Assessing the Impact of Educational Factors on Conceptual Understanding of Geotechnical Engineering Topics

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1. Concept inventories
2. Study framework and assessment measure
3. Institutional contexts
4. Results and discussion
5. Conclusions and future research

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Concept inventories

- **Concept inventory (CI):** any kind of research-based assessment technique that measures conceptual understanding
- Background knowledge probe (pre-test)
  - A CI applied at the beginning of the semester
  - Used to establish students' prior knowledge on a subject before entering a course
- Course knowledge survey (post-test)
  - A CI applied at the end of the semester
  - Used to measure students' learning as a result of the educational experience
  - When the same set of questions are used at the beginning and end of the semester, students' learning gains can be explicitly quantified

Ghanat et al. (2016, 2017)

- Studied the usage of pre- and post- course CIs at four institutions in:
  - Introductory geotechnical engineering courses (Ghanat et al., 2016)
  - Foundation engineering courses (Ghanat et al., 2017)
- Assessed the influence of pedagogical strategies on specific geotechnical engineering and design concepts

Ghanat, S. T., J. Kaklamanos, K. Ziotopoulou, S. I. Selvaraj, and D. J. Fallon (2016). A multi-institutional study of pre- and post-course knowledge surveys in undergraduate geotechnical engineering courses, *ASEE 2016 Annual Conference and Exposition*, New Orleans, Louisiana, 26–29 June 2016.

Ghanat, S. T., J. Kaklamanos, S. I. Selvaraj, C. Walton-Macaulay, and M. Sleep, (2017). Assessment of students' prior knowledge and learning in an undergraduate foundation engineering course, *ASEE 2017 Annual Conference and Exhibition*, Columbus, Ohio, 25–28 June 2017.

Research objectives

- Using the results of CIs at six institutions, assess the impact of **educational factors** on student learning gains in introductory geotechnical engineering courses:
  - Institution type
  - Class size
  - Class meeting time
  - Class length and format
  - Laboratory format
  - Faculty attributes (faculty rank, attainment of P.E.)
- Recommend conditions that may optimize student learning in undergraduate geotechnical engineering courses

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Study framework

- A ten-question concept inventory was developed to assess students' understanding of fundamental concepts in geotechnical engineering
- Tests were administered in introductory geotechnical engineering courses at six participating institutions:
  - Bucknell University
  - The Citadel
  - Merrimack College
  - Tufts University
  - University of Evansville
  - University of Minnesota Duluth

  232 total students
- The same sets of questions were used in CIs at the beginning and end of the semester (neither counted towards students' grades):
  - Background knowledge probe (pre-test)
  - Course knowledge survey (post-test)

Assessment measure

No.	Question	Topic
1	What are some of engineering characteristics of fine-grained soils?	Soil composition
2	What does high relative density and low void ratio indicate?	Soil composition
3	Why do we need to assess the shear strength of soil?	Shear strength
4	What is the difference between compaction and consolidation?	Compaction
5	Why do we compact soils in earthwork?	Compaction
6	Why is determination of water content of soil important?	Soil composition
7	What causes settlement in soils (i.e., sources of settlement in soils)?	Settlement
8	What is the difference between normally consolidated and over-consolidated clay?	Settlement
9	What is difference between the drained condition and undrained condition?	Shear strength
10	The major and minor principal stresses at a certain point in the ground are 450 and 200 kPa, respectively. Determine the maximum shear stress at this point.	Stress

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Institutional contexts

Characteristics of the institutions:

Institution	Location	Type	Carnegie classification	Under-graduate enrollment	No. semesters of data
University of Minnesota Duluth	Duluth, Minn.	Public	Master's: large	10,000	1
Tufts University	Medford, Mass.	Private	Doctoral: highest research activity	5,500	1
Bucknell University	Lewisburg, Penn.	Private	Baccalaureate: Arts & sciences	3,600	1
Merrimack College	No. Andover, Mass.	Private	Master's: medium	3,400	4
The Citadel	Charleston, S.C.	Public	Master's: large	2,700	4
University of Evansville	Evansville, Ind.	Private	Master's: small	2,200	2

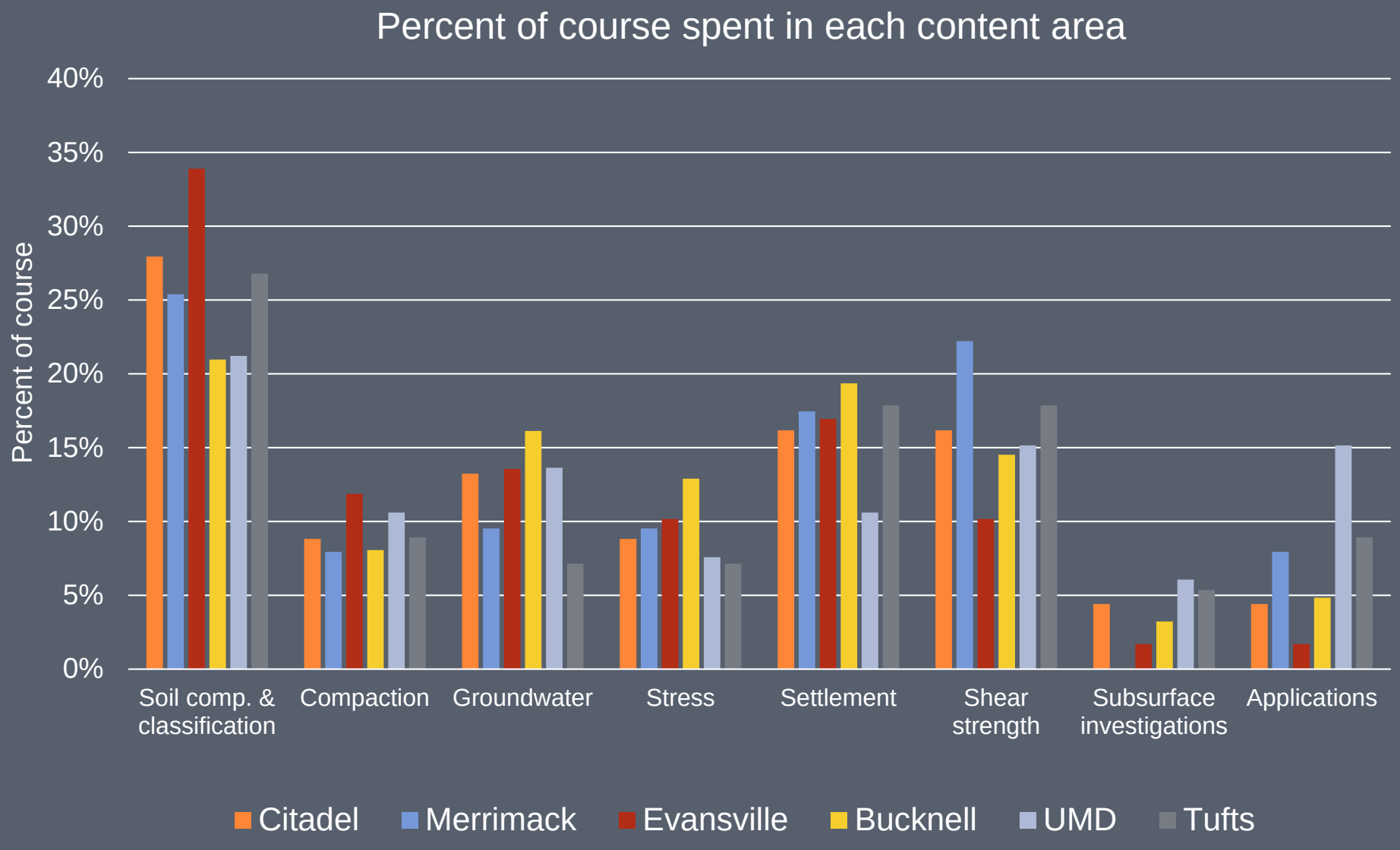
Geotechnical engineering course formats

Institution	**Course title**	**Typical semester taken**	**Class format** (per week)	**Lab format** (per week)
University of Minnesota Duluth	Soil Mechanics	Junior year, fall or spring	Two 75-minute classes	One 2-hr lab
Tufts University	Intro to Geotech. Eng.	Junior year, fall	Two 75-minute classes	One 2.5-hr lab
Bucknell University	Geotech. Eng. I	Junior year, fall	Three 52-minute classes	One 2-hr lab
Merrimack College	Geotech. Engin.	Junior year, fall	Two 75-minute classes	One 2.5 hr lab
The Citadel	Intro to Geotech. Eng.	Senior year, fall	Three 50-minute (day) or two 75-minute (evening) classes	Detached from course; offered in spring
University of Evansville	Soil Mech. & Soil Behavior	Junior year, spring	Three 50-minute classes	One 2-hr lab detached from course

Geotechnical engineering course content

- Soil composition and classification
  - Engineering geology
  - Grain size and plasticity
  - Index properties
  - Phase relationships
  - Soil classification
- Compaction
- Groundwater
  - 1-D Flow
  - 2-D Flow
- Subsurface stress
- Settlement
- Shear strength
- Subsurface investigations
- Applications and case studies
  - Bearing capacity
  - Foundations
  - Earth retaining structures
  - Case studies

Geotechnical engineering course content



Educational factors considered

No.	Educational factor	Values
1	Institution type	Public, private
2	Class size	Small (n < 25), Large (n ≥ 25)
3	Faculty rank	Assistant, Associate, Full Professor
4	Class meeting time	Morning, afternoon/evening
5	Laboratory format	Attached vs. detached from course
6	Faculty obtainment of P.E.	Yes, No
7	Class format	Two 75-minute meetings vs. Three 50-minute meetings

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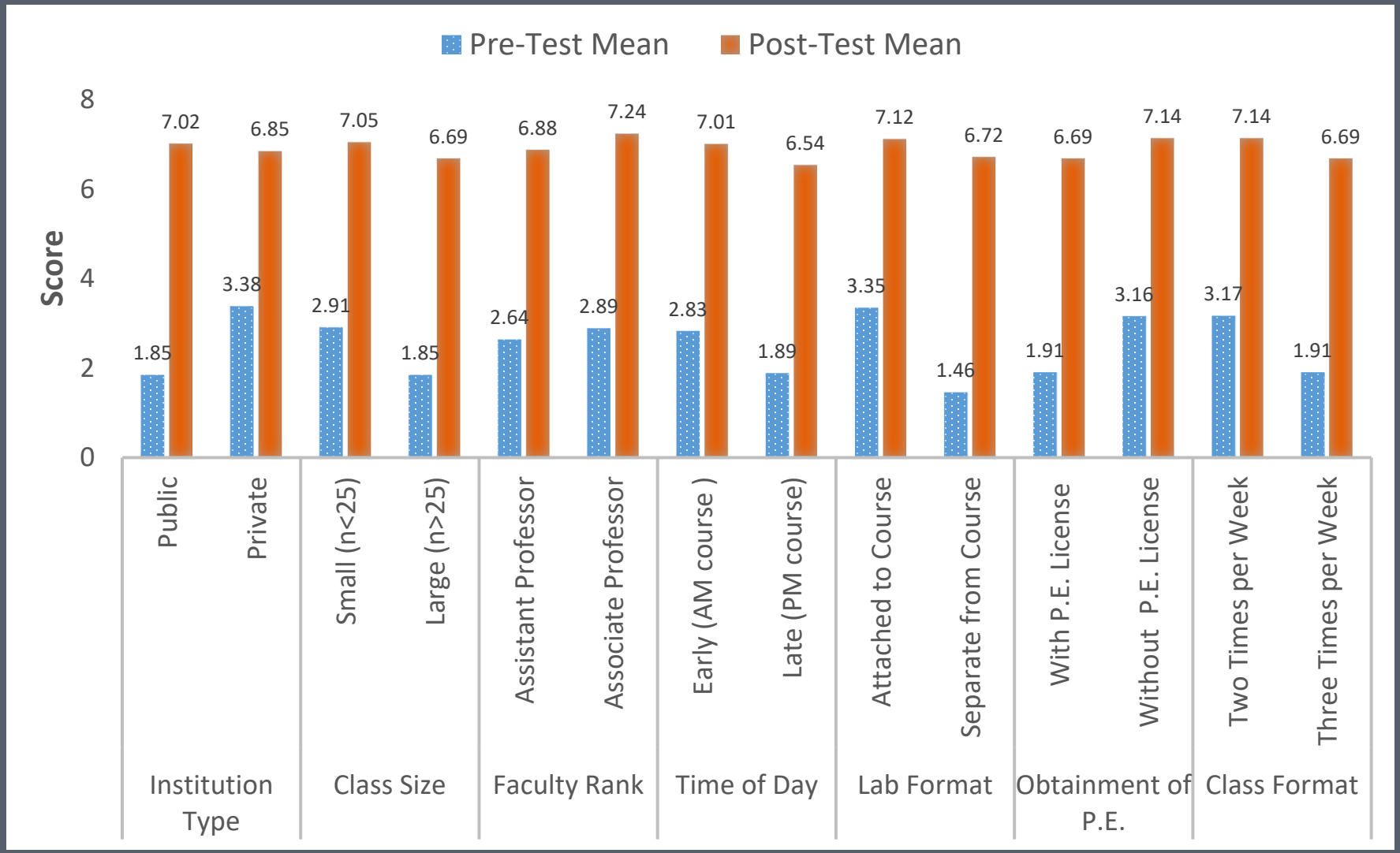
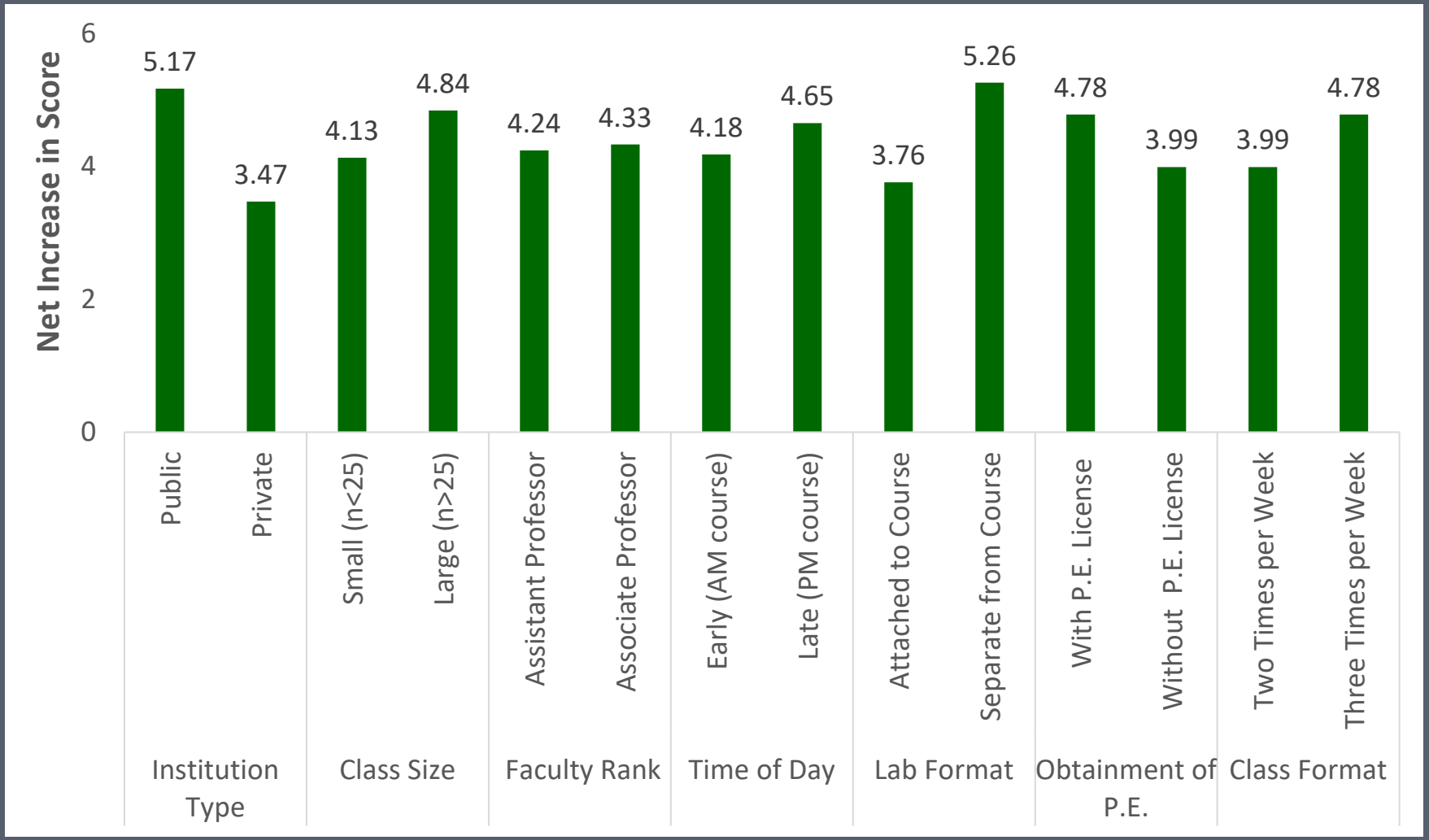
Means of pre- and post-test scores



Means of net increases in scores from pre-test to post-test



Pearson correlation statistical analysis

Correlation between each educational factor and the net increase in score from pre-test to post-test (n = 232):

Educational factor	Correlation coefficient, r	P-value	Correlation
Institution type	0.49	< 0.001	Moderate
Class size	0.06	0.176	None
Faculty rank	0.02	0.402	None
Class meeting time	0.17	0.06	Weak
Laboratory format	0.43	< 0.001	Moderate
Faculty P.E.	0.23	0.09	Weak
Class format	0.23	0.09	Weak

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Conclusions

- Using data from six institutions, we assessed the correlation between several educational factors and students' learning gains in geotechnical engineering topics
- Variables with **moderate** correlation:
  - Institutional type (public vs. private)
  - Laboratory format (detached vs. attached to course)
- Variables with **weak** correlation:
  - Class time (afternoon vs. morning)
  - Class format (Three 50-minute vs. two 75-minute classes)
  - Faculty obtainment of P.E.
- Variables with **no** correlation:
  - Class size
  - Faculty rank

Future research

- The results of this study are limited to the six institutions (with n = 232 student samples); future work with additional institutions may allow for more broadly applicable conclusions
- In addition to the educational factors assessed in this study, future work may link student characteristics, faculty characteristics, and specific instructional methods to conceptual understanding in geotechnical engineering courses
- With additional data, the long-term goal is to identify best practice for organizing civil engineering curricula to optimize gains in student knowledge

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