ŌTAUTAHI CHRISTCHURCH AOTEAROA NEW ZEALAND
35TH AUSTRALASIAN ASSOCIATION FOR ENGINEERING EDUCATION ANNUAL CONFERENCE
8-11 DEC 2024
THE ENGINEER AND THE WORLD

Education and Training of Geotechnical Engineers and Engineering Geologists

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ABSTRACT

CONTEXT

Concerns have been raised by senior members of the geotechnical engineering community in both Australia and New Zealand about shortages of suitably trained staff and skill deficiencies in key and evolving areas of practice. A committee set up under the auspices of the Australian Geomechanics Society and the International Society for Soil Mechanics and Geotechnical Engineering has been tasked with investigating the issue and with providing recommendations.

PURPOSE OR GOAL

The overarching goal is to make a series of recommendations to industry and academia to address issues identified. Preliminary discussions have suggested there are four key questions to answer. First, is to identify where the problem lies, second is to identify any gaps in the skills, training and experience of young professionals, third is to consider the attractiveness of geo-professional career paths and how they could be improved, and finally to consider the roles and responsibilities of universities, industry and societies in addressing any deficiencies.

APPROACH OR METHODOLOGY/METHODS

Representatives of different groups: academics, young professionals and senior professionals have conducted ad-hoc surveys of their peers. Discussion sessions have been organised at a major industry conference and at professional society events in most states. Summaries of these surveys and discussions have been published in Australian Geomechanics. This paper will concentrate on the role of universities using published course offerings, student enrolment and focus groups to gauge student opinions.

ACTUAL OR ANTICIPATED OUTCOMES

Preliminary outcomes from the study include: there are insufficient graduate engineers to meet current demand and the pipeline to geo-specialisations is weak; field work and getting one's hands dirty do not appear to be attractive to current students; there is a lack of geotechnical knowledge in the civil engineering profession; young professionals receive a lot of training, but there is insufficient knowledge and training in the fundamentals. University staff and professional societies are responding by putting on more short courses, but these are not sufficient.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Current university core requirements in geotechnical engineering appear to be insufficient. As a major employer of civil engineering and geology graduates the geo-technical industry needs to work more closely with universities to ensure graduates have the necessary knowledge. Clearer guidance on the skills and experience required to progress post-university may also be required. More needs to be done to communicate geotechnical career options.

KEYWORDS

Education and Training, Geo-professionals

Introduction

The fields of geotechnical engineering and Engineering Geology referred to in this paper as Geo-Engineering fields, are facing a significant challenge: a shortage of qualified graduates. This shortage is becoming increasingly pronounced and has caused implications for the industry. Geotechnical engineering involves the analysis, design, and construction of foundations, slopes, retaining structures, and other systems that are made of, or supported by, soil or rock. The specialized nature of this discipline demands a high level of technical expertise and practical skills at post graduate level, which are currently in short supply among recent graduates.

Concerns about the shortage of graduates in engineering are not new. However, it has been suggested (Clarke, 2011) that the problem is not a shortage of graduates but a shortage of engineering graduates who want to be engineers. We hypothesise that increasingly engineering graduates are not wanting to be geotechnical professionals. For geologists the concerns are more pressing with a recent report (Cohen, 2022) revealing a 40 per cent decline in students completing geoscience degrees in Australia over the past eight years, a trend which is also evident globally.

This shortage in geo-engineering graduates is partly due to a decline in the number of students choosing to pursue geotechnical engineering or Engineering Geology as a career. Various factors contribute to this trend, including a lack of awareness about the field's importance and opportunities, and the perception that it is less attractive compared to other engineering disciplines. There are also very few postgraduate programs in Engineering Geology across Australia and New Zealand.

On the other side, the graduates entering the workforce often exhibit some technical or practical skill gaps. While theoretical knowledge is essential, the ability to apply this knowledge to real-world situations is what distinguishes successful geotechnical engineers. Although the skill sets that students learn during their tertiary education have not changed much over the last 30 years (Atkinson, 2012), the expectations from industry and the skills and technologies required to work on industry projects has changed significantly. It is very important that industry and academia collaborate to provide students with real-world exposure.

The consequences of the abovementioned issues are already being felt across the industry. The shortage of skilled geotechnical engineers can lead to delays in project timelines, increased costs, and potential safety risks. As the demand for sustainable and resilient solutions in infrastructure projects grows, it is very important to support the industry demand with appropriately qualified graduates. This is required to ensure that the quality and safety of critical infrastructure projects are not compromised.

A team of academics and industry experts from Australia and New Zealand are working together on a Geo-Education project to set recommendations and find solutions for the current challenges related to education and training of young graduates in Geo-Engineering fields. Their main goal is to encourage academia and industry to work better together, foster stronger partnerships, enhance educational programs and trainings, and promote the field to attract more students. This paper first provides a summary of the activities that the team has conducted and then investigates the perspective of undergraduate students regarding the Geotechnical Engineering field.

Background and objectives

The Heritage Time Capsule is an initiative from the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) for which detailed information can be found at https://htc.issmge.org/. Current content includes contributions from member societies, technical committees, past-presidents and corporate associates.

The contribution from Australia to the Heritage Time Capsule project was the 50th Anniversary book (Australian Geomechanics Society, 2022). It was the opinion of some colleagues that the book did not sufficiently highlight the contribution of academics to the geomechanics profession in Australia. Related conversations about current challenges in education and industry skill deficiencies led to consideration of the topic of geo-education and future needs. The intent was to understand perspectives from different stakeholders and start the process of formulating a plan and actions to improve the situation. The invitation was extended to colleagues in New Zealand, who have been considering common issues and challenges.

Several sessions have been held to investigate the situation and receive feedback from different industry stakeholders regarding how the problem can be overcome. The first session was held during the ANZ2023 conference on geomechanics in Cairns, reported in Australian Geomechanics (2023), with the initial objectives of capturing information on:

- Education and training needs of the next generation of geotechnical professionals.
- How does the industry manage the resource planning and development?
- The young professional's experience in the industry and how it relates to their university education.

The Cairns session explored the thoughts of various stakeholders and the responsibilities across academia and industry, with a view to providing input into a plan to address any education and training needs identified. A summary report was produced and published in both Australian Geomechanics and NZ Geomechanics News.

To get additional input sessions have been held in Melbourne, Perth, Wellington and Sydney. In Australia, the latest session was held in Sydney during an Australian Geomechanics Society monthly meeting where the following questions were asked from panellists (Australian Geomechanics, 2024.):

- Is there a problem?
- What are the gaps in the skills, training and experience of young geo-professionals?
- What can be done to improve the attractiveness of the profession?
- How is the appeal of our profession?
- What role should universities, industry and societies play in addressing these issues?

In general, the feedback the HTC team received through various sessions were similar and a common set of concerns were raised. It was suggested that the skills the students gain and their performance at university have not changed significantly over the last two decades, but there has been a significant change in the expectations from industry and the skills required for modern construction projects. The complexity of the problems has not necessarily changed, however, the required skill sets in industry have. Universities are facing significant decreases in the number of enrolments for geotechnical related courses, particularly in Geology and as a result the numbers of graduates seeking geotechnical engineering field positions are dropping. Industry highly values students who have some understanding and experience of professional work and are interested in developing connections to industry from the very beginning of students' studies. Currently, the high industry demand for student engineers in construction and infrastructure projects has resulted in students finding jobs easily, and some prioritise their work commitments over their studies for financial reasons. As a result, they cannot perform as well in their studies as in the past and are failing to gain the strong knowledge foundation that is one of the main benefits of a university education. Moreover, many students are pursuing combined degrees with minimal geotechnical content (5% in total).

From an industry perspective, and as highlighted in a mining industry report (AusIMM, 2021), there is a shortage in Mining, Geotechnical Engineering and in particular Engineering Geology graduates. Part of this could be due to lack of sufficient postgraduate programs. There are very few Engineering Geology courses across Australia and New Zealand for instance. As a result, Australia and New Zealand have to hire experts from overseas to work on their national projects. Industry

representatives also reported that many young graduates prefer to have office-based work and that site work is less attractive and puts off graduates from pursuing geotechnical careers. Apart from the shortage of graduates, there are also challenges with some skills in recent graduates. Based on the feedback we received from various industry experts who are working with recent graduates, the graduates are generally meeting the industry's expectations for technical skills, leadership, communication, problem solving, adaptability, teamwork and collaboration, but their industry-specific knowledge and practical skills are below expectation. These skill deficiencies include knowledge of soil and rock mechanics, geotechnical site investigation techniques, report writing, and geological mapping and interpretation. It has been suggested that universities and industry need to collaborate more with each other so that any gaps in education and training can be addressed.

The majority of the feedback received has been from senior geo-professionals. To extend this work we have conducted a study to understand the perspective of the young generation and undergraduate students about Geotechnical Engineering and the attractiveness of the profession. This has included a survey to get input from a broad range of students and some individual and small group discussions.

Survey

An anonymous survey was set up using Redcap. The link to the survey and encouragement to participate was placed on the website of a first-year introductory geotechnical course at the University of Sydney and for a second-year subject at Macquarie University. Most responses were obtained when the survey link was provided during an in-person lecture of second year students at the University of Sydney. The survey was developed with simplicity in mind to ensure accessibility and encourage participation from students unfamiliar with geotechnical engineering. No personally identifiable information was collected, and students were informed that their responses would remain anonymous. As the survey did not involve sensitive data or vulnerable populations, it was exempted from ethics approval. The survey questions were:

1. Where did you first hear about geotechnical engineering?
2. How would you rate your understanding of what geotechnical engineering involves?
3. Are you interested in learning more about geotechnical engineering?
4. Do you find the geotechnical engineering sector attractive as a career option?
5. What factors would most influence your decision to pursue a career in geotechnical engineering?
6. What do you perceive as the biggest barriers to entering the geotechnical engineering field?
7. Do you currently have an engineering related job, and if so, is your job related to Geotechnical Engineering?
8. Which area in Civil Engineering do you see yourself working in after graduating from your undergraduate degree?
9. Would your preferred job consist of mainly site or office work?

Results

There have been 100 responses to the survey, with over 80% of respondents being in their second year of study in civil engineering. Despite their interest in civil engineering 73 students reported that they first heard about geotechnical engineering at university. School was also mentioned by 20 and family and friends by 10. Interestingly careers fairs and events were only mentioned by 6 respondents.

Figure 1 shows the students current interest as gauged by the area where they see themselves working in after graduation. As expected from previous surveys, structural engineering is by far the most popular, as iconic structures are a major attractor for students to take civil engineering, as is the very visible nature of the structures that comprise our built environment. Geotechnical careers are being considered by 10% of the students. This number is maybe elevated by the survey being conducted in a soil mechanics lecture. Interestingly student interests are broadly in line with employment opportunities. Various surveys in Australia and globally have suggested that civil engineering graduates employed in different streams are 15% geotechnical, 20% structural, 40% construction and management, with small numbers in other specialisations and a significant number taking non-engineering career paths. What is perhaps most surprising is the low number of students expressing an interest in environmental careers despite society's concerns with sustainability and climate change.

One of the issues raised in the industry has been that recent graduates are only interested in office work and running sophisticated numerical programs. The survey data suggests that students are expecting to move into careers with a mix of site and office work, and only 10% nominated only office work as their preferred option. This contrasts with industry experience. It is suggested that some geotechnical site investigation tools and procedures need a technical uplift to avoid heavy equipment and manual work to address this issue. The survey did not ask about gender, however, the class that was surveyed had a 70:30 male to female ratio. The interest in a mix of site and office work may also reflect the typical experience of junior engineers that students are aware of. About 30% of the respondents had an engineering job, a large proportion considering that this survey occurred midway through their 2nd year of study and when their knowledge of engineering fundamentals is low. Of those with a job 10% were in geotechnical engineering and 43%, presumably construction related, had some involvement with geotechnical engineering.

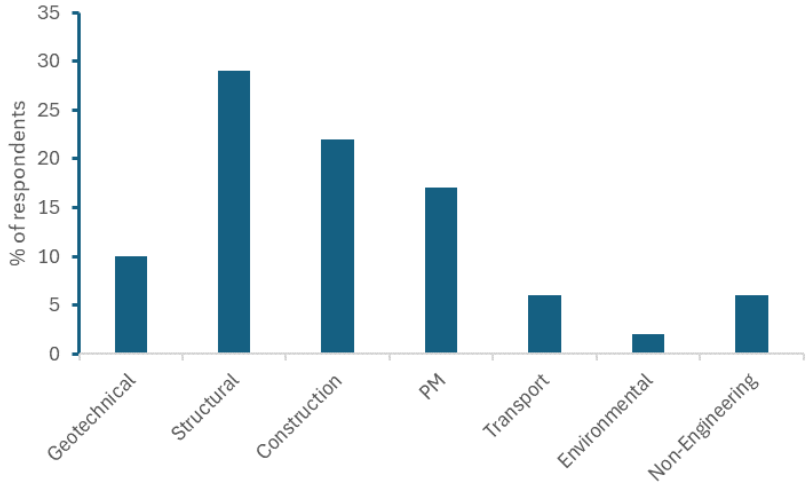

Figure 1: Desired area of work post graduation

The students indicated that their understanding of what is involved in geotechnical engineering is fair. As the survey was given one day after an introductory lecture to geotechnical engineering, this estimation may have been more positive than otherwise. Indeed, discussion with civil engineering students in their first two years of study suggests that they have very little understanding of geotechnical engineering or of the professional career available.

Questions were asked about what factors would help students in choice of career and whether there are any perceived barriers to geotechnical engineering careers. The survey respondents were able to choose multiple factors and 58% chose salary as most important. This was followed by passion, career opportunities, job security, work experience and the least important was

recommendations from lecturers, this received only 13 responses. The potential barriers are shown in Figure 2.

The difficulty question was asked because civil engineering students globally find soil mechanics a challenging subject. A significant number of students see this as a barrier to pursuing geotechnical engineering and could be expected to avoid elective subjects related to geotechnical engineering. It is also clear that the industry does not provide sufficient information, the students are reporting that they do not have sufficient information to make a choice and what a career in geotechnical engineering would look like is a mystery.

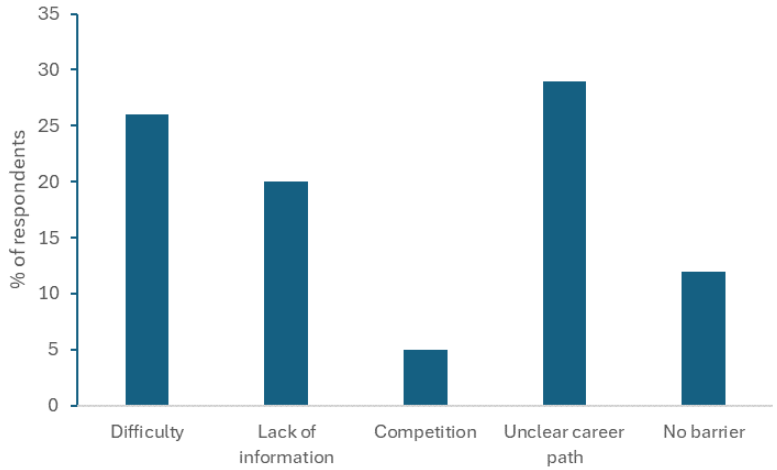

Figure 2: Perceived barriers to pursuing geotechnical careers

Discussion

In addition to the survey data, several small group and individual discussions were conducted to gain a deeper understanding of undergraduate students' perspectives on geotechnical engineering. These discussions revealed that most students had limited exposure to the various disciplines within civil engineering, as well as the associated career opportunities. This highlights a lack of proactive engagement by universities in promoting STEM and geotechnical engineering activities at high school and primary school levels, and a lack of involvement of the geotechnical industry in promoting geotechnical related careers.

In contrast, the perspectives of third- and fourth-year undergraduate students were different. Having obtained a substantial understanding of geotechnical engineering through their coursework, these students had a more comprehensive view of the profession, and many found it to be attractive. Internships provided them with opportunities to experience both office-based and site-based work. Most students expressed a preference for a combination of both environments. However, female students showed a tendency to prefer office-based roles, largely due to the gender imbalance present in site-based engineering environments. This underscores the necessity of encouraging and attracting more women into engineering fields to achieve better gender balance.

Despite their involvement in geotechnical engineering, most interviewees, including those already employed in the field, were not considering pursuing postgraduate degrees in geotechnical engineering or related areas in the near future. This reluctance is primarily driven by the high demand and rewards in the industry from the large number of construction projects underway.

Nevertheless, this trend could lead to future skill shortages among graduates, placing additional pressure on industry firms to invest more heavily in employee training.

Undergraduate students often prioritize achieving high marks over choosing courses that align with specific career paths, highlighting a significant gap in career guidance, especially in specialized fields like geotechnics. Although general and engineering-focused career advising services are available, there is a lack of guidance specifically tailored to geotechnical careers. As a result, students frequently choose easier subjects that offer higher grades over more intellectually challenging core subjects related to geotechnical engineering. However, once they enter the professional world, the importance of these core subjects becomes evident, sometimes prompting them to pursue advanced degrees.

Although geotechnical engineering plays a significant role in civil engineering projects the majority of Australian universities have only 2 core geotechnical courses (6.25%) for a single degree student and 5% for students taking a combined degree. While most universities have geotechnical electives there are a wide range of options available and these would not be taken by many students who ultimately pursue geotechnical careers. There is a need for Masters and other short courses to provide the geotechnical specific skills required by engineers and geologists. The viability of these programs is often questioned by universities and support from industry is critical to their success. It is suggested that a national initiative is required.

Individual discussions were also held with postgraduate students and graduates to gain insight into their perspectives and the challenges they faced. Those who invest in continuing education, such as pursuing Master's or Ph.D. degrees, often gain a deeper understanding of theories and problems in the field. They are typically rewarded with better promotion and salary opportunities. However, it appears that employers prefer to hire graduates with a basic understanding of geotechnics, allowing for on-the-job training at a lower cost. Ph.D. students without local experience also face challenges in the job market due to higher expectations for starting salaries and positions, despite their lack of practical experience. Employers are hesitant to invest heavily in training new hires without experience.

The current educational system needs to better address the disconnect between academic training and industry requirements by encouraging further study that involves a more practical and experience-based approach to geotechnical education. This could include more intensive coursework, practical experiences, and continuing professional development opportunities to ensure that graduates are well-prepared to meet industry demands.

Recommendations

The student surveys indicate that school students receive very little information about the geotechnical field. This lack of awareness continues into university, where all engineering students typically take only two units (6.25%) covering geotechnical engineering. Even in these courses, the nature of geotechnical work and career opportunities are often not discussed. For students pursuing Geology degrees, engineering geology is often only offered as an elective, if at all. This underscores the need for the relevant technical societies and other industry bodies to work individually and collaboratively to produce and disseminate more information on geotechnical careers.

The lack of awareness of geo-professional roles is not new, however it appears that less students are attracted to these professions than in the past. This is particularly the case for geology and engineering geology courses which are seeing a marked decline in student numbers and a reduction in course offerings.

Attracting more students to study engineering and geology would increase the pool of potential geo-professionals and better communication is necessary with the younger generation to explain the skills needed and challenges with modern technologies and multidisciplinary projects. Showcasing remarkable engineering projects from around the world through events and social media is needed to raise awareness of the exciting opportunities in the field, and university outreach programs targeting schools in both urban and remote areas to inform students about the various career opportunities, including in geo-engineering, would be beneficial. Improving the attractiveness of geo-engineering careers is also recommended. Clear advice on career progression, rewards and training should be provided, and not only for geo-professional roles.

Additional support and resources to encourage students to pursue geotechnical careers is recommended. This support could include: encouraging more women to enter the geotechnical engineering profession to address gender imbalance; industry and academia offering scholarships and financial support to students pursuing geotechnical engineering at both undergraduate and postgraduate levels; greater collaboration among industry, academia, and technical societies in promoting the geotechnical profession.

The results from the student survey confirms our anecdotal experience, nevertheless it would be desirable for the survey to be applied at other universities and to explore in more detail how attitudes change over the course of students' studies.

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Acknowledgements

The authors acknowledge the contributions of many people from both Australia and New Zealand who have contributed to the meetings and events organised under the Heritage Time Capsule project investigating challenges in education and training. Without their interest and enthusiasm this work would not have occurred.

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