Multiple Perspectives on Engaging Future Engineers

SASEE 2013

Robin S. Adams
JEE centennial issue: “Will you write a paper on ‘engaging future engineers’?”

Me?

A collection of voices!
We all seem to care about and invest in...

Engaging Future Engineers

Educators
Student Advisors
Outreach Programs
Diversity Programs
Administrators
Learners
Government Agencies
Econimies
Employers
Policy makers
Activists
Communities & cultures
Many good efforts, but persistent questions

Why do so many leave?
Why aren’t my students excited about being in class?
Why aren’t students spending the time needed to be successful?
Why don’t students use prerequisite coursework in my class?
Why aren’t the graduates I hire ready to do ‘real’ engineering work?
Why don’t my students think “out of the box” or “get involved”? 
Why don’t we see more diversity?
Why do we see so few students “switch in” to engineering?
Are we thinking too small? Narrow?

Complex “wicked” problem
Engaging Future Engineers?

Invite thought leaders with different perspectives
“Interparadigmatic” mix for productive conflict and divergent thinking

Broaden the problem space → new “space” of ideas
Multiple perspectives & communities of thought

“Engaging”
- Socio-technical thinking
- Cognitive Connections
- Affective Mediators

“Pre-engineering thinking: modeling”

“Future”
- Modest epistemology
- Trans-disciplinary engineering
- Race, class, gender

“Engineers”
An invitation to you…

How does this connect to you…

As an engineering educator

As a decision-maker about programs

As a leader and changemaker

As a colleague

Are there perspectives you would add?
“Emphasize connections: between the old and the new, between the abstract and concrete, among the ideas and principles of the field, and with their instructors to adapt to the ever-changing world of learning.”
Students need help making connections

**Student experience?**

- The Discipline
- The Curriculum
- Student (learners)

**Student outcome?**

(Not important ≠ Not connected?)
(Not part of “being an engineer”?)

**Importance (seniors)**

- Societal context
- Global context
- Contemporary issues

Source: Atman & Turns, 2010 (N~160, 4 campuses)
Connecting abstract & concrete...

Used to interpret particular case (concrete)

General Domain Knowledge

Particular Case

Yields new information

May modify general knowledge leading to different ideas about how to respond to a new case (transfer)
Connecting understanding & applying…

Making connections “real”…
...students don’t understand “it” until required to use “it”
Findings from a 5 year, 5 school NSF grant to investigate the links among connections to community, belonging, and engagement among undergraduate STEM students. (Wilson et al, 2013)

“Belonging is a fundamental human need…it is ever-present and invisible”
Belonging mediates engagement (N~1500)

Background Factors:
- School Year
- Parent's Educ.
- GPA

Academic Orientation:
- Grades
- Self-Efficacy

Engagement Outcomes:
- Participation
- Effort
- Positive Affect
- Negative Affect

Major Belonging
Class Belonging
University Belonging
CLASSROOM Belonging is critical

- Academic Orientation
- Self-Efficacy

- Major Belonging

- Educator Agency

- Background Factors
  - GPA

- Participation
- Effort
- Positive Affect
- Negative Affect

Correlates significant across 3 or more schools AND all engagement metrics
**Classroom engagement: 250 classrooms across 5 schools**

<table>
<thead>
<tr>
<th>Classroom Engagement</th>
<th>Institution</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sage on Stage (Passive – lecture)</td>
<td>Teaching</td>
<td>89%</td>
<td>38%</td>
<td>43%</td>
</tr>
<tr>
<td></td>
<td>Research</td>
<td>56%</td>
<td>54%</td>
<td>19%</td>
</tr>
<tr>
<td>Connected Sage on Stage (Hybrid of passive and active)</td>
<td>Teaching</td>
<td>11%</td>
<td>60%</td>
<td>41%</td>
</tr>
<tr>
<td></td>
<td>Research</td>
<td>31%</td>
<td>46%</td>
<td>36%</td>
</tr>
<tr>
<td>Guide on the Side (Active learning)</td>
<td>Teaching</td>
<td>0%</td>
<td>2%</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td>Research</td>
<td>13%</td>
<td>0%</td>
<td>45%</td>
</tr>
</tbody>
</table>

“Connected Sage on the Stage” → instructor-student connections, peer belonging
Communicates an ethic of care?
Belonging Needs
“I did horrible [sic] on my first physics test. After the test I was upset and having a horrible day. I went home that weekend and I was able to enjoy time with my family and not think about physics. Next week I was able to do my homework, did everything, and I started understanding better. Then I did better on my next test.” (Teaching)

Safety Needs
Interactions with a wide variety of friends have helped him tone down his hypercompetitive and perfectionist side. Stress has been difficult to manage in the past. Friends have slowed him down, which has allowed him to enjoy what he’s learning more, and the decrease in stress has allowed him to do well in school. (Researcher’s Notes, Private)

Esteem Needs
A friend walked back with him after the test and encouraged him to keep trying. This made the student feel encouraged and made him feel better about the class. (Researcher’s Notes, Private)
Engaging Future Engineers…

Engage Affect
Community Belonging

Connect
Heart & Mind

Engage Connections
Old / New
Abstract / Concrete
Understand / Apply
Demetra Evangelou: Child Development
Nicholas Mousoulides: Math Education, Educational Science
Lyn English: Math Education, Cog Psychology

Engage PRECURSORS to engineering thinking in early formative development

“...reveal the depth and beauty of engineering as the process of *creating civilizations*, in ways that are accessible and inviting to children.”

“...engage students in exploring fundamental engineering ideas and principles...develop the curiosity and drive to learn how engineering shapes their world...”
Engage: “Developmental Engineering”

**Engineering as “vehicle”**

Engineering as context to learn math, physics, chemistry, etc.

**New perspective on STEM integration in pre-college years**

**Engineering as “cradle”**

**Engineering as a way of thinking and learning in contemporary society**

- Develop critical and creative thinking
- Develop abstract reasoning
- Relevancy of math, physics, chemistry, etc.
- Facilitate flexibility and self-initiated learning
- Learn to troubleshoot, learn from failure
- Appreciate role of engineering in society
- Inspire early identification as engineer
Two Examples

Engineering as relationship between **people** and **artifacts**

How does it work?
What is it?  Why create it?

**Engineering as creating mathematical models**

Shareable?
Reliable?
Modifiable?

**Express – test – refine - generalize**

Capitalize on children’s naturally occurring curiosity and agency for self-initiated learning

Window into students’ conceptual understanding as develop a “product”
Engage socio-technical engineering education

“It should be as hard to pull apart the socio from the technical in the educational experience as it is in the realization of successful engineering projects.”

Engineering as technical work

Reframe

Engineering as socio-technical work

Reed Stevens: Learning Sciences, Science & Tech Studies

“…students had vague images of what engineering is, but whatever it was, it did not have much to do with people…. (they develop) increasingly strong us/them views about other college students and some strongly held views about the limited value of academic disciplines whose scholarship pays attention to people.”
Socio-technical engineering

- Government agencies and officials
- Regional committees
- Individuals/groups that live in the area
- Workers that interface with project
- Response workers
- Etc.

New idea!

Individual

Non-technical & technical agents
Complex social structures

Influence and deflect technical object

Disaster Relief System
Engage:
Socio-technical Engineering Education

• Early engineering experiences
  – Counteract role of “outsourced” engineering courses (math, physics, chemistry) in formation of engineering identity and ways of thinking

• “Follow the object” fieldwork
  – The lifespan of a technical object – from inception to realization

• Welcoming home for “people person” who likes engineering
Engaging Future Engineers...

Engage Affect
Community Belonging

Engage Precursors
“cradle” for learning
Early identity formation

Connect Heart & Mind

Engage Socio-Tech
Professional identity

Connect
Lifelong Learning
Engineering in society

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Understand / Apply
Antonio de Figuerido:
Philosopher, Computer Scientist, Electrical Engineer

Engage Transdisciplinary epistemology

“Engineering” is socially constructed and contextual
Aggregate of conflicting values, ways of knowing
Not simple synthesis → generative, emergent

“Is engineering in search of an identity?”

“To engage future engineers we must let them (students) experience
the unique identity of engineering and the beauty of its kaleidoscope
dimensions…building their own configuration of commitments
along these dimensions…and by learning to collaborate and create
collective value across them.”
VARIATIONS
Multiple pathways to BECOME an engineer
Generative ➔ Revitalize Profession

Social complexity
Hermeneutics / Positivist
Create social/economic value

HUMAN SCIENCES
engineer as humanist

BASIC SCIENCES
engineer as scientist

people

Theory

Engineering complexity (Problem/Solution co-evolves)
Negotiation & judgment
Systems thinking

Design

Practice

Matter Theory
Information Life

Logic & precision
Analytical / Positivist
Seeks 1st Principles

Art of “get it done”
Pragmatics
Apprentice/Reflection
Change world
What do first year engineers think?

Multiple entry points – variations of “being an engineer”

First Rank
- Science
- Design
- Human
- Craft

Second Rank
- Science
- Design
- Human
- Craft

120 students ranked abilities and interests (similar pattern among 1800 students)
What do doctoral students think?

Multiple “exit” points – variations of “being an engineer”

19 PhD students in engineering education: ranked abilities and interests
Engaging Future Engineers...

**Engage Affect**
- Community Belonging

**Connect**
- Heart & Mind

**Engage Precursors**
- “cradle” for learning
  - Early identity formation

**Engage Socio-Tech**
- Professional identity

**Connect**
- Lifelong Learning
  - Engineering in society

**Engage Connections**
- Old / New
  - Abstract / Concrete
  - Understand / Apply

- People
- Matter
- Theory
- Practice

- BASIC SCIENCES
  - engineer as scientist

- HUMAN SCIENCES
  - engineer as humanist

- DESIGN
  - engineer as designer

- CRAFT
  - engineer as craftworker
“...engagement means more than recruitment. It means engaging students in critical thinking and in helping them see the importance of critical engineering practice...epistemological challenges that are aimed at getting students to think critically about the taken for granted assumptions we have about how knowledge is produced and about is reliability and ‘truthfulness’. ”
“What causes most gastric ulcers?”

20 year journey
2005 Nobel Prize - Marshall & Warren

Engage: Epistemological challenges

One superior, overarching explanation

Tolerate & accept coexisting, multiple, competing paradigms

Reveal
Self-interest and power – can influence fact, theory, objectives, decisions

Enable
Pluralism in sciences

Promote
Respectful & engaged dialogue

Engage
Future engineers sensitized to urgency of this
Alice Pawley: Engineering Education, Feminist Engineering

“a ‘one size fits all’ mentality does not work in engaging future engineers, particularly for ‘underrepresented’ engineers as a group.”

Julie Trenor: Engineering Education, Materials Science

“Smart, educated people are looking for a silver bullet, a simple answer – but there isn’t one for increasing participation of other underrepresented groups in engineering...”

Engage Intersectionality & Social Justice
People live at the intersection of many social dimensions – these are not “variables” but lived identities.

Engage: Intersectionality

Moving beyond “one size fits all”

IMPACTS

What “counts” as engineering

Who gets to be an engineer

How prepare engineers
Engage: Social justice

Challenging arguments for a more diverse profession / workforce

The economic argument
- STEM diversity enables global competitiveness
- National prosperity

The social justice argument
- Equity & access in participating in STEM career has benefits
- Individual prosperity
- More life-centered designs?

A different take on “nation building”?
Multiple perspectives – Generative questions?

“Engaging”

Socio-technical thinking

Affective Mediators

Pre-engineering thinking: building

Pre-engineering thinking: modeling

Modest epistemology

Trans-disciplinary engineering

Race, class, gender

“Future”

“Engineers”
Engaging Future Engineers...

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Engaging Future Engineers...
Engaging Future Engineers...a new map

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**Connect**
- Lifelong Learning
- Engineering in society

**Theory**
- People
- Matter

**Practice**
- Engineer as scientist
- Engineer as designer
- Engineer as craftworker
- Engineer as humanist

**BASIC SCIENCES**
- engineer as scientist

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Engaging Future Engineers...a new map

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**Engage Precursors**
“cradle” for learning
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**Engage Socio-Tech**
Professional identity

**Connect**
Lifelong Learning
Engineering in society

**Engage Race/Class/Gender**

**Engage Pluralism**
Diversity, intersectionality, social justice

**Engage Connections**
Old / New
Abstract / Concrete
Understand / Apply

**Engage**
People

Theory
Matter

Practice

- HUMAN SCIENCES
  - engineer as humanist
- BASIC SCIENCES
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Engaging Future Engineers?

New language? New ideas? New plans?

Engage Affect
Community Belonging

Engage Race/Class/Gender

Engage Socio-Tech
Professional identity

Connect Heart & Mind

Connect Lifelong Learning
Engineering in society

Connect Epistemologies

Connect Pluralism,
intersectionality,
social justic

Engage Precursors
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Engage Professional Identity

People

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Matter

Practice
One take-away: “Entwinement”
Integrative systems, not separable into parts

From “EITHER / OR” polarities to “AND” holistic thinking

- mind AND heart
- social AND technical work
- engineer AND social actor
- science AND human AND design AND craft
- knowing AND being

Becoming an engineer as traversing many boundaries
Complex? You bet...but, that’s engineering
Another take away?
From new ideas → transformative action

Aims
Purpose of engineering education

Examine arguments

Evaluate arguments

What should be Engineering Education?

Access/Participation
Who gets to be an engineer

Process
How educate future engineers

Consequences of these arguments?
Should we value these consequences?
Who participates in these decisions?