The paper was published in the proceedings of the online International Conference on Geotechnical Engineering Education 2020 (GEE2020) and was edited by Marina Pantazidou, Michele Calvello and Margarida Pinho Lopes. The conference was streamed from Athens, Greece, 23 – 25 June 2020.

Assessment of Graduate Attributes Development in Two Foundation Engineering Design Courses

Y. Nazhat

Department of Civil Engineering, Faculty of Applied Science, the University of British Columbia, Vancouver, Canada

ynazhat@civil.ubc.ca

ABSTRACT: This paper presents a framework, guidelines and findings with respect to assessing graduate attributes in two foundation engineering design courses at the University of British Columbia (UBC). These are both final year technical elective courses within the Civil Engineering undergraduate program at UBC. Canadian engineering programs are required to instil, assess and report on 12 graduate attributes with respect to their students. Of these attributes, these two courses focus on the problem analysis, engineering design, and professionalism attributes. The framework that is described includes the degree structure, the graduate attributes and component indicators, the assessment process and methodology, the data and results obtained, and the resulting continual improvements with respect to the graduate attribute process, the curriculum and student development. Data collected shows improved levels of accomplished skills by students with respect to the various indicators, and show significant increases in student perceptions of teaching quality, and overall satisfaction with the coursework experience. The framework and guidelines as described are contributing to the continual improvement of UBC's Civil Engineering program, and they should be useful to other engineering programs that are planning, or have commenced with, a graduate attributes assessment process. Assessing the development of graduate attributes in specialized elective design courses plays an important role in relation to quality assurance, continual improvement and reporting, and assure alignment between approved and as-taught curricula of problem-based-learning courses.

Keywords: Foundation engineering, graduate attributes, indicators, assessment, program improvements

1 Introduction

Learning outcomes are key to quality education. The modern engineering profession constantly deals with uncertainties and challenging demands from clients, authorities, and the general public. Today's engineers must cope with continual technological changes as well as organisational challenges in the workplace and within their communities. Additionally, they must cope with the economics of engineering practice in the modern world, as well as the legal consequences of the professional decisions they make. Educators occasionally are confused between learning outcomes and learning objectives as the two terms were used interchangeably in education literature. Fiegel (2013) distinguishes learning outcomes as being statements of what students are expected to be able to demonstrate as a result of learning, as opposed to learning objectives that are statements of teacher intention (or goals) for a specific topic, and how particular learning outcomes are linked to courses' materials. As a result, the approach and emphasis in engineering education and accreditation criteria for engineering programs in recent years have been shifted from objective-based/input-based education (number of classes taken, study time and student workload) to outcome-based concepts (Mills & Treagust, 2003; Chung, 2011), meaning what students have learned and are able to do by the time of graduation and beyond (EA, 2017; ABET, 2019).

Changes in the Canadian accreditation requirements in professional engineering have changed the way UBC evaluates its engineering programs. Assessment of students' Graduate Attribute is used to answer the key question about how are students' performances match specified expectations. It also identifies gaps between perceptions of what institutions teach and the actual knowledge, skills, and views students develop program-wide. The quality of an engineering program now depends not only on the objectives and attributes to be assessed but also on the program's teaching and learning practices and assessment of students, including confirmation that the graduate attributes are accomplished.

The modern accreditation approach based on learning outcomes shifts emphasis away from "what is being taught" to "what is being learned". Engineering programs are now required to demonstrate that their graduates are achieving a set of specific learning outcomes with specific requirements about design education, economics, project management, ethics, and industry relevance of their programs. This shift took place in Canada in 2012 when the Canadian Engineering Accreditation Board (CEAB) introduced the outcome-based assessment for the accreditation of Canadian engineering programs (CEAB, 2012). The CEBA accreditation criterion, which includes twelve graduate attributes, emphasizes continual curriculum improvement by engineering programs to monitor and improve their internal process. According to this criterion, each engineering program in Canada must have a system in place for continuously assessing these attributes and using the assessment results to improve their programs. It is a requirement for accreditation that the curriculum criteria be met by all students. This aspect of the engineering accreditation system assures Engineers Canada that graduates meet the academic requirements for licensure by engineering regulatory and licensing bodies without requiring additional technical examinations.

2 CEAB Accreditation

Graduate attributes describe what students are expected to know and can do when they graduate. For each attribute, there is a set of indicators that represent the knowledge, skills, attitudes, or behavior that students should be able to demonstrate and indicate competency level related to the attribute. They measure the achievement of the attribute. CEAB graduate attributes and indicators are called, student outcomes and learning objectives, respectively. There is an important international aspect to Canada's accreditation system. Accreditation bodies in countries who are signatories to the Washington Accord (IEA, 2014) use an outcomes-based assessment that allows substantial equivalency of graduates from relevant organizations of the signatory countries, including Canada.

The Faculty of Applied Science at UBC seeks to assure that, at the time of graduation, engineering graduates possess the twelve attributes identified by the Canadian Engineering Accreditation Board (CEAB). These relate to:

1. A knowledge base for engineering
2. Problem analysis
3. Investigation
4. Design
5. Use of engineering tools
6. Individual and team work
7. Communication skills
8. Professionalism
9. Impact of engineering on society and the environment
10. Ethics and equity
11. Economics and project management
12. Life-long learning

The CEAB criteria are assessed with respect to the 12 graduate attributes and 8 assessment elements. The 8 assessment elements are as follows:

Graduate Attributes:

1. Organization and engagement
2. Curriculum maps
3. Indicators
4. Assessment tools
5. Assessment results

Continual Improvement:

6. Improvement process
7. Stakeholder engagement
8. Improvement actions

CEAB looks for a linkage between the outcomes assessment process and the official curriculum overseeing through programs' specialised groups.

3 Assessment Process

The development of a system for assessing graduate attributes in the Department of Civil Engineering at UBC started in 2014. The plan is executed by two committees within the Department; the Program Improvement Committee (PIC) and Curriculum Committee (CC). PIC develops the Department's graduate attributes and their continual improvement process (GA/CI) as required by the CEAB and coordinates the implementation of the GA/CI process and intended curriculum improvements with the Curriculum Committee. The flow of the assessment process adopted by UBC is shown in Figure 1.

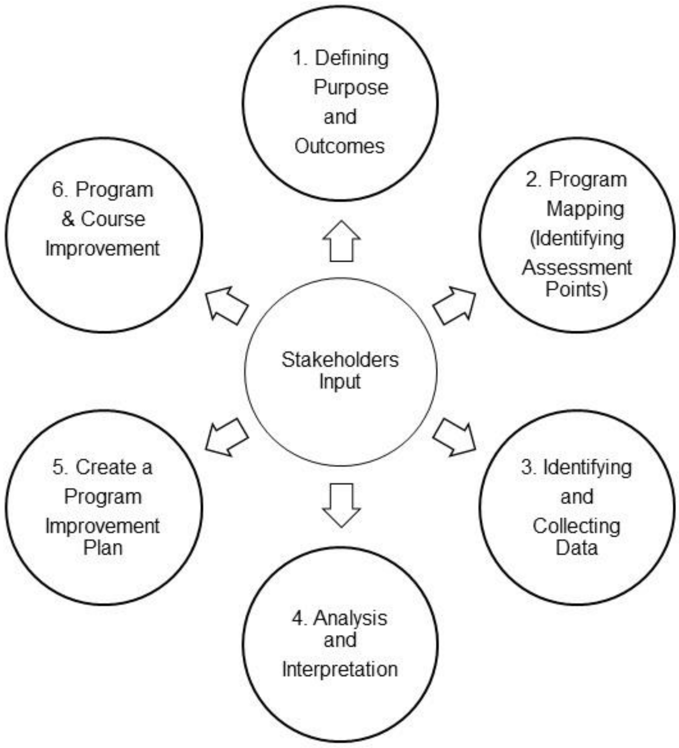

Figure 1. Assessment process adopted by UBC

All activities are performed at the department level. Activities 1 and 6 are conversed with the Faculty of Applied Science to be ultimately sanctioned by the University. Feedback from faculty members, stakeholders, and CEAB are pursued when identifying or revising program objectives and/or plans for program improvements. The department's PIC chair performs the following duties throughout the process of collecting and analysing the data for the accreditation process:

- Develop and monitor the assessment process.
- Meet with stakeholder groups and representatives to provide guidance and answer questions
- Meet with Faculty and University representatives.
- Prepare standard course syllabi and rubrics for the program's courses.
- Meet with the assessment instructors at the start of each term to explain significant assessment aspects.
- Act as a focal point of contact regarding issues that may arise during the assessment process.
- Prepare templates for responding to CEAB questionnaire sections related to the assessment.
- Develop an assessment report for submission to CEAB.

The Department PIC Chair leads the assessment process in collaboration with the program's instructors and the Faculty of Applied Science. The PIC chair acts as a focal point of contact regarding issues that may arise during the assessment process and develops the department's assessment report for submission to CEAB.

4 Assessment Elements

4.1 Graduate Attributes (GA) and Indicators (IN)

The program curriculum map is a matrix with rows that represents the curriculum courses (learning experiences) and columns are the 12 CEAB attributes. Table 1 shows the curriculum map of the foundation design courses analysed in this work. The map indicates to what degree each attribute has been developed (Emphasized, Introduced, Utilized and Not required) in these courses.

Table 1. Curriculum Map of CIVL 410 & CIVL 411 Foundation Engineering Courses

Course	CEAB Graduate Attributes*											
	1	2	3	4	5	6	7	8	9	10	11	12
CIVL 410	E	E	E	E	E	E	E	I	E	E	E	E
CIVL 411	E	E	E	E	N	E	E	U	E	U	I	E

* E: Emphasized (taught and assessed)
I: Introduced (appeared in the course but not assessed)
U: Utilized (required for the course but not taught)
N: Not required by the course

The assessment of each of CIVL 410 and CIVL 411 attributes is conducted by the course instructors. The assessment methods for GA 2 and GA 7 in these courses are listed in Table 2.

4.2 Analyzed Foundation Engineering Courses

CIVL 410 "Foundation Engineering I" and CIVL 411 "Foundation Engineering II" are the two fourth-year technical elective foundation engineering courses in the undergraduate Civil Engineering program at UBC. They are offered during the fall and spring terms respectively.

The objective of CIVL 410 is to give students an opportunity to apply geotechnical engineering concepts by working on design-oriented assignments that are structured to reflect the work in a geotechnical consulting company. Students who go on to specialize in geotechnical engineering will plan, implement and report on such evaluations and will guide design engineers in the use of their recommendations. Students are given field and testing data from geotechnical case histories.

Since geotechnical engineers derive great benefit from the study of case histories as they learn from the experience of others in dealing with similar problems in similar ground conditions, the partner foundation design course, CIVL 411, consists of case histories delivered by geotechnical practitioners. Students are required to prepare a two page summary for each of the 30 presentations covered during the course.

4.3 Assessment Methods

Assessment methods are generally categorized into two categories (Spurlin, 2008): direct and indirect methods. Direct methods, such as oral exams or final written exams, will allow the direct examination or opinion of student knowledge or skills associated with the subject indicators, while indirect methods such as exit surveys or interviews assess views or self-reports that indicate student abilities. CEAB requires that each attribute is assessed by at least one direct method, but a reflective assessment would use both methods of assessment.

Table 2. Direct Assessment Methods for Presented Graduate Attributes

Attribute	Indicator	CIVL 410 Direct Assessment Tools	CIVL 411 Direct Assessment Tools
2. Problem analysis	2.1 Identify and formulate problems 2.2 Analyze and solve problems 2.3 Evaluate solutions	Test questions in quizzes, assignments and final exams that involve problem analysis	Test questions in quizzes & final exams
7. Communication Skills	7.1 Comprehension 7.2 Writing 7.3 Presentations	Written assignments	Written summary reports of case studies

Student and employer surveys and focus groups are developed and used by all UBC programs. The Civil Engineering department conducts employers' consultation and engagement (either via co-op or employers in particular companies and sectors that have direct contact with UBC graduates who are one year to three years after graduation from the Civil Engineering program). Student consultation and engagement through meeting with representatives of the graduating class each year are carried out to collect suggestions for improvement regarding the department's coverage of the various indicators, and whether students have specific suggestions regarding the degree curriculum and other improvements for the program. This is to be followed up with the on-line exit survey directed to each year of the program. The exit survey is distributed to all participating students at the end of the university term. The survey includes student opinion questioners that focus on learning experiences and skill areas. Students are asked to rate each of the statements on a scale of 1 to 5. Besides, students are given the opportunity to provide feedback about the course and comment on their learning experience at UBC.

4.4 Direct Assessment

To evaluate attributes assessment results, it is important to consider a threshold (TH) and a target (T) grade for each course in the program. Thresholds and targets are discussed with the courses' instructors and then regulated by the department PIC. The threshold is the minimum acceptable level of performance on a given indicator, while the target is the intended level of learning proficiency for that indicator (Meyer et al., 2010). If the performance of an indicator is less than its threshold, this means investigation is required to determine its basis, and to suggest means of needed improvement measures. Usually, the improvement efforts will focus on those indicators first, followed by indicators that are below the target performance. The following grades present the civil engineering program goal expectations:

- EE - Exceeds expectations (100 - 90%)
- ME - Meets expectations (89-76%)
- MME - Minimally meets expectations (75-66%)
- DME - Does not meet expectations (65-50%)

For fourth-year courses, grades of 65% and 90% represent the threshold (does not meet expectations) and the target (exceeds expectations), respectively. Figure 2 shows the threshold and target grades relative to CIVL 410 marks from one of the course assignments.

4.5 The Program Assessment Schedule

Multiple courses from the Civil Engineering program are assessed during each year during the six-year accreditation cycle. Each of the twelve CEAB attributes is assessed annually during the cycle. This provides a few rounds of refinement on each attribute prior to any given CEAB visit and allows witnessing improvements associated with detected incompetent attributes during the accreditation cycle. However, the Civil Engineering program does not report on any assessment from its technical elective courses, on the grounds that the assessment process focusses on a “critical” path based on all students, who take the program core courses.

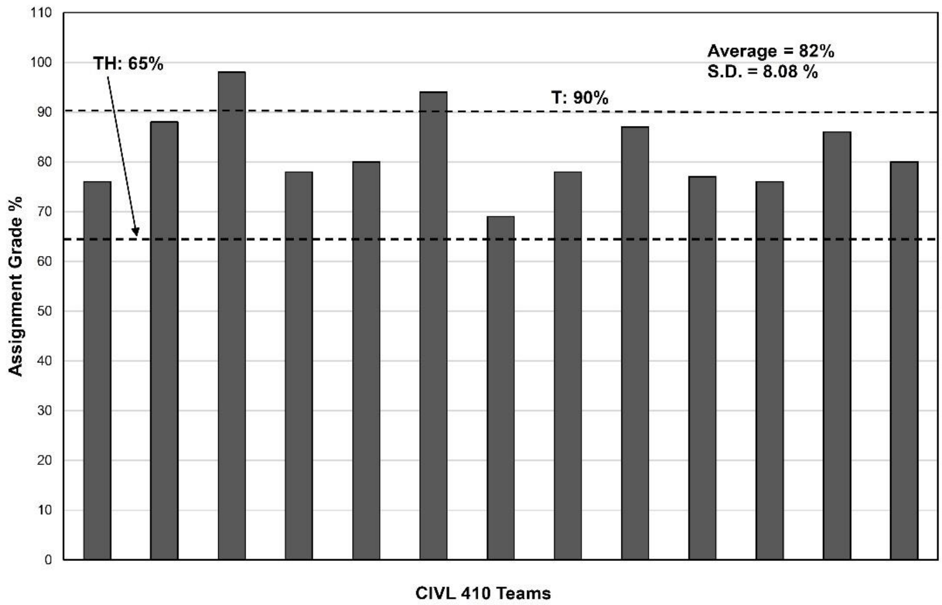

Figure 2. Example of year 2018 class (13 teams of 6 students each) performance in one of CIVL 410 assignments

5 Data Assessment and Results

In this study, CIVL 410 assignments and CIVL 411 summary reports were used to evaluate selected attributes for the Civil Engineering program. The analysis results for GA2 - Problem Analysis skills attribute, and GA7 - Communication Skills attribute, as outlined in Table 2, are shown in Figures 3 and 4, respectively. GA2 has three indicators: IN2.1 (identify and formulate problems), IN2.2 (analyse and solve problems), and IN2.3 (evaluate solutions), while indicators for GA7 are: IN7.1 (comprehension), IN7.2 (writing) and IN7.3 (presentations). Deliverables from these courses’ were evaluated by faculty members and reported to the program PIC. Using the courses’ rubrics, the evaluator graded each indicator and assigned a percentage value as per assigned rubrics. The results show the percentages of students’ achievements exceeding, meeting, minimally meeting and not meeting expectations for each selected indicator. Rubrics of CIVL 410 (including assessment criteria of its assignments) and CIVL 411 are presented in Appendices A and B, respectively.

Figures 3 and 4 show that students’ overall performance are improving during CIVL 410 for the competency of GA 2 from assignment 1 (DME: 9.1% in 2017 and DME: 30.7% in 2018 – i.e. below specified threshold) to assignment 3 (DME: 0% of students not meeting expectations in both years) over the 8 weeks these assignments are apart. The decline in the overall percentage of students exceeding expectations (below target) with respect to GA 2 in Assignment 3 could be related to the more challenging nature and advanced scope of work of this assignment.

The assessment results shown in Figures 3 and 4 are consistent or better than average students’ performance with respect to the corresponding indicators of GA 2 from second-year and third-year core courses of the Civil Engineering program (EE:18%, ME: 40%, MME: 37% and DME: 5%). However, continual monitoring of percentages of students not meeting expectations in assignment 1 in future years would be very helpful in assessing whether improvement in the earlier years of the Civil Engineering program is needed.

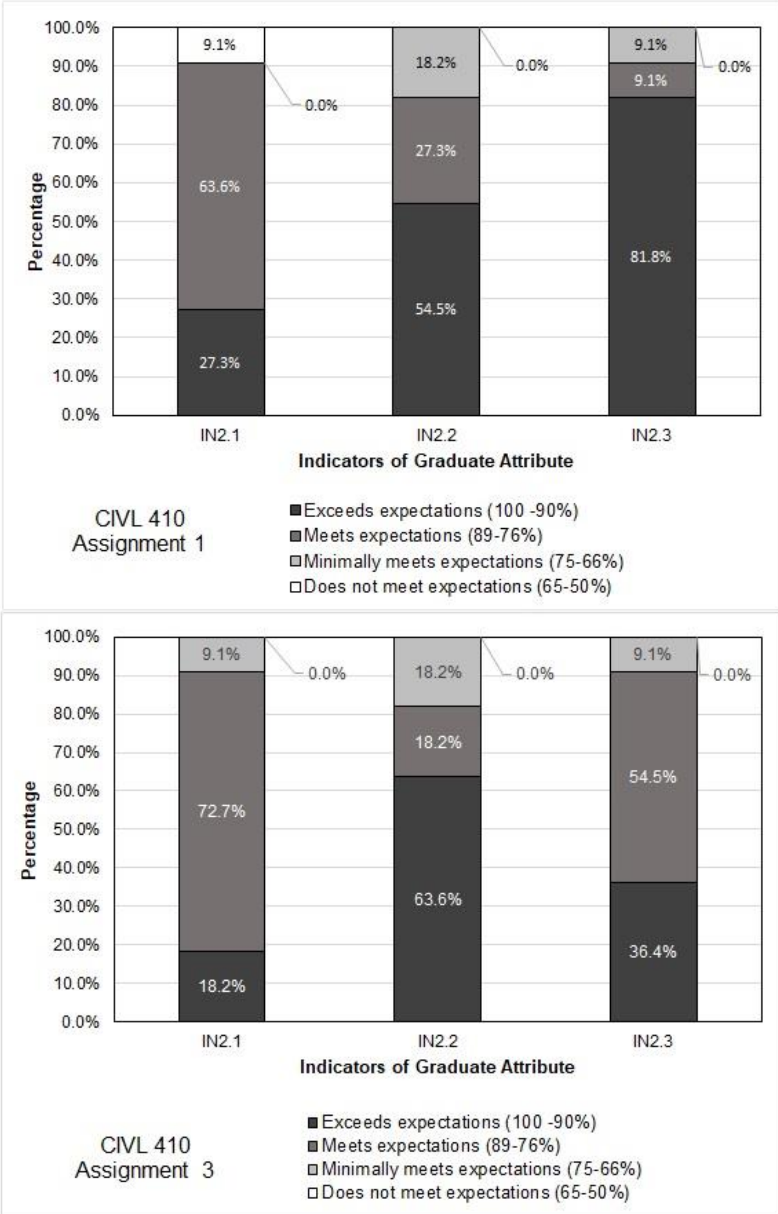

Figure 3. Students' performance in year 2017 for "Problem Analysis" from assignment 1 (week 5 of the term) and assignment 3 (week 12 of the term) using CIVL 410 rubric

The assessment of students' communications skills in CIVL 411 class are presented in Figure 5. The results indicate that 4 - 7% of students not meeting the course expectations. The average of these results is slightly higher than the program-wide expectation of DME of 5% in fourth-year classes. This could be related to the advanced and complex nature of the case histories delivered by geotechnical practitioners to CIVL 411 students. Nevertheless, these findings suggest that more emphasis should be placed by the program PIC and CIVL 411 instructor to address such deficiency and make changes in the way this course is delivered and possibly some other improvements to the degree curriculum (the process has already started) that would advance students' communications skills throughout the previous three years of the program.

6 Conclusions

Focusing on learning outcomes is essential to impart diagnosis and advance teaching processes and student learning. Engineering programs in Canada are expected to demonstrate compliance with the

CEAB graduate attribute criterion with learning attributes and continual improvement measures that form the basis for their accreditation decisions.

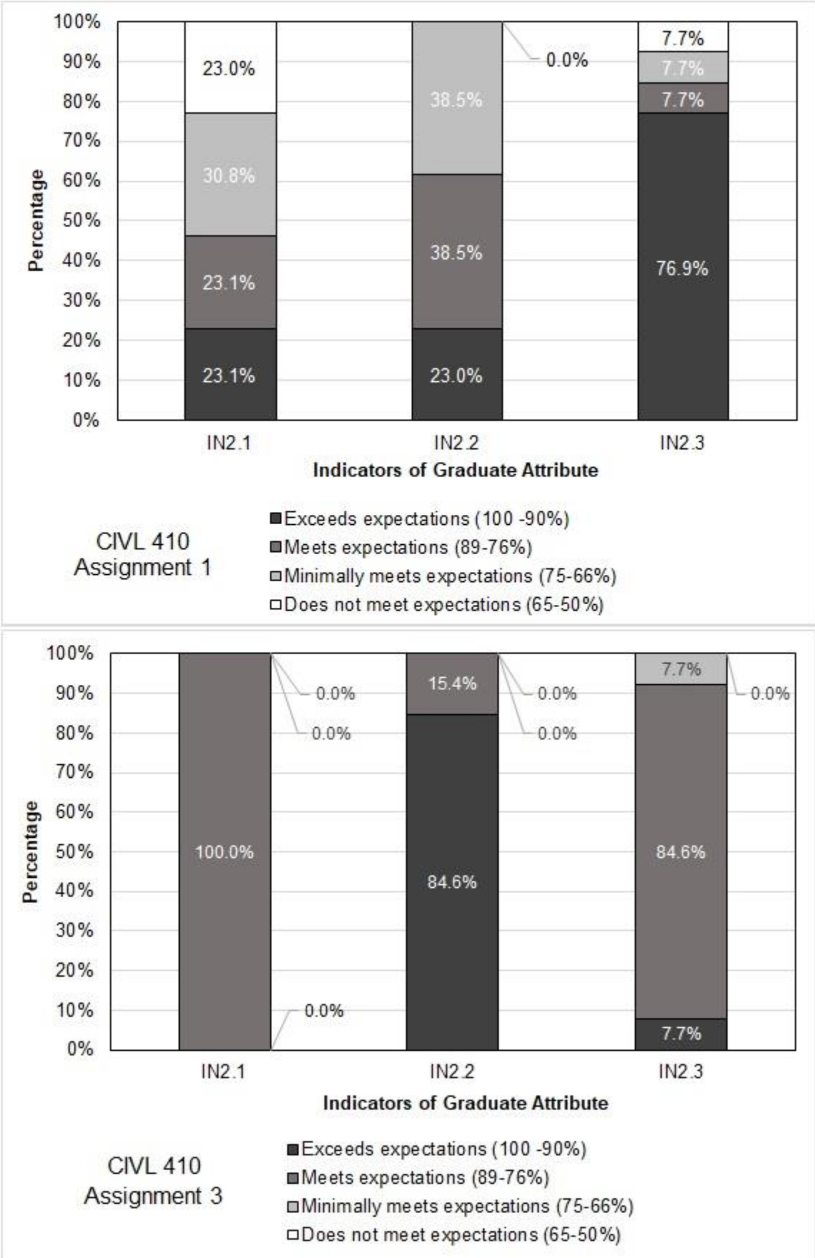

Figure 4. Students' performance in year 2018 for "Problem Analysis" from assignment 1 (week 5 of the term) and assignment 3 (week 12 of the term) using CIVL 410 rubric

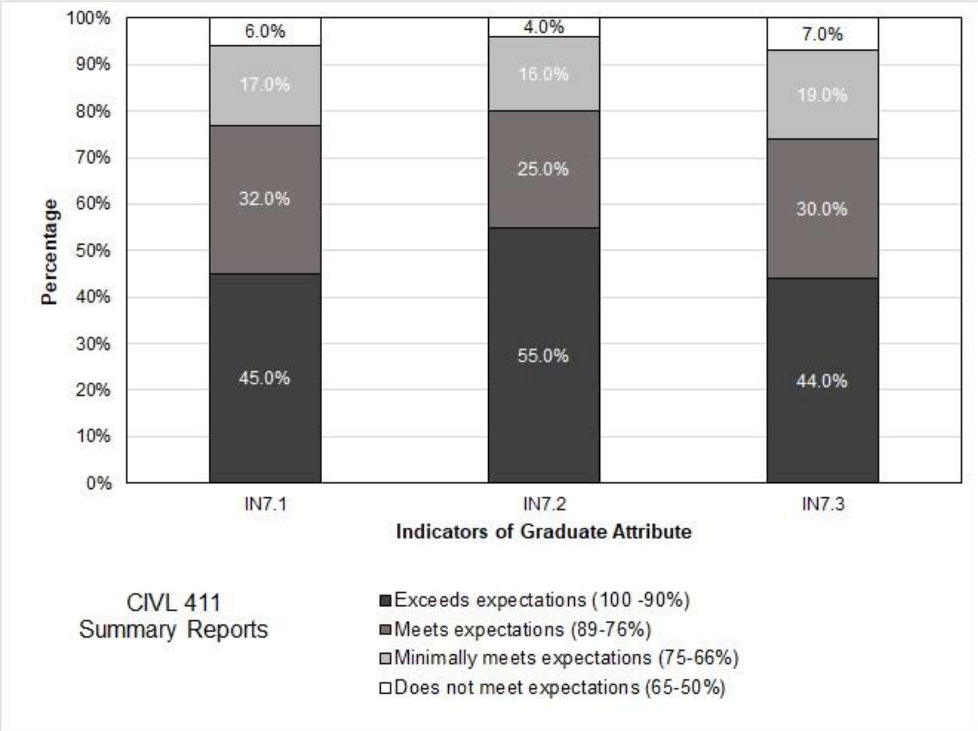

Figure 5. Students' performance in year 2018 for "Communication Skills" attribute using rubric for CIVL 411 summary reports

Students' performance in the investigated UBC fourth-year technical elective foundation engineering courses suggests signs of improved trends in students' learning skills of the selected indicators with reference to students' achievements during previous second and third years of the program.

It is recommended to regularly assess attributes performance of a few selected technical elective courses from the program every year or every second year, whether or not these courses are selected by the department for the assessment report according to the program curriculum map and schedule. This will further highlight whether the improvement of particular attributes in the earlier years of the Civil Engineering program is necessary. Suggestions for improvement in student performance with respect to GA2 "Problem Analysis" indicators 2.1 (Identify and formulate problems) and 2.4 (Evaluate Solutions) to be further emphasized in some third-year core courses; proposing CIVL 311 "Soil Mechanics II" being the prerequisite course of the investigated foundation engineering courses.

It is also recommended to continue improving the delivery of CIVL 410 and CIVL 411 courses with emphasis on teaching and assessing student performance with respect to the non-technical range of graduate attributes relating to teamwork, ethics, life-long learning, design, and professionalism that are challenging to instil, assess and report on. Results from these assessments can contribute to the program assessment and improvement accreditation reports.

References

Accreditation Board for Engineering and Technology (ABET), Criteria for Accrediting Applied and Natural Science Programs, 2018 – 2019. Available on-line at:
https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-applied-and-natural-science-programs-2018-2019/

Canadian Engineering Accreditation Board (CEAB), (2012). Accreditation Criteria and Procedures. CEAB, Ottawa, Ontario.

Chung, C. (2011). Changing Engineering Curriculum in the Globalised World. New Horizons in Education, Hong Kong Teachers' Association, Vol. 59(3), pp. 59-70.

Engineers Australia (EA), (2017). Accreditation Management System, Accreditation Standard – Higher Education, December 2017. Available on-line at: https://www.engineersaustralia.org.au/sites/default/files/2019-08/AMS-STD-10_Accreditation_Standard-Higher_Education_v1.0.pdf

Fiegel, G.L. (2013). Incorporating learning outcomes into an introductory geotechnical engineering course, European Journal of Engineering Education, 38(3), pp. 238–253.

International Engineering Alliance (IEA) (2014). 25 Years Washington Accord, 1989-2014 Celebrating international engineering education standards and recognition. https://www.ieagreements.org/accords/washington/

Meyer, J., Land, R., Baillie, C. (2010). Threshold Concepts and Trans- formational Learning. Sense Publishers, Rotterdam, The Netherlands.

Mills, J.E., Treagust, D.F. (2003). Engineering Education – is problem-based or project-based learning the answer? Australasian Journal of Engineering Education, online publication 2003-04

Spurlin, J.E. (2008). Assessment methods used in undergraduate program assessment. In designing better engineering education through assessment. Edited by Spurlin, J.E., Rajala, S.A. and Lavelle, J.P., Stylus Publishing, Sterling, Virginia.

Appendices

Appendix A – CIVL 410 Rubrics

The marks for CIVL 410 are assigned as follows:

Evaluation Method	Marks %
Individual quizzes	15
Team assignments 1-3 (each assignment contributes 10% of the overall CIVL 410 grade)	30
Peer evaluations (reflect individual tutorials attendance, quality and extent of individual's contribution in team assignments) 10% for PE1 and 5% for PE2	15
Final exam	40
TOTAL	100

CIVL 410 assignment 1 assessment criteria

Task	Mark %
Developing a representative geotechnical model	30%
Selecting representative values of soil properties & discussion of design issues	40%
Liquefaction assessment & recommendations	20%
The overall presentation	10%
Total	100%
Total scaled to 10%	10%

CIVL 410 assignment 2 assessment criteria

Task	Mark %
Part I - Ground improvement using preloading solution - Calculate the likely settlement and the time required for completion of preloading.	30%
Part II - Site preparation scheme by cut and fill approach (engineered fill replacement). Design pad footings that satisfy the following criteria: • Maximum allowable total settlement of the foundations is 40 mm • Maximum allowable distortion due to differential settlement between columns is 1/500 of the span between columns.	40%
Part III – Discuss alternative ground treatment techniques	20%
The overall presentation	10%
Total	100%
Total scaled to 10%	10%

CIVL 410 assignment 3 assessment criteria

Task		Mark %
Design Task 1: Considering suitable basement construction alternatives and briefly discuss advantages and disadvantages.		25%
Design Task 2: The geotechnical design of your selected solution by:		40%
(1) Terzaghi and Peck (1967) apparent earth pressures and hinge method	(20%)	
(2) WALLAP software - Limit Equilibrium Analysis and CP2 methods of calculating Factor of Safety	(20%)	
Understanding risk involved and identifying the geo-hazards that are associated with the proposed basement construction scenarios.		25%
The overall presentation		10%
Total		100%
Total scaled to 10%		10%

Appendix B – CIVL 411 Rubric

The marks for CIVL 411 are assigned as follows:

Evaluation Method	Marks %
First set of Summary reports (abstracts)	5%
Quiz	5%
Second set of Summary reports (abstracts)	10%
Casebook submission	40%
Final Exam	40%
TOTAL	100%

Summary reports (abstracts) to be submitted electronically twice during the term on dates shown in the course schedule. Students' notes for each presentation should also be submitted in electronic format. During the marking process, all summaries and notes will be reviewed.

Marks will be deducted if:

- The presenter, topic and handouts are incorrectly identified;
- There is little or no content from the lecture (as opposed to information in the handouts);
- If significant portions of the summary are just copied from the handouts;
- If there is no evidence of reflection to identify key points of the geotechnical lessons learned;
- Over word limit.

Summary reports are to be organized into a casebook that would serve as a useful tool for future reference. Students must create a digital casebook (folder structure) containing all their summaries, classes' notes, lectures' slides and handouts. The casebook will be submitted by the date of the final exam.

Author's bio

Yahya Nazhat, University of British Columbia, Canada

Dr. Yahya Nazhat joined the Department of Civil Engineering as an instructor in 2014. He worked as a Civil & Geotechnical Engineer in research, construction and consulting practice from 1983-2009 before pursing Ph.D. research during 2009 to 2013 from the University of Sydney (Australia). His PhD had a focus on Behaviour of Sandy Soil Subjected to Dynamic Loading. Having held senior engineering and management positions in industry in both Australia and the Middle East, Dr. Nazhat has long experience in detailed geotechnical investigation and geotechnical studies associated with major infrastructure projects including highways, tunnels, high-rise buildings, airports and rail projects. He has years of experience in piling and deep foundation including design, construction and pile testing. He is a registered Professional Engineer in BC, Canada, a Chartered Professional Engineer in Australia, and a Fellow of the Institution of Engineers, Australia.