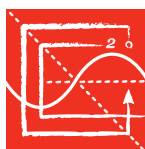




EDUCATION

**The right tool
for the right job—**

The FE as an Outcomes
Assessment Tool



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engineers and surveyors*



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EFFECTIVE AND EFFICIENT USE OF THE FUNDAMENTALS OF ENGINEERING EXAM FOR OUTCOMES ASSESSMENT

2017



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Overview

- Applicability of the FE exam for assessment
- ABET student outcomes that can be measured
- Computer-based FE exam format
- Various methods to use FE exam results for outcomes assessment
- Self-study examples and closing the loop
- Questions and answers

Applicability of the FE Exam for Assessment

- It is a direct method of objective assessment with comparisons of institutional results against national results.
- Assessment does not use pass rates but how students perform on individual exam areas.
- Because there are over 55,000 FE examinees per year, it provides high reliability.

Applicability (cont.)

- Should my institution require the FE exam as a graduation requirement?
 - Many institutions currently do this to measure their full graduating class.
 - This requires a good-faith effort, which is generally determinable only through the amount of time spent on the exam or the random-guessing analysis done by NCEES.

Applicability (cont.)

- What if my institution doesn't require the FE exam as a graduation requirement?
 - A self-selecting group can still be useful for assessment.
 - Anecdotal information indicates that the self-selecting group doesn't change much at a given institution from exam to exam.
 - Criterion for assessment should focus more on the **changes** in results over time rather than just the comparisons to national data that will be presented today.

Applicability (cont.)

- Summary
 - The FE is the only nationally normed examination addressing specific engineering topics currently available.
 - The FE is the only assessment tool available to compare the performance of students in one program with students from other programs.
 - The FE can be used as an assessment tool with a pool of all graduates or with a self-selecting pool.

ABET Outcomes Assessment Possible with FE Exam

- a) An ability to apply **knowledge of mathematics, science, and engineering**
- b) An ability to design and conduct experiments, as well as to **analyze and interpret data**
- c) An ability to **design a system, component, or process** to meet desired needs

ABET Outcomes Assessment Possible with FE Exam (cont.)

- (e) An ability to **identify, formulate, and solve engineering problems**
- (f) An understanding of **professional and ethical responsibility**
- (k) An ability to use the techniques, skills, and modern **engineering tools** necessary for engineering practice

ABET Outcomes Assessment Possible with FE Exam (cont.)

Because institutions also receive a Subject Matter Report on their graduates who attempt the various PE exams, they can use the number of graduates who are successful in passing the PE exam to allow the institution one method of measuring the following outcome:

- (i) A recognition of the need for and the ability to engage in **lifelong learning**

Computer-Based Testing (CBT) Format

- The FE became a CBT exam in January 2014
 - Shorter in time and fewer questions
 - Presented in a different format



Why CBT?

- Candidate convenience
- Quicker score turnaround (7–10 days)
- Uniformity in testing conditions
- Enhanced security
- More innovative way to test

CBT Format (cont.)

- Length
 - The appointment time at test centers is 6 hours.
 - Tutorial–8 minutes
 - Nondisclosure agreement–2 minutes
 - Exam time–5 hours, 20 minutes with a 25-minute scheduled break after approximately 55 questions
 - Brief post-exam survey
 - Total of 110 questions

CBT Format (cont.)

- Testing opportunities
 - Testing windows
 - January–March
 - April–June
 - July–September
 - October–December
- Test center locations
 - Pearson VUE test centers

Test Center Locations

- Nearly 300 Pearson VUE test center locations are available throughout the United States.
- Specific sites near your institution can be located from the NCEES website at the following URL:
 - <http://ncees.org/exams/test-center-locations/>

CBT Format (cont.)

- *FE Reference Handbook*
 - Provided electronically with the exam as a searchable PDF
 - Available for free download and for purchase as a hard copy at <http://ncees.org/engineering/fe/>
- *NCEES Examinee Guide*
- Computer-based practice exams

CBT Format (cont.)

The screenshot shows the NCEES CBT exam interface. On the left, the 'FE REFERENCE HANDBOOK' is open to the 'ENES' section. The handbook contains tables for 'METRIC PREFIXES', 'COMMONLY USED UNITS', 'TEMPERATURE CONVERSIONS', and 'FUNDAMENTAL CONSTANTS'. On the right, a question is displayed: 'The continuous harmonic sine signal is given below:'. A graph shows a sine wave with a period of 2π. The question asks for the minimum sample frequency required to properly digitize the signal. The options are: A. 1 sample per 4 sec, B. 1 sample per 2 sec, C. 1 sample per sec, D. 2 samples per 1 sec.

CBT Format (cont.)

- Content of the exam
 - 7 free-standing discipline-specific exams
 - Chemical, Civil, Electrical and Computer, Environmental, Industrial and Systems, Mechanical, Other Disciplines
 - FE no longer has a common morning portion (breadth module)
 - Selected exam topics that were previously on the breadth module are now tested within each discipline-specific exam.

FE Electrical and Computer Engineering Exam Specification

- Mathematics
- Probability and Statistics
- Ethics and Professional Practice
- Engineering Economics
- Properties of Electrical Materials
- Engineering Sciences
- Circuit Analysis (DC and AC Steady State)
- Linear Systems
- Signal Processing
- Electronics
- Power
- Electromagnetics
- Control Systems
- Communications
- Computer Networks
- Digital Systems
- Computer Systems
- Software Development

Comparison of Level 2 Specifications—Mathematics Subject Area

FE Electrical and Computer

- A. Algebra and trigonometry
- B. Complex numbers
- C. Discrete mathematics
- D. Analytic geometry
- E. Calculus
- F. Differential equations
- G. Linear algebra
- H. Vector analysis

FE Civil

- A. Analytic geometry
- B. Calculus
- C. Roots of equations
- D. Vector analysis

FE Civil Engineering Exam Specification—Example of Engineering Design

13. Structural Design

- A. Design of steel components (e.g., codes and design philosophies, beams, columns, beam-columns, tension members, connections)
- B. Design of reinforced concrete components (e.g., codes and design philosophies, beams, slabs, columns, walls, footings)

Other Exam Specifications

- Available at <http://ncees.org/engineering/fe/>



So, what actual data are available, and what can you do with the data?



Subject Matter Report



Examination: Fundamentals of Engineering (FE)
Report Title: Subject Matter Report by Major and Examination
Exam administered: Jul 21 - Nov 30, 2004
Examiners included: First-Time Examiners from ECABET Accredited Engineering Programs
Graduation Date: Examinees Testing within 12 months of Graduation Date

Name of Institution:	EXAMPLE	
Major:	Civil	Civil

	Institution	ABET Computer ²
No. Examinees Taking ¹	31	2,659
No. Examinees Passing	26	1,760
Percent Examinees Passing	84%	70%

Uncertainty Range for Scaled Score ⁴ ± 0.18

	Number of Exam Questions	Institution Average Performance Index ³	ABET Computer Average Performance Index ³	ABET Computer Standard Deviation	Ratio Score ⁴	Scaled Score ⁴
Mathematics	7	9.6	9.5	2.0	1.00	0.00
Probability and Statistics	4	10.4	10.3	3.5	1.00	0.09
Computerized Tests	4	10.2	9.9	3.7	1.00	0.00
Office and Professional Practice	4	12.3	11.3	3.8	1.11	0.32
Engineering Economics	4	10.7	10.3	3.6	1.06	0.17
Statics	7	10.7	9.5	2.8	1.13	0.43
Dynamics	4	10.6	10.3	3.6	1.06	0.17
Mechanics of Materials	7	9.7	9.7	2.5	1.00	0.00
Materials	4	9.7	9.2	3.1	0.95	-0.16
Fluid Mechanics	4	10.5	10.9	3.4	0.96	-0.12
Hydraulic and Hydraulic Systems	6	9.7	9.4	2.5	1.00	0.14
Structural Analysis	6	9.7	9.9	2.9	1.09	0.32
Structural Design	6	8.6	8.6	2.8	0.94	-0.19
Geotechnical Engineering	9	9.5	9.4	2.3	1.01	0.05
Environmental Engineering	6	9.2	9.0	2.2	1.00	0.00
Environmental Engineering	6	8.9	8.8	2.7	1.01	0.04
Computerized	4	11.5	11.5	3.7	1.00	0.04
Surveying	4	8.4	8.1	3.6	1.04	0.08

1. 8 Examinations have been removed from this data because they were flagged as a medium priority.
 2. Computerizer includes all examinations from programs accredited by the ABET commission listed.
 3. Performance index is based on a 0-15 scale.
 4. These scores are made available for assessment purposes. See the NCEES publication entitled, "Using the FE as an Outcome Assessment Tool" at <http://www.ncees.org/ncees/education/research/>.

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By using any of the information contained in this report the report recipient agrees to respect and be bound by these terms conditions and limitations regarding the use of NCEES data. Your cooperation is appreciated.

Subject Matter Report (cont.)

- Reports are generated twice a year.
 - In July for the January–May testing period (Spring)
 - In January for the July–November testing period (Fall)
- The report is specific to
 - An institution,
 - Students within an engineering degree program at that institution, and
 - The discipline-specific exam that those students completed.

Subject Matter Report (cont.)

- Data are provided for all examinees testing within 12 months of graduation (either before or after graduating).
- Only first-time takers are included.
- Random guessers are removed from the report.
- National performance data, with standard deviation information, are also provided for the same degree program and same discipline-specific exam.

Subject Matter Report (cont.)

- For each topic, the students' performance is given as a Performance Index on a scale of 0–15.
- The Performance Index is indirectly related to the average number of questions answered correctly.
- This is necessary because each examinee receives a different set of questions within each topic area.
 - Any one examinee's set of questions may be harder or easier than another examinee's set.

Subject Matter Report (cont.)

- Getting the data
 - NCEES sends links to reports directly to an institution via email.
 - If you don't know, NCEES can tell you who receives your institution's reports.
 - Reports also include information on the specific institution's examinees who took the FE or PE exam more than 12 months after graduation.

The specifics of using the FE exam for outcomes assessment

Getting Started

- **Faculty** should be involved.
- Identify areas of strength.
- Acknowledge areas that are not emphasized.
- Set program-specific goals for each area.

Table from Self Study Showing the Use of the FE as One Measure for a Specific Outcome

Outcome	Applicable FE Exam Category
a. An ability to apply knowledge of mathematics through differential equations, science, ...	Math
b. An ability to design and conduct ...	None
c. An ability to design a system, component, ...	Structural Design
d. An ability to function on multidisciplinary teams	None
e. An ability to identify, formulate, and solve engineering problems	Engineering Mechanics, Strength of Materials, Fluid Mechanics, Structural Analysis
f. An understanding of professional and ethical responsibility	Ethics and Professional Practice
g. An ability to communicate effectively	None
h. The broad education necessary to understand the impact of engineering ...	None
i. A recognition of the need for, and an ability to engage in life-long learning	None
j. A knowledge of contemporary issues	None
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Computational Tools, Surveying
l. An ability to apply knowledge of technical areas appropriate to civil engineering	Environmental Engineering, Hydraulics/Hydrology, Soil Mechanics and Foundations, Structural Design, Transportation

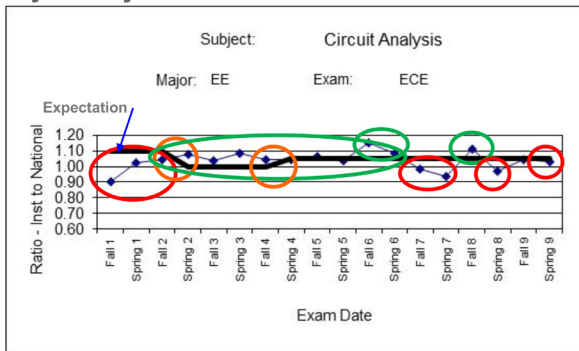
Suggested Analysis Techniques

- Choose your longitudinal time basis.
 - Performance from multiple examination windows
 - Academic year performance
- Choose your presentation method.
 - Ratio method
 - Scaled score method

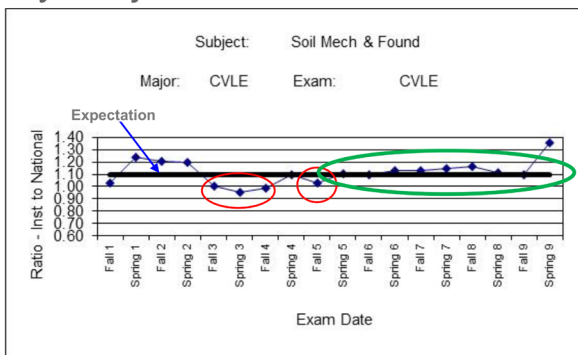
Ratio Method

- The ratio score is simply the ratio between the program's performance index (P.I.) in any topic area and the P.I. of the comparator performance.
 - Ratio score = Program P.I./Comparator P.I.

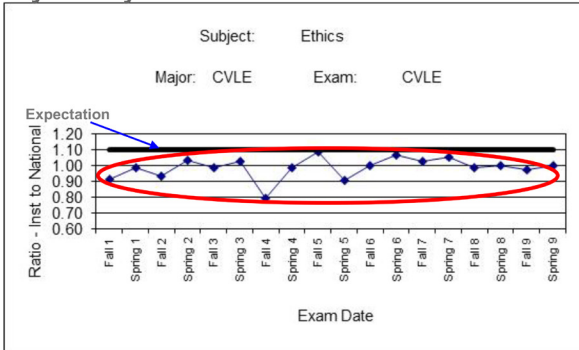
Comparison of Ratios by Subject Area

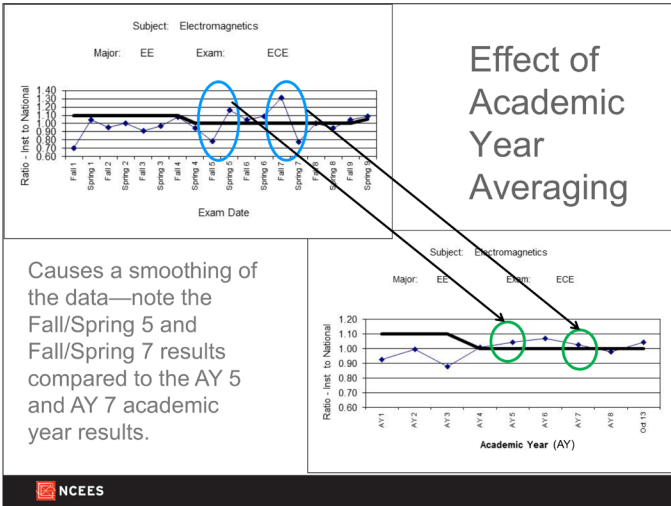


Comparison of Ratios by Subject Area



Comparison of Ratios by Subject Area



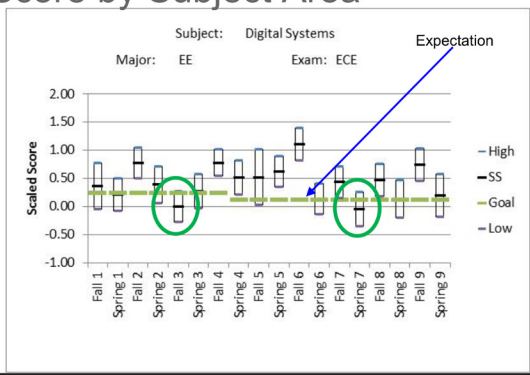


Scaled Score Method

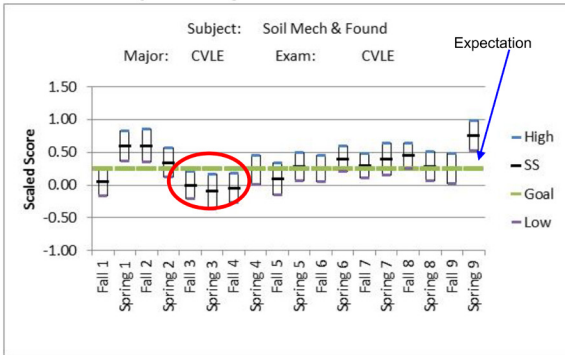
Define Scaled Score (S.S.)

$$S.S. = \frac{PI \text{ for Univ X} - PI \text{ comparator}}{PI \text{ comparator standard deviation}} \pm \frac{1}{\sqrt{\# \text{ of takers at Univ X}}}$$

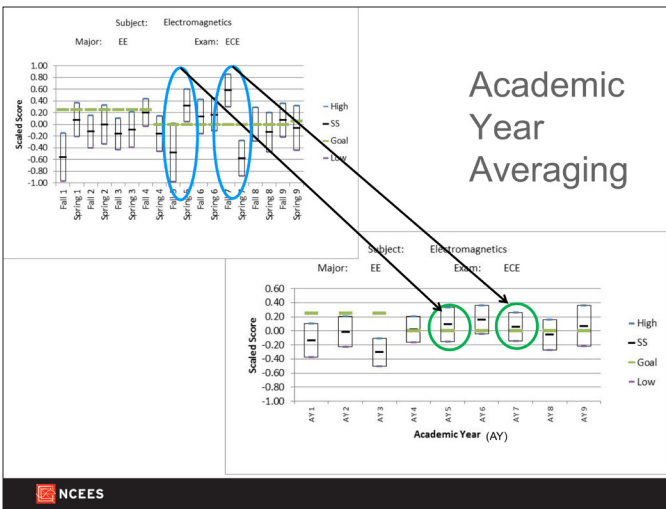
Comparison Using Scaled Score by Subject Area



Comparison Using Scaled Score by Subject Area



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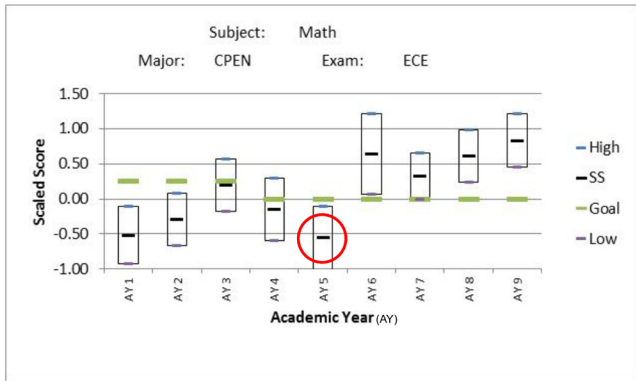


NCEES

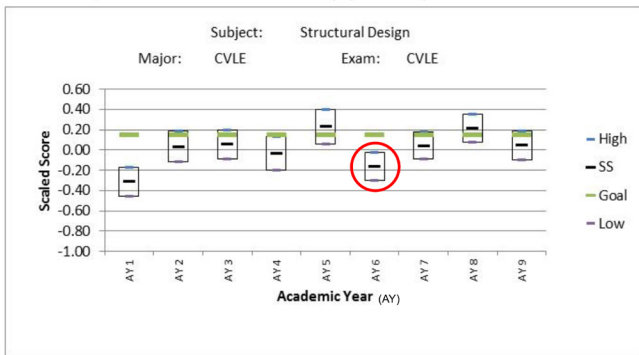
Examples of Assessing Some of the ABET (a)–(k) Outcomes

NCEES

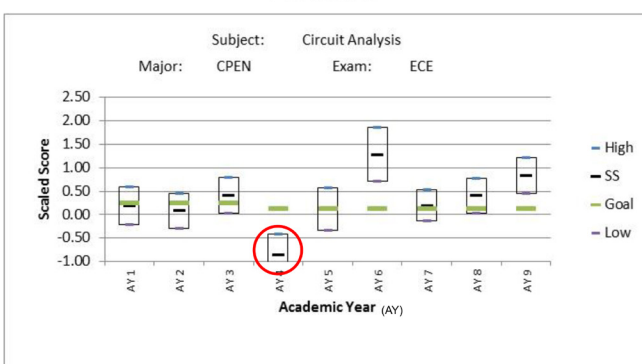
Ability to Measure ABET (a) Math and Science



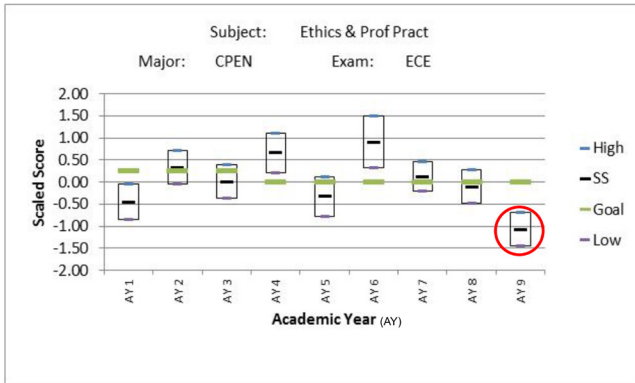
Ability to Measure ABET (c) Design



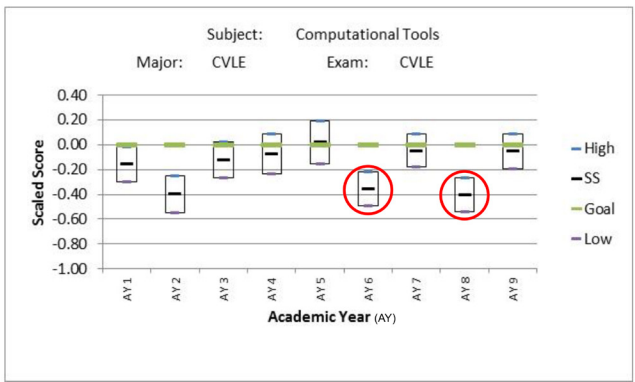
Ability to Measure ABET (e) Solve Engineering Problems



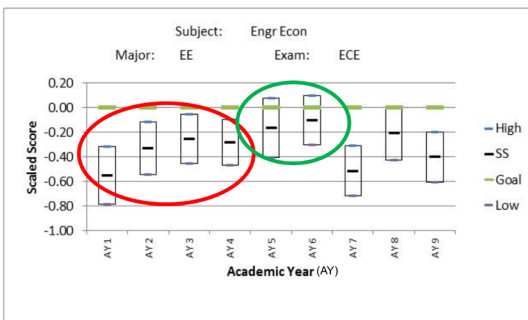
Ability to Measure ABET (f) Ethical Responsibility



Ability to Measure ABET (k) Engineering Tools



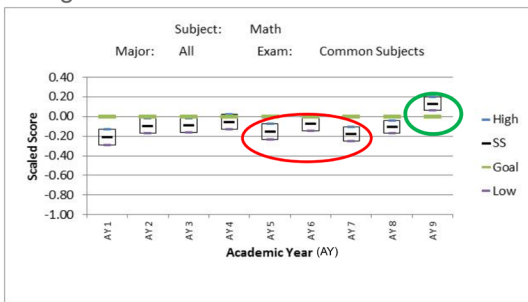
Ability to Measure ABET (e) Solving Engineering Problems or (k) Engineering Tools Using Engineering Economics



- Lectures on engineering economics were added to the senior design sequence during AY 5.

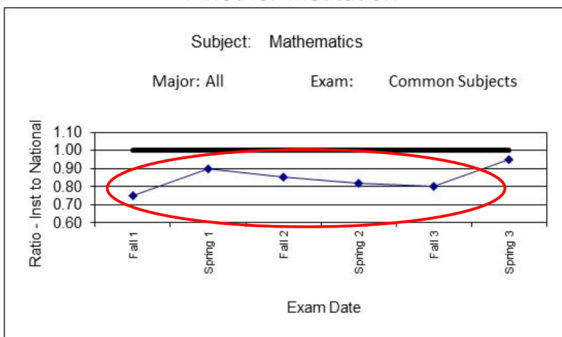
Collegewide Assessment Is Possible

Collegewide Assessment of Math



- Math agreed in AY 6 to make changes to the calculus sequence, including discontinuing the use of graduate students as instructors. Took 3 years for positive results.

Collegewide Assessment of Math – Another Institution



- Long-term issue. Math has agreed to incorporate applied mathematics assignments with results pending.

Conclusions

- Discipline-specific assessment information can be gleaned from this exam.
- FE exam provides a direct, quantitative assessment technique.
- The Subject Matter Report provides comparative data.
- NCEES sends a link to the Subject Matter Report directly to your institution via email.

Conclusions (cont.)

- The FE exam is one effective assessment tool to be used as part of your institution's full assessment package.

Additional Resources

For more information on reports, email fereports@ncees.org

Download today's presentation at <http://ncees.org/engineering/educator-resources/>

Additional Resources

For further information, contact:

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NCEES Exam Development Engineer

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Questions?



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