Launching Geotechnical Education into the 21st Century

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ABSTRACT: This paper was inspired by the findings of GEOTEaCH; a forum set up by the authors to chart the future of geotechnical education in Ireland. The inaugural GEOTEaCH colloquium at the University of Limerick in October 2006 hosted geotechnical educators from Ireland and the UK. These events are intended to set the agenda for advancing geotechnical education in Ireland. This paper explores the educational challenges in a digital age and presents suggestions for engaging students in the learning process.

1 INTRODUCTION

The time demand placed on full time undergraduate students is fast approaching that of the professional practitioner. There are numerous activities competing for their personal time; most students' are in part-time employment and all have a multitude of social interests to satisfy. There is little doubt that a major sea change is taking place in Ireland's 21st century education which can be linked to our increased prosperity and thriving economy. Full-time students now seek greater access and flexibility in the way they receive and advance their education.

There is also an emerging consensus that the modern engineer must hold skills over and above those provided by the current four-year Bachelors degree. A recent report by the American Society of Civil Engineers (ASCE 2007) sets forth the vision of civil engineering in 2025; it points to engineers of the future as innovators and industry leaders, having excellent communication skills and project management prowess. Similar sentiments are contained in Galloway (2008). These aspirations represent a radical change from the traditional analytical focus of the Bachelors degree in engineering and necessitate a serious re-think of engineering education. A five-year Masters of engineering programme is soon to be introduced in Ireland as the minimum educational standard for chartered status; this presents an opportunity to provide these additional skills to engineers of the future.

This paper demonstrates how students taking instruction in geotechnics can develop some of these skills without adversely impacting on the scientific rigour demanded by the subject area.

2. DESIGNING COURSE CONTENT

The discussion presented in this paper is centred on the geotechnics courses offered to students of construction management and civil engineering at the University of Limerick (UL) and the National University of Ireland Galway (NUIG) respectively. The model used in the design of the modules is based on the flow chart shown in Figure 1. Initially, the global course goals are established; these are very often dictated by departmental policies, professional bodies, new technology or industry demands. Once these have been established, the students' skills in relation to the module content must be considered, i.e. whether they have the necessary background knowledge to enable them to succeed in the module. An instructional analysis is then performed which outlines the key and subordinate concepts that will be covered in the module (see Figure 2).

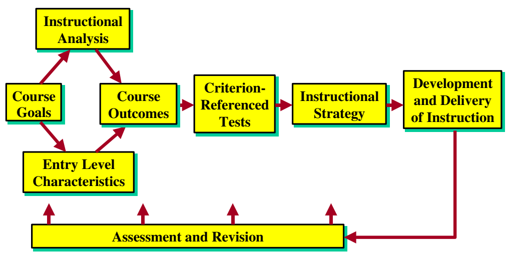

Figure 1: Systematic design of course instruction (Ressler, 2006).

At this point the learning outcomes for the module are written; these specifically state what the learners should be able to do based on the instructional analysis and their entry-level characteristics.

The model proposed in this paper incorporates the following strategy for instruction:

- The instructional strategy considers how the material can be best delivered to meet the course goals. This is often guided by an understanding of the learning process and responding to this by effective teaching.
- The delivery includes orientating the student as to why the information is important and how it relates to prior knowledge.
- The learning outcomes for the module are designed to provide the information in a way that stimulates critical thinking about the subject.
- The use of models or props assist in communicating technically challenging concepts which can then be examined by providing opportunities for the students to apply the information in familiar and unfamiliar contexts.
- Assessment should be dynamic and innovative and may include some of the following: quizzes, oral exams, laboratory projects, end of semester exam or group exercises.
- The final phase of the instruction involves assessing the learners' performance. The assessment is only of value if it is followed by prompt feedback so that gaps in knowledge or understanding can be addressed, thereby closing of the learning 'circle.'

3. INNOVATIONS AND COURSE DELIVERY

3.1. *Innovations*

Proficiency in the practice of geotechnical engineering requires experience in the field, so the training of geotechnical engineers must be accompanied by carefully planned field trips and site visits. At UL, an introductory module in geotechnics (Figure 2) incorporates a significant proportion of fieldwork to develop and foster these skills at undergraduate level.

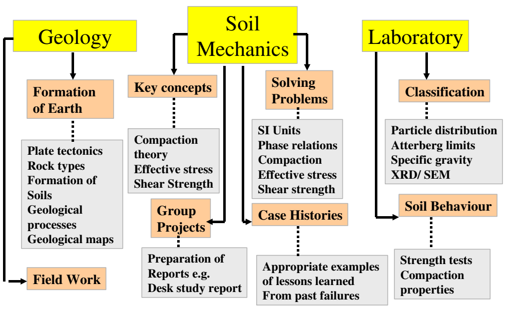

Figure 2: Instructional Analysis for an introductory geotechnics module.

The module includes instruction in the fundamentals of geology as a prelude to the study of soil mechanics. The geology component provides the context from which the origins of soil can be understood and the principles of soil mechanics introduced. Stewart's (2007) series on "Earth: the power of the planet" is used to illustrate the interplay of earth's natural forces such as ice, atmosphere and volcanoes and how they have shaped the ground profiles encountered in engineering practice. Keenan's (1998) documentaries are then used to illustrate the outcome of these forces on the Irish landscape. These documentaries bring geology's role in geotechnical engineering to life in the classroom and serves as the background for a two-day geology field trip that follows.

The trip takes place along Waterford's picturesque Copper Coast in the South East of Ireland. Geologists from the Geological Survey of Ireland guide the students on how to read the landscape and identify features that impact on geotechnical engineering; such as flood planes or Karst features. Back on campus, the students get an opportunity to observe and log the excavation of trial pits (Figure 3). After carefully describing the various soils encountered, bulk samples are taken to the laboratory for classification and use in subsequent tests to assess soil behaviour. Other activities include the *in-situ* construction and compaction testing of an earth embankment.

Figure 3: Students logging trial pits and recovering bulk samples

3.2 *Problem Based Learning (PBL)*

In the lectures, the fundamentals of soil mechanics are presented through PBL and extensive use is made of well-documented case histories. It is the authors' experience that the most effective case histories are those in which the students are familiar with the practice or principle at the heart of the case history. At NUIG, the poor engineering behaviour of estuarine silt is reinforced by presenting a case history in the form of a dispute between a contractor and a consultant. The dispute centres on the interpretation of available Site Investigation (SI) data. The students' find this an engaging experience and requires them to think critically about soft soils.

Phillips (2008) describes a PBL exercise that emphasises the importance of proper field control in soil compaction. The case involves the construction of a 150mm concrete slab-on-grade for a large industrial warehouse floor. Within two years of completion the slab-on-grade exhibited a number of defects including tilting in some of slab bays. Dry density tests performed on 'undisturbed' soil samples retrieved from beneath the slab are given to the students who plot the data on the corresponding moisture-density relationship for the soil. The students' discover that the field dry densities reported by the technician have moisture contents greater than the optimum moisture content and plot above the zero air voids (zav) line (Figure 4).

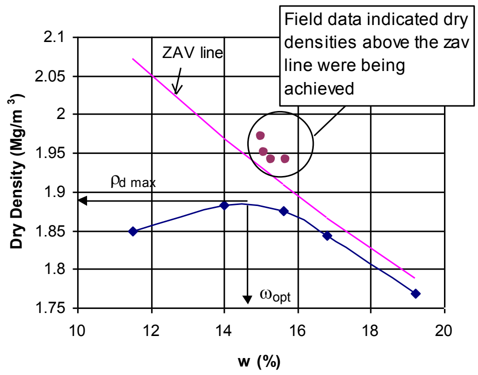

Figure 4. Reported field densities plotted on moisture-dry density graph.

There can be little argument that poorly controlled fill contributed to the tilting of slabs observed in some bays of the defective floor. The students are left to ponder on these outcomes in advance of a lively class debate on the subject of ethics.

3.3 *Course Delivery*

When delivering the technical components of the modules, the lectures are presented using a variety of media. PowerPoint is used for initial exposure to a new topic or a case history – a useful tool for its visual impact and for setting the overall context of a topic. The dominant media however remains the chalkboard, which is self-pacing and flexible. Prepared board notes are used to facilitate the efficient delivery of the key tenets with reference to a core text for further detail on the topics. Frequent use of classroom assessment techniques are used to monitor the effectiveness of the learning and to make adjustments and clarifications necessary in following lectures. Sixty percent of the module marks is assigned to Continuous Assessment (CA) work while Technology Enhanced Learning (TEL) is utilised to distribute course material, issue course announcements, facilitate discussion groups and assist the grading of the CA.

3.4. *Pilot Programme*

It has been the authors' experience that student numbers participating in modules delivered in the traditional lecture format are dwindling despite best efforts to engage students in the learning process. Poor performances in CA and examination results mirror the lack of participation in the lectures. Therefore, in an effort to redress the situation, the approach summarised in this paper for delivering geotechnical education is being piloted at UL. The CA element of the module contains the following tasks:

- Four online quizzes, worth 5% each, are issued after completing key soil mechanics topics;
- A desk study report for a proposed campus development is also undertaken as a team-based exercise and accounts for 15% of the module marks. To assist with these written assessments, students are given a grading rubric that highlights how high marks can be achieved for written work. The rubric is also accompanied by a brief that outlines the essential requirements of the assignment.
- The laboratory work trial pits and construction of an earth embankment, discussed earlier comprises 20% of the module marks.
- The final 5% is devoted to a formal class debate on a technical topic, for example, Peck's (1962) seminal paper "Art and Science in Subsurface Engineering" is used as the basis of a debate on 'risks associated with geotechnical design using proprietary computer software.' A lecturer specialising in technical communications assists in assessing the performance of the participating teams.

These tasks fulfil the technical rigour demanded in a soil mechanics module and improve the students' soft skills in the process.

4. STUDENT PERFORMANCE AND FEEDBACK

The heavily weighted CA component encourages the students to work throughout the module. The formal assessment of the module learning outcomes indicates that students who become actively involved throughout the module perform better in CA and examinations. Students who attend less regularly however, or do not submit CA work found it difficult to make up for lost CA marks in the final exam.

The student feedback to date on these modules is broadly positive, the greatest adjustment for the students is the increased workload associated with courses having a large percentage of CA. They find this change very demanding compared to the traditional module having less CA and a heavily weighted end of semester exam. However, the form of assessment proposed is more akin to working conditions in the real world therefore; students who adjust to this system perform better in the module assessments and improve their work management skills. Moreover, the benefits garnered from TEL are acknowledged and the prompt feedback on the internet quizzes encourages reflective learning. The posting of course notes and course announcements is also popular because of their accessibility through the internet. Some minor difficulties were encountered with the TEL but these were confined to network issues such as limits on file sizes when submitting written assignments and the system logging out students after a period of inactivity.

5. CONCLUDING COMMENTS

The teaching model discussed in this paper evolved from the GEOTEaCH colloquium. The student feedback on the approach piloted at UL has been positive; they find the adjustment to active participation throughout the module both challenging and rewarding. The incorporation of case histories and PBL assessments has proven very popular. There is growing recognition of the benefits to be gained from delivering engineering instruction through active participation of the student throughout their programme.

The instructors can expect to invest significant time setting up such a model, but this can, in part, be offset by the use of TEL which increases efficiency particularly in the delivery and assessment of course material, thus permitting more time to be devoted to the task of teaching. Finally, in addition to gaining the basic principles of soil mechanics and how they are applied in practice, the students also benefit from improved written and verbal communications skills through assessments that mirror the duties and tasks performed by the geotechnical engineer.

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