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New Approaches for Teaching Soil and Rock Mechanics Using Information and Communication Technologies

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Abstract

Soil and rock mechanics are disciplines with a strong conceptual and methodological basis. Initially, when engineering students study these subjects, they have to understand new theoretical phenomena, which are explained through mathematical and/or physical laws (e.g. consolidation process, water flow through a porous media). In addition to the study of these phenomena, students have to learn how to carry out estimations of soil and rock parameters in laboratories according to standard tests. Nowadays, information and communication technologies (ICTs) provide a unique opportunity to improve the learning process of students studying the aforementioned subjects. In this paper, we describe our experience of the incorporation of ICTs into the classical teaching-learning process of soil and rock mechanics and explain in detail how we have successfully developed various initiatives which, in summary, are: (a) implementation of an online social networking and microblogging service (using Twitter) for gradually sending key concepts to students throughout the semester (gradual learning); (b) detailed online virtual laboratory tests for a delocalized development of lab practices (self-learning); (c) integration of different complementary learning resources (e.g. videos, free software, technical regulations, etc.) using an open webpage. The complementary use to the classical teaching-learning process of these ICT resources has been highly satisfactory for students, who have positively evaluated this new approach.

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1. Introduction

Soil and rock mechanics are disciplines whose aim is to describe and characterize the behaviour of soils and

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rocks, respectively. If we take into account that civil works are always built on, in or with soil and/or rock, then the significance of these disciplines in civil engineering studies is evident. Soil and rock mechanics studies usually have a strong conceptual and methodological basis, which has to be understood and assimilated by engineering students for a subsequent application to solve real engineering problems. Our experience shows that undergraduate civil engineering students encounter serious difficulties in understanding this content, mainly due to a lack of key background knowledge of hydraulics and continuum mechanics, two disciplines closely related to soil and rock mechanics. This situation has motivated a greater use of information and communication technologies (ICTs) and to incorporate them into the classical teaching-learning process of soil and rock mechanics subjects in an effective way. The ICTs described in this paper are: (a) implementation of an online social networking and microblogging service (using Twitter) for gradually sending key concepts to the students throughout the semester (gradual learning); (b) online available detailed virtual laboratory tests for a delocalized development of lab practices (self-learning); and (c) integration of different complementary learning resources (e.g. videos, free software, technical regulations, etc.) into an open webpage.

2. Implementation of an online social networking and microblogging service

Nowadays, most students have smartphones or alternative devices (e.g. tablets, laptops, etc.), which are mainly for personal use. Additionally, students are regular users of social networks and media and are very familiar with them. Consequently, we used Twitter as a tool for regularly (daily) submitting short geotechnical ideas (up to 140 characters), called "geotechnical pills", which contain highly conceptual content previously explained during theory sessions (Figure 1). For example, in a tweet, we can briefly explain concepts like "a normally consolidated soil is one which has never been affected by an effective stress higher than the one acting on it at present" or that "the consolidation process finishes when the excess pore pressure is equal to zero". As a result, students gradually receive information related to the subject that can be also complemented with additional content on a webpage, allowing them to progressively assimilate the conceptual contents (Figure 1). The messages can also include news, videos, etc. from the area where they live (e.g. if a slope in their city has failed or if soil improvement is being carried out in a certain place) in order to provide a much more real vision and even to allow them to see and visit themselves the processes or phenomena under study.

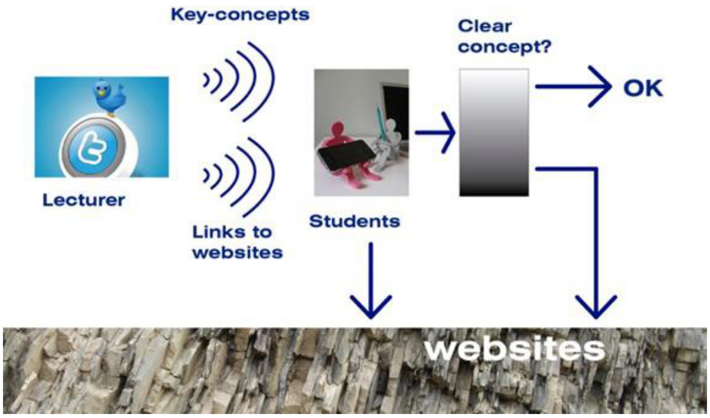

Fig. 1. Use of Twitter as a teaching tool for soil and rock mechanics.

3. Online virtual laboratory tests

Some geotechnical tests (e.g. an oedometer test) can last more than a week and cannot be fully performed during teaching hours. Consequently, we have prepared online laboratory resources (Figure 2), which allow the students to overcome this problem. These resources completely reproduce geotechnical tests (e.g. triaxial tests, oedometric tests, slake durability tests, etc.) following standard procedures, and containing various sections, such as title page, equipment required for the test, normalized testing procedure and calculation of results. There are also animations with conceptual schemes, detailed and general pictures and explanatory texts for a fuller understanding of the procedures, their purpose and their interpretation (Tomás et al., 2013a). These resources are a detailed and flexible way to study different laboratory procedures and allow students to view the complete performance and interpretation of laboratory tests (Tomás et al. 2013b). These resources complement face-to-face theory and laboratory sessions.

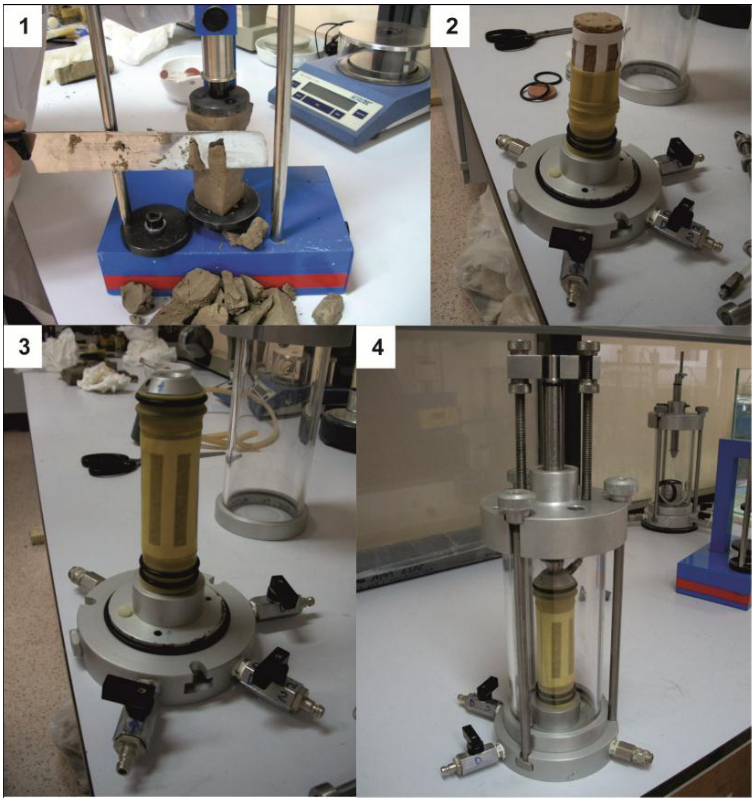

Fig. 2. Screenshots of a geotechnical test (e.g. CD triaxial test) included in the virtual laboratory tests library (Tomás et al., 2013c).

4. Complementary learning resources

In addition, to the previously described resources, other resources have been elaborated, compiled and centralized in an open webpage (http://web.ua.es/en/ginter/). The webpage contains videos (e.g. for explaining geotechnical tests - Hernández and Santamarta, 2012- or geotechnical processes, figure 3), didactic itineraries and field trips, digital technical regulations, didactic experiments for the determination of soil and rock properties and the simulation of geotechnical processes, free software and spreadsheets for solving geotechnical problems (e.g. stress and settlement computations), links of interest, etc. These resources are useful for solving problems, studying and improving understanding of key concepts.

5. Proposed methodology for integrating ICTs into the teaching-learning process

The use of computers, slides and other ICT resources during the teaching and learning process is becoming more widely extended among university lecturers. In this paper, we describe our experience with incorporating ICTs in the classical teaching-learning process of soil and rock mechanics subjects, and explain in detail how we have successfully developed different initiatives. The methodology used is summarized in Figure 4. Classes are given as usual by means of theoretical explanations using slides and blackboard. For the explanation of some phenomena, the teacher can also use videos and animations, which are permanently available on a webpage as complementary material. Additionally, the students can complete the learning process by means of a virtual laboratory, developing the tests in a decentralized way (at any moment and from any place). Note, that the students can also download complementary resources like technical regulations and free software for completing the class notes and to practise problem solving.

Fig. 3. Partial sequence of a video illustrating the geotechnical phenomenon of topple in rock slopes. Video from the French Geological Survey, 2013. http://www.youtube.com/watch?v=b_zAAPLEWFQ.

The teaching-learning process is also complemented with the use of tweets. These short messages provide continuous information about the more conceptual notions studied in class. Additionally, the aim of tweets is to motivate students by highlighting the social repercussions of topics related to geotechnics, such as geotechnical hazards. This is a useful and effective way to motivate and make students aware of the importance of soil and rock mechanics. Finally, we have incorporated a virtual geotechnical laboratory for reproducing soil and rock mechanics tests following standard procedures. These resources allow the student to carry out lab practices from anywhere and at anytime. Note that these practices are only a complement to the lab practices that the students perform in a laboratory that allows them to reproduce and complete the tests and even to learn how to obtain and compute different geotechnical parameters. Summarizing, in this work, we have described the methodology we have implemented into soil and rock mechanics subjects, consisting of a combined use of different ICTs (i.e. Twitter, virtual lab practices and other complementary learning resources) to support classical classes. The acceptance of the use of these ICT resources by the students has been shown to be very high (measured in terms of access statistic to the webpages and followers in Twitter). Furthermore, the general satisfaction of the lecturers has also been very high, who have noted a more effective assimilation of complex concepts and lab procedures.

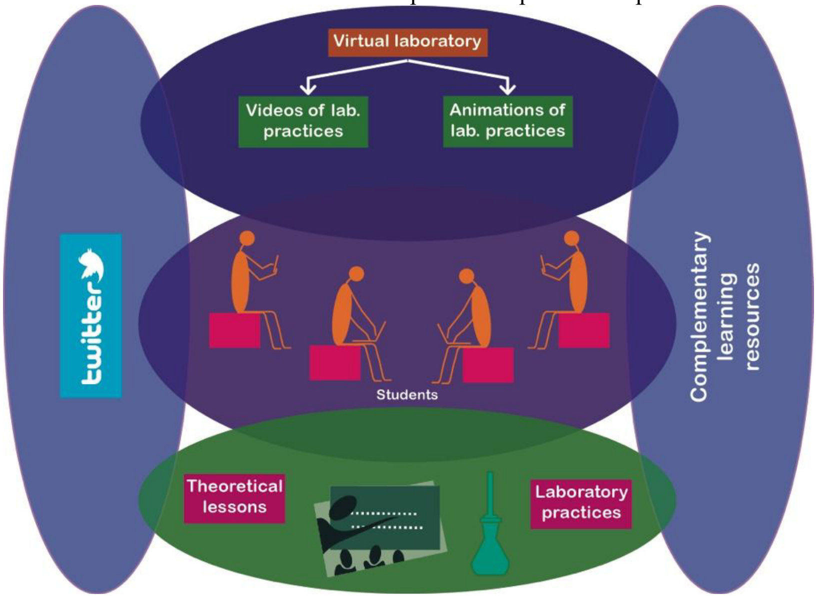

Fig. 4.Proposed methodology for the integration of information and communication technologies in soil and rock mechanics classes.

6. Conclusions

A methodology based on the integration of ICTs such as Twitter, virtual lab practices and other resources into the classical teaching-learning process of soil and rock mechanics has been proposed in this paper. The application of these different resources has been positively valued by students improving their assimilation of complex concepts. In the future, it would be useful to expand this methodology to other geotechnical subjects from advanced courses (master) such slope stability, geotechnical forensic analysis and geotechnical instrumentation and monitoring in which conceptual concepts are also very significant. Complementarily, we would like to create new smartphone applications in the future to be incorporated to the proposed methodological teaching-learning process.

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