DEVELOPMENT OF ACTIVE-LEARNING UNITS IN NUCLEAR ENGINEERING

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Outline

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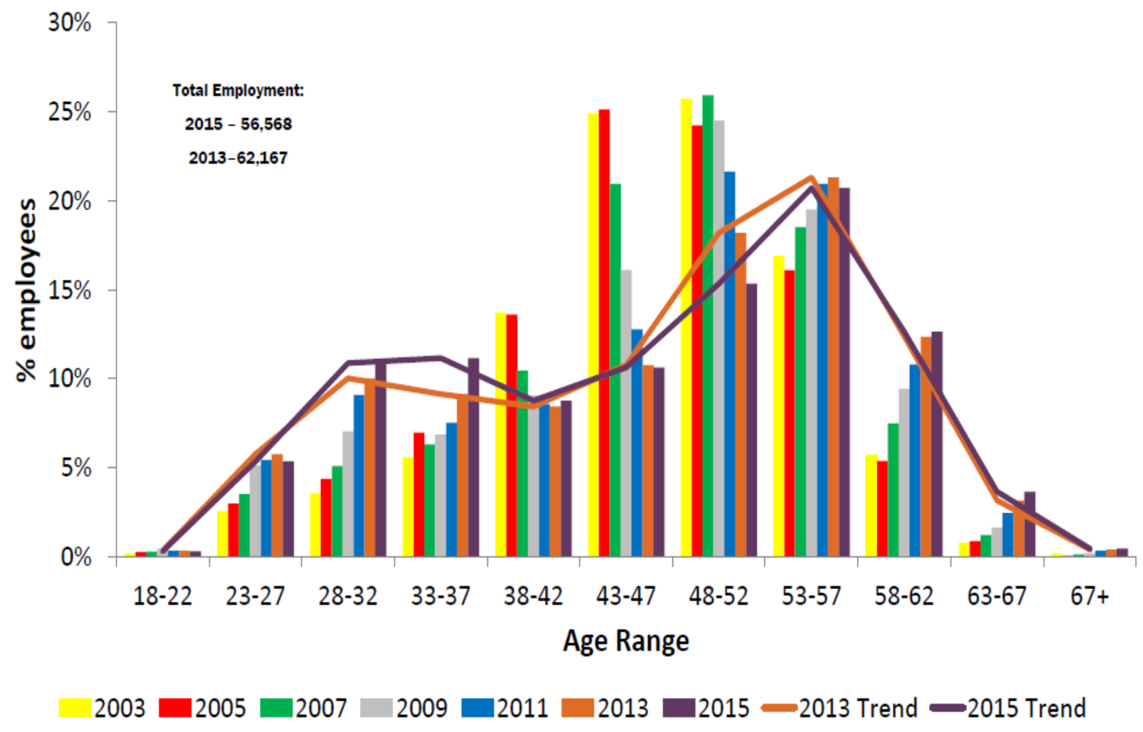
- **Assessment Plan for Active Learning Units**
- **Conclusions: Expected Impacts**

Background: Aging Nuclear Workforce

- **There is challenge replacing the aging workforce in the nuclear industry.**
  - Examples: The aging of United States nuclear workforce.
  - High percentage of the United State's nuclear workforce are nearing retirement.
  - The increasing trends from 2003 to 2015 is very significant for ages above 53 years.



McAndrew-Bena vides , E. (2015). NEI's 2015 Nuclear Workforce Survey. Nuclear Energy Institute.

Background: Aging Nuclear Workforce

- **Key questions and some solution approaches:**

	Project Questions	Solution Approach and Activities
1	How can a STEM curriculum enhance nuclear engineering skill-set development?	Integrated active-learning and hands-on units.
2	How can we increase the retention and graduation rates of women and underrepresented minorities in nuclear engineering programs?	Early alert and mentoring based on continuous assessment with improvement feedback.
3	How can STEM programs address the problem of replacing the United States aging nuclear workforce?	Students-industry bridge activities and broaden the participation of underrepresented minorities.

- This presentation focuses on item 1 solution approach: Active Learning

Active Learning Integrated Nuclear Education (ALINE) Project

- **Active Learning Model:**
  - A learning model that engages students in class and/or lab activities that promote problem-solving (Savery, 2015), analysis, synthesis and evaluation of the material being learned.
  - The students participate in doing things instead of just listening.
- **Three modes of active learning that will be used in the ALINE project:**
  - Participation of students' groups in problem-solving.
  - Participation of students' groups in hand-on skill development.
  - Simulation.

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows, 9, 5- 15.

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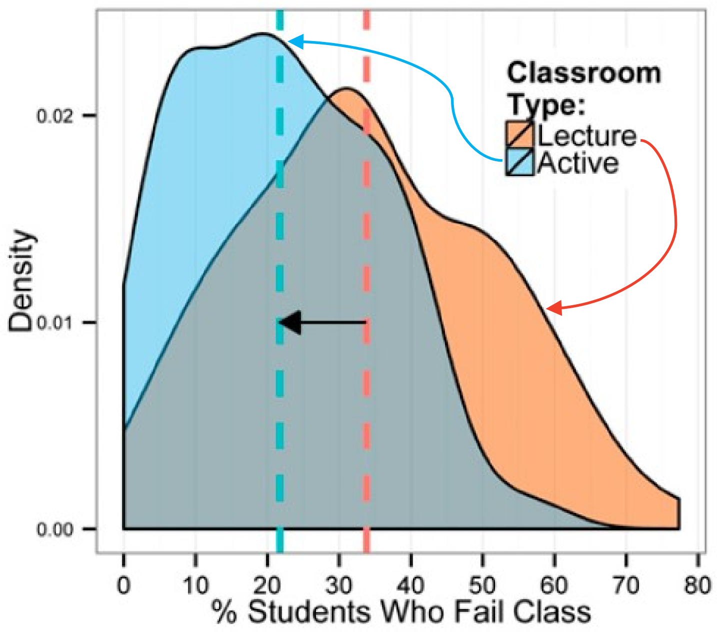
Active Learning Integrated Nuclear Education (ALINE) Project

- **Goal:**
  - Enhance student learning and strengthen STEM education in the areas of nuclear power and nuclear systems.
- **Specific Objectives:**
  - Enhance students learning and technical skills to improve their preparation for success in pursuing STEM graduate programs and careers in nuclear engineering.
  - Study the effects of the active-learning model and units on nuclear skill-set development.
  - Enhance the STEM pipeline to improve retention and graduation rates in nuclear engineering programs and increase the participation of women and underrepresented minorities in the nuclear workforce.

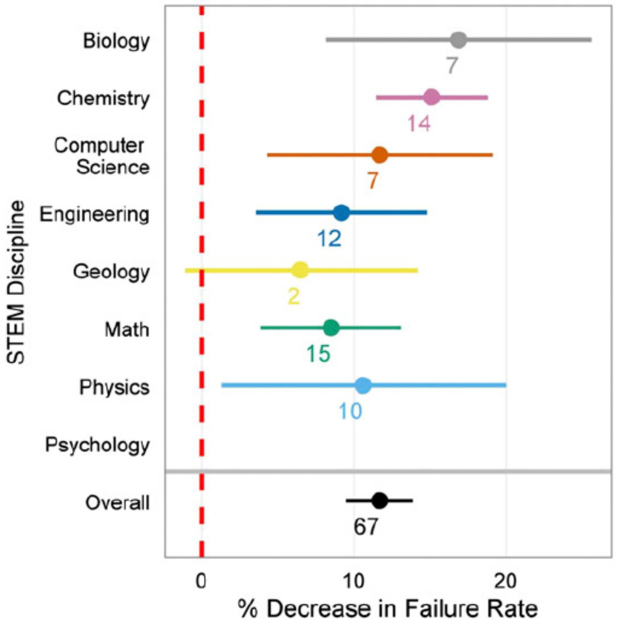
Active Learning Integrated Nuclear Education (ALINE) Project

- **Evidence-based data confirm that active learning increases student perforce in STEM courses:**

Freeman, S. , Eddy , S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences , 111(23), 8410-8415.

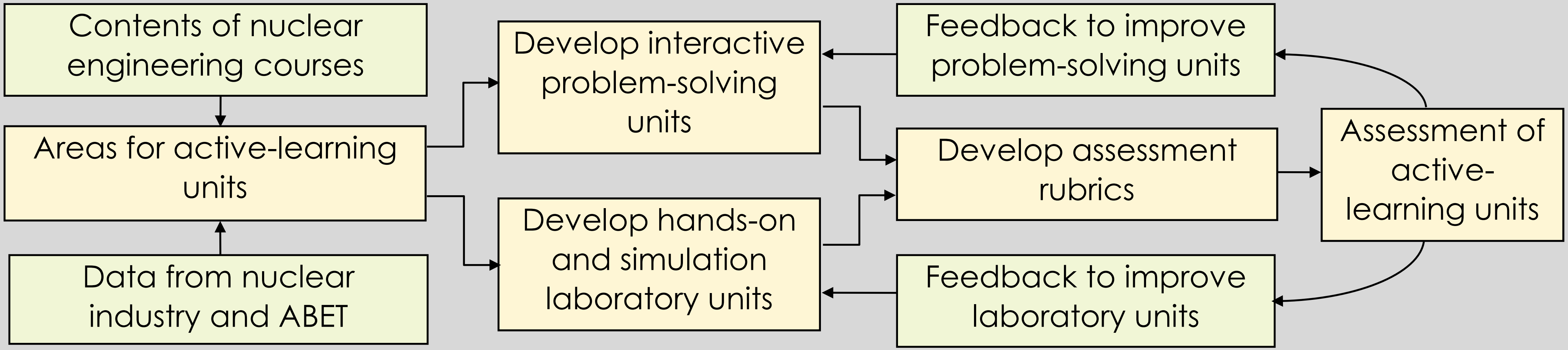


(a) **Kernel density plots of failure rates for lecturing and active learning. The mean improvement is 12%.**



(b) **Effect sizes of active learning by discipline. Number of independent studies shown below each point. 95% confidence intervals.**

Approach to Integrating Active Learning Unites in Nuclear Engineering Courses



ABET is the Accreditation Board for Engineering and Technology.

Planned and Target Areas for Active Learning Units: Problem-Solving Interactive Units

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- **The problem-solving interactive units are aimed at:**
  - Mastering fundamental principles and concepts.
  - Better understanding of how equations/formulae translate and/or apply to real-life engineering situations.
- **Problem-solving also enhances the understanding of how different parameters in an equation interact with each other (such as dependency relationships).**
- **The practicality aspect is understanding how different components of an engineering systems function together to accomplish the goals for which they are designed.**

Planned and Target Areas for Active Learning Units: Problem-Solving Interactive Units

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- **The problem-solving interactive units to be developed:**

Introduction to Nuclear Engineering	Nuclear Reactor Engineering I	Nuclear Reactor Engineering II
1. Radioactivity and half-life. 2. Binding energy. 3. Atom density. 4. Radiation interactions. 5. Radiation dose. 6. Radiation shielding. 7. Stopping power. 8. Fission.	1. Neutron interactions. 2. Neutron cross-sections. 3. Neutron attenuation. 4. Neutron flux. 5. Neutron transport. 6. Reactor criticality calculations.	1. Reactor core analysis. 2. Reactor power generation. 3. Heat transfer in reactor core.

Planned and Target Areas for Active Learning Units: Hands-On Interactive Units

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Unit	Hands-on Lab	Knowledge and Skills to be Acquired	Course
1	Nuclear Instruments Electronics	• Understand and master basic nuclear instrumentation electronics and techniques in radiation measurements.	Introduction to Nuclear Engineering
2	Geiger-Mueller Counters	• Half-life determination, linear absorption coefficient, and counting statistics.	
3	Calibration of Gamma Source and Survey Meters	• Skills to calibrate a gamma standard source and use that information to calibrate radiation survey meters.	
4	Gamma Spectroscopy Using NaI Scintillators	• Master the use of NaI scintillation detectors. • Radio-isotope identification skills: identification and composition of an unknown nuclear material.	
5	Measurement of Dose Using TLD and other Dosimeter Systems	• Understand the use of thermo-luminescent (TL) material and other dosimeter systems to measure dose. • Calibration curve for gamma rays on TL dosimeters.	
6	Radiation Survey	• Skills on surveying an area to locate hidden radioactive materials. • Skills to survey areas of contamination, applicable to nuclear power plants	Nuclear Reactor Engineering I
7	Radiation Shielding	• Know how to apply the principles of As Low As Reasonably Achievable (ALARA) in radiation protection as practiced in nuclear plants.	
8	Neutron Detection	• Skills on neutron activation measurements of trace elements.	

Hands-on units are mostly aimed at enhancing skill-set development in nuclear engineering.

Planned and Target Areas for Active Learning Units: Simulation Interactive Units

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- **Simulation units will serve two key purposes:**
  - **First, they will provide deeper understanding of nuclear concepts and systems.**
  - **Secondly, simulation will enhance skill-set development, where student will use software packages to design and simulate nuclear systems such:**
    - Neutron interaction and flux distribution in a nuclear reactor core.
    - Nuclear heat generation and heat transports in reactor elements.
    - Power plant cooling systems.
    - Power generation system efficiency.

Assessment Plan for Active Learning Units

At time of entering the course: Collect data for stratified randomization among treatments – GPA, Standardized test (ACT), and Pretest relevant to content.

Active-learning class: Students in class with active-learning units.

Control class: Students in class with no active-learning units.

Assessment: Two assessment types.
- Test on each class module (active-learning unit assessment).
- Course grade (overall active-learning assessment).

Statistical Analysis: Comparisons based on stratified randomization parameters (prior GPA, ACT, and Pretest) using assessment grades for students within similar (prior score) groups.

<u>Assessment Criteria (for reliability and consistency)</u>:

- **Student Equivalence: Stratified randomization will be used to ensure that the comparison groups (active-learning group and control group) are similar.**
- **Instructor Equivalence: the same instructor will be in both the active-learning group and control group classes.**
- **Examination Equivalence: The assessments that will be given to students in the active-learning group and the control group will be identical.**

Conclusions: Expected Impacts

- **The ALINE project will benefit:**
  - The nuclear workforce.
  - STEM education in the production of highly skilled women and underrepresented minority graduates in nuclear engineering fields.
  - Transfer students from 2-year community college to 4-year STEM programs.
  - Infrastructure for teaching and research in nuclear engineering fields
- **While advancing discovery and understanding in STEM-based integrative active-learning model, the project promotes:**
  - Teaching (active learning units).
  - Training (integrated hands-on and industry co-ops).
  - Learning (curriculum enhancement).

Thank You