

# Turning Undergraduate Class Projects into Successful Graduate Research Projects

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THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE



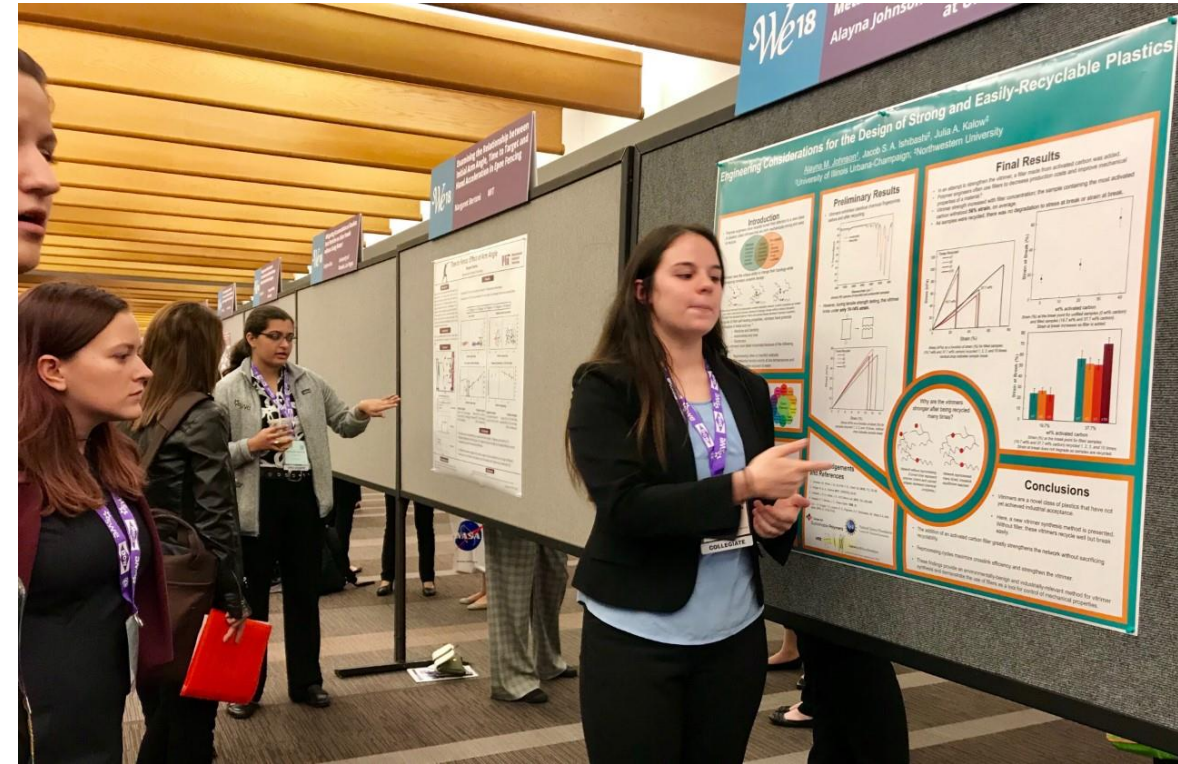
# Learning Objectives

- Explain motivation for undergraduate research
- Describe class projects to cultivate general research skills
- Describe class projects to cultivate topical research skills

# Motivation for Undergraduate Research

## *Opportunities*

- Improved likelihood for advanced degrees <sup>1</sup>
- Improved self-motivation and self-directed learning <sup>2</sup>
- Extended time of mentoring



1. S. H. Russell, M. P. Hancock and J. McCullough, "Benefits of undergraduate research experiences," Science, vol. 316.5824, pp. 548-549, 2007.
2. R. Boniak, "Overcoming challenges in field research for non-science majors," in F. Wilson & J. Thomas, Handbook for Undergraduate Research Advisors (pp. 123-129). Lanham, MD: Rowman and Littlefield.

# Motivation for Undergraduate Research

## *Challenges*

- Finding balance of motivation and training <sup>1</sup>
  - Finding students with sufficient maturity <sup>2</sup>
  - Lack of experience with research methodology
  - Lack of experience with solving problems
- 
- *What is the difference between an undergraduate and a graduate student?*

1. D. Evans, "The challenge of undergraduate research," Association of American Colleges and Universities, Peer Review, vol. 12, no. 2, 2010.
2. E. Wenderholm, "Challenges and the elements of success in undergraduate research," inroads, The SIGCSE Bulletin, vol. 36, no. 4, 2004.

# Meeting the challenges

- Building a project into a course allows for “casting a wide net”
- More information about technical preparation
- Targeted time to develop research skills
- Develop interest in specific research types

# Two approaches:

- *General research skill development*
- *Topical research development*

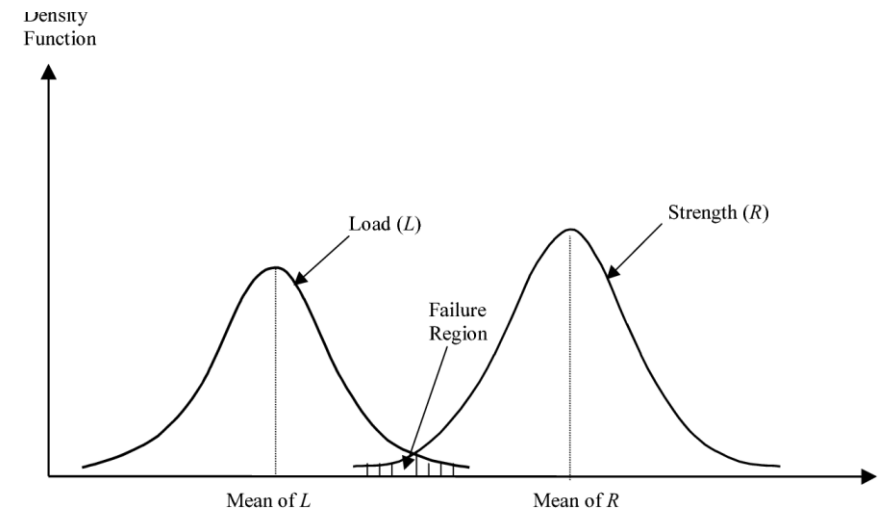
# General Research Skills

## Objectives

- Project objectives support course objectives and research skills

## Skills

- Experimental design
- Instrumentation and measurements
- Statistical analysis of results

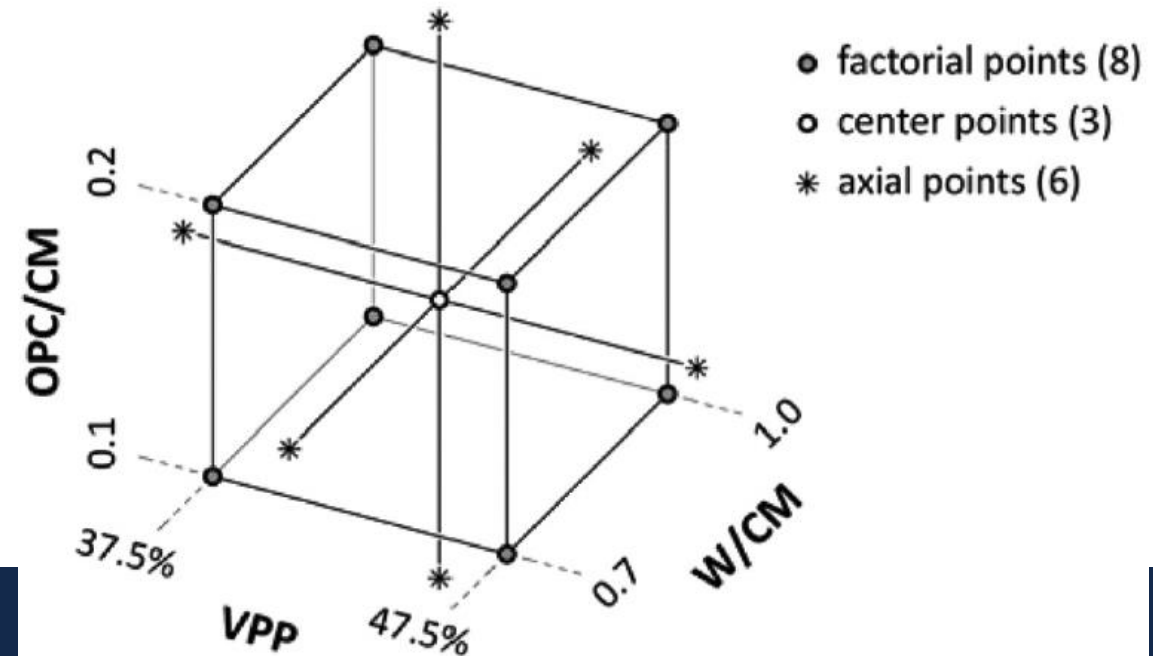
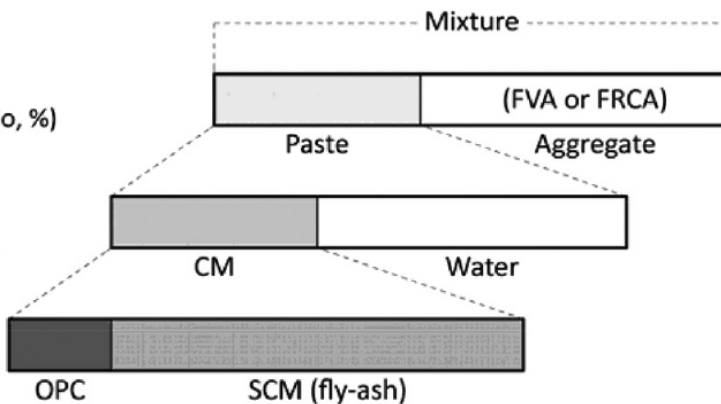


### Factors:

**VPP**  
(volume ratio, %)

**W/CM**  
(mass ratio)

**OPC/CM**  
(mass ratio)



# Example: Experimental Design Project

## *Course*

- Measurements and instrumentation
- Senior and graduate students

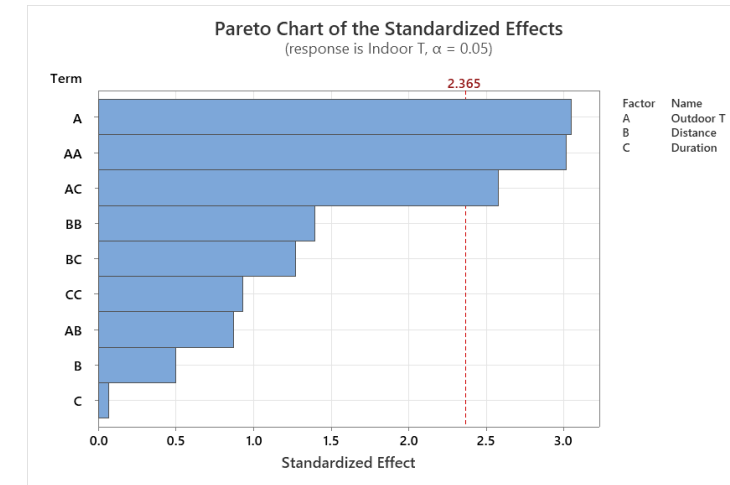
## *Objective:*

- Find and investigate some phenomena that is measurable
- Students develop a research question, hypothesis, experimental plan, and data analysis
- Project is area-agnostic

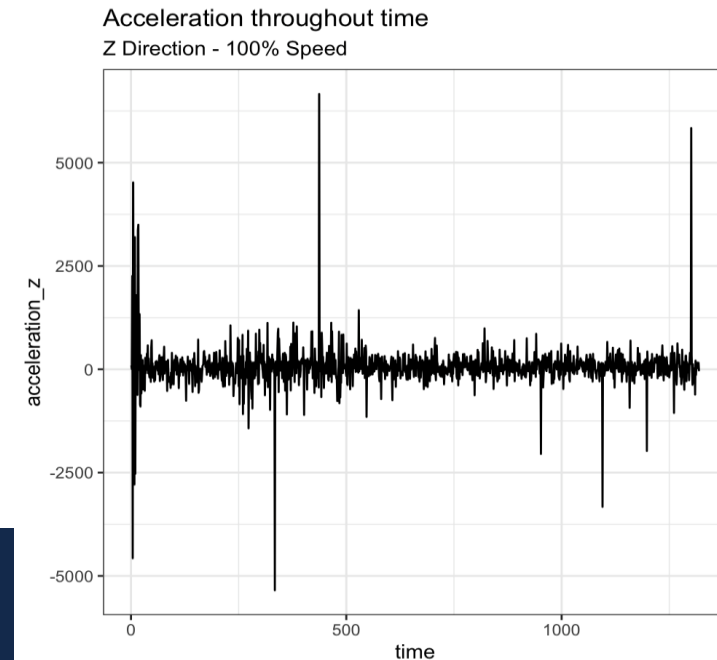
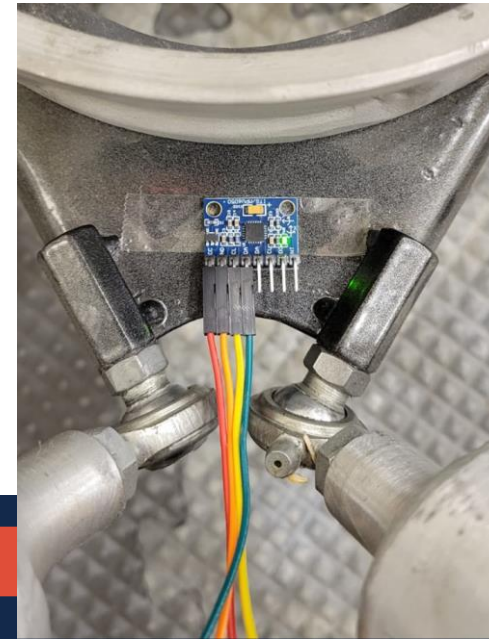


# Example: Experimental Design Project

Effect of vestibules on building temperature



Correlating machine movement with vibration



# Topical Research Skills

## *Format*

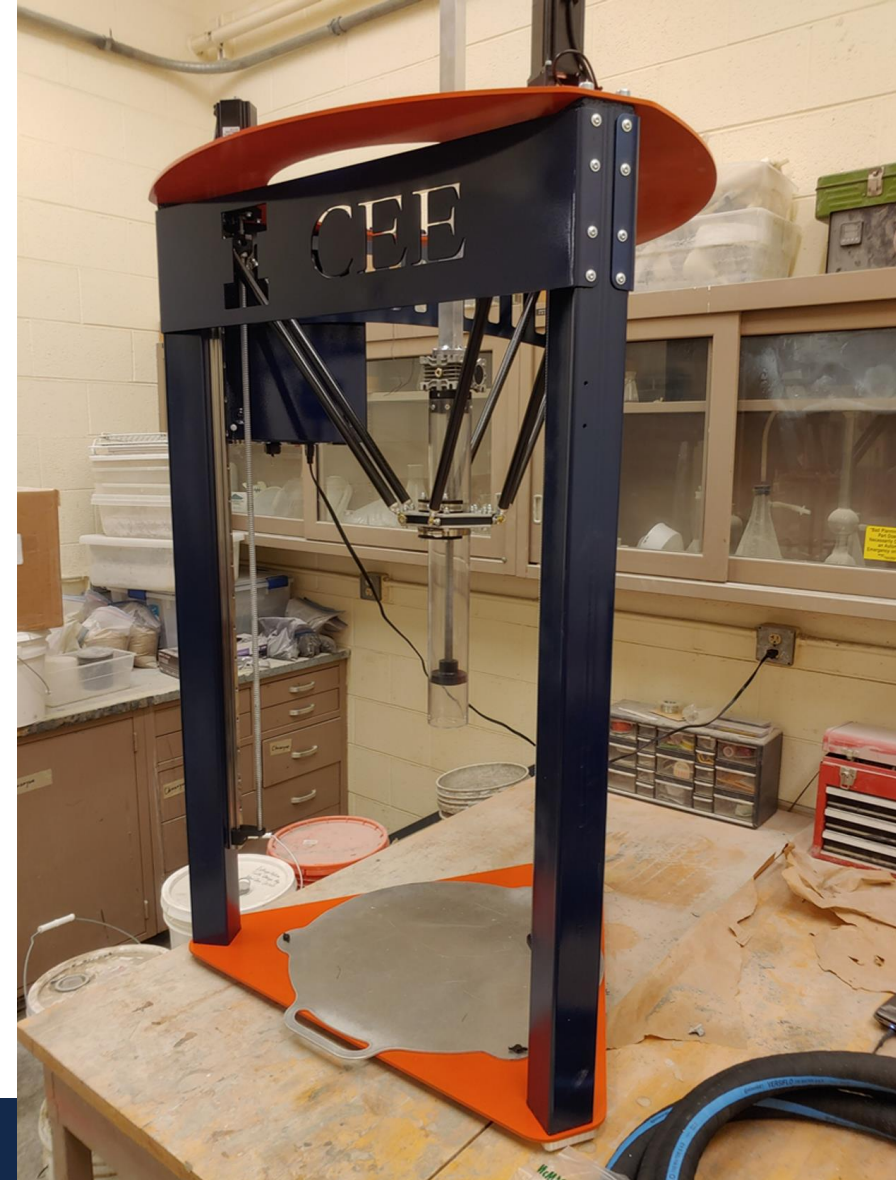
- Project objectives align with research and support course objectives
- “Crowdsourced” testing and development

## *Skills*

- Literature review
- Introduce experimental design
- Standard testing and data analysis
- Problem solving

# Example: 3D Printed Concrete

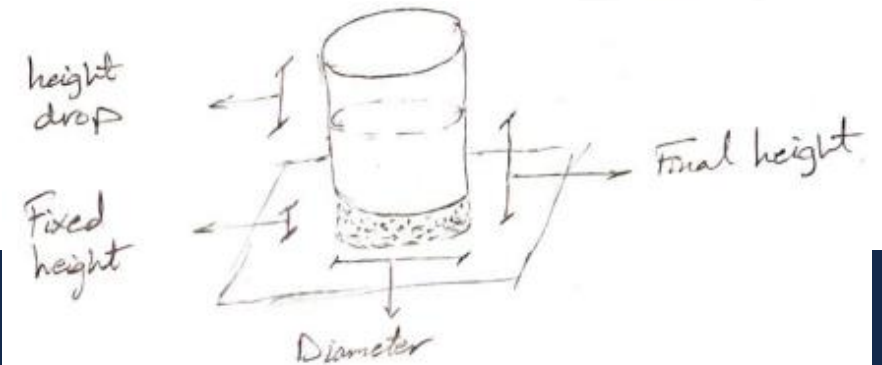
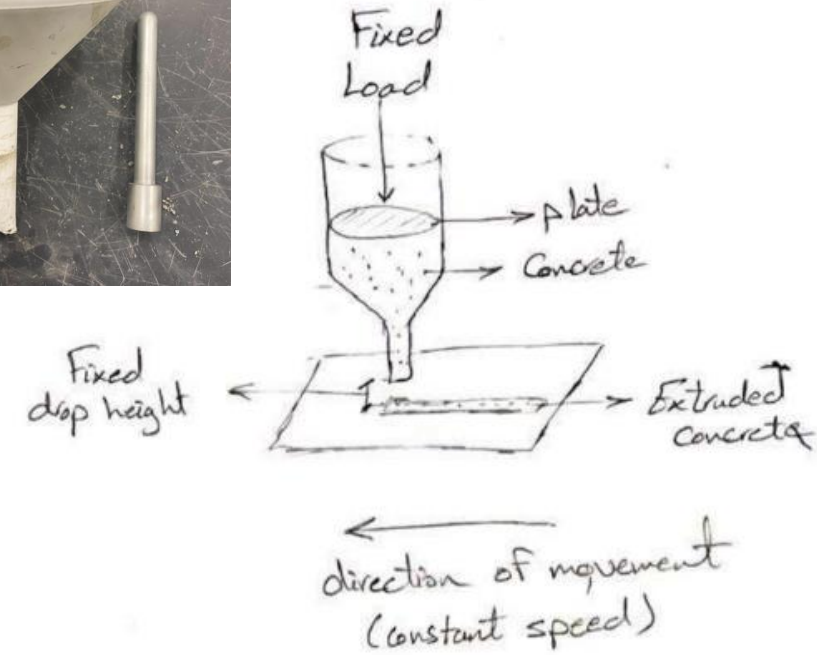
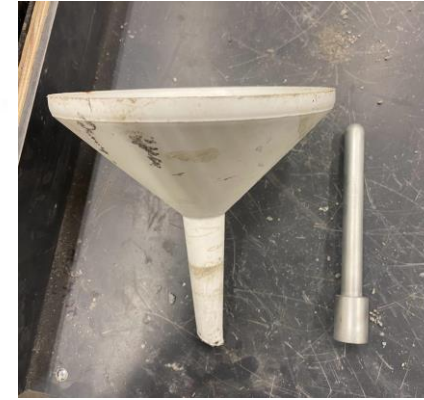
- Course
  - Concrete materials
  - Senior and graduate students
- Objectives
  - Develop a test to assess workability of mortar
  - Develop a mortar mixture for 3D printer
- Students review relevant literature, implement an experimental design, problem solve, and iterate a design
- Recruitment into a specific graduate research project



# Example: 3D Printed Concrete

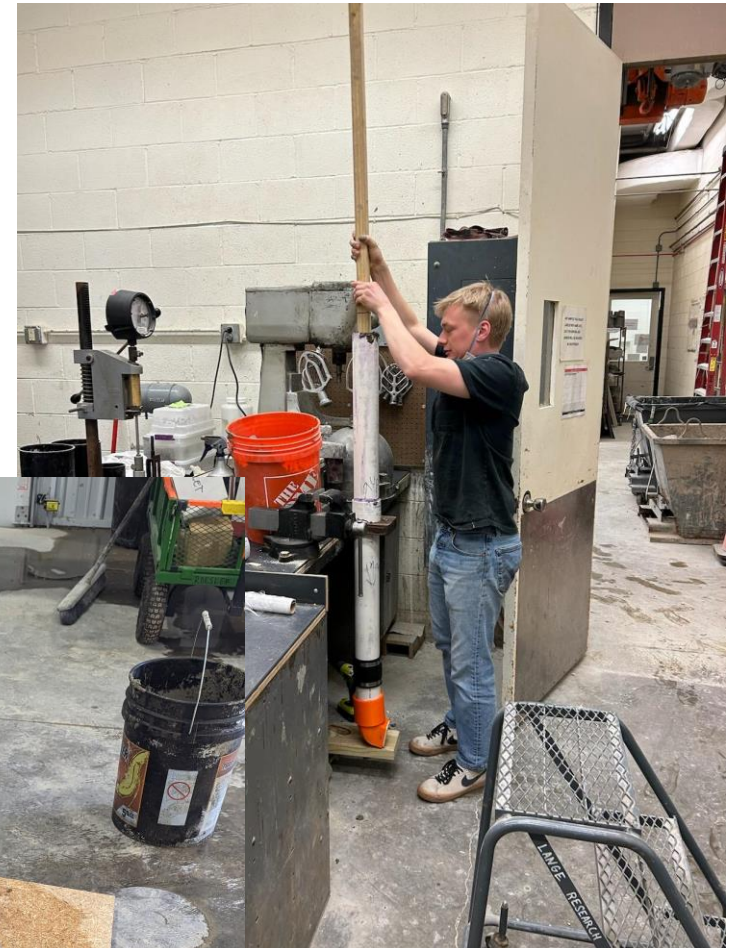
**Workability Testing**  
Creative development of standard tests

**Mixture Development**  
Factorial approach to mixture design for printing



# Outcome: 3D Printed Concrete

- Literature background of printed concrete
- Experience with mixture design
- Alternate ideas about workability



# Summary and future work

- Undergraduate research has numerous positive outcomes for students, and present opportunities for course project integration
- Course projects can equip students with basic research skills and knowledge that are transferrable to a graduate program
  - General research skills
  - Topic-specific skills
- Expanded project offerings will support areas across the department
- Data collection regarding student outcomes