EDUCATING ENGINEERS: INTEGRATING NANOTECHNOLOGY WITHIN AN EXISTING CIVIL AND ENVIRONMENTAL ENGINEERING CURRICULUM

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Project Goal

Develop and implement an integrated nanotechnology theme within the existing CEE undergraduate program focusing on environmental implications associated with end-of-life management of nanomaterial-containing products/wastes.

1. Introduce content using problem-based learning modules in existing courses
2. Enhance integration by linking content between courses

List of Courses Impacted

- Freshman
  - ECIV 101: Introduction to Civil Engineering (R)
- Junior
  - ECIV 303: Civil Engineering Materials (R)
  - ECIV 303L: Civil Engineering Materials Lab (E)
  - ECIV 350: Intro. to Environmental Engineering (R)
  - ECIV 350L: Intro. to Environmental Engineering Lab (E)
- Junior/Senior
  - ECIV 555: Principles of Municipal Solid Waste Engr. (E)
  - ECIV 533: Geosynthetics and Geotechnical Design of Landfills (E)
  - ECIV 490: Introduction to CEE Research (E)

R = required; E = elective

List of Courses Impacted + Activities

- Freshman
  - ECIV 101: Introduction to Civil Engineering (R)

    Problem-based Learning Modules:
    1. Dimensions of a sedimentation basin for particle removal
    2. Mass of single walled carbon nanotubes (SWNTs) needed to remove natural organic matter in water treatment system

- Junior
  - ECIV 303: Civil Engineering Materials (R)

    Group Project:
    Investigate the impact of material properties (e.g., strength) when incorporating nanomaterials

  - ECIV 303L: Civil Engineering Materials Lab (E)

    Problem-based Learning Modules:
    Design and manufacture nanomaterial-containing cement composites for nuclear waste storage

List of Courses Impacted + Activities

- Junior
  - ECIV 350: Intro. to Environmental Engineering (R)

Problem-based Learning Module:
1. Dimensions of a sedimentation basin for particle removal
2. Relationship between particle size and surface area and how this relates to contaminant removal

Group Project:
Produce a “nanomercial” highlighting potential environmental impacts associated with nanomaterials

All “nanomercials” are posted on the project YouTube Channel:
https://www.youtube.com/channel/UCLnCwjvSZgGjKWFyt_Mny4Q

Traditional Lectures:
Introduction to nanotechnology and what a nanomaterial is

List of Courses Impacted + Activities

- Junior/Senior
  - ECIV 350L: Intro. to Environmental Engineering Lab (E)

    Problem-based Learning Module:
    Determine the mass of TiO_2 required to disinfect water for a small community

  - ECIV 555: Principles of Municipal Solid Waste Engr. (E)

    Problem-based Learning Module:
    Estimate the possible concentration of nanomaterials in leachate from a landfill in which nanomaterial-containing consumer products are discarded

    Traditional Material Presentation (Lectures):
    Introduction to nanotechnology and what a nanomaterial is

List of Courses Impacted + Activities

- Junior/Senior
  - ECIV 533: Geosynthetics and Geotechnical Design of Landfills (E)

    Problem-based Learning Module:
    Determine the ultimate tensile strength (psi) of the geomembrane in a landfill liner system if exposed to nanomaterials

  - ECIV 490: Introduction to CEE Research (E)

    Problem-based Learning Module:
    Conduct independent research on a nanomaterial related topic

Note:

- *All problem-based modules integrate concepts with course content and nanotechnology*
- *Modules in ECIV 555 and 535 were linked, and conducted simultaneously.*

Student Exposure

- 70% of our undergraduate student population was exposed at least once (over a 3 year period)

Times of Exposure (at least)	1	2	3	4
Number of Students	259	105	23	4

Student Feedback: Survey Results

- Survey emailed to all students impacted at least once
- 45 students responded
- During the past three years, do you recall learning about the subject of nanotechnology or nanomaterials in your ECIV courses?

Yes	No
87%	13%

Student Feedback: Survey Results

- *Based on what you learned, what specific concept or concepts about nanomaterials stand out the most for you?*

Category	Number of Students
Applications (uses of nanomaterials)	14
Surface Area	9
Environmental Implications	9
Strength	6

"I was surprised to learn how common nanomaterials are. They are in countless household and beauty products and could have a large impact on our environment."

Student Feedback: Survey Results

- *Please indicate your level of agreement with the following statements. You may skip any statement if you feel it does not apply to you (scale from 1 – 5):*

Question	Average Score
Because nanotechnology was covered in more than one course, I was able to understand several different dimensions of the topic.	3.95
I enjoyed revisiting the subject of nanotechnology in more than one course	3.56

Student Feedback: Survey Results

- *In a few words, what did you like about the nanotechnology classes you experienced?*

Category	Number of Students
Being provided the opportunity to learn cutting-edge material	15
Interactive projects	4
Creative thinking	3
Learning about the formation of nanomaterials	1

"The projects were interactive and made us think outside the box considering not many undergraduate students have been exposed to nanotechnology material."

Student Feedback: Survey Results

- *Were there aspects that you did not like? If so, what were they and why didn't you like them?*

Category	Number of Students
Forced content	3
Repetitive	3
Problem-Based Learning	9
Nothing Described	16

"They are always just thrown in the class because of the grant. It doesn't go along with what we are learning."

"Also, the PBL questions are never explained well and are very frustrating because we are never prepared for those types of questions."

Activity Assessment: Focus Groups

- There was a general consensus that there is a desire and need for classes in nanotechnology and for that content to be incorporated into a greater number of courses.
- Students responded favorably to the linking of activities between the two solid waste courses:
  - *"We liked how it crossed the two courses, so we could see how it's affecting not just one area, but two different ones."*

Lessons Learned

- Student (based on focus group interviews, surveys, assignments)
  - Students are open to and excited about being exposed to new, emerging technology
  - Better/smoother integration of content within courses is needed
- Faculty (based on interviews)
  - Some students are resistant to problem-based learning; they are uncomfortable with the lack of definition of the kinds of problems they are given
  - Developing modules is an iterative process
  - Introducing a “theme” across a curriculum is possible

Lessons Learned

- Faculty (based on interviews) – cont'd
  - Because of changes in the order students take courses in their Junior/Senior years, linking between courses can be difficult

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Thank You!
Questions?

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