CHARTING THE PATH TOWARD THE FUTURE
Geotechnical Engineering Education
6 INTERNATIONAL CONFERENCE

3rd John Burland Lecture
Changing attitudes, organization and scale in engineering education: The teacher as a go-between and TC306 as a knowledge broker

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Prof. Burland preparing for his lecture at TC306's 3rd conference, SFGE 2012, in Galway, Ireland, chaired by Prof. Bryan McCabe

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Two audiences for the paper & two possible talks

Changing attitudes, organization and scale in **engineering education**:
The teacher as a go-between and TC306 as a knowledge broker

Producing geotechnical engineering teaching materials for **soil compaction**:
Proposed and implemented changes in attitude, organization and scale

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Objectives of the presentation

- **Draw attention to the content of teaching** and to teaching materials
- **Advocate changes** that add the role of the teacher as a go-between and the role of TC306 as a knowledge broker
  - **Provide example of** the advocated **changes** with teaching materials for soil compaction
- **Enlist peer reviewers** for the developed teaching materials

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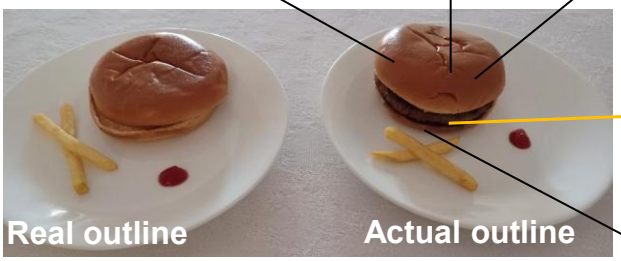
Outline: changing attitudes (1,2), organization of content (3,4), and scale (4,5), enriching roles (6)

1. Geotechnical engineering instructors need better **educational material**

2. Educational material needs **peer review**

3. Educational material needs to be developed within the framework of **pedagogical content knowledge**



4. Development of **small-scale** open educational material for **soil compaction** within the proposed framework

5. Examples of combined **small-scale** educational material and **crowdsourcing**

6. Enriched role of teacher (go between), expanded role of TC306 (knowledge broker)

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About the "engineering education" in the title

- **Education** is too many different things to different people
- To focus this presentation I will distinguish between

Content	vs	Method
e.g. soil compaction (geotechnical engineering)		e.g. problem-based learning (medicine, engineering …)

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Education → Content → Educational materials

- Educational materials, or course materials:
  - are specifically designed and produced to be used in instruction or can be used in instruction with minimal adaptation
  - include **textbooks** in printed or electronic format, published papers, online material, such as videos of any kind, and educational software of any kind, including education versions of commercial software*
- Educational materials will be categorized into **teaching materials** and learning materials

*Skoumios & Skoumpourdi (2018)

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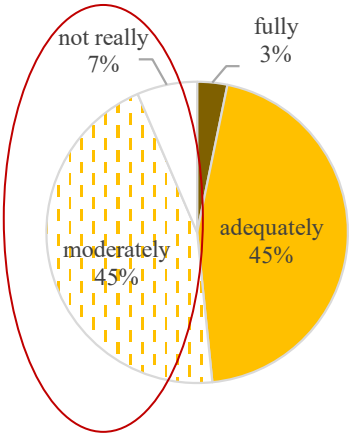
Do we have the educational materials we want?

- Survey question: Are you satisfied with the **educational material you currently use** in your teaching?
- Finding: **52%** of materials used are below personal standards



Pantazidou & Calvello (2024)

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The question of peer review

- Given that,
  - educational material is the only artifact* left behind by a teacher
  - most university teachers are steeped in the tradition of research
- **How come our only artifacts are not peer-reviewed?**
- Hypothesis: we have an alternative quality control measure for education, student evaluations
  - what are student evaluations good for, according to the education literature?

* see inspiring argument by Shulman (1993) on judging the value of teaching artifacts

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The case for student evaluations and peer review

- Students' self assessment is not correlated with respondents' performance*
- Students' responses serve as valuable "customer satisfaction reports" for educators and administrators
- **For teaching material quality — better ask peers**

* Ambrose et al. (2010), Deslaurier et al. (2019), Kruger & Dunning (1999), Yadav et al. (2010), Yadav et al. (2019)

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So far, we discussed indirectly about content through educational materials

→ to motivate changes about how we perceive facts

Now we will go to the heart of content and view it from a teaching perspective

→ to motivate changes about how we approach knowledge

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Let's view content from a teaching perspective

knowing content to teach it ↔ pedagogical content knowledge*

* "knowledge of the ways of representing and formulating the subject that **make it comprehensible to others**" (Shulman, 1986)

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Let's view X (e.g. compaction) from a teaching perspective

knowing X
to teach it ↔ pedagogical knowledge of X*

pedagogical content knowledge: concept introduced by Shulman (1986)
* pedagogical knowledge of X: **application of the concept**

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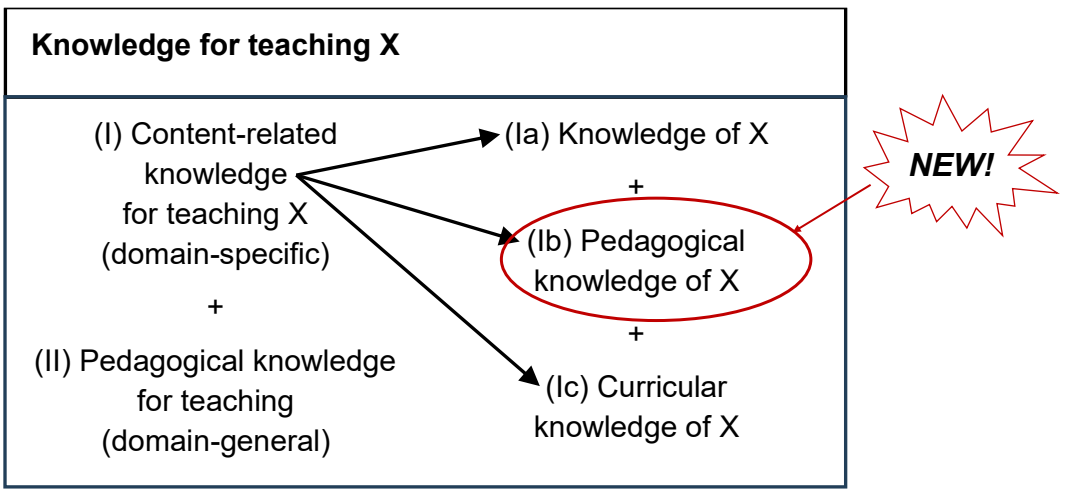
domain-specific vs domain-general knowledge for teaching X



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Ingredients of pedagogical content knowledge

- "*the most powerful analogies, illustrations, examples, explanations and demonstrations*"
  - pedagogical knowledge of X is all about explaining for understanding!
- "*an understanding of what makes the learning of specific topics easy or difficult* "
  - includes students' misconceptions, i.e. what might stand in the way of understanding

quoted excerpts from Shulman (1986)

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Pedagogical knowledge of X and educational materials

- Hypothesis: we can find fragments of pedagogical knowledge of X (illustrations, explanations) in the textbooks of the domain
  - examples for **soil compaction**
- Claim: keeping in mind the ingredients of pedagogical content knowledge helps in the production of educational materials
  - if we aim at cumulative progress

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NEXT (slides 18-19 and 23-31)

→ examples of **pedagogical knowledge of soil compaction** extracted from textbooks (& open questions)

→ example of developing **educational material for soil compaction** within the framework of pedagogical content knowledge (& internal rewards for the developer!)

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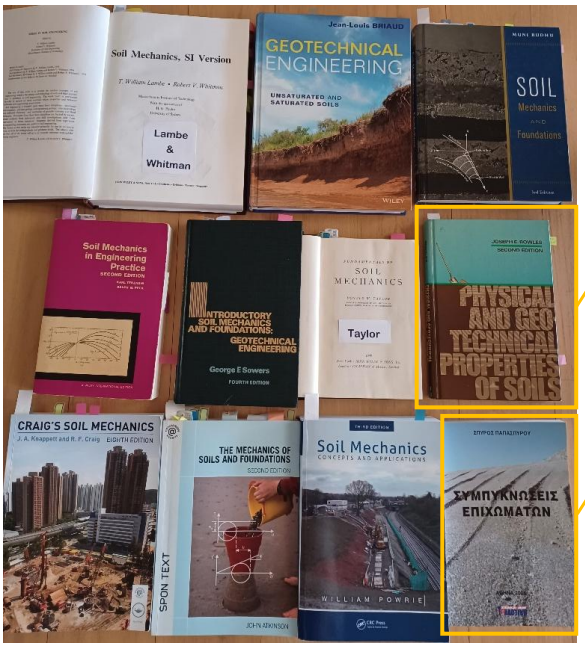
Survey of:

- **9 introductory textbooks**
- **1 specialty textbook**
- **1 specialty book**

- Taylor (1948), Terzaghi & Peck (1967), Sowers (1979), Lambe & Whitman (1979), Knappett & Craig (2012), Atkinson (2007), Powrie (2014), Budhu (2011), Briaud (2013)
- Bowles (1984)
- Papaspyrou (2006)



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Soil compaction: a form of soil improvement

- Main idea: standard compaction test in the laboratory guides field compaction with rollers

- Run 5-6 tests
- Increase the amount of water in each test
- Plot the **compaction curve**: the relationship between amount of water and soil density

photos taken at NAMA LAB

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FACT

→ Soil Mechanics relies on tailored testing procedures designed to yield targeted results (more so than other civil engineering specialties?)

CONSEQUENCE

→ We depend on the graphical representation of the results

PEDAGOGICAL DECISION

→ Which graph best represents **soil compaction for teaching**?

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PEDAGOGICAL DECISION

→ Which graph best represents **soil compaction for teaching**?

WHAT IS AT STAKE?

→ Our choice becomes the archetype. That one graph will shape students' concept of **soil compaction**.

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MY PERSONAL RESOLUTION

→ The best I can do as a teacher is choose the simplest graph that reflects *my concept* of **soil compaction**.

BONUS!

→ In doing so, I'm challenged to clarify that understanding myself!

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Archetypal compaction graphs* in classic textbooks

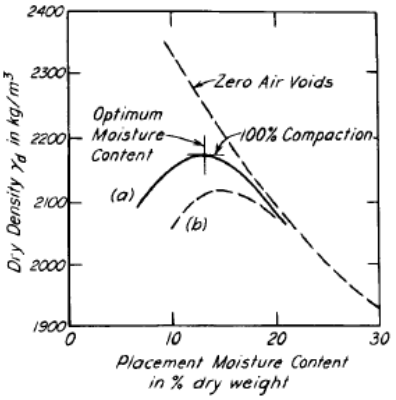

Fig. 50.1. Terzaghi & Peck (1967)

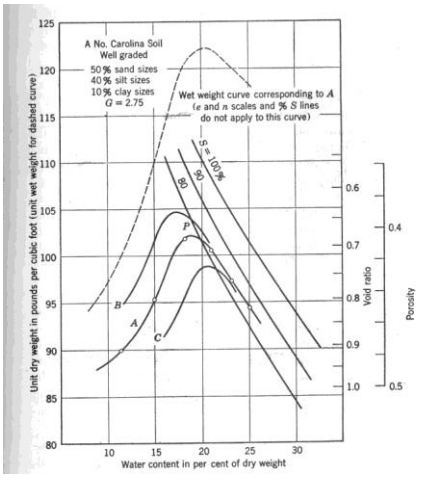

Fig. 18.2 Taylor (1948)

* Commentary in Text S2, Supplement of Pantazidou (2025)

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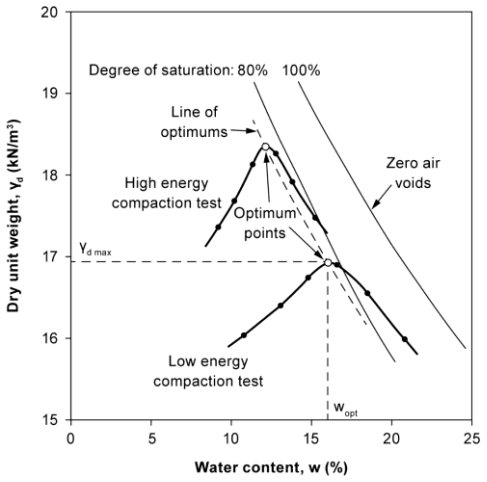
My archetypal compaction graph and some (un)desirable features*



modified from Fredlund & Rahardjo (1993)

Desirable (3/9)

1) Dry unit weight γ_d in Y axis

2) At least two constant degree of saturation, S, lines

3) Known specific gravity G_s used in constructing constant S lines

Undesirable (1/2)

1) Unknown soil

* commentary in Supplement of Pantazidou (2025)

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Textbooks: pedagogical knowledge of soil compaction (sampling)

- Taylor (1948) includes three measures for density: dry unit weight, γ_d, porosity, n, void ratio, e
- Powrie (2014) adds specific volume, v

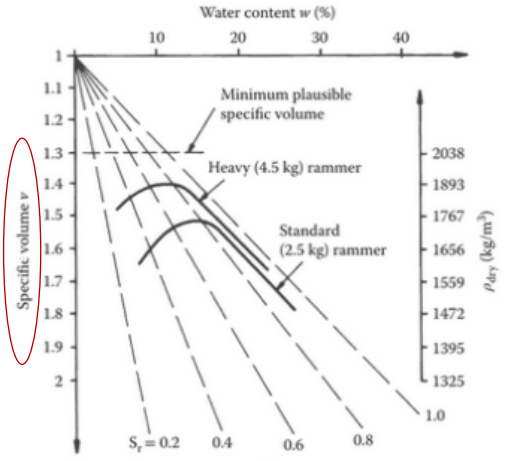

Fig. 1.19b from Powrie (2014), used with permission by the author

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Textbooks: unanswered questions (sampling)

- Compaction basics in textbooks applicable to all soils?
  - Only Bowles (1984) writes unequivocally that for coarse-grained soils "a curve is usually not drawn to obtain maximum density".
    - Papaspyrou (2006) adds: Optimum water content is not determined, because it has no meaning for very permeable soils. For these soils, water is liberally applied during compaction to assist in particle rearrangement.
- What saturation values to expect at and past the optimum point?
  - My tentative answer: around 10-15% for soils with sizeable fine-grained content

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Adding to the pedagogical knowledge of soil compaction: development of targeted teaching materials

- Target: help students explore alternative ways to describe how dense soil is
- Target: promote degree of saturation as a key soil parameter (despite its unsuitability to replace water content for compaction specifications)
- Target: stress the variety of compaction curves (even for a subset of soils with sizeable fine-grained fraction)
- Target: guide students to think about the role of soil particles in defining the soil's personality (big idea)

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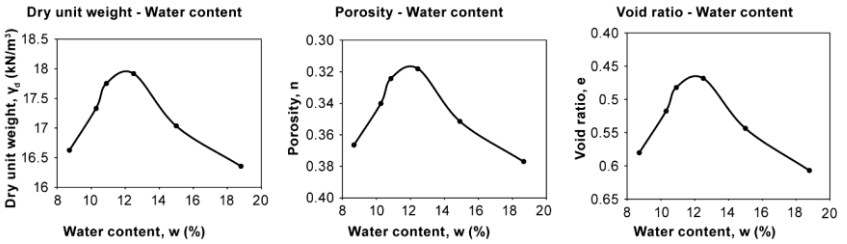
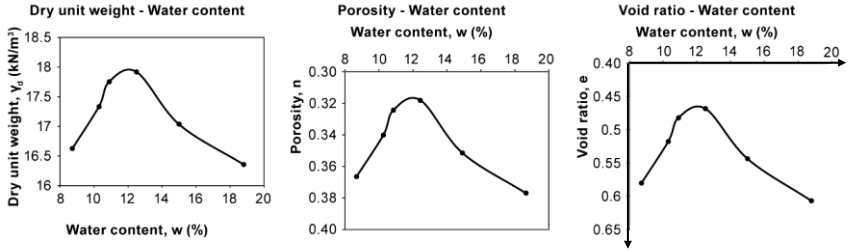
Alternative ways to describe how dense soil is



data from Das (1997)



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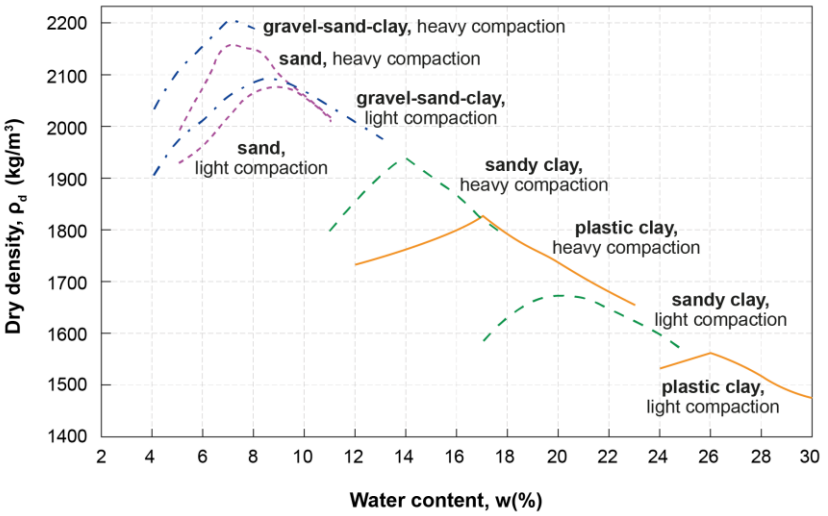
Soil particles is to soil what yarn is to textile (big idea)



data from Croney & Croney (1998)

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Teaching material for soil compaction: 10 figures

Table A1. List of contents of Online Supplement

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Is there a future for soil compaction?

- In research?
  - Researchers on compaction in the past, who-is-who in geotechnical engineering (William Lambe, Harry Seed, Mike Duncan)
- In education?
  - Compacted soil a model for soil in depth, overconsolidated soil?
  - "Building with soil" as introduction to "building on soil"?
  - Maybe through teaching unsaturated soil mechanics? (Bicalho, 2025; Vulpe & Beckett, 2025)

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Small is doable by an individual and is rewarding!

- Reducing the scale: smaller than a textbook, smaller than a paper
- Reducing the scale offers the luxury of focus
- Connecting to the collective pedagogical knowledge offers the privilege of serving as go-between for great minds

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Small is manageable by a technical committee

- Reduced scale of contribution
  - is compatible with volunteer work and facilitates peer review
- Reduced scale of contribution combined with crowdsourcing
  - produces output and permits reaching out
- Reaching out: from knowledge hub, TC306 becomes knowledge broker

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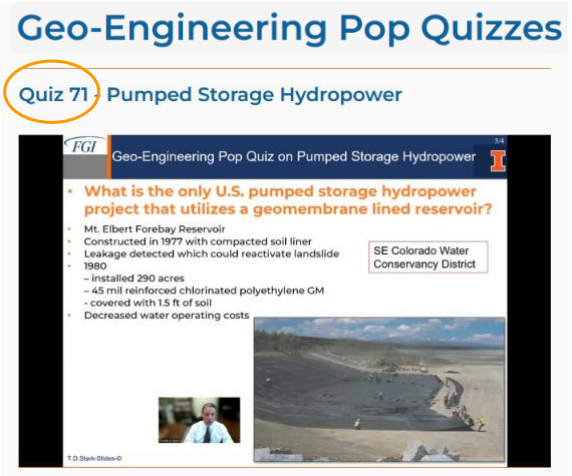
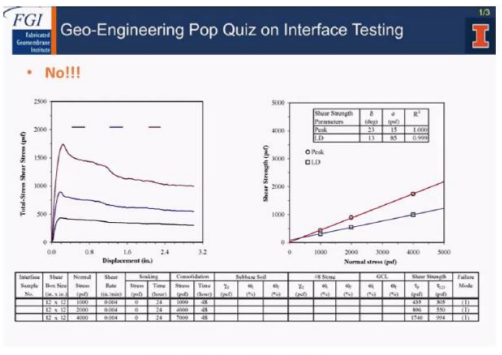
GEE post: Geo-engineering pop-quizzes by Timothy Stark (Calvello, 2022)



Fabricated Geomembranes Institute (2025): Stark, T., Geo-engineering Pop Quizzes, https://www.thefgi.org/resources/geo-engineering-quizzes

3. Contribution by Polyxeni (Tzeni) Kallioglou *(quiz in video 30)*

My favorite geo-engineering quiz question is No 30, which **asks about the identification of the residual strength based on results** (shear stress – displacement curves) of three geosynthetic interface direct shear tests at various normal stress levels. Since the maximum displacement recorded at the end of each test is not enough to achieve the residual shear strength –which is activated at significantly larger displacements–, the suggestion is to either perform ring shear tests or extrapolate direct shear test results out to the residual strength conditions.



Still from video 30 - Interface Testing

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Summary & Conclusions: 1/5 push button for change

- **Make it known we do not have the educational materials we want**
- Evidence: TC306 questionnaire
- Change in: perception (of facts)→ attitude
- **Desired result: motivate development of teaching materials**

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Summary & Conclusions: 2/5 push button for change

- **Promote a culture of peer exchanges in education**
- Evidence: research data (limited scope of student evaluations)
- Change in: perception (of facts) → attitude
- **Desired result: peer selection, peer review of teaching materials become mainstream**

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Summary & Conclusions: 3/5 push button for change

- **Recognize that teaching in a specific field requires its own body of knowledge, distinct from both evidence-based teaching practices and subject-matter expertise**
- Evidence: education literature (concept) & **examples** for **soil compaction**
- Change in: perception (of knowledge) ↔ organization of content
- **Desired results: the framework of pedagogical content knowledge informs the design of instructional materials, thereby advancing pedagogical understanding within the discipline**

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Summary & Conclusions: 4/5 push button for change

- **Teachers acting as go-betweens for people and ideas promote the value of derivative work**
- Evidence: my word & **examples** for soil compaction (after peer review!)
- Change in: attitude → involvement
- **Desired results: motivation for involvement in the absence of external reward**

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Summary & Conclusions: 5/5 push button for change

- **TC306 and similar groups acting as knowledge brokers facilitate the creation of small-scale educational materials**
- Evidence: **about to happen (next step)**
- Change in: scale & organization of logistics
- **Desired results: reduce commitment, increase involvement → address teachers' needs**

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the contribution of this talk to the teaching of geotechnical engineering

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