Developing Connections during Introductory Coursework: Engineering Virtual Studio
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Alice Ndikumana performing research on the electricity of the heart in the lab of Dr. Igor Efimov
Standard Test Method for Football Shoulder Pads

Matthew Hasmonek, Zoe Haemer, and Cody Katz

Zoe Haemer, Matthew Hasmonek, and Cody Katz

Rawlings Sports

Department of Biomedical Engineering, Washington University in St. Louis

December 14, 2017

Components

The Model

Testing Method

References
The nation needs more engineers who are brighter, more creative, and more innovative (NAE: Engineer of 2020), but nationwide, students drop out of STEM and become disillusioned by “sink or swim” foundational courses unclearly related to their interests.
“We’re losing an alarming proportion of our nation’s science talent once the students get to college,” says Mitchell J. Chang, an education professor at U.C.L.A. who has studied the matter. “It’s not just a K-12 preparation issue.” Professor Chang says that rather than losing mainly students from disadvantaged backgrounds or with lackluster records, the attrition rate can be higher at the most selective schools, where he believes the competition overwhelms even well-qualified students. ...

Other deterrents are tough freshman classes, typically followed by two years of fairly abstract courses leading to a senior research or design project. “It’s dry and hard to get through, so if you can create an oasis in there, it would be a good thing,” says Dr. [David E.] Goldberg, who retired last year as an engineering professor at the University of Illinois at Urbana-Champaign and is now an education consultant. He believes that the president’s chances of getting his 10,000 engineers is “essentially nil,” if we continue on the current path.
Many see engineering education as a formulaic, boring, individualistic endeavor driven largely by the acquisition of highly atomized, esoteric technical skills.

Even those who recognize engineering as a venue for solving major problems facing humanity often become discouraged in the early years.

Seemingly endless drudgery of courses ... appear to be largely disconnected, not only from their interests, but also from the broader picture of what engineering could be, and should be, about.

-Gretchen Kalonji, NAE, 2005
Washington University Biomedical Engineering

**First Year**
Introduction to Biomedical Engineering (BME 140)
General Chemistry I, II (Chem 111A, 112A)
General Chemistry Laboratory (Chem 151, 152)
General Physics I, II (Phys 117A, 118A)
Calculus II, III (Math 132, 233)
Principles of Biology I (Biol 2960)

**Second Year**
Biomechanics (BME 240)
Differential Equations (Math 217)
Computer Science I (CSE 131) or Engineering / Scientific Computing (CSE 200)
Introduction to Electrical Networks (ESE 230)
Principles of Biology II (Biol 2970)
Physiological Control Systems (Biol 3058)
Engineering Mathematics (ESE 319)
Humanities/Social Sciences electives
How do we help students stay connected and creative during “sink or swim” foundations?
Engineering Virtual Studio

One credit, pass/fail, online environment to provide structure, community, and development across the major

- Introductory reading / multimedia
- Mathematical model
- Small-group online discussion
- Class-wide discussion of group leaders

- Artifact archival and annotation
- Portfolio presentations
- Essay on self in major and profession
- Library of creativity, values, goals
Real Engineering, Problems, Modeling, Solutions

\[ \Delta V = I_e R_m \]
\[ R_m = \frac{r_m}{A} \]
\[ r_m \approx 1 \text{ M}\Omega \text{ mm}^2 \]
\[ Q = C_m V \]
\[ C_m = c_m A \]
\[ c_m \approx 10 \text{ nF/mm}^2 \]
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NSBE’s mission is to increase the number of culturally responsible Black engineers who excel academically, succeed professionally, and positively impact the community.

• The National Society of Black Engineers at Washington University has invested its time, energy, and resources into bettering the St. Louis community.

• Every year we strive to mentor and educate rising elementary and high school students about the merits of a quality education and the available opportunities in the world of engineering.
Engineering Virtual Studio (EVS) and NSBE
Hire NSBE to
• alpha test bulletin material, to advise on readability, understandability, and effectiveness ✓
• mentor small-group online discussion ✓
• assist expansion of EVS from BME to the rest of the SEAS departments
• harvest established bulletins for material to aid in NSBE activity, e.g. pre-college outreach.

Bring NSBE to center of development of underclassman development – leverage and strengthen NSBE mentorship, leadership in scholarship and pre-professional identity

(Open question – build / work with local / national NSBE directly?)
Engineering Virtual Studio

One credit, pass/fail, online environment to provide structure, community, and development across the major.

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Build toward scholarly and pre-professional identity and goals.

- Introductory reading / multimedia
- Integration across local & global ideas
- Small-group online discussion
- Class-wide discussion of group leaders

Insightful integration across curriculum, real world, real STEM products / problems.
Semesters 1-2: Connections introduced by course staff
Semester 3: Connections small group driven, toward personal interests
Semester 4: Dovetail of two threads, real world check on emerging ideas on connections, scholarly and pre-professional identity build
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Desired outcome: Experienced integrative and innovative thinkers, seekers, and builders of personal meaning and connection
Preliminary Data

1. For each discussion topic 95% of students participated on time and 93% of rotating group leaders posted group summaries on time.

2. Personal reflection essays, with the same initiating prompt, were assigned each semester. 118 Fall Semester and 96 Spring Semester essays were compared for each student and evaluated with the criteria below:

   Write a reflective essay on your experience to date, including the past semester. Include your ideas and view of how each semester course relates to your path in biomedical engineering and a broadly thought-out view of how you see yourself not only here in BME & WUSTL, but post-graduation.
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**Development of a scholarly identity**

- FALL 2012: 71%
- SPRING 2013: 30%
- GROWTH in SP2013*: 23%

**Insight into how core curricula relates to BME**

- FALL 2012: 68%
- SPRING 2013: 45%
- GROWTH in SP2013*: 11%

**Development of a pre-professional identity**

- FALL 2012: 54%
- SPRING 2013: 38%
- GROWTH in SP2013*: 8%

*Growth in an area was judged to be increased detail or a more mature perspective on the topic.

“All of my classes have fed into the other, from calculus and learning about cross and dot products, to physics and stresses and strains. All which appears to be disorderly has order…”
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pre-EVS: 7 / 106 essays with iPad / iPod drawing + browbeating

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Coming: Pilot intervention -> pilot educational research (very short view & long view)

- Qualitative analysis of growth in discussion and reflection writing
- Surveys on motivation, connection, identity
- To-be-developed quantitative metrics on valuation (personal investment)
MIDFIELD (70k students, 1987-2004) (Ohland et at 2008)

Figure 4. Academic disengagement from engineering-related and liberal arts courses for persisters. Error bars display standard errors of means. No survey was administered in Sem 7.
MIDFIELD (70k students, 1987-2004) (Ohland et at 2008)

Disengagement from Engineering-related Courses forPersisters and Non-persisters

Normalized Disengagement Score

Sem 1  Sem 2  Sem 3  Sem 4  Sem 5  Sem 6  Sem 7  Sem 8

Sem 2 NP

Sem 3 NP

Sem 4 NP
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Google-ification? (Importance of capture; challenge of Blackboard proper)
One entrepreneurial mindset module per semester (4 in all) to deliver KEEN foundations
“In the long run, making universities and engineering schools exciting, creative, adventurous, rigorous, demanding, and empowering milieus is more important than specifying curricular details.”

Charles Vest, MIT
Educating the Engineer of 2020: Adapting Engineering Education to the New Century, NAE, 2005

This project: Foster integrative, independent, innovative thought and identity formation in freshman and sophomores

Big idea: Flipped major – 1\textsuperscript{st}/2\textsuperscript{nd} year builds mindset, skillset for each student to drive their own training and pre-professional plan action (24/7, in/out classrooms, campus, beyond)

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