The application of research-based learning principles to the redesign of an environmental geotechnics course with examples

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SUPPLEMENT – Tabulated Contents

This supplement includes examples from the educational material produced for the course in the paper title. Table S1 lists these examples and indicates their relationship to learning principles 1 to 5 and the corresponding teaching strategies. The examples are numbered, as indicated in Table S1a (learning principles 1 to 3) and Table S1b (learning principles 4 to 5), and presented as Exhibits S1 through S20, as shown in the list of contents below. When the example is a PowerPoint presentation, a sample slide is included in the supplement and the entire presentation is available at: users.ntua.gr/mpanta/Teaching_EN/EnvironmentalGeotechnics

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Table S1a. Learning principles 1-3, major goals originating from each principle, selected strategies to achieve goals [adapted from Ambrose et al. (2010)], suggested implementation of strategies and examples of implemented strategies in an environmental geotechnics course included as Exhibits 1 to 12 in the Supplement.

Principle number and description				
Principle short name	Main goal	Selected strategies	Strategy implementation (Correspondence to examples-exhibits)	Implementation examples†
1. Students' prior knowledge can help or hinder learning				
Prior Knowledge	Activate prior knowledge	Link material from other courses and within the course (trigger recall)	• Enrich each lecture with diagnostic quiz-type questions (S1)	**Exhibit S1** Quiz-type questions for Units 2-4, 6-8
			• Create material to highlight links among civil engineering courses (S2)	**Exhibit S2** Comparison of orders of magnitude of Elastic Modulus – Hydraulic Conductivity & Assignment with MATLAB®
	Identify-address prior inaccurate knowledge	Ask students to justify their reasoning (uncover prior beliefs)	• Elaborate beliefs about prerequisite concepts – devise interventions (S3)	**Exhibit S3** Background on the ground coffee – instant coffee analogy
			• Uncover beliefs about key concepts – devise interventions (S4)	**Exhibit S4** Pantazidou (2009)
2. How students organize knowledge influences how they learn and apply what they know				
Knowledge Organization	Build dense and meaningful connections	Provide organization structure of subject matter, lectures, course	• State essential questions – build course units around them (S5)	**Exhibit S5** Table 2
			• Assign meaningful titles to course subunits (S6)	**Exhibit S6** Presentation titles for Units 4, 6-7
			• Reorder course contents to make apparent necessity of certain course units (S7)	**Exhibit S7** Presentation for qualitative description of transport in water
			• Provide qualitative introductions to quantitative approaches (S7)	
			• Highlight connections among key topics: introduce-apply-reinforce (S8)	**Exhibit S8** Excerpt from text (Section "Methodology-driven changes")
3. To develop mastery, students must acquire component skills, practice integrating them, and know when to apply what they have learned				
Mastery	Practice component skills	Break complex tasks into component tasks	• Unpack complex phenomena into their constituent mechanisms (S9)	**Exhibit S9** Additional material for contaminant transport related to the schematic in Figure 1
			• Distill each course unit into main understandings (S10)	**Exhibit S10** Main points and main understandings for Units 4, 6-7
	Practice integration	Scaffold complex task performance	• Transition gradually from qualitative to quantitative (S7, S11)	**Exhibit S11** Presentation for experiment at Borden
			• Provide answers to essential questions (S12)	**Exhibit S12** Answers to essential questions

† Educational material in addition to exhibits (PDF, PPT, MATLAB® files) is available at: users.ntua.gr/mpanta/Teaching_EN/EnvironmentalGeotechnics

Table S1b. Learning principles 4-5, major goals originating from each principle, selected strategies to achieve goals [adapted from Ambrose et al. (2010)], suggested implementation of strategies and examples of implemented strategies in an environmental geotechnics course included as Exhibits 13 to 20 in the Supplement.

Principle number and description				
Principle short name	Main goal	Selected strategies	Strategy implementation (Correspondence to examples-exhibits)	Implementation examples†
4. Students' motivation determines, directs, and sustains what they do to learn				
Motivation	Increase subjective value of goal	Assign authentic, real-world tasks	• Create a case study for each course unit (S13)	**Exhibit S13** Presentation of case study: Graces Quarters
			• Create realistic assignments (S14), midterm (S15) and final exam questions (S16)	**Exhibit S14** Homework assignment based on oil released in a refinery in Iran **Exhibit S15** Problem concerning a spill near river in the US from midterm exam **Exhibit S16** Problem concerning a fictitious permeable wall in a real flow field from a final exam
	Hold expectation for successful attainment of goal	Align objectives-assessment-instructional practices, Articulate expectations, Use rubrics	• Use Understanding by Design framework (S17)	**Exhibit S17** Wiggins and McTighe (2005)
			• Highlight connections between learning outcomes and assigned work (S18)	**Exhibit S18** Table 3
5. Goal-directed practice coupled with targeted feedback enhances the quality of students' learning				
Communication	Practice towards specific goals	Be specific about goals, State learning outcomes	• Communicate essential questions in course introduction (S5 – Table S1a)	
			• Provide detailed learning outcomes for each course unit (S19)	**Exhibit S19** Detailed learning outcomes for Units 4, 6 and 7
			• Highlight connections between learning outcomes and assigned work (S18)	
	Provide feedback	Provide feedback at the group level	• Discuss in class answers to quiz questions (S20)	**Exhibit S20** Discussion on the answers of selected quiz questions

† Educational material in addition to exhibits (PDF, PPT, MATLAB® files) is available at: users.ntua.gr/mpanta/Teaching_EN/EnvironmentalGeotechnics

References

Ambrose, S.A., Bridges, M.W., DiPietro, M., Lovett, M.C. and Norman, M.K. (2010). How learning works: 7 researched-based principles for smart teaching, Jossey-Bass, San Francisco, CA, USA, 301 p.

Pantazidou, M. (2009). Student understanding of the concept of soil structure guides instructional interventions, 17th Int. Conf. on Soil Mechanics and Geotechnical Engineering, October 5-9, Alexandria, Egypt, pp. 2758-2761.

Wiggins, G. and McTighe, J. (2005). Understanding by design, Expanded 2nd Edition, Association for Supervision and Curriculum Development, Alexandria, VA, USA, p. 370.