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Developing a Project Based Learning Assignment for Geotechnical Engineering

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ABSTRACT

The current methods of engineering education are under significant pressure to reform. Increasing complaints from industry regarding graduates being inadequately prepared, high failure rates among most engineering programs, and results from a number of engineering education research studies showing problems with traditional teaching methods; this is forcing a push towards different approaches. In an undergraduate geotechnical engineering course at the University of Southern Queensland (USQ), a project-based learning (PBL) assignment has been developed and used for the past three years. It is for slope stability and bearing capacity problems revolving around a real life building collapse in Shanghai in 2009. During this assignment, students are tasked with determining the cause of collapse using computer software, and presenting it in a technical report. Feedback from students has been positive, and samples of this have been provided. This paper describes the development of this assignment, with both the advantages and the challenges.

KEYWORDS: Geotechnical, Education, Project-based learning, Slope stability, Bearing capacity

INTRODUCTION

Changes in the demographics of universities that have emerged over the past twenty years are forcing a change to teaching methods. The percentage of people going to university is much higher (Biggs and tang, 2011). With the limited time available in a semester, it is important to find better ways to engage students. Changing technology, increasing reliance on computers and software, and expectations of students and industry are different (Quintela and Santana, 2007). Where students used to use textbooks and libraries, they now use the internet. Everyone expects to be able to use a computer, or even a smartphone, and results are expected over a much shorter period.

Geotechnical engineering is complex, and increased reliance is being placed on numerical modelling, both in research and in practice. Uncertainty is a fundamental problem in geotechnical engineering, both with the geometry and material parameters required. Traditional 'chalk and talk' methods have been found lacking by Felder (1988) who found that it is too inflexible, and the amount of students that were responding poorly was increasing as more people were going to university. This is consistent with Prince and Felder (2007) who state that student centric methods, where the staff respond to students, were shown to be more effective as opposed to teacher centric methods where students respond to the teacher.

One of these methods is Project Based Learning (PBL). This is referred to as an integrated approach to teaching, in which students learn the required material in the course of a realistic problem. This is opposed to the traditional deductive method, where students are taught fundamentals and analytical approaches, and then move onto applying them to textbook problems. The critical difference between the two is the motivation and enthusiasm that the student feels towards the content. In the integrated approach, the theory and background is brought in as needed for the problem, and thus the student is able to connect to the material better (Felder, 2012).

When combined with modern technology it may appear a very modern approach. However, the concept that people learn best through active engagement is quite old, and is often credited to philosophers Socrates and Aristotle. Its relevance to modern universities is often credited to Dewey (2007), who recommended more interactive approaches to engineering teaching. While praise of PBL is fairly widespread, unsuccessful implementation can lead to very high student disapproval if the problem is inappropriate, and/or the required theory and background information isn't easier enough to access. The difficulty of creating a suitable assignment dissuades many staff, particularly in the engineering area where the potential gains are actually very high.

The objective of this paper is to demonstrate the successful development of a PBL assignment into an undergraduate geotechnical engineering course at USQ. There is demand for alternative assessment of geotechnical engineering due to its complexity, and the need to be realistic and relevant for its industry, and also due to poor performance of other assessment methods.

A TRADITIONAL ASSIGNMENT

In a traditional assignment, students may be given a very basic 'textbook' version of a problem, such as that shown in Figure 1. This will require the employment of a procedure and formulae taught in class, by hand or by the use of a standard spreadsheet, or possibly very basic usage of software to solve.

One of the problems here is that geotechnical engineering deals with a high level of uncertainty, where judgment and simplifications frequently need to be made in order to be able to produce a solution. These problems also have no context, and so students can be left wondering what the linkage is to real design and construction. Students can only see the "trees", but not the forest. Besides, students are not able to experience that important part of technical writing experience.

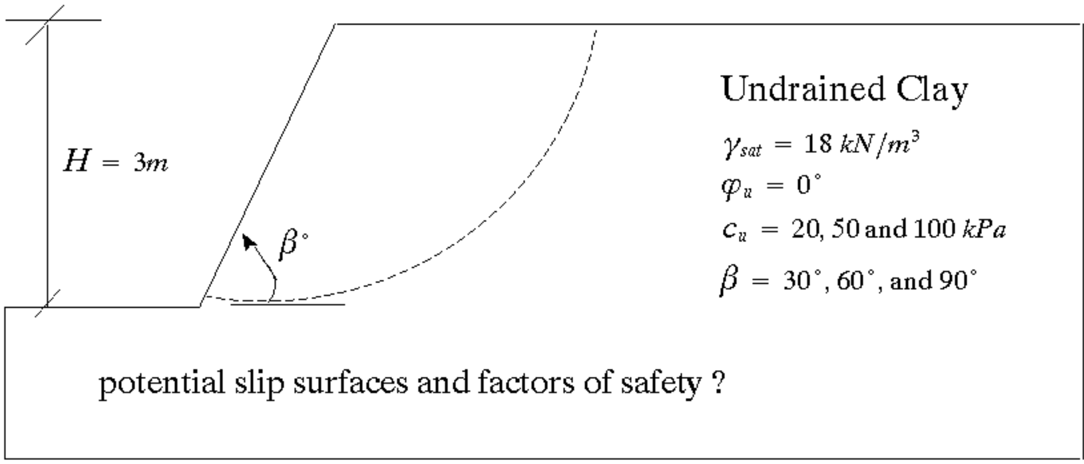

Figure 1: A traditional slope stability assignment

DEVELOPING THE PBL ASSIGNMENT

A novel PBL assignment was developed for CIV3403 Geotechnical Engineering at USQ. The concept behind the development and the required process is as follows:

- Pick a problem which is relevant to the content and difficulty of the course.
- It must have enough information for students to research.
- The software must be available and easy enough to learn to do the problem before the due date.
- There must be enough 'room' in the problem for HD students to achieve better than A students.

The developed one-page assignment given to students is given below:

At around 5:30am on June 27 2009, an unoccupied 13-storey building in the Minhang district of Shanghai city toppled over killing one worker.

Figure 2: Shanghai building collapse (Wall Street Journal, Asia, 2009)

It was reported in the Wall Street Journal that: "According to the Shanghai Daily, initial investigations attributed the accident to the excavations for the construction of a garage under the collapsed building. Large quantities of earth were removed and dumped in a landfill next to a nearby creek; the weight of the earth caused the river bank to collapse, which, in turn, allowed water to seep into the ground, creating a muddy foundation for the building that toppled."

A team of experts and government officials examined the cause of collapse and prepared a report that was made available from CIV3403 Study Desk. It was noted that a theoretical analysis was not included in the report.

The assigned task was to conduct slope stability analyses using computer software Slope/W or/and FLAC/Slope and prepare a technical report to support the final outcome of investigation.

SOLUTION PROCEDURE & EXPECTED OUTCOMES

Students were provided with a comprehensive rubric which was to be used to mark the assignments, this has been provided in Table A1. This matrix identified the main headings, such as presentation, research and theory, and assignment requirements, and set out under 15 subheadings, the levels of return which would justify a grade of HD, A, B, C or F. This clearly told the students the levels of effort staff were expecting. A complete marking rubric can be found in the appendix of this paper.

Other than this very little information about the problem was given, and thus the first step was for the students to redefine the problem in terms which made it solvable within the limitations of their knowledge and the available software. An example of this is shown in Figure 3.

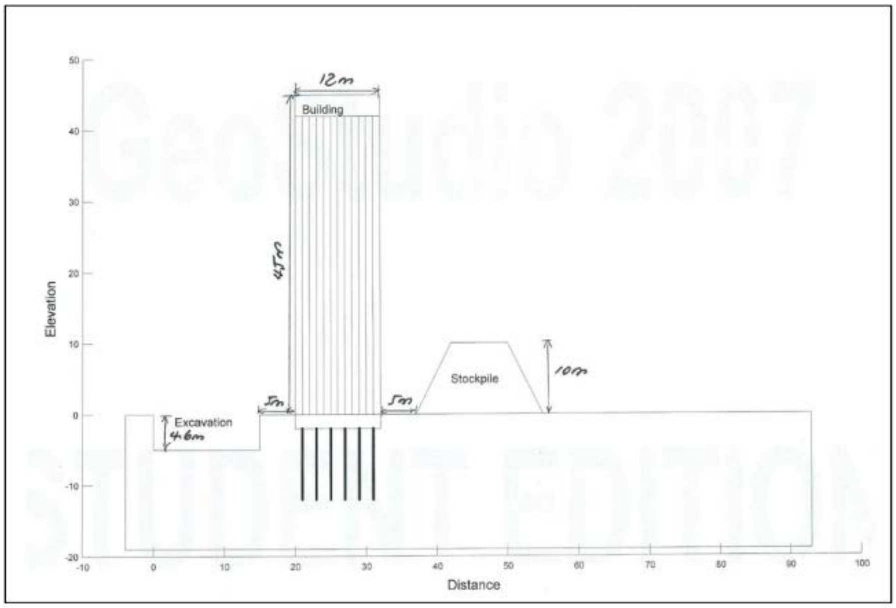

Figure 3: Diagram showing a typical example after redefining the problem

This required a substantial amount of research on the geometry and properties of the building site, soil properties, and groundwater conditions. Many aspects of these required assumptions and simplifications to be made, and thus there was no absolute correct answer.

As demonstrated in the marking rubric in the Appendix, marks were awarded for:

- the quality of the problem definition and its justification;
- the approach with which they were trying to solve the problem;
- the quality of the computer modeling; and
- the quality and organization of the technical report.

DISCUSSION OF SUBMITTED WORK

As might be expected, a wide range of quality of assignments was submitted, with more than 150 scripts in each of three years. As well as the report from the Shanghai Daily, a number of other newspaper reports are available on the internet, and a common thread among many was sensational reporting for maximum news benefit, with a frequent lack of technical justification. It was necessary for the students to be able to sift through these, and extract the useful factual data without being biased by the unsupported conclusions.

Since first setting the assignment, some authoritative technical publications have appeared on the same subject, so it was also necessary for students to assimilate these, but not to plagiarize the results and conclusions, often from more advanced software than they had available.

Responses ranged from about 12 to over 100 pages, with one or two each year failing to submit a reasonable effort, but the vast majority having a fair go. The PBL approach also highlighted some fundamental misunderstandings amongst the students, and one of the most common arose from the confusion surrounding undrained shear strength, "undrained cohesion", and apparent cohesion. Loose terminology and use of symbols in published papers was a major contributor, which would not affect those well versed in geotechnical engineering, but is a trap which easily ensnares those still engaged in the learning process.

Another similar problem frequently arose because of the special use which we, as geotechnical engineers, have given to words which occur in everyday use. This is particularly true of drained behavior, and saturated soils. Students may not actually read all the text book material assigned to them, find it hard to understand how a soil can be simultaneously saturated and drained. Aspects such as this made marking quite difficult, because it is so fundamental to the subsequent analysis that failure to grasp these concepts makes most of any subsequent analysis meaningless.

Since there are no "exact answers", it is necessary for markers to read every script, which takes considerable time and effort. With over 150 assignments to mark in a short period, it has also been essential to share the workload. Means need to be found to ensure that a consistent scheme is being applied. The scheme which we have used has been based on a spreadsheet, in which the marks assigned by the Course Moderator to each of the main headings, are split according to an agreed weighting between each of the sub-headings. Each aspect is then judged against the detailed criteria set for each sub-heading, and a numerical score determined. Adding these resulted in a grade achieved for each main heading, and subsequently a grade achieved for the assignment. It was found that, when a number of assignments were allocated to each marker, such as 40, there was excellent agreement between markers in the range and distribution of grades awarded. This gave confidence that consistent standards were being set and achieved.

STUDENT RESPONSE

USQ has a feedback procedure whereby students are able to provide feedback online. Questions that are asked include commenting on effective and ineffective aspects of the course, as well as general suggestions for the course.

Positive Responses

I am working in a very active geotechnical environment, and the comments are very positive from my professional geotechnical colleague : seniors, juniors and a PhD.

The assignment was great, which helped me with understanding the course material better, and problems were realistic. It's great experience to make the connection between theories and the real life scenario, which gave me a taste of my future career.

For a subject that I thought I would just 'do' and try and pass to get it out of the way, I ended up really enjoying this subject. And I have also found myself wanting to understand these areas more and wanting to investigate the areas in my own time. I now have an interest in it!

Over all I think this course was fantastic. I actually remember the contents of the assignments and I actually understood them! I think back to so many other courses and I don't remember hardly anything to do with the assignments!

Negative Responses

Trying to learn the geotechnical packages was a little hard, need a session dedicated to introducing the software.

Assignment 2 needs a bit more direction. It had good intentions, and while I know it was meant to test student's ability for analysis and problem solving, I was always a little confused.

CONCLUSION

A PBL assignment has been developed for an undergraduate geotechnical engineering course. This assignment follows an integrated approach where students are given a realistic problem and learn the required topics of a standard geotechnical course in the process of solving it. Students learn geotechnical fundamentals and concepts, the process of problem definition, technical writing, and are introduced to the commercially used software packages.

The challenges in setting up this type of assignment are considerable: finding a suitable problem that fulfils the required conditions isn't easy, initial student disapproval can be dissuading, and marking can be more time-consuming. Despite this, it is recommended for geotechnical teaching as it is more suitable and relevant than traditional classroom teaching. Student feedback and response from the course has been very positive. It is more engaging for the student, and more satisfying for the staff.

REFERENCES

1. Biggs, J., & Tang, C. (2011). Teaching for quality learning at university: What the student does. McGraw-Hill Education (UK).
2. Quintela, A., & Santana, T. (2007). *Teaching geotechnical works using professional practice*. Paper presented at the Proceedings, International Conference on Engineering Education (ICEE), Coimbra, Portugal.
3. Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering education*, *78*(7), 674-681.
4. Prince, M., & Felder, R. (2007). The many faces of inductive teaching and learning. *Journal of College Science Teaching*, *36*(5), 14.
5. Felder, R. M. (2012). Engineering Education: a Tale of two paradigms. Shaking the Foundations of Geoengineering Education, Bryan McCabe (Editor), Marina Pantazidou (Editor), Declan Phillips (Editor), 9-14.
6. Dewey, J. (2007). "Experience and Education". Simon and Schuster.
7. Wall Street Journal, Asia. http://www.wsj.com/asia

APPENDIX

Table A1: Marking rubric given to students

	Component (% of marks allocated)	F 0-49%	C 50-64%	B 65-74%	A 75-84%	HD 85-100%
Presentation (10%)	*Marking requisites*	No	Yes			
	Overall presentation	No effort	Poor	Adequate	Good	Excellent
	Language skills	Unacceptable	Basic – many mistakes	Adequate – some mistakes	Good – few mistakes	High level – very few mistakes
Research (10%)	*Evidence of research*	None	Some – not beyond the set text	Adequate – attempt has been made	Good – decent research	Excellent – extensive research
	Quality of resources	None or unacceptable	Basic	Adequate	Good	High level
	Knowledge of study materials	None	Limited	Adequate	Considerable	Excellent
	Reference list	None or unacceptable	Basic	Adequate	Good – a range of sources	Excellent – authoritative sources
Technical Matter (80%)	*Executive Summary*	None or unacceptable	Basic – not clear	Adequate – provides enough info.	Good	Excellent – clear, concise, with required info
	Table of Contents	None	Basic		Comprehensive	
	Introduction and background	None or unacceptable	Basic	Adequate information	Good	Excellent – provides all required information
	Problem Definition (discussion, justification, etc.)*	Inadequate - little to no discussion	Basic level of discussion	Adequate – many aspects are covered	Good – most aspects are discussed	Excellent – all required aspects defined and justified
	Discussion of methods (FLAC/slope and Slope/w)	Little or no discussion on topic	Basic discussion on topic	Adequate discussion on topic	Good discussion on topic	High level – extensive research is evident

*Numerical Analysis of the problem**	None, unacceptable, many aspects incorrect	Basic analysis, simplistic approach	Adequate analysis, inconclusive approach	Good analysis, a good approach	Excellent, approach is comprehensive
Supplied computer files	No	Yes			
Conclusions and recommendations	None	Basic	Adequate	Good – has made many conclusions	Excellent – problem has been solved, recommendations given

*High weighting given to these sections