NSF RED: Supporting Convergence Development through Structural Changes to an ECE Program

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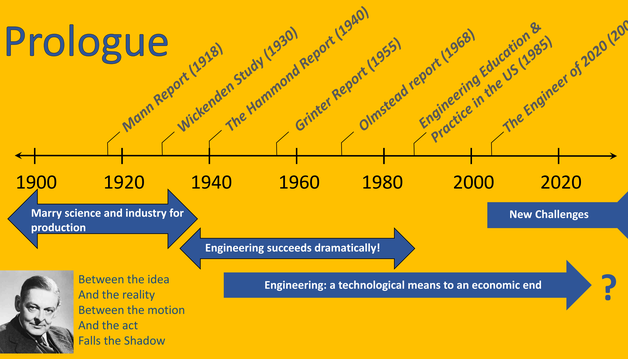
Prologue



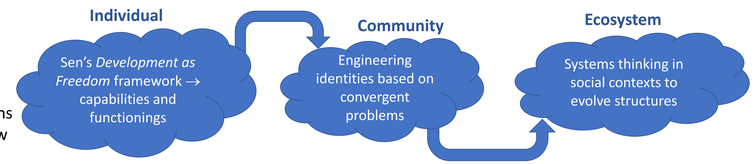
Between the idea
And the reality
Between the motion
And the act
Falls the Shadow

NSF RED @ Bucknell Manifesto

- Social sciences and the humanities are as an important foundation for engineering as are mathematics and physical science.
- Technical skills have little value without autonomy and agency, which arise from giving students freedom to pursue what they value.
- There is too much focus on developing a narrow set of technical capabilities and not enough on introducing students to new functionings.
- Emphasize enaction - teach students to do what is right, not know what is right to do.
- The point where these elements come together is being termed "convergence".

The challenge is no longer to tame science for industrial use, but rather to help industry address human and systemic issues by shifting our undergraduate degree programs from means-focused technical disciplines to equipping students to solve complex, convergent problems in social and human contexts.

Theory:
Changing assumptions requires creating new ways to see purpose



Activities	Status	Implementation & Results
Introduce convergent problems across the curriculum	Initial trials	• Interviews and research to define undergraduate convergence skills & attitudes • Initial implementation in four-year design sequence using action research
Change grading structures to emphasize engagement, engineering knowledge & skills, context, communication, and collaboration.	Ongoing modification	• Preliminary experiments showed feedback provides valuable feedback to students on capabilities valued by the program, at the current time the method is too faculty time-intensive for wide-spread implementation • Development of tagged "praise" rubric system ongoing.
E-portfolios to have student construct narratives	Initial trials	• E-portfolios implemented in three courses. • Results inform program-wide implementation. • Adoption of e-portfolio system across entire university
Integrate educational software to gain 5 hours/week	Survey completed	• 100 products across 15 categories • Integration of two products across increasing classes – Perusall and Gradescope.
Establish community of transformation	Delayed due to COVID	• Not applicable

Framework

"Vision without action is a daydream.
Action without vision is a nightmare."
- Japanese Proverb

Development as Freedom – a topic that can be complicated and divisive

Freedom from (negative)
Freedom is never voluntarily given by the oppressor, it must be demanded by the oppressed.
- M. L. King

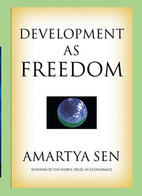
Freedom to (positive)
So far as a Man has a power to think, or not to think; to move, or not to move, according to the preference or direction of his own mind, so far is a Man Free.
- Locke

Autonomy
The capacity to direct oneself to those ends which one's reason rightly recognizes as choiceworthy.
- Aristotle

Responsibility
The ability to govern one's actions on the basis of reason, and not desire.
- Kant

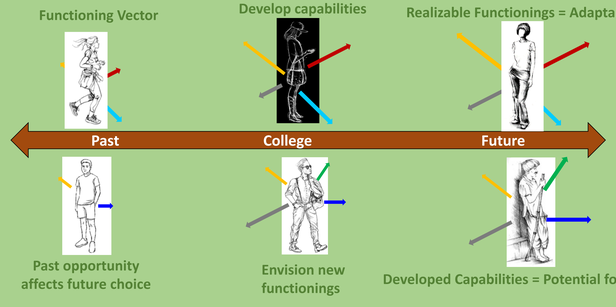
Amartya Sen's Development as Freedom

Sen argues that the expansion of freedom is central to development – "both as the primary end and as the principal means".



Defining Freedom in a Degree Program: Functionings and Capabilities

- Freedom is measured by an individual's functionings and capabilities.
- Functionings are what a person values doing or being.
- Capabilities are the functions a person is actually able to achieve in their life.



Provocation: Can you state the freedoms students are guaranteed in your program?

Results

Baseline Data Collection

What pedagogical methods are currently in place?

How do methods differ by year and topic?

What are insights into student experiences?

Convergence skills and understanding of social context are needed

Interest in expanding the range of teaching methods used

The most desired change is working more one-on-one with students, particularly by faculty with a theoretical focus.

Create low stakes "sandbox" courses.

Faculty believe positive change can occur

Attempts to incorporate social context or integrate projects into courses feel contrived particularly early in the curriculum.

Dialectic between theoretical and professional skills

Lecture predominates in theory-based classes

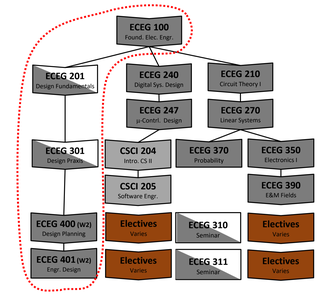
Few faculty prioritize holistic student development

Structures (credit systems and how grades are assigned) constrain innovation

Perceived barriers to change

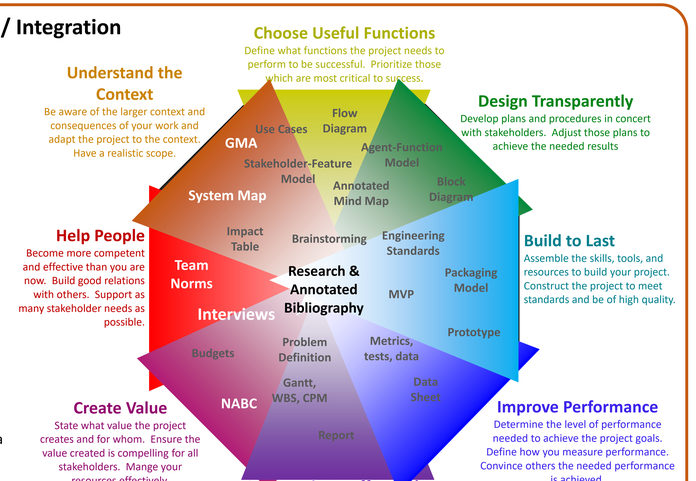
- resource availability (particularly time),
- fear (of failure, change, career prospects),
- the changing characteristics of students, and
- structural/institutional challenges.

Initial Curricular Implementation / Integration



Integrating Convergence – A Representational Approach

- Initial implementation in five course design sequence spanning four years.
- Build in opportunities for convergence through a common design framework incorporating eight lenses.
- Integrate formal design representations to address convergent problems.
- Establishing "convergence library" to help student link engineering tasks to larger contexts and experts in other disicplines.



E-Portfolios

Trial #1: Explore the discipline in a first year course to elicit functionings.

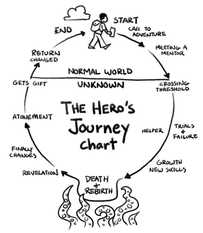
Student Prompts:
- What is important to me?
- What topics and ideas spark my curiosity?
- How do I define success in my academic life? What will career success look like for me?
- What extracurricular activities do I enjoy and what have I learned about myself from participating in these activities?
- Why have I chosen Electrical or Computer Engineering as my college major?

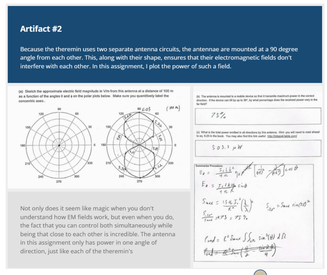
Highlight of the e-portfolio assignment was an interview with a practicing engineer to explore how their work intersected with student interests.

"One of the feedbacks which stood out to me was that I would benefit from being more open minded. Honestly, I am very glad I got this feedback, because I have generally thought of myself as an open minded individual, but perhaps that was not completely correct. Generally, I would say that I am very open minded when it comes to things such as political views… On the other hand, I have always been a person who likes doing things in my own way…Although this is something I still need to work on, I hope that I have somewhat improved over the course of the last two iterations."

Trial #2: Simple project e-portfolio in a design course focusing on capabilities.

Trial #3: The Hero's Journey in a Design Course focusing on capabilities and functionings





Trial #4: Relate class work to topic of personal interest in a theory course, focusing on capabilities and functionings

Current Plan for Programmatic e-Portfolio

- First Year – identify functionings and explore the major
- Second Year – tie work in classes to career pathways, identify opportunities
- Third Year – Hero's Journey with themes of personal transformation, reflection on trials and failure, what has been gained.
- Fourth Year – reflection on identity and new functionings

Brief Conclusions

- Baseline interviews and ethnographic observations → broad support for more individualized student trajectories.
- Resources and structural limitations provide barriers.
- Faculty believe limitations to personalized instruction arises from students.
- Constraints on faculty time a significant barrier.

Next steps:
- Develop undergraduate-level definitions of convergence – differences between theoretical or professional foci?
- Converge faculty beliefs around theoretical preparation, professional skills, and student development.
- Establish communities of transformation for faculty, students, and staff.
- Faculty professional development on how to provide convergent projects/content

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