RESEARCH-BASED STRATEGIES FOR CREATING INCLUSIVE CLASSROOMS IN ENGINEERING

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IFEES June 2019
Acknowledgements

IUSE/PFE:RED 1632053
Revolutionizing Engineering Diversity
reved.rowan.edu

IUSE: 1610164
Algae Grows the Future
algaegrowsthefuture.wordpress.com

NSF EEC 1539140/1748499
Promoting LGBTQ Inclusion in Engineering
diversity.ASEE.org/lgbtq
DIVERSITY IN ENGINEERING
Prevent Nuclear Terror
Engineer the Tools of Scientific Discovery
Carbon Sequestration
Restore and Improve Urban Infrastructure
Provide Energy from Fusion
Provide Access to Clean Water
Engineer the Tools of Scientific Discovery
Manage Nitrogen Cycle
Make Solar Energy Economical
Advance Personalized Learning
Engineer Better Medicine
Secure Cyberspace
Reverse Engineer the Brain
Enhance Virtual Reality
8.5 B by 2030
The need to increase diversity

1 million additional STEM graduates needed by 2022

President’s Council of Advisors on Science and Technology (2012)

Most viable way to achieve this is to
Increase retention

Key reason for leaving STEM is
Unwelcoming climate

Disproportionate effect on
Minorities

President’s Council of Advisors on Science and Technology (2012)

Creating an inclusive climate benefits
ALL students

Diversity is essential to the intellectual and social development of
ALL students


Diversity increases
Innovation and productivity

Herring (2009)

Creating an inclusive climate
30% ↑

Employee engagement
Human Rights Campaign (2014)
Completion Rates for STEM-aspiring UG students

White and Asian Students

URM Students

Source: Eagan et al. (2014)
Engineering educators will need to:

• Recognize, recruit, cultivate and retain untapped talent from a diverse population
• Create an inclusive culture which is essential for learning, development, engagement, and retention
Complex factors contribute to lack of diversity
Impact of culture

Social, psychological, structural dimensions

Connections between personal identities & academic domains

Effort and achievement

“beyond predictions based on socioeconomic or academic indicators”

Source: NAE (2016)
WHAT SHOULD I DO
To build inclusion in my engineering classroom?
SET THE TONE ON DAY 1
Include a diversity statement on the syllabus

“It is my intention that students from all backgrounds and perspectives will be well served by this course, and that the diversity that students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, socioeconomic background, family education level, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. Your suggestions are encouraged and appreciated.”
Respect name and pronoun use

• Bring a roster with last names only; ask students for first names
• Provide an opportunity for students to tell you their pronouns
  • Use get-to-know you index cards
Openly discuss accessibility and accommodations

“Your academic success is important. If you have a documented disability that may have an impact upon your work in this class, please contact me. Students must provide documentation of their disability to the Academic Success Center in order to receive official University services and accommodations.”

Source: http://miamioh.edu
Expose students to positive role models

• Highlight the contributions of individuals from diverse backgrounds and marginalized groups

• Invite speakers with different backgrounds, representing different identities
Communicate a multicultural ideology

Examples in thermodynamics

- Under-floor heating (China, 5C BCE)
- Human- or water-powered fans
- Water wheels (Eurasia, 3C BCE)
- Cooking stove; ice cream maker—(American women, 1800s)

Chinese underfloor heating

Riley (2009); Riley (2003)  
Zhang & Chen (2016)
USE SOCIALLY RELEVANT EXAMPLES
Make Engineering Relevant to All Students

• All students perform better when content is presented in a relatable context
  • Introduce new topics using familiar examples
  • Use examples relevant to individuals and their communities
  • Use a diverse set of examples to address a diverse group of students
Example: Social Justice in Control Systems Engineering

**Original Problem:** You are to design a Proportional/Integral (PI) control system for a tank with controllable flow input $q_{in}$. The level of liquid in the tank must be carefully regulated.

The desired specifications are:
- Settling time equal to 10 seconds
- Overshoot of 15%
- Zero steady state error for unit step reference

The tank has an area of 100m$^2$, the density of the liquid is such that $\rho g = 10000$ kg m$^{-2}$s$^{-2}$ and the flow resistance at the outlet valve is 400 kg m$^{-4}$s$^{-1}$.

Johnson et. al (2015)
Example: Social Justice in Control Systems Engineering

**Rewritten problem:**
A remote village has won a grant to install a tank that can provide household water during the dry season. To ensure a balance between protecting the pump (extending its lifetime as long as possible), ensuring enough water for the village’s needs, and not wasting water by overfilling the tank, you are asked to design a PI control system to control the liquid level in the tank…
EMBRACE AN ASSET-BASED MODEL OF DIVERSITY
Funds of knowledge

• Traditional engineering culture and curricula value theory ("knowing that") over practical experience ("knowing how")

(Carnegie Foundation Report Educating Engineers)

• Nontraditional students often possess practical skills that should be viewed as an asset

• Make their funds of knowledge visible and valued
  • View nontraditional backgrounds a strength rather than a weakness to be overcome
  • Use students as authorities – encourage students to pose questions and answer questions
INCLUSIVE CLASSROOM ACTIVITY
Encourage a growth mindset

- Give students time and space to attempt difficult problems
- Encourage collaboration
- Allow students to analyze and discuss solutions
- Help students reflect on mistakes and misconceptions

TedX Talk by Dave Paunesku
https://www.tedxspokane.com/?p=5022

https://sites.dartmouth.edu/learning/2017/05/18/understanding-the-growth-mindset/
Rearrange the furniture

Traditional

Group Pods

https://ctl.yale.edu/ClassroomSeatingArrangements
References


