What kinds of educational material are useful for and desired by university instructors? The case of Geotechnical Engineering

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Abstract: An online questionnaire was developed to find out (i) whether geotechnical engineering instructors have available a variety of satisfactory educational material and (ii) the types of educational material they desire. The title of the questionnaire was phrased as “What Geotechnical Engineering Educational Material can we dream of?”, in order to convey that the main purpose of the survey project reported herein is to learn about these desired educational materials. In doing so, the survey also aims to assemble information on related issues, such as: existing educational materials, where do instructors search for them and how satisfied they are with available material. The questionnaire has 12 close-ended (four yes/no and eight multiple choice) and four open-ended questions. From the 94 completed questionnaires received, 63 were deemed to be conscientious attempts to answer its questions and were analyzed in detail. The most revealing findings from the close-ended questions include the following. The majority of the instructors (52%) are not adequately satisfied with the material they use. Likewise, whereas a significant percentage has searched for additional material, a little less than half of them (45%) are not satisfied with material found. Respondents need materials for their lectures, materials to engage students outside lecture time and, to a lesser extent, materials to assess students. In terms of topics of interest, case studies and laboratory-related educational materials are the most popular. The online supplement of the paper includes broad-stroke and fine-stroke descriptions of desirable educational materials that provide directions for developing them.

Keywords: Geotechnical engineering education; Teaching needs assessment; Educational material development

1. Introduction

In the internet era, a common assumption is that instructors –university instructors included– have available a variety of satisfactory educational material to choose from for their lectures. However, having many sources available is akin to having the phonebooks for businesses of previous decades, known as "yellow pages", which are not helpful if the goal is to identify quality professionals. The starting point of the work presented herein is using a questionnaire to test this abundance assumption for instruction in geotechnical engineering, one of the disciplines of civil engineering, in particular for its accuracy for undergraduate instruction.

Educational material is a common research topic in the literature for lower levels of education, since it is anticipated that teachers may have some knowledge gaps (Davis et al., 2016). In contrast, the high content expertise of university instructors often leads to the conclusion – questioned herein– that this literature is irrelevant to tertiary education. However, since teaching at all levels has some common elements, even the literature for primary-secondary education can yield some useful overarching guidelines for desired educational material. For instance, teachers appreciate the educational materials that are *educational* for themselves as well, i.e. not only for students (Ball and Cohen, 1996). Such guidelines offer domain-general criteria for the usefulness of educational material. For tertiary education, efforts for "educating educators" essentially target: (i) content outside their main area of expertise but within their broader field, e.g. geosynthetics within geotechnical engineering (Zornberg et al., 2020); and (ii) educational topics, by means of various domain-general short courses or certificate-granting programs attended by instructors from all disciplines, such as those offered in the UK by universities and accredited by the organization Advance Higher Education –formerly Higher Education Academy. To the authors' best knowledge there has been no effort to re-educate educators for teaching in their discipline. If there were, most probably the standard would be quite high, even for undergraduate topics. That's why the goals of the questionnaire described herein aim very high, beyond the merely doable and all the way to the dream-able. The existing literature provides useful examples of questions asked (Skoumios and Skoumpourdi, 2018), and also the questions left out provided food for thought. Specifically, primary and secondary education teachers are rarely asked what materials they want; instead, education researchers create material and study how they are received by teachers (Ball and Cohen, 1996; Davis et al., 2016).

The main purpose of the survey project reported herein is to find out the types of educational material geotechnical engineering instructors would like to have available. To provide a broader context for the collected information, the online questionnaire developed also aimed to collect information on related issues, such as: existing educational materials, where do instructors search for them and how satisfied they are with available material. The ultimate goal of the project is to facilitate dissemination and production of shareable educational material deemed by geotechnical engineering instructors to be useful and desirable.

2. Methods

2.1. The questionnaire

The overall question asked in order to achieve the main research purpose was phrased as: "What Geotechnical Engineering Educational Material can we dream of?". This question served as the questionnaire title. The phrasing was meant to free respondents from the constraints imposed by their own available time and knowledge. The main question was framed with ancillary questions arranged in the four sections shown in Table 1: Section A – material used in instruction (phrased as "Your Educational Material"), Section B – searching for educational material and Section C – dream educational material. There is a final Section D, which asks for demographic data, including instructional experience. In total, the questionnaire consists of 16 questions, 12 close-ended (four yes/no and eight multiple choice) and four open-ended. The complete questionnaire with the possible answers to close-ended questions and their percentages is included in online Supplement A (Pantazidou and Calvello, 2023a: Table S1).

To guide respondents, the questionnaire starts with an introductory page stating the ultimate goal of the project, which is the use of the survey results for the development of shareable educational material for geotechnical engineering at undergraduate level. The introduction also includes a definition of educational material, adapted by Skoumios and Skoumpourdi (2018). Respondents are guided to think of educational material as anything they use in their teaching that (i) is specifically designed and produced to be used in instruction or (ii) can be used in instruction with minimal adaptation. It includes textbooks in printed or electronic format, published papers, online material, such as videos of any kind, and educational software of any kind (including educational versions of commercial software). For the purposes of this questionnaire, educational material excludes demonstrations involving physical objects or

testing equipment but includes the results produced by such demonstrations, provided they are well documented so that they have educational value independently of the actual physical demonstration.

Section A has four questions. Question 1 asks respondents whether they have developed any shareable educational material themselves and, if the answer is yes, to provide examples (Question 2). Question 3 is a central question that asks how much or little satisfied are the respondents with the educational material they use and, if they are fully satisfied, to provide examples (Question 4). The wording "fully satisfied" was purposefully selected in order to guide instructors to select the very best from the material they use in order to ensure usefulness for other instructors.

Section B has six questions asking respondents if and where they search for educational material (Questions 5 and 7) and for which geotechnical engineering topics they search (Question 6). Question 8 is another central question asking respondents how satisfied they are with some of the material found and, if they are satisfied, to provide examples (Question 9). For material found the standard for examples was lowered to just "satisfied" (compared to "fully satisfied" for material used), in order to get a picture of what instructors would be happy –but not necessarily delighted– discovering without doing work themselves. The final question in Section B, Question 10, is also key for the project's aim and asks for reasons why any unsatisfactory material found was inappropriate, in order to collect usefulness criteria for the production of future educational material.

The core of the questionnaire, Section C, has two questions, 11 and 12. Question 11 is open-ended and asks respondents to imagine and describe a "wish list of Educational Materials" also expressed as "the educational material of our dreams". This is the only obligatory question of the questionnaire, i.e. respondents have to type something in order to proceed. Question 12 is multiple choice and asks respondents to select possible obstacles for developing themselves their dream material.

Lastly, Section D asks for demographic data, such as country (Question 13), instructional and professional experience (Questions 14 and 15), and whether respondents have had any formal training in Education (Question 16). The questionnaire was made available to respondents through the platform Survey Monkey.

112 Table 1. Questionnaire: phrasing and type of questions and numbers of responses analyzed.

ID	Question	Type	Replies (ISSMGE + TC306)
Section A – Your Educational Material			
Q1	Have you ever developed shareable educational material yourself?	yes/no	62 (42+20)
Q2	If you answered "yes" to Question 1, please give examples and sources if you have made this material publicly available (e.g. give URLs, references of papers)	open ended	24 (13+11)
Q3	Are you satisfied with the educational material you currently use in your teaching?	likert: 4	62 (42+20)
Q4	If you answered "Fully" to Question 3, please provide sources (e.g. books, URLs, references of papers) of the material used in your teaching, including subject and course/module.	open ended	1 (1+0)
Section B – Searching for Educational Material			
Q5	Have you ever searched for educational material to augment what you have/use?	yes/no	61 (40+21)
Q6	If you answered "yes" to Question 5 (= have you searched), for which geotechnical engineering topic(s) have you searched?	choices: 9+other	53 (37+16)
Q7	If you answered "yes" to Question 5 (= have you searched), where/how have you searched?	choices: 5+other	53 (37+16)
Q8	Were you satisfied with any material found?	yes/no	53 (37+16)
Q9	If you were satisfied with some of the material found ("yes" in 8), please give examples, sources (e.g. URLs, references of papers) and a brief description of how you incorporated the material in your teaching, including subject and course/module.	open ended	24 (17+7)
Q10	If you were not satisfied with some of the material found (answered either "yes" or "no" to Question 8), in what way was the material inappropriate?	choices: 4+other	39 (28+11)
Section C – Dream Educational Material			
Q11	Please imagine and describe the "educational material of your dreams", regardless of whether you believe there exists or that someone might produce it. Assume that there is a "Santa Claus for Geotechnical Engineering Instructors" who delivers all year round. Please describe what you would ask Santa, including subject and course/module where you would use the material. NOTE This “dream material” could be the same as the material you described in the answers to Questions 2, 4 or 9.	open ended	47 (28+19)
Q12	What might make it difficult for you to develop the "educational material of your dreams"?	choices: 8+other	61 (41+20)
Section D – Demographic Data			
Q13	Country of the University where you teach	choices: country	61 (40+21)
Q14	Instructional experience	categories: 5	61 (40+21)
Q15	Professional experience	choices: 6+other	61 (41+20)
Q16	Have you had any formal training in Education? NOTE Formal training may range from one short course to certificate-granting programs offered by a university teaching and learning center or a state agency.	yes/no	63 (42+21)
Q17	Please write your name and e-mail if we have your permission to contact you and ask further elaboration on your answers to Questions 2 (material developed), 9 (material found) and 11 (dream material). You may also leave us comments in the same box.	open ended	25 (25+0)

2.2. Two groups of respondents

Respondents to the questionnaire belong to two groups. The first group is the technical committee on Geo-engineering Education (TC306) of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) (TC306 group). This is a group of members of the ISSMGE who are nominated by national societies for Soil Mechanics and Geotechnical Engineering to represent them in the technical committee for education. The first author of the paper is the TC306 chair and the second author is the TC306 secretary. The questionnaire was made available in the summer of 2019 for the TC306 group, which at the time had 34 members. Members were informed about the questionnaire through e-mail. A total of 23 responses were received from the TC306 group.

The second group is the wider community of geotechnical engineering educators who follow the ISSMGE activities (ISSMGE group), i.e. it is a superset of the first. The questionnaire was made available to the wider community in the fall of 2019, after being disseminated as follows. The results from the responses of the TC306 members were presented at a special session on education during the 17th European Conf. on Soil Mechanics and Geotechnical Engineering that took place in Reykjavik, Iceland. Attendees of the special session were invited to respond. In addition, the questionnaire was announced in a news item of the September 2019 News & Information Circular, which is sent by the ISSMGE to the officers of all the national societies and the ISSMGE technical committees for further distribution. A total of 71 responses were received from the ISSMGE group between September 2019 and January 2020. In the version of the questionnaire for the wider community there was an extra optional question in Section D asking for the respondent's name, e-mail and permission to be contacted for further elaboration on answers.

2.3. Screening of the answers

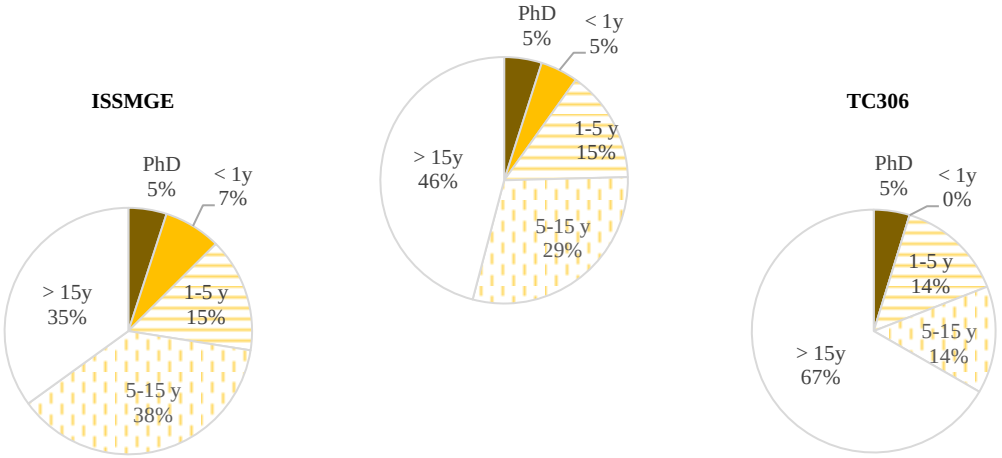
It takes 10 minutes to read carefully all questions and complete the 12 yes/no and multiple choice questions of the questionnaire. Depending on how seriously the respondents treat the exercise, extra time is needed to write responses for the "other" option of four multiple choice questions and, mainly, for the open-ended questions. Because several completed questionnaires contained only a few answers (mostly to the easy close-ended questions) and were missing

demographic data (ISSMGE group), it was decided to take into account only the more conscientious attempts to complete the questionnaire.

This "conscientiousness filter" left 21 responses in the TC306 group and 42 responses in the ISSMGE group. Of the latter 42 responses, 25 were signed. Only the answers from those 63 questionnaires have been compiled for perusal or analysis by anyone interested, see EXCEL file in online Supplement B (Pantazidou and Calvello, 2023b). Likewise, only these answers were taken into account in preparing the tables and figures of this paper, with the exception of any useful answers to the open-ended questions: one such answer was found, see Section 3.3 and Table S3 in online Supplement A (Pantazidou and Calvello, 2023a). The survey platform used to collect and analyze the results provides typical time spent on the questionnaire, taking all the responses together. Typical time was 12:26 for the TC306 group and 9:27 for the ISSMGE group. When taking into account only the more conscientious attempts, and excluding data for five respondents that suggest they took a break while working on the questionnaire (e.g. time spent from 51 to 98 minutes), the mean time spent was about 12.5 minutes for the TC306 group (min: ~3′, max: ~23′) and 11 minutes (min: ~4′, max: ~30′) for the ISSMGE group.

3. Results

When comparing the answers from the two groups, three sizeable differences stand out. As expected, instructional experience (Question 14) is significantly higher for the TC306 group compared to the ISSMGE group: the percentages of the Instructors-Professors with experience more than 15 years are 67% and 35%, respectively. The percentages for the various cohorts defined on the basis of experience is shown in Figure 1. The second sizeable difference is that a higher percentage of the TC306 respondents answer to Question 1 that they have developed shareable educational material (55%) compared to the ISSMGE respondents (33%) (Figure 2). The third sizeable difference is the lower percentage of the respondents from the TC306 group searching for additional educational material (Question 5), 76% vs 92% (Figure 3). It is probable that the last two differences are complementary. In the remainder of this section, the presentation of the answers is arranged in terms of the intention of the questions. When the percentages from the two groups did not differ significantly, the answers from the two groups were merged.



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173 Figure 1. Instructional experience of respondents (Question 14).

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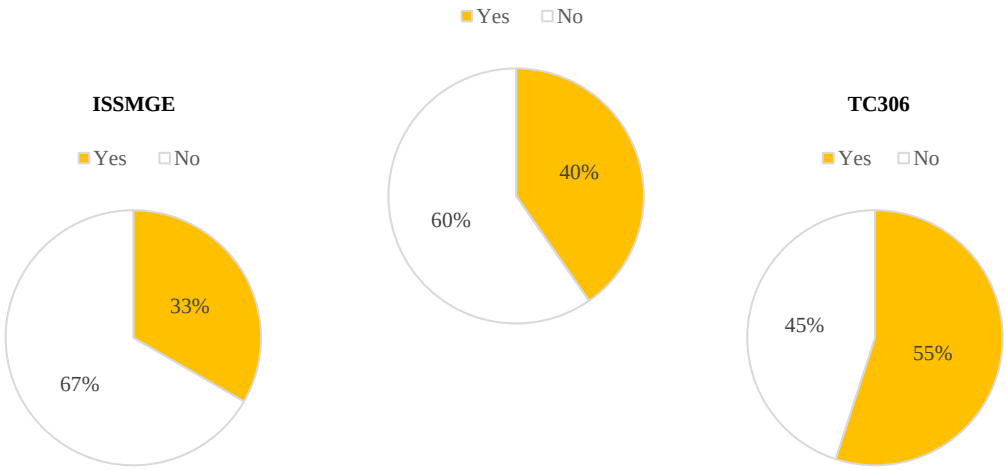

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176 Figure 2. Answers to Question 1 “Have you ever developed shareable educational material yourself?”

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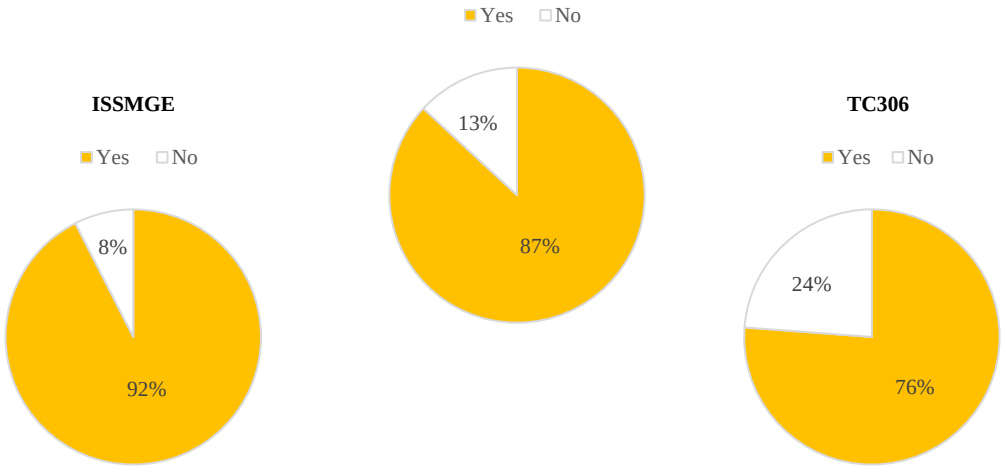
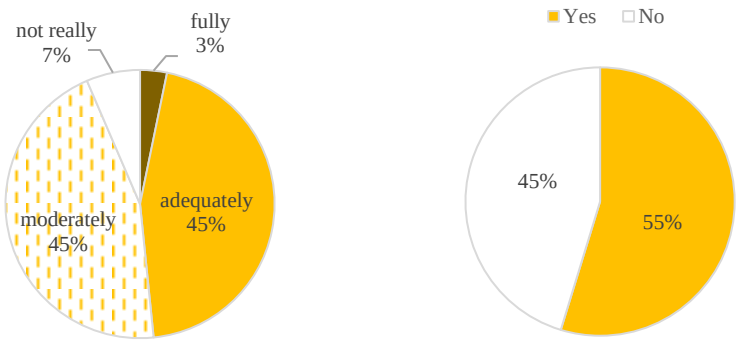


Figure 3. Answers to Question 5 “Have you ever searched for educational material to augment what you have/use?”

3.1. Testing the abundance hypothesis for education materials

The answers to Questions 3 and 8 reveal that a large percentage of instructors would like to have better teaching materials. As shown in Figure 4a, the majority of the instructors (52%) are not adequately satisfied with the material they use (55% of the TC306 group and 50% of the ISSMGE group). Similarly, as shown in Figure 4b, a little less than half (45%) are not satisfied with material found after searching (56% of the TC306 group and 40.5% of the ISSMGE group). Similar percentages are found when the larger groups, i.e. all submitted answers, are taken into account: 54.5% of the TC306 group and 54% of the ISSMGE group are not adequately satisfied with the material they use, while 53% of the TC306 group and 46% of the ISSMGE group are not satisfied with the material they have found after searching. In other words, the decision to exclude the less conscientious responses did not alter the gist of the findings: the abundance assumption mentioned in the introduction does not represent the majority of geotechnical engineering instructors when the criterion of satisfaction is used as filter.



(a) (b)

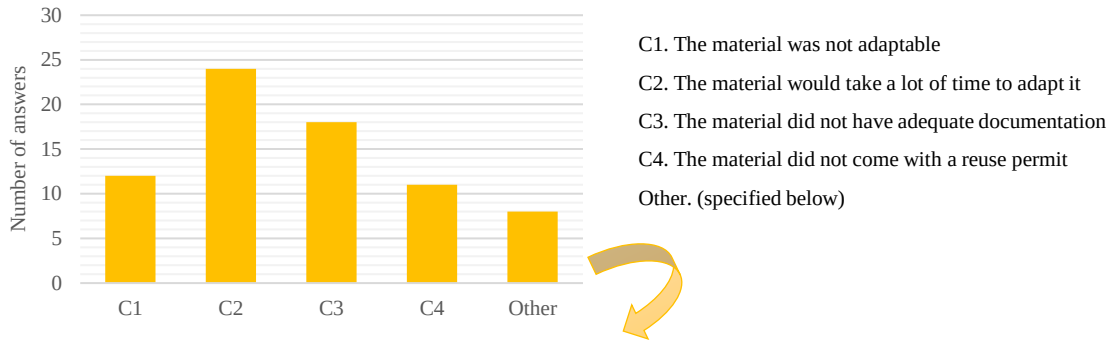
Figure 4. (a) Answers to Question 3 "Are you satisfied with the educational material you currently use in your teaching?" (b) Answers to Question 8 "Were you satisfied with any material found (after searching)?"

3.2. Instructors' searches for educational materials

A large majority of the respondents (87%) answered to Question 5 that they search for material to augment their own (Figure 3). Question 6 asks for topics searched and admitted as answers eight typical subjects in introductory geotechnical engineering courses (e.g. consolidation, foundations), one potentially –depending on interpretation– more advanced topic (soil constitutive modeling, e.g. stress distribution, shear strength) and the option "other". This question ended up being of relatively low value because of the low variety of answers. As shown in Figure S1 in Supplement A (Pantazidou and Calvello, 2023a), no topic stands out, with either a sizeably low percentage (suggesting that instructors do not need to search for it), or high percentage (suggesting a significant need of instructors for additional material to teach it). The highest numbers in a total of 53 answers were for Laboratory Testing (32 answers, 60%), Field Testing and Foundations (31 answers each, 58%). The answers to the "other" option mainly included advanced topics or referred to type of material ("look for exam questions, books and papers") rather than topic. The most popular sources where respondents search (Question 7) are scholarly journal papers (41%) and additional textbooks (38%) (see Figure S2 in Supplement A), while in the "other" category, by far the most popular category is general internet searches for videos.

Question 10 illuminates the reasons why some material found may not be useful for teaching purposes. This question was answered by 39 respondents, from both subsets (either satisfied with some of the material found or not satisfied with any material found). The primary reason for dissatisfaction is when the material found requires a lot of time to adapt it (62%), while 46%

of the respondents further note the lack of adequate documentation (see Figure 5). The other two options for dissatisfaction, "material was not adaptable" and "material did not come with reuse permit" were true for 31% and 28% of the respondents, respectively. There were eight "other" answers (21%), further elaborated as follows: 1) lack of videos (which were deemed to be more suitable for undergraduates) or 2) videos not being appropriate, 3) the preponderance of solutions for idealized problems and the lack of real problems that lack simple solutions or 4) complexity of material unsuitable for undergraduate instruction, 5) broken links no longer available, 6) lack of good textbooks in spoken language, 7) time needed for adaptation mentioned again and 8) testing for demonstration purposes performed non-rigorously, without satisfying standards.



1) lack of videos (which were deemed to be more suitable for undergraduates) or 2) videos not being appropriate, 3) preponderance of solutions for idealized problems and the lack of real problems that lack simple solutions or 4) complexity of material unsuitable for undergraduate instruction, 5) broken links no longer available, 6) lack of good textbooks in spoken language, 7) time needed for adaptation mentioned again and 8) testing for demonstration purposes performed non-rigorously, without satisfying standards.

Figure 5. Answers to Question 10 "If you were not satisfied with some of the material found, in what way was the material inappropriate?"

3.3. Questions with answers intended for the dissemination of educational materials

The questionnaire includes three open-ended questions (Questions 2, 4 and 9) aiming to collect examples of useful educational material for dissemination purposes; each question is addressed to the subset of the respondents who answered affirmatively to a previous question. As already mentioned, a good number of respondents, 11 of the TC306 group (55%) and 14 of the ISSMGE group (33%) replied to Question 1 that they have developed shareable educational material (Figure 2). The authors visited all websites included in the answers in order to review the material and simulate the experience of an instructor searching for educational material. When information provided was incomplete, they made an effort to locate the missing information in order to provide both a description and a full reference. Unfortunately, even with this extra effort, only a small percentage of the answers can be used for the intended purpose of

243 dissemination. Out of the 11 answers to Question 2 provided by the TC306 group, only four
244 were valid, i.e. useable, and out of the 13 answers provided by the ISSMGE group, only one
245 was valid (see Table S2 in Supplement A). For the remaining answers, documentation provided
246 was too general (e.g. reference to a software used), vague (e.g. "journals and papers"),
247 "shareable" was interpreted in a narrow sense (e.g. only for the students at the institution of the
248 respondent) or consisted of brief descriptions without links or links of sites in languages other
249 than English, with content that could not be reviewed. Question 4 asking instructors for fully
250 satisfactory teaching materials they use yielded only one answer from the ISSMGE group,
251 which was unsigned and vague ("too many to list... mainly books, site visits, case studies"), so
252 the respective total number of answers is zero in Table S1. Finally, Question 9 asks for examples
253 of the satisfactory materials respondents found in their searches. Although 29 respondents were
254 satisfied with material found, there were only 24 answers to this complementary open-ended
255 question, most of which were inadequately detailed. As a result, Question 9 yielded only eight
256 valid recommendations (see Table S3 in Supplement A). Table S3 is the only instance in the
257 paper where an answer from an incomplete questionnaire is included, because it was a valuable
258 answer (a textbook recommendation). Again, a good number of the answers were vague,
259 precluding access or review of the materials mentioned. A common characteristic of many
260 answers, valid and invalid alike, was that they focused mostly on sources (e.g. URLs of websites
261 or repositories, names of scientific societies), i.e. they followed the "yellow pages" approach,
262 without giving recommendations for specific examples (e.g. which video from the website was
263 satisfactory, which guidance document from the scientific society was useful).

264 ### 3.4. Dreaming of educational materials for geotechnical engineering

265 A total of 47 responses were received for the open-ended Question No 11, which asked for
266 examples of "dream educational materials". The answers from the TC306 group and the
267 ISSMGE group were merged, because their differences were non-significant. The answers vary
268 in length from 1-2 lines to full paragraphs; gathered together, they extend over five pages (over
269 2500 words). Many of the answers are thoughtful and imaginative. However, lack of adequate
270 detail and specificity also characterized these responses. This was equally true for both groups,
271 despite the fact that TC306 members, who were contacted about the questionnaire via e-mail,
272 were sent as an example the first author's "wish list" with specific examples (see excerpt No 6
273 in Table S4) in order to encourage similarly detailed examples or, at least, choosing from the
274 given wish list (only one respondent chose from the list). Perhaps, and understandably so,

respondents felt that a detailed answer would not qualify as a dream. In the absence of detailed answers, the authors followed a 3-step analysis procedure, which is described next.

As a first step, they read the comments several times in order to develop a sense for recurring ideas. A first coarse categorization distinguished answers on the basis of the purpose of the desired educational material. According to this coarse categorization, instructors mostly need: (a) suitable educational materials (e.g. videos, case histories) to present in their lectures specific topics to students (55%, appears in 26/47 answers) and (b) materials to engage students, especially outside lecture time, such as software, textbooks, notes, videos, games, competitions (43%, appears in 20/47 answers). Fifteen of the answers (32%) mention a variety of specific topics: foundations and constitutive modeling are the two most popular topics, mentioned in 8 answers, followed by retaining walls (4 answers), groundwater flow and slope stability (3 answers each).

In the second step, they devised the detailed coding scheme shown in Table 2, in order to quantify the frequency of the themes appearing in the answers. Fifteen different themes were identified, grouped in the following three categories: i) medium, for ideas addressing the means of instruction; ii) teaching and learning, further subdivided in three subcategories –components of instruction, applications, promoting certain attitudes–; and iii) assessment, for proposals related to the evaluation of the students. Videos are by far the most frequently proposed medium for a wide range of "dream proposals" (it appears in 43% of the answers), coupled with the following characteristics: short (very often mentioned), engaging, animated, selected, well done. Within the teaching and learning category, among the many themes selected by a good number of respondents –e.g. case studies, example problems and laboratory-related educational materials– it is worth pointing out the significant request for materials that address visual and conceptual understanding and the active involvement of students.

In the third step, each author made an independent selection of the subset of answers that either describe an exciting prospect or provide adequate detail for the production of educational material. When these answers were longer than a few lines or contained a list of wishes, the authors excerpted the most inspirational parts and those illustrating the frequent themes in Table 2. These excerpts from 14 selected answers are included in Table S4 of Supplement A (Pantazidou and Calvello, 2023a). Six of the 14 selected answers (43%) make reference to case studies, indicated by the coding procedure to be the most popular "teaching and learning" theme. To underscore the high frequency of the references to case studies, which appear in 15

307 of all answers (32%), the relevant excerpts from these answers are included in Table S5 of
308 Supplement A.

309 Table 2. Coding Scheme for answers to "Dream materials" for geotechnical engineering instruction.

Themes	Frequency (in 47 answers)
Category: MEDIUM	
Written text (e.g. books)	6
Video	20
Online material (e.g. portal, hypertexts, app)	5
Software[1]	3
Photographs	4
Illustrations (figures, graphs)	4
Category: TEACHING AND LEARNING	
Subcategory: Components of instruction	
Basic theory (lecture)	5
Example problems (tutorials)	8
Lab and field testing	9
Subcategory: Applications	
Case histories (good practices, failures)	15
Example projects	2
Subcategory: Promoting certain attitudes	
Visual and conceptual understanding	8
Active involvement	10
Category: ASSESSMENT	
Exam questions	2
Self-assessment	1

[1] The focus of the questionnaire is on introductory – undergraduate courses, hence software is viewed as a medium for understanding, i.e. the emphasis is on its results, not on learning to run the software.

310

311 ## 3.5. Obstacles preventing dreams from materializing

312 When asked about the obstacles that prevent respondents from developing themselves the
313 educational material of their dreams (Question No 12), the distribution of responses from the
314 two groups are nearly identical (see Figure 6a). The major obstacle reported is insufficient time
315 (which indirectly reflects lack of funding) at a frequency of 80% (49/61 answers), followed by
316 insufficient knowledge of IT (46%), insufficient support by assistants or funding (38%), and
317 insufficient recognition for work in education (38%). A small but not negligible percentage
318 (15%) mentions as obstacles insufficient communal content knowledge and/or insufficient
319 personal content knowledge. From these two answers, most interesting is the realization that

the geotechnical community lacks some knowledge necessary for the production of quality education materials, which may point to outstanding research needs. A more detailed picture emerges when only the responses of the more experienced cohorts are taken into account, as shown in Figure 6b. When considering the most experienced respondents (> 15 years), none has selected insufficient communal content knowledge and a very small minority has selected insufficient personal content knowledge and insufficient soil data. However, the second most experienced cohort (5-15 years) appears to be of markedly different opinion with regards to whether communal knowledge is sufficient: this most dynamic cohort of geotechnical engineering instructors is of the opinion that we lack not only the financial and technical means but also content knowledge.

Figure 6. (a) Answers to Question 12 "What might make it difficult for you to develop the 'educational material of your dreams'?" (b) Obstacles for developing the 'dream educational materials' (Question 12) vis a vis instructional experience (Question 14).

3.6. Investigation of trends

Further investigation of trends between cohorts produced some expected results, e.g. that experienced instructors have developed more shareable educational materials, as well as some findings initially deemed unexpected, e.g. respondents with some formal training in education (Question 16) have developed less shareable educational materials (Figure 7). A possible

explanation for this trend could be that respondents with formal training in education have higher standards and are less willing to embark on a very demanding task. Another explanation may be that training in education, as already mentioned, is domain-general and, as a result, gives precedence to method and de-emphasizes content.

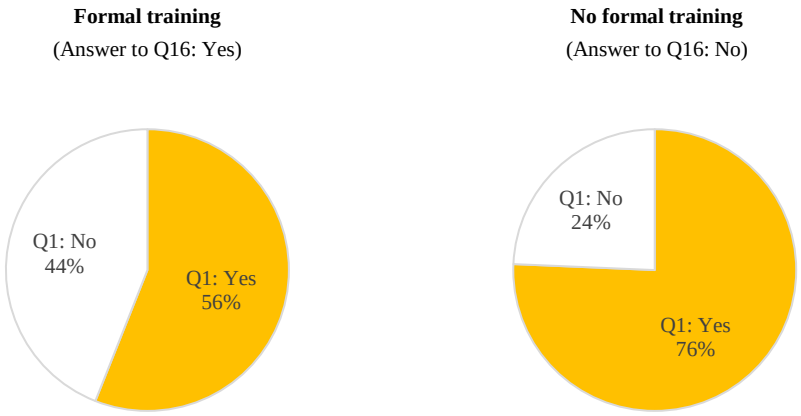


Figure 7. Answers to Question 1 "Have you ever developed shareable educational material yourself?" vis a vis formal training in Education (Question 16).

4. Discussion of results and recommendations

4.1. Lacking adequate educational materials: is Geotechnical Engineering an exception?

The high percentage (45%) of the geotechnical engineering instructors who replied negatively to Question 8 "were you satisfied with any material found after searching" establishes that there is room for improvement. It is probable that this high dissatisfaction percentage is related to Geotechnical Engineering's unique feature to deal with a natural material, which necessitates making connections with true soils (see answers 1, 2, 7 in Table S4, Supplement A) and actual cases (all 15 answers in Table S5, Supplement A). In order to investigate any peculiarity of Geotechnical Engineering, a comparison was made to the answers of the similar question "Did you have difficulties finding sources of educational material for your courses?", from a questionnaire sent to all the engineering instructors at the National Technical University of Athens (NTUA), the home institution of the first author. From the 213 NTUA instructors from all engineering disciplines who responded, only 21 (9.9%) reported having difficulties (NTUA-CTL, 2023). The NTUA respondents were further asked to give the thematic fields for which they had difficulties locating sources. Thematic fields mentioned include both established fields, e.g. metallurgical engineering and databases, and cutting-edge topics, e.g. nanomaterials

and computer vision. Interpretation of the significant difference in the percentages reporting difficulties should take into account two salient differences between the two questions. The NTUA question is phrased negatively (did you have difficulties), restricting the number of respondents who answer the accompanying open-ended question, and it does not further inquire whether material found was satisfactory, in which case the difference between the two sets of percentages would be smaller. It is worth noting that because funding from the Greek Ministry for Education resulted in the creation of Centers for Teaching and Learning (CTLs) at all Greek universities at the same time during the academic year 2022-2023, like NTUA-CTL, CTLs from other Greek universities circulated their own version of "needs assessment" questionnaire. The questionnaires of these other CTLs, which are created by specialists in Education, focus mostly on training needs of respondents in matters of pedagogy and lack a question about needs for educational materials. In contrast, because NTUA is a strictly technical university, its CTL is coordinated by an engineering faculty member and, as a result, the NTUA questionnaire included questions on needs for educational materials. Hence, it is possible that the abundance assumption will never be a topic for investigation at centers for teaching and learning serving the domain-general education needs of tertiary education instructors and, as a result, this unexamined assumption will survive like urban legends do.

4.2. Lacking a culture for sharing meaningfully and reviewing critically educational material

The results presented in Sections 3.2 and 3.3 taken together suggest that the practice of providing inadequate documentation for educational material is widespread, as shown by the often incomplete information provided by respondents for their own educational material (Question 2), and by the high frequency inadequate documentation is given as a reason for dissatisfaction with educational material found (Question 10). It is likely that this is an ingrained habit for educators, hence changing this "no explanations given" culture will require concerted interventions. One such intervention could be to require educational material to be accompanied by brief "teaching notes" including the purpose/reason for creating it.

Educators also appear to be uncomfortable with judging existing materials and selecting the most useful: only in a few instances complete references are given to specific materials (i.e. not the entire list of publications of a scientific society). This paper, as a mild intervention to change this "no choice" culture, reports some usable open-ended answers to Questions 2 and 9 (Tables

S2, S3 in Supplement A), when possible with complete references and a particularly interesting specific example (see No 1 in Table S2 and No 3 in Table S3, Supplement A).

Shulman (1993) wrote in his inspirational article "Putting an end to pedagogical solitude" about the drawbacks of the private nature of teaching, and urged instructors to adopt instead the public culture of research, i.e. publicize their educational material and take the responsibility of judging the educational material of their colleagues. The creation of opportunities for instructors to offer small-size contributions to the geotechnical engineering education community (ISSMGE – TC306, 2023) may be a step towards the change of teaching from private to public endeavor. Small-scale contributions can be more easily reviewed and circumvent the obstacles mentioned in the answers to Question 12 (lack of time/funding/support, lack of recognition).

The sizeable difference in searching for educational materials between the TC306 and the ISSMGE groups might be (partly) attributed to the higher instructional experience of the TC306 respondents. It is unfortunate that those who can better judge educational materials are less likely to search for them. Hence, it would be desirable to establish some communication lines between more junior and more senior colleagues, for instance with the juniors searching and submitting carefully selected materials to the seniors for reviewing.

The results of the detailed investigation of the reasons why some materials are unsatisfactory (Question 10) underscores the difference between merely uploading raw educational material and truly sharing educational material, i.e. facilitating review and use by others, through appropriate accompanying documentation (an "education manual" so to speak). It is recommended that educators move away from considering "uploaded" and "shareable" to be almost synonymous and towards providing mini manuals of use explaining their thinking to their colleagues. In terms of infrastructure, it is recommended to create a repository for case studies developed specifically for geotechnical engineering instructors, consolidating in one place prior TC306 efforts (Belokas et al., 2013; Orr and Pantazidou, 2013; Pantazidou, 2016; Viggiani, 2018).

5. Conclusions

• The majority of geotechnical engineering educators do not have available the educational materials they would desire. This finding contradicts the –largely unexamined– popular belief that there is no scarcity of quality educational material at the university level.

• Not surprisingly, the responses of geotechnical engineering educators indicate that quality educational materials require team efforts, IT support and funding. Confirming the need for quality educational material for geotechnical engineering instruction will improve the odds for securing funding for its development.

• Less expected and worthy of further investigation is the finding suggested by more than 10% of the responses that additional research may be necessary for improving the quality of educational materials used in geotechnical engineering instruction.

• Recommendations for the enrichment of educational materials used in geotechnical instruction include (i) developing a varied infrastructure for publicizing and reviewing educational material, such as a repository for references and brief descriptions of case studies developed specifically for instruction, (ii) promoting infrastructure permitting small-scale contributions and (iii) developing educational material for specific topics with the desired attributes identified in the literature, i.e. educational to educators and students alike, and herein, i.e. interactive and aiding visual and conceptual understanding.

• While no one topic stood out clearly above all others, educational material for foundation topics and in particular bearing capacity and stress distribution underneath loaded areas will be useful to a good percentage of geotechnical engineering instructors.

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Declaration of interest

The authors have no conflicts of interest to declare. All co-authors have observed and affirmed the contents of the paper and there is no financial interest to report.

Authors' contributions

Marina Pantazidou: Conceptualization, Questionnaire – original draft, Initial data analysis, Writing – original draft. Michele Calvello: Questionnaire – review & editing, Final data analysis, Writing – review & editing.

Data availability

The datasets generated and analyzed in the course of the current study are available in online Supplement B (Pantazidou and Calvello, 2023b) as an EXCEL file.

References

Ball, D.L., & Cohen, D.K. (1996). Reform by the book: What is –or might be– the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, 25(9), 6-8,14.

Belokas, G., Dounias, G., Pantazidou, M., & Tsatsanifos, C. (2013). The initiative of the Hellenic Society for Soil Mechanics and Geotechnical Engineering to support the development of case studies suitable for instruction & a slope stability example, Paper No 1.12b, *Proc. 7th Int. Conf. on Case Histories in Geotechnical Engineering*, Chicago, IL, May 1-4.

Davis, E., Janssen, F., & Van Driel, J. (2016). Teachers and science curriculum materials: where we are and where we need to go. *Studies in Science Education*, 52(2), 127-160.

ISSMGE – TC306 (2023). News item on the 9th International Congress for Environmental Geotechnics, Special session on education and open call for sharing educational material, https://www.issmge.org/news/teaching-material-samples-for-environmental-geotechnics-the-collection-is-growing (accessed September 20, 2023).

National Technical University of Athens, Center for Teaching and Learning, (NTUA-CTL) (2023). Needs assessment questionnaire addressed to NTUA instructors (in Greek).

Orr, T.L.L., & Pantazidou, M. (2013). Case studies used in instruction to achieve specific learning outcomes: The case of the embankments constructed for the approach to Limerick Tunnel, Ireland, Paper No 1.15b, *Proc. 7th Int. Conf. on Case Histories in Geotechnical Engineering*, Chicago, IL, May 1-4.

Pantazidou, M. (2016). Special Issue Case Studies Developed for Instruction, Editorial. *Int. Journal of Geoengineering Case Histories*, 3(4), 203-204. doi: 10.4417/IJGCH-03-04-00.

Pantazidou, M. and Calvello, M. (2023a). Online Supplement A containing additional analysis of survey data. https://www.mygeoworld.com/file/139943/sr-pantazidoucalvello-annex (accessed September 20, 2023).

Pantazidou, M. and Calvello, M. (2023b). Online Supplement B containing the full dataset from the survey. https://www.mygeoworld.com/file/139942/sr-pantazidoucalvello-survey (accessed September 20, 2023).

Shulman, L.S. (1993). Putting an End to Pedagogical Solitude. *Change*, 25(6), 6-7.

Skoumios, M., & Skoumpourdi, Ch. (2018). Use of educational material for Mathematics and Physics, *Proc. 3rd Hellenic Conference on Educational Material for Mathematics and Physics*, Rhodes Island, Greece, Nov. 9-11, pp. 18-65 (in Greek).

Viggiani, C. (2018). Porto Tolle test embankment – A full scale experiment on the consolidation of a thick clay layer, TC306 case-study webinar, ISSMGE Virtual University.

Zornberg, J.G., Touze, N., & Palmeira, E.M. (2020). "Educate the Educators": An International Initiative on Geosynthetics Education, *Proc. ISSMGE Int. Conf. Geotechnical Engineering Education GEE 2020*, June 23-25, Athens, Greece.