culture to:

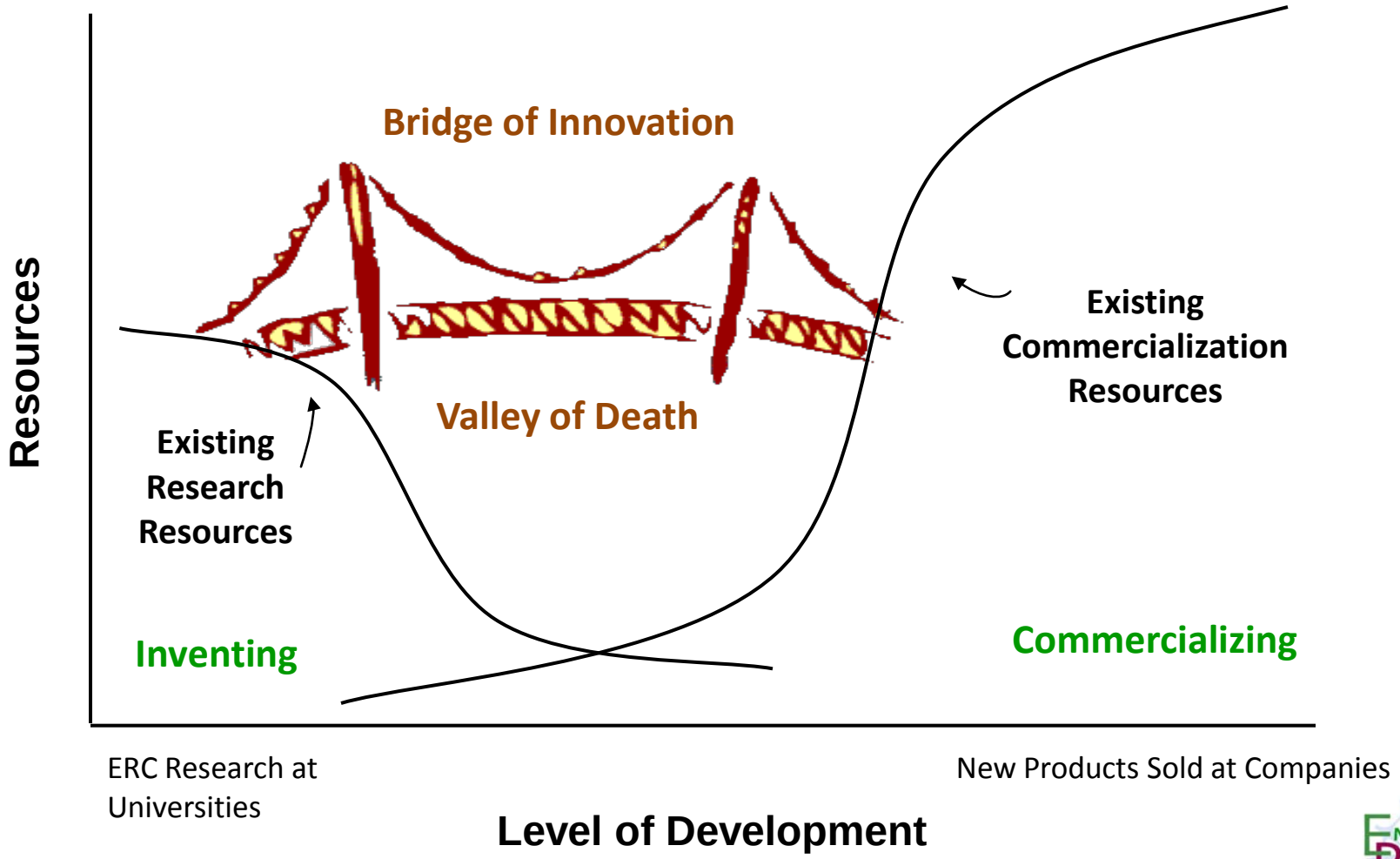
- Support translational research with small firms
- Develop more creative & innovative engineers
- Partner with economic development organizations
- Reward mentoring
- Partner with 1-3 foreign universities to provide cross-cultural, global research and education experiences
- Long-term pre-college partnerships




Adapted from slide created by Angus Kingon, Brown

# Between Invention and Commercialization

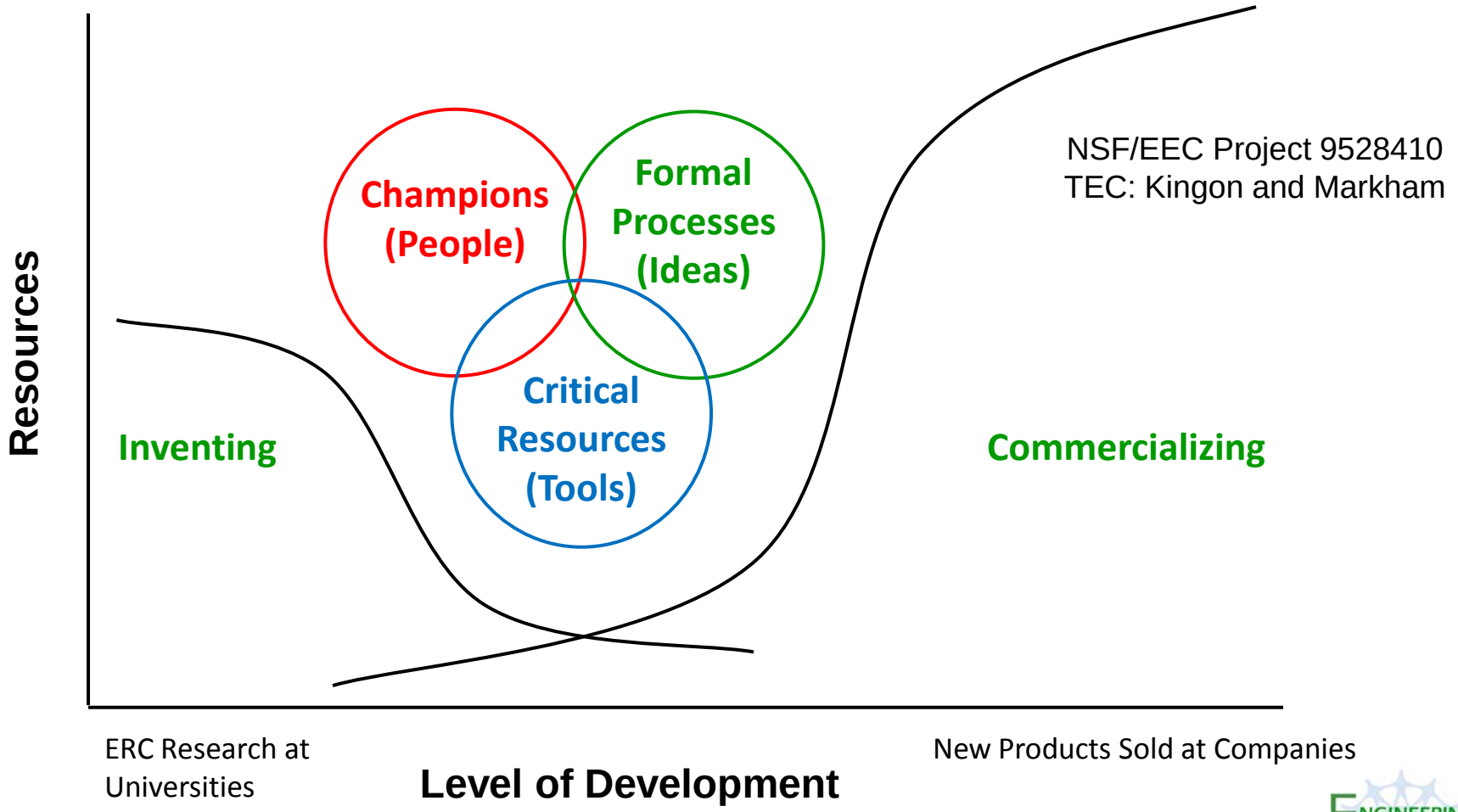
## Innovation Program to Bridge the Valley of Death




Credit: Dr. Deborah Jackson, 2011

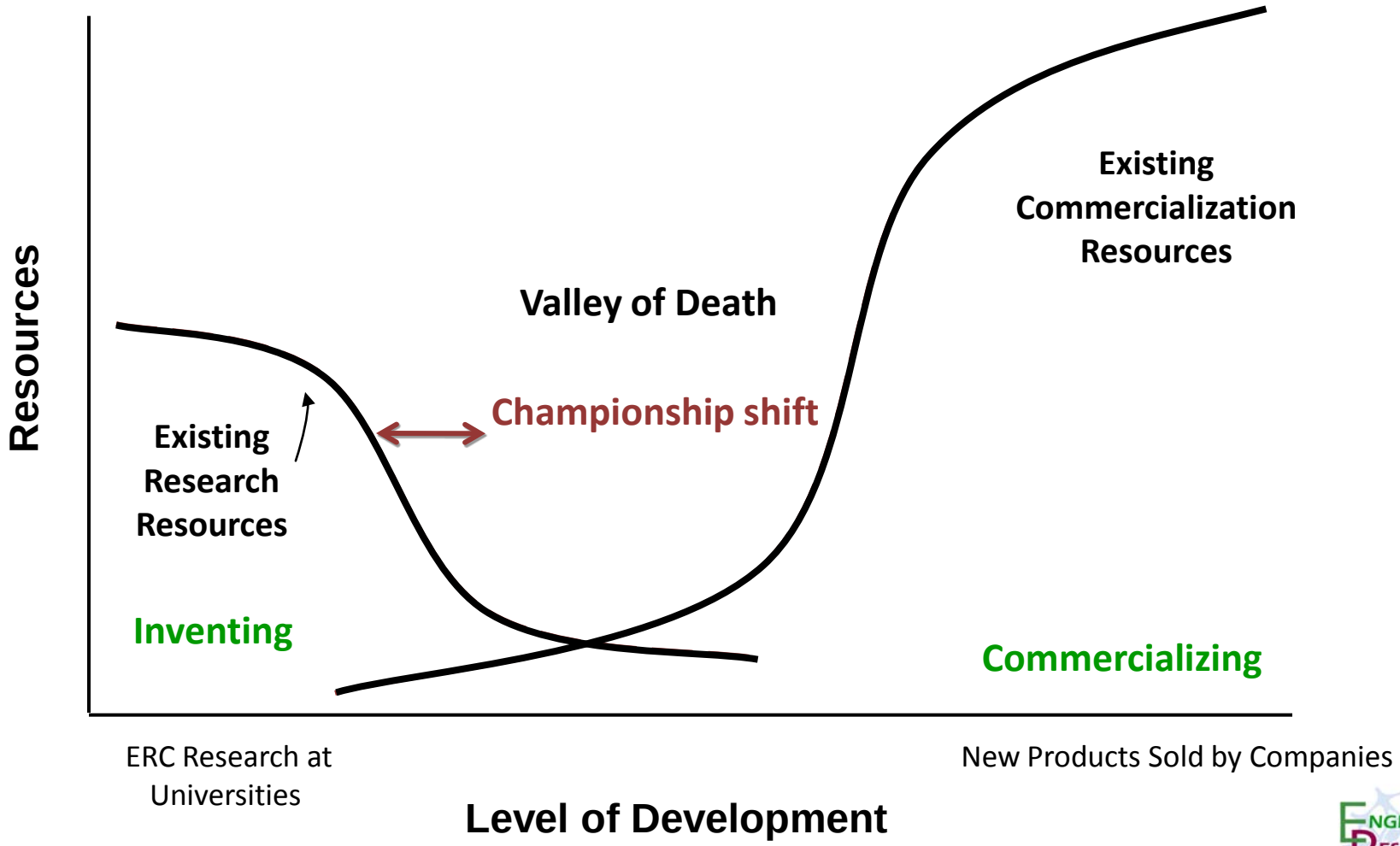
# Closer Look at the Valley of Death

## Overlapping Structural Resources and Activities




Credit: Dr. Deborah Jackson, 2011

# Innovation Bridge Structures Turn "Valley of Death" into "Challenge Basin"




Credit: Dr. Deborah Jackson, 2011

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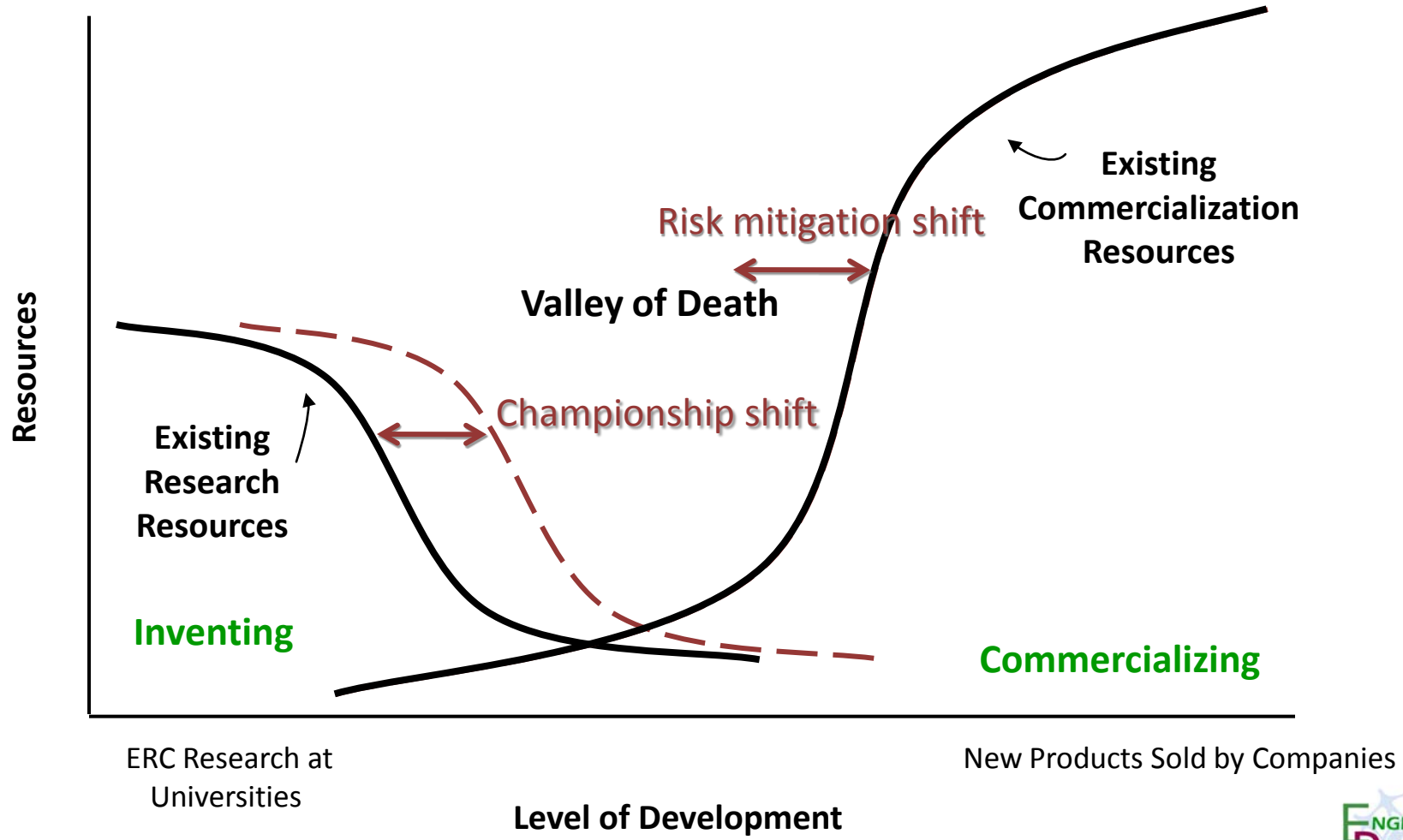



Credit: Dr. Deborah Jackson, 2011

# Innovation Bridge Structures Turn "Valley of Death" into "Challenge Basin"

ERC Research at Universities

New Products Sold by Companies

**Level of Development**

# Engineering Education
# EEC Strategic Plan 2007-2011

- Retention and throughput in our engineering schools remain a critical problem.
- Retention: 98% of the students who left STEM degree programs cited *poor teaching* by the faculty. (1997 study by Seymour and Hewitt)
- Retention: Of those students who began studies in an Engineering UG program, only 56% completed the degree by age 30.
- Throughput: Engineering graduation rate is in the low 60's%.
- Therefore, what is missing are the links between teaching effectiveness and retention/graduation.
- How does quality in the classroom impact the revenue streams of an engineering college?

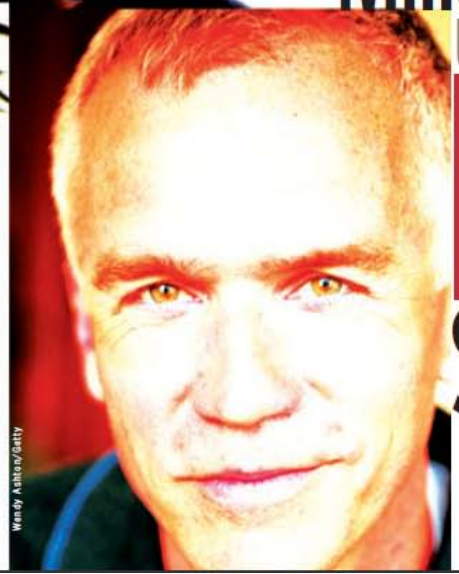
By Al Soyster

# Who and how are we teaching?

Ryan Romanelli/Getty



David Lees/Getty



Wendy Ashton/Getty

## Boomers & Gen-Xers Millennials

An essential component of facilitating learning is understanding learners. The learning styles, attitudes, and approaches of high school students differ from those of eighteen- to twenty-two-year-old college students. The styles, attitudes, and approaches of adult learners differ yet again. How well do college and university faculty, administrators, and staff understand these differences? How often do they take the differences into account when designing programs or courses?

*Diana Oblinger is the Executive Director of Higher Education for Microsoft Corporation. She has served as a Senior Fellow for the EDUCAUSE Center for Applied Research (ECAR) as well as Vice-President and Chief Information Officer for the University of North Carolina.*

# UNDERSTANDING THE NEW STUDENTS

By Diana Oblinger



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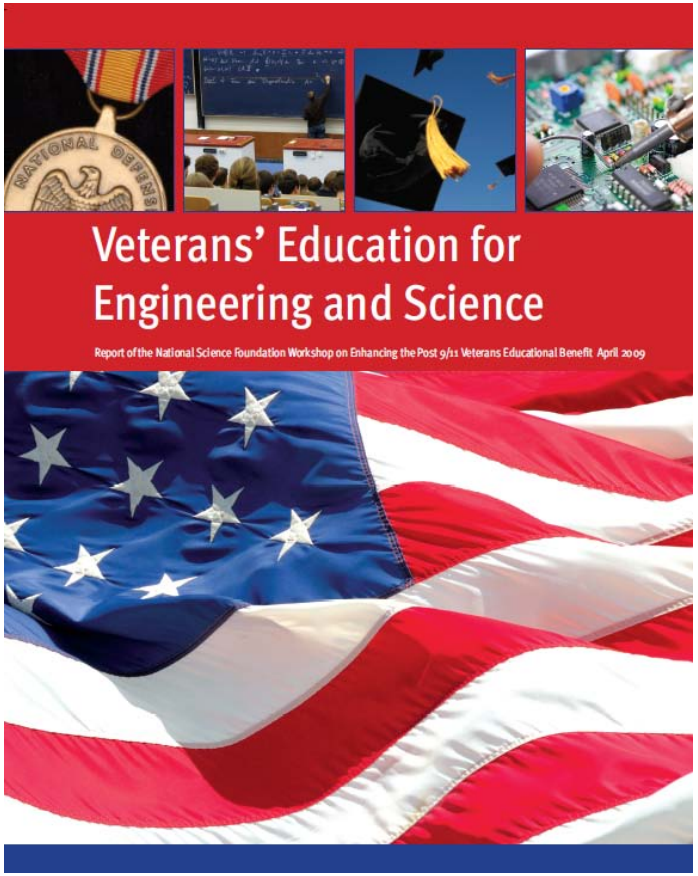
# Engineering Education Research Programs

- Innovations in Engineering Education, Curriculum, and Infrastructure (IEECI)
- Engineering Education Programs (EEP)
- Engineering Education Research (unsolicited, 2x/yr)
- Research Initiation Grants in Engineering Education (RIGEE) – Replaced IEECI FY11
- Ethics Education for Science and Engineering (EESE)
- Nanotechnology Undergraduate Education (NUE) in Engineering
- Bioengineering and Bioinformatics Summer Institutes (BBSI)
- International Research Experiences in Engineering (IREE)

Red = terminated

# Innovations in Engineering Education, Curriculum, and Infrastructure (IEECI)




- 2008 Act significantly expands benefits to veterans
  - *36 months of tuition limited to maximum in state tuition for state university.*
  - Monthly Housing Allowance
  - $1000 for Books and Supplies
- 2.1 M veterans are eligible (est.)
- 46% of veterans use benefits for four year college
- Veterans are *nontraditional*
- 98% US citizens

Replaced by RIGEE NSF 11-507
Due date: March 31, 2011

# Innovation Education

- AdComm report 3-10-11, Goal 2, gap identified: "The goal lacks discussion on how to educate students about innovation/commercialization, and the working group suggest this be added as a 4th potential recommendation.
- EEC Response: National Center for Innovation Education

- Adcom, Goal 2, suggested outcome #2: "Improved technology transfer processes and academic intellectual property policies.
- EEC Response: Gen-3 ERC. Developing a strategy to cultivate the Innovation Ecosystem – for Academics
- EEC Response: ERC Supplement Opportunity for Collaboration (SECO)

- Adcom, Goal 2, suggested outcome #3: "Improved education of students about innovation and commercialization of university research:
- EEC Response:
  - National Center for Innovation Education
  - Industry supplements to the ENG GRF

# Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) Centers:
# **National Center for Innovation Education**

- NSF 10-569
- DUE/EEC
- A comprehensive and coordinated set of activities to address the challenge of educating engineers to be innovators
- $10-million over 5 years
- Co-funded 50-50 between ENG and EHR
- Expected outcomes
  - Create engineers who are more innovative
  - Build new knowledge about how to educate engineers to be innovative
  - Develop new tools to measure innovativeness

# Building a collaborative community of scholars and practitioners

**"Valley of Death?"**

How do we bridge the divide?

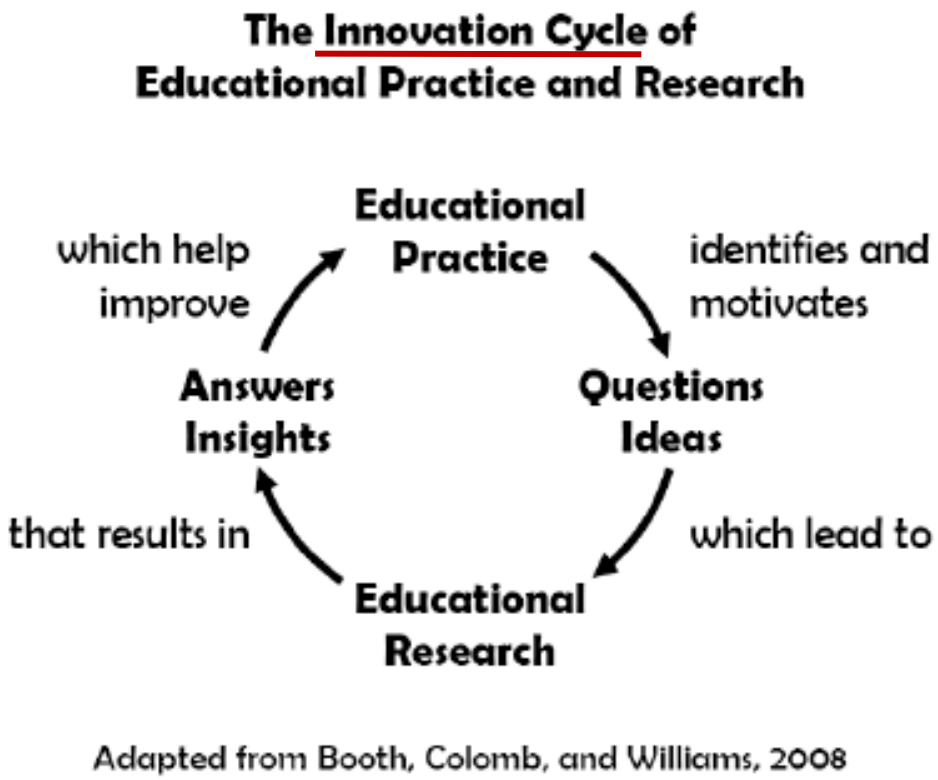
Engineering education researchers

Engineering education practitioners

By Al Soyster

# What is Engineering Education Research?

## Think ERC 3-Tier Chart




"**Creating a Culture for Scholarly and Systematic Innovation in Engineering Education ,**"
ASEE, 2009.

# Human Resource Development

- CAREER
- Research Experiences for Undergraduates (REU)
  - Supports the involvement undergraduates in ongoing research
  - $8M/year available for engineering; deadline for site proposals in Aug. each year
  - MOU with DOD AFOSR
- Research Experiences for Teachers (RET) in Engineering
  - Supports the active involvement of K-12 teachers and community college faculty in engineering research to bring knowledge of engineering and technological innovation into their classrooms
  - $3M/year available
  - CISE now engaged - $1.2M FY11
  - $2M for FY12
  - Solicitation is NSF11-509

# Graduate Students

- Graduate Research Fellowships (GRFP)
- GRFP Engineering Innovation Fellows
- GK-12 Fellowships

# Broadening Participation

- Broadening participation
  - What are our objectives?
  - How do we achieve these objectives?
  - How do we evaluate / measure it?
  - Can best practices be documented (e.g., through a federal interagency committee)?
  - How do we engage the broader community with the desire to participate once the opportunities are clear?
- Where do we really go from here?
  - Minimal changes over the many years of serious investment
  - Many disjointed programs
- Are we asking the right questions?
- Are implementation approaches off-track?
- Do we really want to achieve broadening participation? Do we have a sense of urgency?

**"The significant problems we face cannot be solved at the same level of thinking we were at when we created them." Albert Einstein**

# Influencers and Realities

- Federal initiatives
  - America COMPETES Act
  - American Competitive Initiative
  - Rising Above the Gathering Storm
  - Energy Policy Act
  - Engineering Grand Challenges
  - Etc., etc., etc.
- World / National events
  - Budget
  - War/Global Unrest
  - Leadership changes
  - National disasters
  - Etc., etc., etc.
- Trickle down effect to the State/Local levels
  - How do state governments respond?
  - What do these federal initiatives really mean at the local level? Ex. Pipeline issues are local. (AdCom report, Recommendation 3B)
  - How do we engage the broad community?

# Proposed EEC Future Portfolio

- Centers
- Engineering Education
  - Research
  - Practice
- Engineers of the Future

# Centers

- ERCs : important model to evolve
- Gen-3 relevant
- Evaporate the Valley of Death
- Framework to support SEES, CIF21, Education Research, and other priorities

# Engineers of the Future

*"…for much of its recent history, engineering education seems driven more by external "threats" than by internal reflection and visions of how best to design a better future."*

- 1960's – Soviet threat (Sputnik): **Scientific Engineer**
- 1970's – Economic threat (Japanese manufacturing prowess): **Transactional Engineer**
- 1980's – Demographic threat (retirements & sagging ENG enrollments): **Managerial Engineer**
- 1990's – Global threat (relative decline of U.S. competitiveness in global context & ubiquitous IT): **Global Engineer**
- 2000's – Environmental threat (imperative global sustainability): **Holistic Engineer**

**"Creating a Culture for Scholarly and Systematic Innovation in Engineering Education,"** ASEE, 2009.

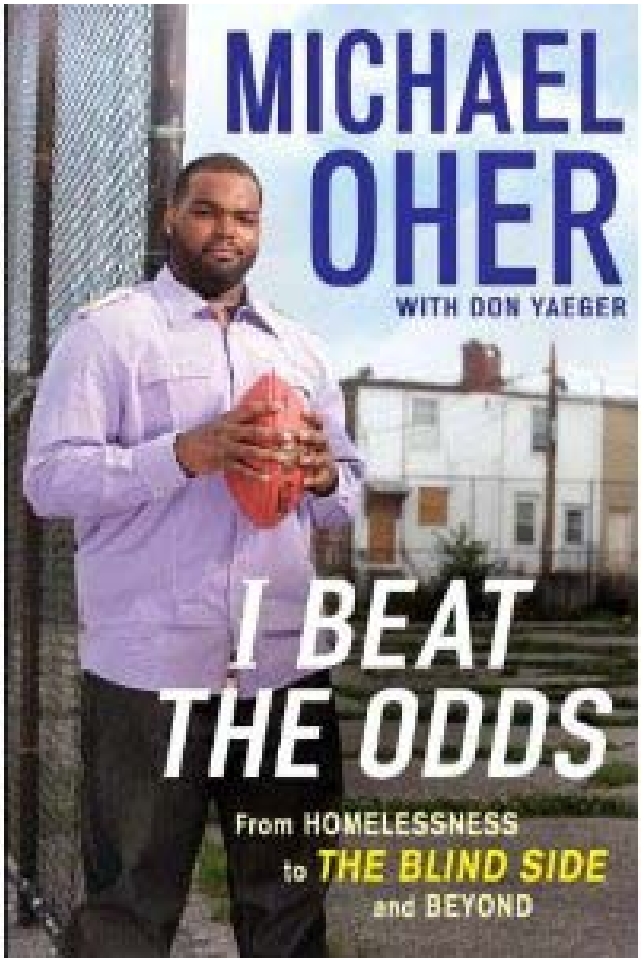
# Engineering Education Research and Practice

- Develop the rich scholarly activity that is growing rapidly
- Support practitioner activities
- Bridge the education researcher and practitioner communities
- Develop alternative pathways for engineering education
  - Most pipeline issues are local (Rec. 3B, ENG Strategic Plan)
  - Re-entry of students (AS, BS, etc.)
  - Veterans
  - Broadening participation

# EFRI: Engineering Education Research?

- Who are our students? (Large % non-traditional)
- Broadening participation
- Alternative pathways
- Cultural differences
- Socioeconomic issues – **poverty**
- Organizational behavior
- "Innovation Ecosystem"
- Faculty careers
- Accreditation
- Partnership engagement: universities/industry/government**/non-profits**

# Socioeconomic Issues & Poverty




- Homelessness
- Addiction
- Lack of food* and clothing
- No adult supervision
- Foster care
  - 25,000 kids/yr. “age out”
  - Many with no high school diploma
  - 70% of these kids wish they could go to college
  - < 10% enroll in college
  - < 1% graduate from college
  - Homeless
  - Twice as many kids with PTSD than veterans returning from war zones

* “You are not poor if you know where your next meal is coming from.”

# Engineers of the Future

- CAREER
- “Holistic” education (ASEE CCSSEEI Report 2010)
- Nontraditional students (Veterans, etc.)
- Engineering pipeline programs (RET, REU, etc.)

*“…because education, in a way, dislocates very many people from their natural talents. and human resources are like natural resources; they’re often buried deep. You have to go looking for them. They’re not just lying around on the surface. You have to create circumstances where they can show themselves.” Sir Ken Robinson, Feb. 2010*

# EEC = The Integrator
# A Critical Function