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Measurable performance indicators of student learning outcomes: a case study

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ABSTRACT: Determining student learning outcomes is a crucial step in maintaining and improving teaching and learning quality in education. Accrediting bodies require educational institutions to develop assessment systems to analyse students learning outcomes. The main objective of this article is to discuss learning outcomes using performance indicators within rubric-based assessment systems. This article complements various studies about assessment and was intended for newly established engineering programmes seeking international accreditation. In this study, an example was given of a grading scale mapped to performance indicators. The student learning outcomes at the programme level were determined by combining and averaging the performance indicators of programme courses. Comparative analysis was conducted between the direct assessment results and those of indirect assessments based on surveys distributed to programme constituents including students, alumni and employers.

Keywords: Learning outcomes, teaching assessment, accreditation, continuous improvement, engineering education

INTRODUCTION

Student learning outcomes can be defined as a student's ability to demonstrate a set of skills after completing a course. Educational experts distinguish between student learning outcomes at the course, programme and institutional levels [1]. They are interlinked and can be assessed qualitatively or quantitatively using measurable performance indicators for each outcome [2-4].

Student learning outcomes at the course levels must cover the learning hierarchy as proposed by Bloom's taxonomy, starting from attainment of knowledge, comprehension or understanding, application, analysis, synthesis and evaluation [5][6].

At the programme level, interpersonal (behavioural or attitude) skills including written and oral communications, ethics and professionalism, teamwork and leadership must be incorporated to ensure students also possess the skills to succeed in a professional setting. Student learning outcomes at the programme level can be derived from the learning outcomes at the course level, and the learning outcomes at the institutional level can be derived from the learning outcomes at the programme level.

In engineering education, students are expected to achieve these technical outcomes: to design engineering components or systems; to apply knowledge of science and mathematics in engineering; and to conduct and interpret engineering experiments. Other outcomes include interpersonal skills, such as written and oral communication, teamwork and leadership, and lifelong learning [7][8].

At the Prince Mohammad Bin Fahd University (PMU), student learning outcomes for the civil engineering programme follow the Accreditation Board for Engineering and Technology (ABET) student outcomes, which cover technical and soft skills. The ABET is an international accreditation body with headquarters in the United States, and most of ABET-accredited engineering programmes use ABET-prescribed student outcomes. However, ABET suggests that programmes seeking accreditation can develop their own student learning outcomes at the programme level, provided they are in line with the outcomes below:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyse and interpret data

(c) *an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability*
(d) *an ability to function on multidisciplinary teams*
(e) *an ability to identify, formulate, and solve engineering problems*
(f) *an understanding of professional and ethical responsibility*
(g) *an ability to communicate effectively*
(h) *the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*
(i) *a recognition of the need for, and an ability to engage in life-long learning*
(j) *a knowledge of contemporary issues*
(k) *an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice* [9].

Out of 11 outcomes, six of them are related to interpersonal skills, such as communication, leadership, teamwork, ethics, professionalism and lifelong learning. The remaining five learning outcomes (*(a), (b), (c), (e)* and *(k)*) are focused on engineering design and analysis. At the higher level (i.e. institutional or university), student learning outcomes arguably can be called graduate competencies or attributes [10].

As at the programme level, student learning outcomes at the institutional level must cover basic learning skills, such as knowledge, cognitive and interpersonal (behavioural) skills. At PMU, student learning outcomes at the institutional level have six learning competencies:

I. Communication competency: ability to communicate effectively in English and Arabic in professional and social situations.
II. Technological competency: ability to use modern technologies to acquire information, communicate, solve problems, and produce the intended results.
III. Critical thinking and problem solving: ability to reason logically and creatively to make informed and responsible decisions and achieve intended goals.
IV. Professional competency: ability to perform professional responsibilities effectively in both local and international contexts.
V. Teamwork: ability to work effectively with others to accomplish tasks and achieve group goals.
VI. Leadership: ability to be informed, effective and responsible leaders in the family, the community and the Kingdom [11].

The six competencies practised at PMU are unique among Saudi Arabia's universities. They were commended as one of the key institutional strengths by ABET team evaluators. Student learning outcomes at the programme level must be compatible with those at the university level [12].

It can be shown that the learning outcomes at the programme level can be fully correlated to the learning outcomes (competency) at the university level (Table 1). Furthermore, assessment of student competency at the university level can also be determined quantitatively. Presenting students' rating with respect to the university competency or graduate attributes would enhance a student's ability to work at a professional level. Because of this, PMU has started issuing a competency rating to each graduated student in addition to an academic transcript. Arguably, the graduate attributes can be extracted directly from some of the key courses that focus mostly on the development of student interpersonal skills, such as internship and senior design project courses.

A separate rubric with key performance indicators can be developed for each university competency [13]. However, in this article, quantification of graduate attributes was generated based on student learning outcomes at the programme level, with the intention of showing outcome consistency between the university and programme level.

Table 1: relationship between PMU learning outcomes (competency) and CE student learning outcomes.

PMU competency	CE student learning outcomes										
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
I							X				
II		X			X						X
III	X		X		X			X			
IV						X		X		X	
V				X							
VI								X	X	X	

Learning outcomes should be distinguished from learning objectives. The objective refers to the teacher or programme perspective rather than the student. Student learning outcomes and learning objectives can be stated at various levels. At the programme level, they is called programme educational objectives (PEOs) and are one of the important accreditation criteria that need to be assessed and evaluated. The PEO is intended to be achieved by engineering graduates within five years of their graduations, which is different from the learning outcomes that are intended to be achieved at the end of a course (e.g. after four years). However, PEOs must be supported by the student learning outcomes or in other words they must be mapped congruently to each student learning outcome. The Department of Civil Engineering (CE) at PMU has the following PEOs:

- PEO1: graduates have successful and professional careers in civil engineering and related industries, and meet the expectations of the prospective employers.
- PEO2: graduates demonstrate leadership and effectively undertake services within their profession and contribute to sustainable development in their communities.
- PEO3: graduates pursue their professional development through continuous lifelong learning, advanced studies and membership in professional societies.

At present, the PMU Department of Civil Engineering has enrolled about 160 students supported by five teaching professors, two laboratory instructors and one laboratory technician. The Department has four modern engineering laboratories (materials, geotechnical, surveying and hydraulic) to support teaching and learning. Civil engineering students are required to complete 139 credit hours to earn a Bachelor's degree. This 139-credit-hour accomplishment comprises 17 hours mathematics, 17 hours sciences, 57 hours engineering topics and 48 hours general social science.

The curriculum was designed in accordance with ABET specifications, with respect to math, science and engineering course requirements [9][14]. The PMU CE Department has been accredited by ABET Engineering Accreditation Commission and the next cycle of visits will be conducted in the next two academic years.

In this article, student learning outcomes at the programme level and competency at the institutional level will be assessed and analysed. It is obvious that students can be assessed straightforwardly at the course level by a standardised numerical scale measurement (e.g. 0-100) or letter grading (e.g. A to F). At the programme and institutional levels, the assessment requires different indexing to indicate learning outcomes. The assessment of 1 to 100 is too refined to indicate outcome achievement, and in this article four-scale rating is used to assess learning outcomes [15].

ASSESSMENT STRATEGY

Key performance indicators (KPIs) and rubrics for each programme outcomes were developed based on the applicability and practicality of assessing courses against the outcomes. The rubrics considered basic criteria, weight for each criterion and level [16]. Table 2 shows an example of outcome (*a*), its KPIs and rubric. The remaining programme outcomes, KPIs and rubric can be seen in a document issued by the Department [17]. Most of the KPIs are limited to four (e.g. outcome (*c*) and some have only one indicator (e.g. outcomes (*i*) and (*j*), which are interpersonal skills related). Outcome (*c*) is designed to have the most indicators because of its design-oriented outcome.

Table 2: Rubric for outcome (*a*).

Outcome *(a)*: *ability to apply knowledge of mathematics, science and engineering*				
Criteria	Low (1)	Needs improvement (2)	Good (3)	Excellent (4)
a1: Apply mathematics to solve engineering problems.	Fails to understand and apply proper linear algebra and differential calculus in solving engineering problems	Shows limited and less than adequate application of linear algebra and differential calculus in solving engineering problems	Demonstrates satisfactory application of linear algebra and differential calculus in solving engineering problems	Understands and applies proper and accurate linear algebra and differential calculus in solving engineering problems
a2: Apply concepts and theories of science and engineering.	Fails to apply fundamental concepts and theories in solving science and engineering problems	Shows limited and less than adequate understanding of theory and concepts in solving engineering problems	Demonstrates satisfactory application of proper concepts and theory in solving engineering problems	Understands and applies proper and accurate concepts and theories in solving engineering problems
a3: Convert science and engineering problems to solvable mathematical models.	Fails to transform science and engineering problems into solvable mathematical models	Shows limited and less than adequate transformation of science and engineering problems into solvable mathematical models	Demonstrates satisfactory transformation of science and engineering problems into solvable mathematical models	Understands and applies proper and accurate transformation of science and engineering problems into solvable mathematical models

The assessment tools included quizzes, examinations, term projects, laboratory experiments, internship training reports and senior design project exercises. The Faculty maintains a numerical value for each course, a course assessment report and a teaching improvement strategy. It should be noted that not all KPIs are applicable to each course.

For example, courses without laboratory experimentation will not mention outcome assessments about conducting experiment and experimental data analysis, which is one of the performance indicators for outcome (*b*). Normally, in one semester three measurements are taken for each course covering one mid-term examination, one final examination and a group term project. The examination and project questions reflect the KPI in the assessment. No homework assessments are required since they are only intended for student practice.

Table 3 shows an example of a student assessment for an engineering course, for outcomes (*a*) and (*e*). Each question was devised in accordance with the KPIs including the maximum grade students can attain. The rubric was developed based on a four-scale assessment and so the student grade needs to be converted. Each student will have a unique set of performance value, and averaging outcomes values for all students will result in the overall performance for that specific course.

Table 3: Sample of rubric assessment for a civil engineering course.

Question	ABET KPI	Maximum grade	Student grade	ABET KPI (1-4 scale)	Maximum	Student grade
1	a1	20	10	2	35	24
	a2	5	4	3		
	a3	10	10	4		
2	e1	20	16	3	65	46
	e2	35	30	3		
	e3	10	0	1		
Total					100	70

Note: KPI = key performance indicator

The teaching faculty checks whether the outcome is below a threshold value (e.g. 2.5) and identifies the teaching improvements if they are required. If the outcome values for one course are averaged with the other courses with the same outcome assessments, this will result in the overall student learning outcomes at the programme level. This is the focus of this article.

Table 4 shows 10 courses used as indicators for outcomes assessment at the programme level. The main justification for not including all engineering courses is that the measure must reflect the ability of civil engineering students to master key design courses. If all engineering courses are included in the assessment, this would under-represent performance because students at the early engineering level do not have ability in design and analysis.

Table 4: Selected 10 courses for student learning outcomes assessment at the programme level.

No.	Course name	Code no.	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
1	Materials in Civil Engineering	CVEN 3322	■	■			■						
2	Reinforced Concrete Design	CVEN 3312			■		■						■
3	Engineering Measurements	CVEN 3341	■	■		■						■	■
4	Environmental Engineering Fundamentals	CVEN 3331						■		■	■		
5	Hydraulic Engineering	CVEN 4432	■	■			■						
6	Intro to Geotechnical Engineering	CVEN 4423	■	■	■		■						■
7	Design of Steel Structures	CVEN 4313			■		■						■
8	Construction Management	CVEN 4314	■								■		■
9	Water and Waste Water Treatment	CVEN 4333			■			■	■				
10	Learning Outcome Assessment III	ASSE 4311			■	■	■	■	■	■	■	■	■

The Civil Engineering Department Council decided that the 10 courses selected must cover major civil engineering disciplines, including structures, environment, geotechnical and construction management. Apart from the transportation engineering course, courses were selected at the junior and senior level that are design and/or laboratory-based.

It is seen from Table 4 that outcome (*e*) is measured the most (six times). This is because outcome (*e*) is related to basic engineering skills for students to identify, formulate and solve engineering problems. This is followed by outcomes (*a*), (*c*) and (*k*), which relate to the design and analysis of engineering problems. With respect to outcome measurement frequency, course Learning Outcome Assessment III (No. 10), also known as the senior design project, has the greatest frequency (nine) from outcomes (*c*) through (*k*). This is because the senior design project demonstrates the mastery of all the important skills that students are expected to acquire by the end of their undergraduate studies [18-20].

Outcomes *(d), (g), (h)* and *(j)* were taken twice; this is due to the nature of interpersonal skills assessment that can only be measured through non-conventional ways; for example, by using self-evaluation in teamwork exercises, peer review and evaluation of lifelong learning.

ANALYSIS RESULTS

Assessment of the programme outcomes has been conducted for six semesters within three academic years (2016 to 2019). Student learning outcomes *(a)* to *(k)* can be quantified by averaging the KPIs for each outcome. Summarised in Figure 1 is the result for the 11 outcomes since the academic year 2016 to 2017. A line indicating threshold value (2.5) is also shown in the graph.

Unlike the assessment conducted for each course, the numerical values for the programme outcomes are presented up to one decimal point to indicate a refined level of attainment. This seems to contradict developing a rubric with a rounded value of 1 to 4. However, the refined outcome values will be useful later to support justification for continuous teaching improvement. It would be difficult to observe trends for outcome improvement if they are presented only in rounded numerical values.

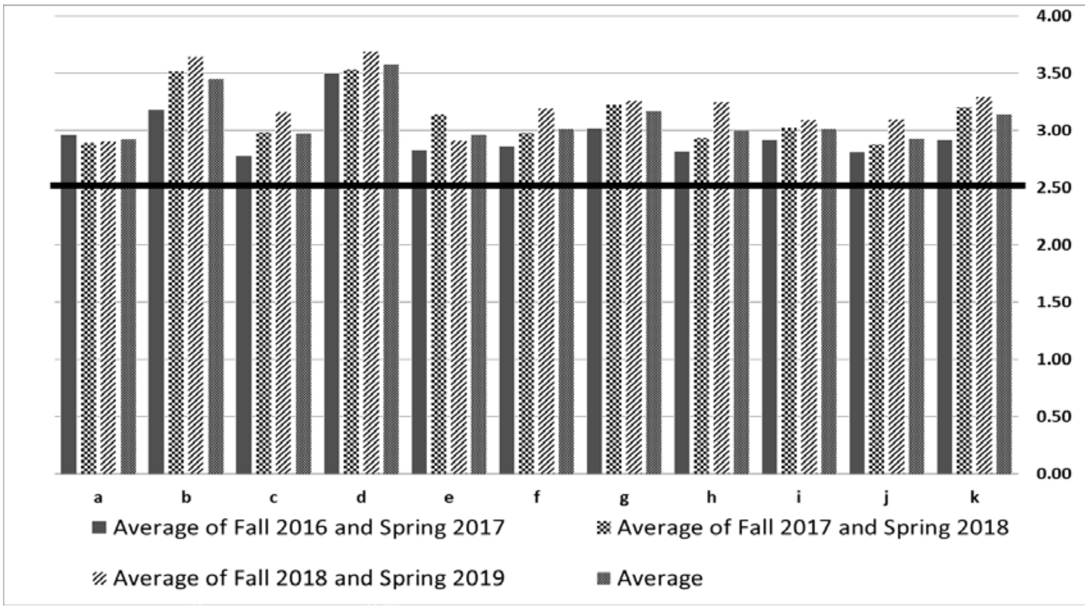


Figure 1: Student learning outcomes at the programme level.

In general, it can be observed that the target outcomes were achieved, all values are above the threshold value (2.5). Looking closely at the average values, outcome (*a*) has the lowest value relative to the other outcomes. Although it is higher than the target value, this could indicate that teaching staff should pay more attention to students' abilities in applying knowledge of mathematics and science in engineering. Except for outcomes *(a)* and *(e)*, the other outcomes showed improvement in the past three academic years.

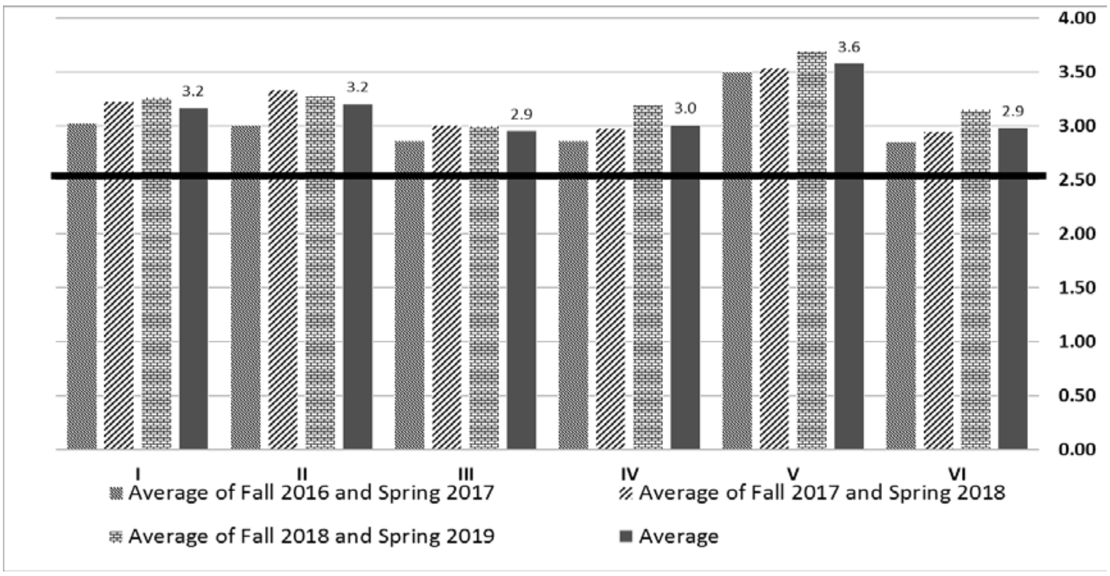


Figure 2: University competency (graduate attributes).

The lowest outcome (*a*) has led to students' low performance in outcome *(e)*, i.e. student ability to identify, formulate and solve engineering problems. The highest outcome value was (*d*), which is about teamwork. This was followed by outcome *(b)*, student ability to conduct laboratory experimentation. It can be deduced that students are excited to learn as a team as most laboratory-based learning is team-based. It is strongly encouraged that teaching involves teamwork exercises and uses factual and self-learning discovery (i.e. experimentation).

Graduate attributes (competency) can be quantified (Figure 2) using Table 1. As at the programme level, the highest performance was obtained in teamwork (competency V). This is expected because of the one-to-one correlation between the programme and university learning outcomes. The lowest performance was for competency III, which is critical thinking and problem-solving. This is consistent with the programme level where ability to apply mathematics and science (outcome *(a)*) and ability to identify, formulate and solve problems (outcome *(e)*) had the lowest values. The graduate attributes are rarely used as important criteria in the programme accreditation process. This exercise has been undertaken to demonstrate compatibility between the university and programme student outcomes.

DISCUSSION

The student learning outcomes at the programme level can be determined using learning outcomes at each course level (CLO). To do this, mapping must be provided between course and programme outcomes. Then the rubric assessment for each CLO needs to be developed as the KPI for the *direct* programme assessment.

Table 5 shows an example of the relationship between course learning outcomes and programme outcomes for the Design of Steel Structures course. The rubric is developed for each CLO using a four-scale rating. The weight distribution between programme outcomes mapped to one CLO must be determined. For example, CLO3 is mapped to programme outcomes *(a)* and *(c)*, and the weight distribution needs to be defined, such as 30% for outcome *(a)* and 70% for outcome *(c)*.

Table 5: Student learning outcomes mapping for the course, Design of Steel Structures.

Student learning outcomes at the course level (CLO)	Student learning outcomes at the programme level
CLO1: Perform appropriate structural analyses based on the loads assigned for design	*(a)*
CLO2: Determine various loading conditions and select critical load for use in structural design	(*e*)
CLO3: Perform design and analysis of structural members, connections and systems	(*a*), (*c*)
CLO4: Produce design sketches or a drawing necessary for cost estimation	(*c*), (*k*)
CLO5: Apply local building codes and engineering standards in structural design	(*c*)
CLO6: Use modern computer software for steel structural analysis and design	(*k*)

As is in the *direct* programme outcome assessment measure, finding the overall student learning outcomes at the programme level is done by averaging all outcomes for selected courses (Figure 3). The main difference here is that this technique requires assessment tools (examinations, projects) that are CLO-specific. There are pros and cons about using this method. The major concern about the *direct* programme outcomes assessment is that the assessment is determined and calculated indirectly via the CLOs.

The main concern for the *direct* measure is that developing assessment tools (tests, projects) related to the KPIs at the programme level - which by nature are very general - is challenging. There is a detailed method that can relate CLOs for each course directly to each KPI at the programme level [4]. By using this refined method, weight factors need to be applied to simulate the contribution of each CLO into the KPI. Regardless of various methods of assessment, major accrediting bodies such as ABET have no big concern with simple or detailed methods provided the results can support teaching improvement.

The ABET has introduced new student outcomes compacting the previous 11 outcomes *(a)* to *(k)*) into seven *(1)* to *(7)* outcomes [14].These new outcomes became applicable in the 2019 to 2020 cycle of accreditation, and a programme can retain the 11 outcomes or transform them into the new ones. The mapping between ABET new outcomes and *(a)* to *(k)* outcomes can be seen in Table 6. For programmes that will undergo an accreditation cycle within the next two to three years and plan to use *(1)* to *(7)* outcomes, while at the same time would like to utilise the old *(a)* to *(k)* data, conversion can be done according to the mapping in Table 5, with few adjustments on how to incorporate several outcomes into one new outcome.

For example, as shown in Table 5, outcome (*k*) can be proportionately added to outcomes *(1)*, *(2)* and *(6)*. Incorporating *(a)* to *(k)* outcomes shows outcome performance trends *vis-à-vis* the old *(a)* to *(k)* data. Key performance indicators need to be redeveloped similar to the previous KPIs for the *(a)* to *(k)* outcomes.

Table 6 shows the conversion of *(a)* to *(k)* to *(1)* to *(7)* outcomes. Again, except for the outcome *(1)* (identify, formulate and solve engineering problems by the application of mathematics and science), all other outcomes showed improved definitions, particularly outcome *(5)* (teamwork). Looking at the average value for the three academic years, outcome 4 (ethics and professionalism) shows the lowest value. This is through combining outcomes *(f)*, *(h)* and *(j)* that already had low scores (Figure 1); this is not crucial since the performance has improved year-by-year.

Table 6: Mapping of ABET *(1)* to *(7)* to *(a)* to *(k)* student outcomes.

ABET new student outcomes (versus *(a)* to (*k)* outcomes)	
1	*an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics* (*(a)*, *(e)* and *(k)*)
2	*an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors* (*(c)* and *(k)*)
3	*an ability to communicate effectively with a range of audiences (g)*
4	*an ability to recognise ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts* (*(f)*, *(h)* and *(j)*)
5	*an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (d)*
6	*an ability to develop and conduct appropriate experimentation, analyse and interpret data, and use engineering judgment to draw conclusions* (*(b)* and *(k)*)
7	*an ability to acquire and apply new knowledge as needed, using appropriate learning strategies (i)*

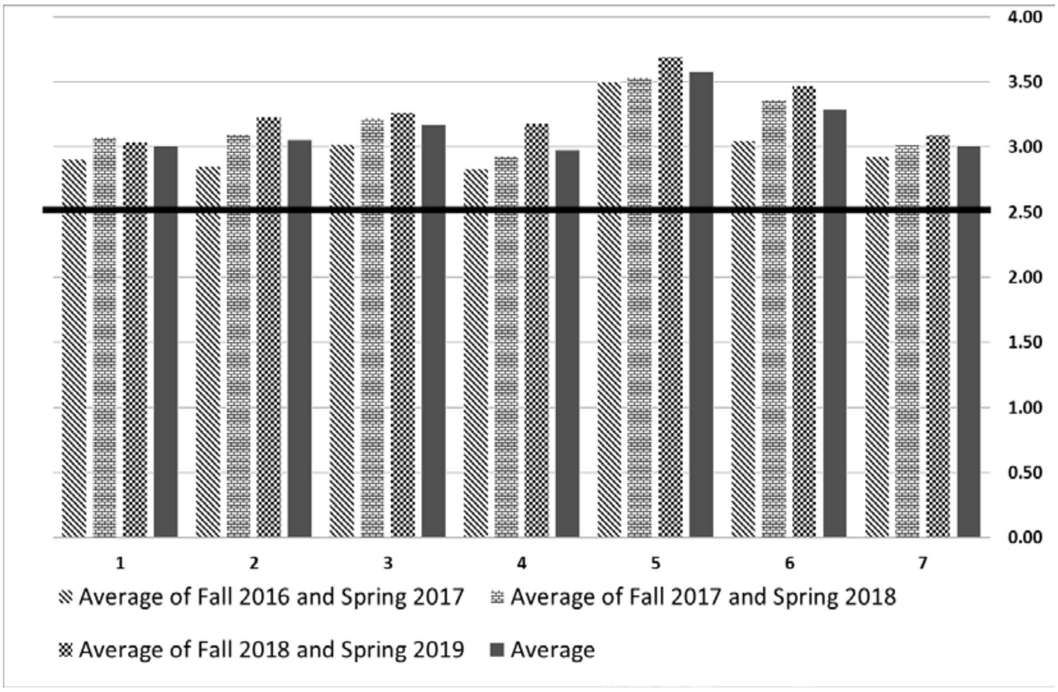


Figure 3: Student learning outcomes (*(1)* to *(7)*) since the academic year 2016-17.

INDIRECT ASSESSMENT

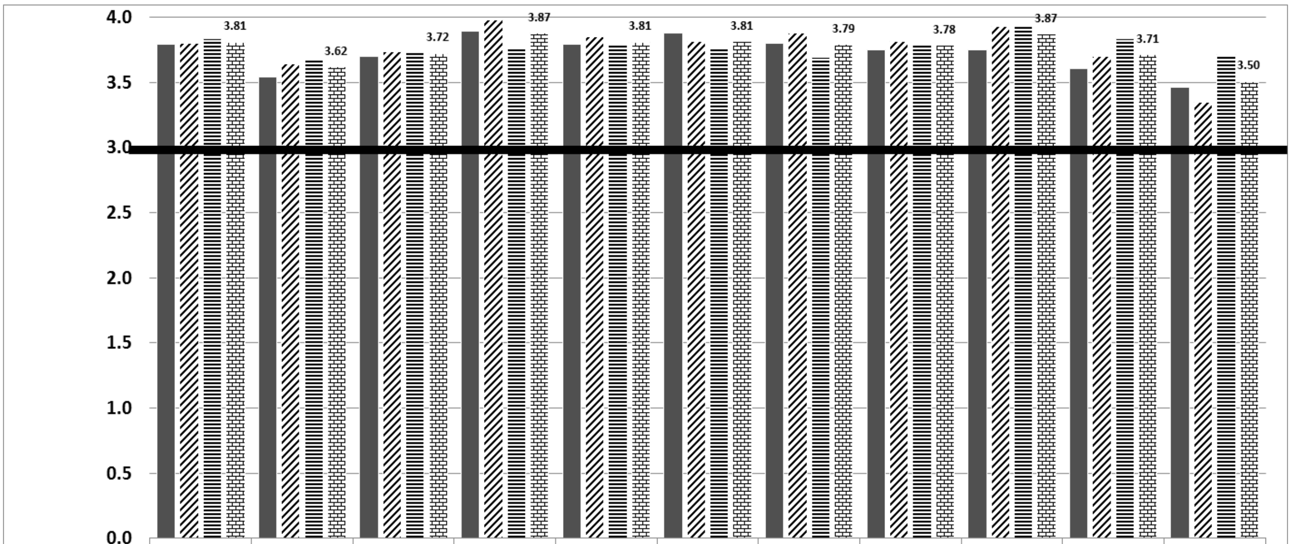
A survey was conducted of senior graduating students to rate their abilities with respect to the student learning outcomes of the PMU civil engineering programme. Provided by this survey is a programme comparative performance relative to the direct assessment method presented earlier in this article. It should be noted that surveys for assessing learning outcomes are called indirect assessments, and this term should not be confused with the programme outcomes assessed via course or programme learning outcomes as described in the previous paragraph.

Feedback was sought on how far the Department has been successful in preparing graduates with the required knowledge and skills to meet the programme outcomes and programme educational objectives. A 100% response rate for graduating students was obtained at the end of spring. To be consistent with the direct assessment, the survey used a four-rating scale, with four indicating *excellent* and one, *low* or *unsatisfactory*.

Summarised in Figure 4 is the survey result conducted during the past three academic years, including the average values. Student learning outcomes *(a)* to *(k)* were used in this survey. Clearly students have rated highly their abilities to meet the outcomes (3.5 or above). The survey is subjective relative to the direct measure that uses measurable indicators for the assessment (examinations, project exercises, laboratory reports, and so on). That explains why the value (3.5) is higher than the direct measure (2.5). However, it should be noted that this survey is only one of several inputs considered for programme improvement. In general the students are satisfied with their achievement on all outcomes.

The highest result was obtained for outcome *(d)* (teamwork), which is consistent with that obtained from the direct measure. The lowest value was obtained for outcome *(b)* (laboratory experimentation) followed by outcome *(k)* (using modern engineering design tools). The result seems contradictory, with those obtained from the direct assessment showing high values for the laboratory experimentation and using modern engineering tools.

Students seemed less confident in these two areas that are intended to develop students' ability in mastering technological tools in engineering problem solving. Corrective actions, including introducing software-based learning in design, such as engineering drawing and replicating laboratory equipment to stimulate factual-based learning, have been taken to improve student confidence. Also, introducing two semester senior design project courses is to be implemented to enrich student engineering design experience using up-to-date tools or computer software.



	a	b	c	d	e	f	g	h	i	j	k
Spring 2017	3.8	3.5	3.7	3.9	3.8	3.9	3.8	3.8	3.8	3.6	3.5
Spring 2018	3.79	3.63	3.73	3.97	3.85	3.81	3.87	3.81	3.92	3.69	3.35
Spring 2019	3.83	3.67	3.73	3.75	3.78	3.75	3.69	3.79	3.92	3.83	3.71
Average	3.80551282	3.61542735	3.71956197	3.87117521	3.80607906	3.81089744	3.78573718	3.7825641	3.86538462	3.70882479	3.50482906

Figure 4: Graduating senior exit survey results since the 2016 to 2017 academic year.

Another survey was conducted to obtain feedback from employers. The response rate was low due to a low number of civil engineering graduates within the past seven years. Unlike survey questions distributed to the senior graduating students, the survey questions to employers were designed to reflect the actual assessments for employees who have been working in an engineering company for up to five years.

Table 7 (see Appendix), has a summary of the survey questions and results. Unlike the direct assessment rubric and survey to the senior exit students, a five-point scale was used, from five (strongly agree) to one (strongly disagree). The associated student learning outcomes and programme education objectives (PEOs) are also presented along with the survey questions.

The survey results show an overall satisfaction among the employers on the quality of education at the CE-PMU programme. Again, to adjust for subjectivity the benchmark value was set at 3.75. While most of the scores are above the benchmark of 3.75, the score for questions 1 and 3 are on the lower side indicating: 1) a need for improvement in the students' ability to possess basic principles and skill in the civil engineering areas; and 2) a need for improvement in using instrument and measurement tools in civil engineering. It can be observed that lack of confidence in conducting laboratory experimentation (outcome *(b)*) is the main source for these low scores. The results were consistent with those obtained from the indirect assessment (survey) conducted of graduating students.

CONCLUSIONS

Based on direct and indirect assessment results conducted for three academic years, since 2016-17, graduates from the PMU civil engineering programme appear to achieve all student learning outcomes at an acceptable level. Despite this, improvements still are needed in several areas. This is facilitated through curriculum upgrades, including: 1) introducing an engineering drawing course to enhance student ability applying mathematics, particularly in understanding complex geometry; and 2) splitting the senior design project (capstone) course into two semesters to improve student learning through modern engineering design tools.

Corrective actions also have been taken to improve teaching and learning practices. These include: 1) upgrading laboratories by replicating key laboratory equipment to improve student participation and motivation; and 2) updating existing design software to bring students closer to up-to-date engineering practice.

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BIOGRAPHIES

Dr Tahar Ayadat is an Associate Professor of Civil Engineering at Prince Mohammad Bin Fahd University (PMU), Al Khobar, Kingdom of Saudi Arabia. He earned his PhD in civil engineering from Sheffield University, England, in 1991. His major expertise is in geotechnical and geo-environmental engineering. Dr Ayadat has about 30 years of academic and practical experience in conducting design, analysis, inspection, expertise and management of various projects, such as domestic, commercial and industrial constructions, bridges, roads and railways, dams, site rehabilitation, and so on. He has published more than 100 papers and technical reports in refereed journals, international conference proceedings and government (public) domains. He supervised and co-supervised many MSc and PhD theses. Dr Ayadat is at present a registered Professional Engineer (PEng) in the Province of Quebec, Canada. He also has been a member of the Canadian Society of Civil Engineering since 2004.

Mr Danish Ahmed is at present a laboratory instructor in the Civil Engineering Department at Prince Mohammad Bin Fahd University (PMU), Al Khobar, Kingdom of Saudi Arabia. His major expertise is in seismic testing of reinforced concrete structural members, retrofitting and finite element modelling. He completed his Master of Science in Civil Engineering (Structures), in 2009-2012 in the Department of Civil Engineering at King Fahd University of Petroleum and Minerals, Kingdom of Saudi Arabia, and in December 2005-2008, he completed a Bachelor of Science in civil engineering in the Department of Civil Engineering at Sir Syed University of Engineering and Technology, Pakistan. He received a bronze medal and university scholarships for outstanding academic performance.

Dr Saidur R. Chowdhury is an Assistant Professor in the Civil Engineering Department at Prince Mohammad Bin Fahd University (PMU), Al Khobar, Kingdom of Saudi Arabia. He completed his PhD in environmental and geo-environmental engineering at Western University (UW) in Canada. Dr Chowdhury is a Professional Engineer (PEng) in the province of Ontario in Canada. He has more than two years of postdoctoral experience at both Western University and the Simpson Environmental Corporation in Burlington, Ontario, as well as in the University of Saskatchewan. He has published scientific papers in refereed journals and international conference proceedings, as well as technical reports for different environmental consulting companies in Canada. Western University has acknowledged his research contribution by honouring him with the prestigious R.M. Quigley Award (2011) for Research Excellence. He is registered with the Ministry of Environment and Climate Change to act as a Qualified Person (QP) for Environmental Site Assessment (ESA) and treatment under Ontario Regulation 153 / 04.

Dr Andi Asiz is an Associate Professor and Chair of the Civil Engineering Department at Prince Mohammad Bin Fahd University (PMU), Al Khobar, Kingdom of Saudi Arabia. His major expertise is in structural engineering and mechanics. He has more than 15 years of academic and practical experiences in conducting analysis, design, inspection and monitoring of various engineered structures, from reinforced concrete and steel buildings, pre-stressed concrete bridges to timber structures. He has published more than 50 papers and technical reports in refereed journals, international conference proceedings and government (public) domains. In collaboration with the University of New Brunswick in Canada, he is at present co-supervising and advising doctoral students in structural engineering. He obtained his PhD degree in civil engineering from the University of Colorado at Boulder, USA. Dr Asiz is at present a registered Professional Engineer (PEng) in the Province of New Brunswick, Canada. He also has been a member of the American Society of Civil Engineers (ASCE) since 1997.

Table 7: Employer survey result.

No.	To what level do you agree with the following statements about CE graduates of PMU?	Average score
1	Possess a basic knowledge of the principles and skills related to civil engineering (outcomes *(a), (c)*); (PEO1)	3.3
2	Can apply their knowledge and skills in finding engineering solutions to technical problems at work (outcomes *(c), (e)*); (PEO1)	3.8
3	Possess an ability to use instruments and measurement tools as needed in the practice of the engineering profession (outcomes *(b), (k)*); (PEO1)	2.8
4	Possess an ability to engage in advanced education, research, and development (outcome *(i)*); (PEO3)	4.2
5	Possess critical thinking and problem-solving skills (outcome *(e)*)	4.5
6	Can work independently without the need for supervision (outcomes *(d), (i)*); (PEO2)	4.2
7	Possess an ability to work within a team environment (outcome *(d)*); (PEO2)	4.7
8	Possess an ability to communicate effectively (outcome *(g)*); (PEO1)	4.5
9	Possess good technical writing skills (outcome *(g)*); (PEO1)	4.5
10	Possess sound project management and leadership skills (outcome *(h)*); (PEO2)	4.3
11	Possess the minimum requirements/competence for obtaining a job for an entry level position (outcomes *(h), (i)*); (PEO1)	4.4
12	Possess the technical competence to advance in their career (outcome *(i)*); (PEO3)	3.8
13	Involved in the development of new and valuable ideas (outcomes *(h), (j)*); (PEO2)	4.2
14	Possess the ability to acquire new knowledge and skills on their own (outcome *(i)*); (PEO3)	4.3
15	Understand the need for continued professional development (outcome *(i)*); (PEO3)	4.3
16	Demonstrate an understanding of workplace procedures and practices (outcome *(f)*); (PEO2)	4.0
17	Demonstrate an understanding of professional and ethical responsibility (outcome *(f)*); (PEO2)	4.5
18	Overall, we are satisfied with the technical competence and professional attitude of PMU CE graduates (outcomes not applicable); (PEOs 1, 2)	4.5
19	I would recommend the PMU civil engineering programme to a friend or relative (outcomes not applicable)	4.5