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Editorial overview for the themed issue on Geotechnical Engineering Education

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Editorial

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Abstract

This special issue contains fifteen (15) peer-reviewed papers on geotechnical engineering education (Geo-engineering education). The themed issue includes the fundamental and interdisciplinary areas of geo-engineering: geomechanics (soil mechanics and rock mechanics), engineering geology, geotechnical engineering, and environmental engineering. This editorial presents a brief introduction of each article and highlights its key findings, main points, and conclusions. The papers in this issue cover a wide range of Geo-engineering topics in undergraduate curricula. This themed issue brings together articles from different universities and countries with inequalities in research funding for the current and future mutually beneficial exchange of ideas and experiences in Geo-engineering education. While this issue focuses especially on Geo-engineering education, some approaches or strategies presented here have applications to different topics in education and teaching.

1. Introduction

This themed issue included fifteen (15) peer-reviewed papers on geotechnical engineering education (Geo-engineering education). The issue includes the fundamental and interdisciplinary areas of Geo-engineering: geomechanics (soil mechanics and rock mechanics), engineering geology, geotechnical engineering, and environmental engineering.

Geotechnics are mainly represented by three international societies (i.e, the International Society for Soil Mechanics and Geotechnical Engineering, *ISSMGE*, the International Society for Rock Mechanics, *ISRM*, and the International Association for Engineering Geology and the Environment, *IAEG*), together with several other international societies, associations and groups (e.g, the International Geosynthetics Society, *IGS*). The international and regional associations have provided guidance and promotion for developing geo-engineering education and training at different levels (Pantazidou & Calvello, 2024, and Almeida et al., 2024).

The integration of technology and new tools in engineering education has created value and opportunities for advances in Geo-engineering education over the last decades. Normally, this useful information is dispersed and eventually published throughout journals and conference proceedings, and it is often difficult to identify suitable publication for research or professional purposes in Geo-engineering education. It is important therefore a themed issue dedicated solely to geotechnical engineering education in an open access international journal of geotechnical engineering and geoenvironmental engineering.

The papers in this issue cover the topics of computer-aided teaching-learning, education case studies, laboratory-to-field experiments, development of transferable educational material, and discussions of key concepts relevant to Geo-engineering education at undergraduate level. Some articles explore more than one topic. The wide range of topics and enthusiastic response illustrates that this theme is an important one for Geo-engineering (in its broad sense) and the wider society. A brief introduction of each article and highlights its key findings, main points, and conclusions are provided to hopefully stimulate further research. Together, the 15 articles that appear in this themed issue make contributions that help address solutions and challenges in Geotechnical Engineering Education. It is worthwhile to mention that all the published papers were submitted to revision by experts from the international geotechnical community.

2. The themed issue's articles

The themed issue's articles are grouped into three broadly linked categories as follows:

- development of transferable geo-engineering educational material and computer-aided teaching-learning;
- case studies and laboratory-to-field experiments relevant to geo-engineering education;
- discussion of key concepts in geo-engineering education.

The development of transferable geo-engineering educational materials and computer-aided teaching-learning used to guide learning and teaching processes is not a trivial

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task and requires the academia-industry collaboration to produce high-quality educational material. Thus, the papers grouped herein in the categories namely “case studies and laboratory-to-field experiments relevant to geo-engineering education” and “discussion of key concepts in geo-engineering education” provide resources for “development of transferable geo-engineering educational materials”. Some papers could be fitted into one or more of the three considered categories.

2.1 Development of transferable geo-engineering educational material and computer-aided teaching-learning

The paper by Pantazidou & Calvello (2024) presents a survey project developed to find out the types of educational material (*EM*) geotechnical engineering instructors-Professors would like to have available. The study also collects information on existing *EM*, where do instructors search for them and how satisfied they are with available *EM*. The survey participants include members of the technical committee on Geo-engineering Education (*TC306*) of the *ISSMGE*, and geotechnical engineering educators who follow the *ISSMGE* activities. The results reveal that most of the instructors are not adequately satisfied with the *EM* they use, a significant percentage have searched for additional *EM*, and many of them are not satisfied with *EM* found. The study also notes that the major obstacle in developing *EM* is insufficient time (or indirectly lack of adequate funding) and technology competency.

The paper of Mendonça & De Bona Becker (2024) describes the conception of a didactic video that uses a reduced model to address the issue of slope stability, presenting the main anthropic aspects that may contribute to landslides, as well as their consequences. They also present how the video was used in different spaces of education and the evaluation by an undergraduate class in civil engineering at the Federal University of Rio de Janeiro in Southeastern Brazil. The detailed description of the didactic video and the results make the paper a valuable source for replicating the experiment. Similar instructional small-scale model can be developed for teaching other geotechnical engineering concepts.

Chrusciak et al. (2024) discuss the potential of gamification as a tool for teaching and learning in geotechnical engineering. The paper describes background information for developing and implementing game-based learning in Geo-engineering education, specifically on basic soil characterization. The results suggest that gamification has the potential to make geotechnical engineering education more interactive and engaging. The approach is relatively easy to apply to traditional geotechnical engineering coursework and requires only a modest effort to adopt. Exploring the effectiveness of the game in various contexts and with diverse student populations constitutes a key direction for future research.

Lemos et al. (2024) investigate the incorporation of information and communication technologies on the teaching-learning process of various themes of geotechnical engineering, from laboratory tests data handling and processing to slope stability and rock mass stability numerical analysis. It is illustrated with several practical examples developed by the authors. The activities were conducted in geotechnical disciplines of a civil engineering course in southeast Brazil aiming to promote active learning and improve teaching quality. Based on the results of an applied feedback questionnaire, it was observed that most students were satisfied with the resources used in the classroom, suggesting that the implemented didactic digital tool facilitate learning and comprehension of the practice of geo-engineering, in addition to enabling the investigation of geotechnical engineering problems more efficiently considering the variability of different input parameters based on descriptions from observations.

2.2 Case studies and laboratory-to-field experiments relevant to geo-engineering education

Almeida et al. (2024) describe an international educational initiative of *IGS* to facilitate the exposure of geosynthetics and associated technologies to undergraduate civil engineering students for over a decade. Emphasis is given on the experience of the Brazilian Chapter of *IGS*, which has already conducted programs. The educational outcomes of the programs currently offered are being evaluated and they suggest excellent acceptance of the course by participants and undergraduate students at various universities.

Mascarenha et al. (2024) draw attention to the need of geotechnical interaction with society through extension activities, teaching, and research, in some cases using social networks that are part of the reality of modern engineering practice. The article highlights that the effectiveness of the extension activities requires a broader participation and engagement of professional associations, funding and evaluation agencies, education departments schools, and education, science, technology and innovation government sections.

Ferreira (2024) analyzes methodological experiments from the teaching-learning process carried out in the geotechnical area of the civil engineering program at three universities in Northeast Brazil for more than 40 years. Three integrated experiments are presented and discussed. In the first experiment, collaborations between industry and academia in the Geo-engineering area are discussed. The second experiment integrated students and educators from different areas of the civil engineering program around a multidisciplinary project, while the third brought together undergraduate and graduate (master and doctoral) student research activities into a single Geo-engineering project. The study shows the use of teaching-learning experiences carried out in geotechnical engineering, contributing to the development of technical skills and professional competencies of civil engineers. The interaction between the university, society and government institutions in problem solving also contributed.

Ribeiro et al. (2024a) discuss some points of the evolution of engineering geology based on a structured and comprehensive research of historical facts in engineering schools. The study included the main topics considered in the teaching of engineering geology and challenges and solutions of the teaching experience at undergraduate and graduate levels. Engineering geology teaching has undergone different phases and adaptations to the evolution of knowledge and research procedures. According to the study, it focuses on four large groups of didactic activities for the current decade and, perhaps, for the next one in several countries. The first group refers to access to materials of each topic and the second includes face-to-face activities on the solution of practical problems related to a specific topic. The third group focuses on field and laboratory works, whereas the fourth explores comprehends development and analyses of specific civil work projects, mineral exploration, and environmental problems. The paper demonstrates the wide relevance of engineering geology education across a range of research opportunities and applications.

França et al. (2024) present a case study of implementing an in-class/ex-class activity conducted in the introductory Soil Mechanics course at a public university in North Brazil. Additionally, the study discusses students' perception regarding development of the proposed activity. The activity comprised three phases: selection of Geotechnical Engineering problems on university campus, documentation and analysis of each situation, and presentation of solutions considering technical, environmental, and social aspects. The article reports encouraging results. The community-based approach in dealing with real problems and work in groups appears to be a successful approach for teaching-learning Geo-engineering courses.

MacRobert (2024) presents three geotechnical design projects set by the author, along with three interventions used to scaffold student progress. Projects included the design of an industrial waste facility for dry filtered residue, design of remedial works for a clay river embankment subject to undercutting, and design of a remining method for mine slimes contained behind a sand embankment. Interventions included requiring students to prepare, present and critique presentations based on weekly stage gates, collaboratively brainstorming, and ranking high level implications of a design, and collaboratively brainstorming specific implications of a design. It is observed that care must be taken when implementing such interventions to ensure they remain student driven, or the learning benefits of a capstone design course may be lost.

The paper by Macedo & Oliveira (2024) discusses the application of information and communication technologies to promote learning in soil mechanics courses at undergraduate level. It was presented and discussed an experience in implementing an active learning strategy called "Guided Exercises" in two consecutive soil mechanics courses of the civil engineering undergraduate study programme at the University of Aveiro, Portugal. The results of the study showed that students considered the strategy useful for the understanding of the concepts covered in the courses and those who used the methodology had a better approval ratio.

Ribeiro et al. (2024b) describe a study undertaken to mitigate climate change effects or adapt cities to them during an undergraduate course of Study and Behaviour of Soils in Sustainable City Management. Students are faced with the need to present solutions to solve an urban problem by implementing a green solution. It is called a co-creation academic activity. This project-based learning methodology is seen as an active learning process, and three cases of the academic activities are described in the paper. Students' perceptions, academic results and assiduity are compared to enhance the benefits of the adopted approach in geotechnical education. Preliminary results are presented that illustrate better students' performance.

2.3 Discussions of key concepts in Geo-engineering education

Three papers by research-active geotechnical Professors (Maranha das Neves, 2024, Salgado, 2024, Ledesma, 2024) revisit and discuss key concepts in Geo-engineering education. The papers raise several important insights that are not analyzed in detail in many textbooks, and the authors illustrate the importance and relevance of consider them in a modern Soil Mechanics course.

The paper by Maranha das Neves (2024) addresses the importance of the critical state theory (*CST*) as the foundation of modern soil mechanics teaching. Some ideas concerning where and how soil mechanics has been taught are also introduced and discussed. The fundamentals about plastic design of geotechnical structures are highlighted. The article ends calling attention to the outstanding contribution of the *CST* for a unified understanding of the soil behavior. Its pedagogic benefits are of great worth.

Salgado (2024) focuses on mechanics-based geotechnical engineering applications. The paper reviews some of the major decisions that were made by the engineers and researchers who developed geotechnical engineering to the point at which it was an identifiable separate discipline and the consequences that these decisions have had on the development of the discipline and on its teaching. The paper identifies some key modelling choices that were made that have had an undeservedly disproportionate impact on the teaching and practice of geotechnical engineering. The focus of the paper is therefore on these decisions and choices, and what should be taught in their place today. Challenges that future geotechnical engineers may face, as well tools that will be available to them, are also discussed in the context of what should be taught in undergraduate and graduate courses.

The technical note by Ledesma (2024) presents valuable insights into the difficulties that arise when teaching shear strength of soils, and the limitations of the Mohr-Coulomb strength criterion. The author suggests that in an undergraduate Soil Mechanics course it would seem more convenient to consider a strength envelope and some fitting parameters useful for computations, but without a specific physical meaning. Those difficulties are related to the drained/ undrained behavior of soils, but also to the fact that cohesion is a tricky parameter, with a misleading physical meaning, depending not only on the properties of the contacts between particles, but also on external conditions (i.e., saturation or unsaturation).

3. Closing comments

In general, papers published in this themed issue present comprehensive work on some of the Geo-engineering education solutions and challenges. It is clear from the contributions submitted for this special issue and other recent work that education and training is a wide important theme to Geo-engineering, which until recently had little comprehensive attention.

Many solutions and challenges are currently being investigated and debated and this themed issue is a good overview of the current research topics and teaching-learning innovative methodologies used for shaping and developing students' broad critical thinking skills and providing global context for Geo-engineering problems. Guidance is giving for successful implementation of such initiatives and experiences in different contexts. There remain several outstanding issues, including more case studies of academia and industry collaborations for sharing of ideas, expertise, and best practices in Geo-engineering education.

It is hoped that the papers published in this themed issue are useful to the researchers, academicians and professionals working in Geo-engineering education.

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Declaration of interest

The author has no conflicts of interest to declare.

Data availability

No dataset was generated or evaluated in the course of the current study; therefore, data sharing is not applicable.

List of symbols and abbreviations

CST	Critical state theory
EM	Educational Material
ISSMGE	International Society for Soil Mechanics and Geotechnical Engineering for Rock Mechanics
ISRM	International Society for Rock Mechanics
IAEG	International Association for Engineering Geology and the Environment
IGS	International Geosynthetics Society
TC 306	Technical committee on Geo-engineering Education of the ISSMGE

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