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Utilizing Learning Outcomes Assessment for Civil Engineering Program Evaluation and Improvement: A Case Study

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Abstract Learning outcomes have been used as quality indicators in engineering education practices around the world. Learning outcomes are output based and can be assessed and measured relative to standardized educational resources. This article documents the design and implementation of Civil Engineering (CE) program assessment process at a relatively new university to meet national and the international program accreditation requirements and to satisfy labor market needs that require certain skills. The paper highlights the CE program and program's learning outcomes; maps the relation between learning outcomes and university competences, and assess the CE program performance based on surveying constituents including senior students, alumni, employers and faculties. Finally, it suggests adjustments to the CE curriculum to complement the study findings. The study methodology and findings provides an in-depth experience for development of CE program in a developing country and tools to evaluate the program performance towards enhancing the program's educational outcomes to meet national and international accreditation requirements and job market demands.

Keywords Learning Outcomes (LOS), Civil Engineering Education, Quality Assurance, Accreditation

Introduction

The Kingdom of Saudi Arabia (KSA) has recently invested heavily in the education sector, especially in setting up new schools and universities [1-2]. The KSA government has allocated over 25 percent of the county's total budget to education including vocational training, and has spent around $US13.17 billion on education and research [3]. University education as known today in Saudi Arabia began in 1957 [4]. With the inauguration of 10 new universities during the past few years, the higher education system has expanded to include 24 government universities,18 primary school teacher's colleges for men, 80 primary school teacher's colleges for women, 37 colleges and institutes for health, 12 technical colleges, and 24 private universities and colleges [3, 5]. Prince Mohamed Bin Fahd University (PMU), the case study, is a private university located in the Eastern Province of KSA and was established in 2006 [6-7]. The rapid development of Saudi Arabia and the large expansion of the industrial sector, as a result of increasing oil revenues, has impacted educational practices by increasing the awareness of the need for producing qualified university graduates who are capable of performing key attributes required in professional practices [5, 8]. Companies are more inclined to value engineering graduates who possess additional non-technical qualities as well as technical know-how for the job. Employers, as well as academic accreditation entities are putting pressure on universities to incorporate robust assessment techniques into engineering programs [8]. Attributes here are highly related to what students could actually perform after they finish their engineering study. In other words, graduate attributes are program learning outcomes [9].

Learning Outcomes (LOS) are measurable statements of student knowledge and skills expected upon graduation. LOS define what the students should know and be able to do upon completion of a particular course topic or program [10-12]. Moreover, LOS are useful in ensuring that students understand expectations, and that instruction is constructively aligned with assessment [13-14]. Establishing and measuring LOS is an ongoing process that benefits from revision over time as the organization changes and as additional research is published in this area [15]. The assessment of LOS has become a primary focus for engineering education today [8, 16-17]. A comprehensive study conducted in 2013 by the National Institute for LOS Assessment in the United

Stated found that LOS for students are now the norm in American higher education. In 2013, about 84% of all colleges and universities had adopted stated LOS for all their undergraduates, an increase of 10% from 2009 and there is significantly more assessment activity now than a few years ago [18].

This article documents the design and implementation of a Civil Engineering (CE) program assessment process at a relatively new university to meet national and the international program accreditation requirements and to satisfy the skills demanded by the local labor market. The paper highlights the CE program and the program's LOS; maps the relation between LOS and university competencies, and assesses the CE program performance based on a comprehensive questionnaire surveyed to constituents including senior students, alumni, employers, and faculty members regarding satisfaction in achieving the LOS; and, finally, suggests adjustments to the CE curriculum to incorporate the study findings.

Program Learning Outcomes

The LOS and learning objectives are sometimes used interchangeably in the literature [12, 19-20]. However, the LOS should be distinguished from learning objectives; LOS are student-centered which means they provide students with clear expectations of what they should achieve in a course or program of study; while learning objectives are designed in the perspective of the teacher or the program [21-22]. Nonetheless, LOS and objectives should be aligned to each other, since LOS can be derived or written based on learning objectives, moreover, both LOS and objectives should be measurable to assure that students have achieved the program's LOS [23].

Historically, LOS have been categorized into three major domains of learning: cognitive, affective, and psychomotor [24-25]. Recent development in the educational practice further categorizes LOS into more expanded domains. Following the model developed in the European Qualification Framework [26], Saudi Arabia National Qualification Framework (NQF) categorizes learning outcomes into five major domains including: knowledge skills, cognitive skills, interpersonal skills & responsibility, communication skills, and psychomotor skills [27-28]. In engineering education, the knowledge domain represents basic skills that are developed through recognizing and understanding learned subjects, for example, students' ability to explain and describe facts, concepts or theories. Cognitive domain is one step higher than the knowledge domain requiring student's ability to apply knowledge in real situation. Interpersonal skill is a learning domain that is related to student's ability to function as an individual and team player in solving engineering problems. Communication skill requires students to be able to communicate effectively using appropriate and latest technology. The psychomotor domain is about development of coordinated motoric or movement skill that normally require speed, repetition, precision, and execution [29]. This domain is rarely applicable in engineering. These five learning domains will be utilized later in this study in categorizing LOS.

LOS must be observable, achievable, and measurable. Measuring how well LOS are achieved is a challenging task, requiring continuous assessment and professional judgment from all program constituents involving faculty, students, alumni, and industry. The assessment process can also convey useful information to faculty and administrators on the effectiveness of the design and delivery of the educational program. It can also develop, in the long-term, instruments to obtain comparable information on what students actually have learned [30-33]. There are direct and indirect methods commonly used to assess LOS for higher education practices. The direct assessment method includes analyzing performance through student portfolios, comprehensive examination before graduation, and professional engineering licensure tests. Some countries have standardized tests as a direct measure for LOS [34]. However, not all countries in the world including Saudi Arabia have such an exam. The indirect assessment method normally utilizes surveys distributed to various program constituents regarding how satisfactory LOS has been achieved. In this study, the indirect assessment method via survey was utilized to measure constituents' satisfaction of the level of achievement of the program's LOS.

Civil Engineering Program at PMU

PMU is a private university located in the Eastern Province of KSA. PMU adopts a highly innovative student-centered approach to impart education, offers chances for students to explore genuine paths to learn and innovate when being groomed for their future roles as hard-core professionals. PMU College of Engineering (COE) offers Electrical, Mechanical, and Civil Engineering undergraduate programs for male students and an undergraduate Interior Design program only for female students [2,6-7].

At PMU, university wide learning competencies are used instead of learning outcomes (LOS). Competencies here are aimed at developing personal characteristics that can fulfill labor job market requirements. The six PMU learning competencies/ outcomes are as follows:

- Communication Competency: the ability to communicate effectively in both English and Arabic in professional and social situations.

- Technological Competency: the ability to use modern technologies to acquire information, communicates, solve problems, and produce intended results.
- Critical Thinking and Problem Solving: the ability to reason logically and creatively to make informed and responsible decisions and achieve intended goals.
- Professional Competency: the ability to perform professional responsibilities effectively in both local and international contexts.
- Teamwork Competency: the ability to work effectively with others to accomplish tasks and achieve group goals.
- Leadership Competency: the ability to be informed, effective, and responsible leaders in family, community, and the Kingdom.

With the exception of the psychomotor domain, it can be seen that the above competencies or outcomes are nearly identical to the five NQF learning domains described earlier.

The CE curriculum was designed based on the needs of Saudi Arabia's industrial entities and employment outlets and is dedicated to provide highest quality broad-based technical and scientific education. It was designed as a unique university in Saudi Arabia in terms of balancing technical (engineering) and social (behavioral) skills. The CE program offers a four-year bachelor degree with 139 credit hours covering 50 courses. More than half of the total credit hours (73 credit hours) are devoted to engineering and design courses and the remaining half are for basic (core) courses covering humanity, social and behavioral sciences, math and natural sciences, and assessment capstone series. The CE department currently has enrolled around 150 students.

The Department of CE at PMU has three educational objectives:

- To instill in its students a sense of the scholarship and leadership of the CE profession.
- To educate and prepare students for a lifelong career as practicing professional civil engineers who are ethical and socially responsible.
- To produce graduates with a strong academic base for advanced studies.

Table 1 on the left column presents the CE program LOS that are already categorized into five major learning domains according to NQF. As a comparison, the left side column presents standardized LOS used by international accreditation body based in the United States, Accreditation Board for Engineering and Technology (ABET) [35]. The relation between the CE program LOS and PMU competencies is shown in Table 2. To emphasize the overall vision and mission of the university, the programs LOS support the university competencies with stronger relation shown in the technological and professional competencies followed by problem solving and communication skills.

Table 1: CE Program Outcomes and ABET *a-to-k* Student Outcomes

CE Program Outcomes (Note: parentheses indicates corresponding ABET outcomes)	**ABET Student Outcomes**
I. Knowledge skills:	
1. To recognize the impact of engineering solutions to economic, environmental and society and to improving quality of life. (*h*)	(*a*) an ability to apply knowledge of mathematics, science, and engineering
2. To recognize the knowledge of contemporary issues in planning, designing, constructing, and rehabilitating civil engineering infrastructures. (*j*)	(*b*) an ability to design and conduct experiments, as well as to analyze and interpret data
3. To develop techniques and skills using modern engineering methods and tools needed in civil engineering practices. (*k*)	
II. Cognitive skills:	(*c*) an ability to design a system, component, or process to meet desired needs
*4.*To identify and apply knowledge of mathematics and sciences and in civil engineering problems (*a*)	
5. To design and conduct experiments, as well as to analyze and interpret data required for solving civil engineering projects. (*b*)	(*d*) an ability to function on multi-disciplinary teams
6. To design optimum system/component of civil engineering facilities/infrastructures to meet desired needs using realistic constraints. (*c*)	(*e*) an ability to identify, formulate, and solve engineering problems
7. To identify, formulate, and solve civil engineering problems and to evaluate and synthesize information in order to provide best alternative solutions. (*e*)	(*f*) an understanding of professional and ethical responsibility
III. Communication and Information Technology skills:	
8. To function effectively in multi-disciplinary construction project/civil engineering teams. (*d*)	(*g*) an ability to communicate effectively
9. To prepare professional written materials, graphical	(*h*) the broad education necessary to

communications and deliver professional oral and written presentations. (*g*)	understand the impact of engineering solutions in a global and societal context
IV. Interpersonal skill & responsibility:	
10. To act professionally and ethically and recognize the impact of liability issues in civil engineering projects and constructions. (*f*)	(*i*) a recognition of the need for, and an ability to engage in life-long learning
11. To recognize the need in life-long learning and to engage in continuing education of professional/engineering skills. (*i*)	(*j*) a knowledge of contemporary issues
V. Psychomotor skill:	
12. To effectively articulate civil engineering ideas or problems in sketches, drawing or diagrams (*g*)	(*k*) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Table 2: Mapping of CE program outcome to PMU competencies

PMU Competency	Program Learning Outcomes											
	I			II				III		IV		V
	1	2	3	4	5	6	7	8	9	10	11	12
Communication								X	X			X
Technological Competence	X	X	X	X	X	X	X					
Critical Thinking and Problem Solving				X	X	X	X					
Professional Competence				X	X	X	X	X	X	X	X	X
Teamwork								X				
Leadership								X		X	X	

Table 3: Results of senior-exit students survey about student learning outcomes

	Outcomes Category	LO	Students' Appreciation (%)						Partial Scores	Overall Scores
			S(5)	M(3)	F(2)	W(1)	N(0)	UT		
		h	75	12.5	12.5				4.38	
I	Knowledge Skills	*j*	75	12.5	12.5				4.38	4.05
		k	37.5	37.5	12.5	12.5			3.38	
		a	25	50	25				3.25	
		b	37.5	25	37.5				3.38	3.44
II	Cognitive Skills	*c*	37.5	25	37.5				3.38	
		e	50	25	25				3.75	
	Communication &	*d*	62.5	25	12.5				4.13	4.00
III	Information Tech. Skills	*g*	50	37.5	12.5				3.88	
	Interpersonal Skill &	*f*	75	12.5	12.5				4.38	4.38
IV	Responsibility	*i*	75	12.5	12.5				4.38	

S = strong, M = medium, F = fair, W = weak, N = none, UT = unable to tell & LO = Learning outcomes

Assessment Method

As was discussed previously, the major purpose of the student LOS is to ensure that graduates of the program are adequately prepared to enter the practice of CE. Recognizing that the performance of students and graduates is an important consideration in the evaluation of a program's quality, a system of ongoing assessment was conducted by the Department of CE to continuously improve the effectiveness of the program. For this purpose, indirect assessment and analysis was conducted in the department involving four different constituents including: (1) senior-exit students (N=42), (2) alumni (N=37), (3) industry represented by employers (N=15), and (4) All faculty members. The aim is to assess how well our students have achieved the different LOS (CE outcomes 1 through 12 or ABET outcomes *a-to-k*), i.e. the ability and the performance of our students with regard to these specific and measurable outcomes.

These five categories embedded in CE PMU outcomes were used throughout the assessment and the corresponding ABET student outcomes (*a-to-k*) were mentioned as reference. The surveys were performed based on the following considerations:

- Each learning outcome was surveyed to the four populations defined above using a six-level Likert-Type scale that included: *strong*, *medium*, *fair*, *weak*, *none* and *unable to tell*. For senior student population the opening question is *How well do you think you have achieved the following student learning outcomes?*; for the CE alumni, *How well do you think you have achieved the following student learning outcomes?*; for the employer, *How well do you think your employee(s) have achieved the* *following learning outcomes?*; for the faculty, *How well do you think your students have achieved the following student learning outcomes?*. Comments and suggestions were provided at the end of the multiple-choice appreciation (question). Name and occupation of the surveyed person were made optional.

- Furthermore for the purpose of survey analysis, a system of points was implemented to these ranks as follows: strong (5 points), medium (3 points), fair (2 points), weak (1 point) and none (0 point or void).
- The psychomotor skill in Category V was not surveyed at the moment, since this can be categorized together into communication skill (Category III or ABET outcomes *d* and *g*).

Findings and Discussion

Survey to senior (exit) students

A series of interviews were conducted with the entire list of CE senior exit students. The results obtained are summarized in Table 3. In order to perceive and quantify more clearly the answers or the appreciations of the students, two scales were introduced:

- Partial scores: it was instituted for each learning outcome and it is defined as the sum of the product between students' appreciation (in percentage) and the related mark or point.
- Overall scores: it was established for each outcomes category and it is defined as the average of the partial scores.

The results obtained for partial and overall scores are presented in Figures 1 and 2 in the histogram format. From Figure 1, it can be deduced that the students' appreciations concerning the different learning outcomes can be grouped into two levels or categories:

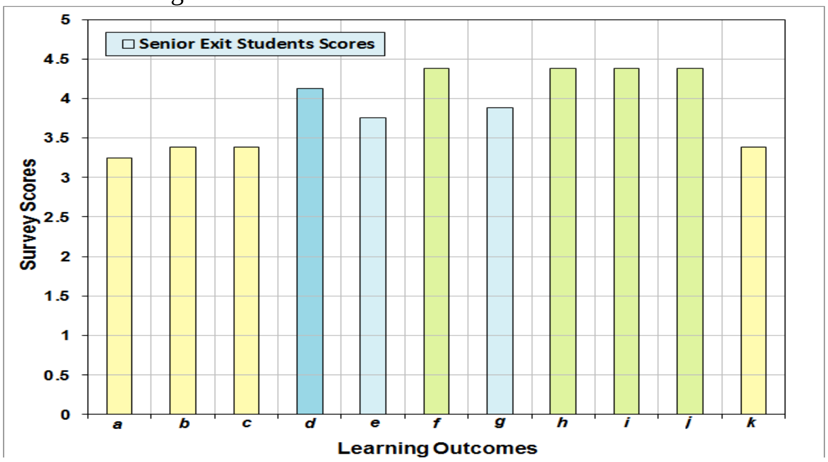

Figure 1: Scores of senior exit students' survey about student learning outcomes

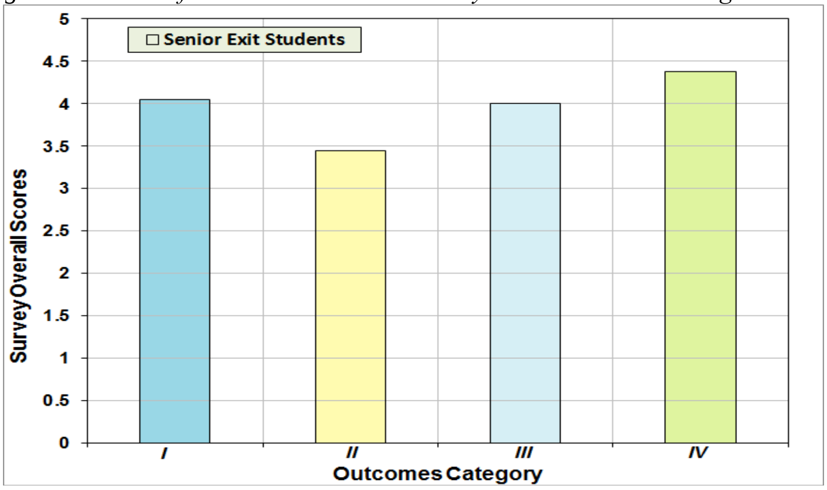

Figure 2: Overall scores of senior exit students per outcomes category

1. Above Average performance (it includes the ABET learning outcomes *d*, *f*, *h*, *i* and *j*): Scores above 4 out of 5 were categorized as Above Average indicating that the students have a satisfactory ability to function on multi-disciplinary teams, understanding professional and ethical responsibility as well as

the importance of professional licensure, understanding the impact of engineering solutions in a global and societal context, recognizing the need for, and an ability to engage in life-long learning and knowing contemporary issues.

2. Average performance (it includes the ABET learning outcomes *a*, *b*, *c*, *e*, *g* and *k*): Scores between 3 and 4 out of 5 were categorized as Above Average indicating that the performance of the interviewed students, concerning these learning outcomes, is acceptable. Accordingly, the students have design competence and once graduated they are able: *i*)- to solve defined and open-ended engineering problems, *ii*)- to produce engineering reports using written, oral and graphic methods of communication, *iii*)- to use computers to solve engineering problems and to evaluate solutions, and *iv*)- to be aware of current techniques in CE practice. However, it is worthy to note that the lowest scores were noted for the learning outcomes *a & b*, suggesting that the students have some difficulties: *i*)- to apply math and science to CE problems, *ii*)- to select and apply appropriate statistical methods for basic data analysis, and *iii*)- to set up and conduct engineering experiments, and to present experimental results through appropriate graphical display.

Figure 2 shows the variation of overall scores related to the outcomes categories. This figure indicates that the recognition of interviewed students are adequate for categories I, III and VI; whereas, difficulties are noted for category II (cognitive skills).

Survey to CE alumni

A series of phone interviews was conducted with the CE program alumni. In total, 63% of the Alumni that were contacted responded to the interview. The survey results are presented in Table 4. The partial scores and overall scores were calculated for the alumni survey results and presented in Figures 3 and 4 in histogram format.

Table 4: Results of Alumni Survey about student learning outcomes

	Outcomes Category	LO	Alumni' Appreciation (%)						Partial	Overall
			S(5)	M(3)	F(2)	W(1)	N(0)	UT	Scores	Scores
		h	75.0	25.0					4.8	3.9
I	Knowledge Skills	*j*	50.0	37.5	12.5				4.4	
		k	37.5	25.0	37.5				2.6	
		a	50.0	50.0	0.0				4.3	3.4
		b	25.0	50.0	12.5	12.5			3.1	
II	Cognitive Skills	*c*	0.0	62.5	12.5	25.0			2.4	
		e	50.0	37.5	12.5				3.9	
	Communication & Information	*d*	75.0	12.5	12.5				4.4	4.4
III	Tech. Skills	*g*	87.5	0.0	12.5				4.4	
	Interpersonal Skill & Responsibility	*f*	62.5	37.5					4.3	4.1
IV		*i*	50.0	50.0					4.0	

S = strong, M = medium, F = fair, W = weak, N = none, UT = unable to tell & LO = Learning outcomes

Figure 4 shows that the alumni' appreciations concerning the different learning outcomes can be grouped into three levels or categories:

1. Performance above average: the alumni reported above average performance in 7 out of the 11 learning outcomes including learning outcomes *a, d, f, g, h, i,* and *j*. The results show that the alumni believes that they have strong capacity: to identify and apply knowledge of mathematics and science in all CE areas, to function effectively in multi-disciplinary construction project/civil engineering teams, to act professionally and ethically and recognize the impact of liability issues in CE projects and constructions, to prepare professional written materials, graphical communications and deliver professional oral and written presentations, to recognize the impact of engineering solutions to economic, environmental and society and to improving quality of life, to recognize the need in life-long learning and to engage in continuing education of professional/engineering skills, and to recognize the knowledge of contemporary issues in planning, designing, constructing, and rehabilitating CE infrastructures
2. Average performance was reported in two of the learning outcomes (*b* and *e*). This indicates that alumni find their confident in ability to design and conduct experiments, as well as to analyze and interpret data required for solving CE projects and to identify, formulate, and solve CE problems and to evaluate and synthesize information in order to provide best alternative solutions is just adequate.
3. Below average performance was reported in two of learning outcomes (*c* and *k*).Scores below 3 out of 5 were categorized as Below Average. This indicates that alumni find their ability to design optimum system/component of CE facilities/infrastructures to meet desired needs using realistic constraints and

to develop techniques and skills using modern engineering methods and tools needed in CE practices is below average.

4. Figure 4 shows that the alumni believe that they have above average capability in categories III and IV, which are Communication and Information Technology Skills, and Interpersonal Skill and Responsibility. While adequate capability in the other two categories I and II (Knowledge and Cognitive Skills) was observed. The overall results show that the alumni have a good set of CE skills. Instruction should focus in improving design and problem analysis capabilities among students. The alumni also addressed the need to incorporate design and drafting software as an integral part of the CE program.

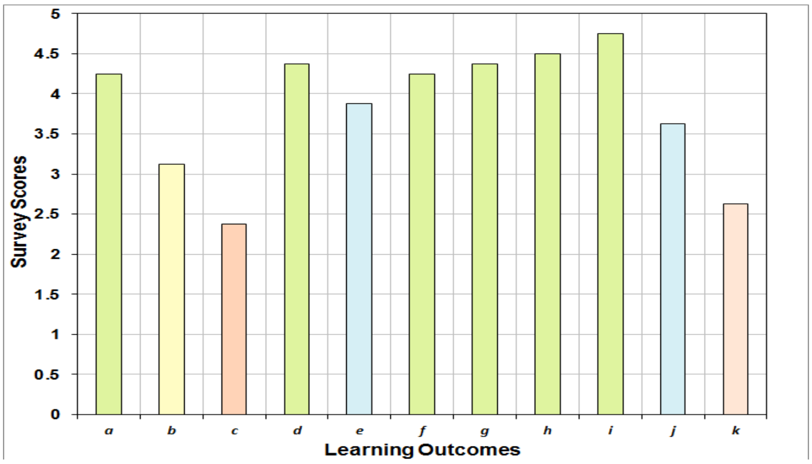

Figure 3: Scores of Alumni students' survey about student learning outcomes

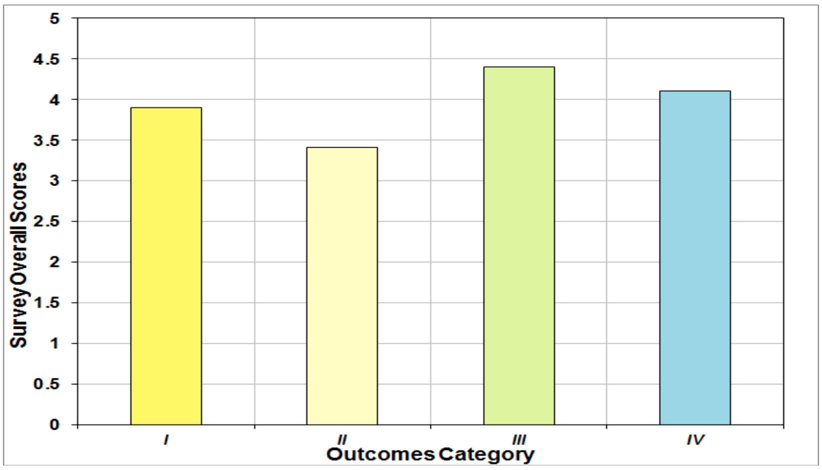

Figure 4: Overall scores of Alumni students per outcomes category

Survey to CE employer

Eight local employers were phone interviewed to get more insight into the CE alumni performance in duties. The survey results are documented in Table 5. Following the same procedure, the partial score and overall score were prepared and presented in Figures 5 and 6. The results show a similar trend as those observed in the other three surveys but with lower thresholds in the cognitive skills set, whilst the employer expressed their high appreciation to the alumni above average Communication and Information Technology Skills and Interpersonal Skill and Responsibility Skill, which are highly needed in the Saudi labor market. The below average cognitive skills among the employed alumni can be referred to the fact that most of the above average GPA students are currently enrolled in graduate school. Again, as was in the alumni survey the employer stressed in the need to incorporate design and drafting software's into the CE program and the need to improve the students design and analytical capabilities (Cognitive skills).

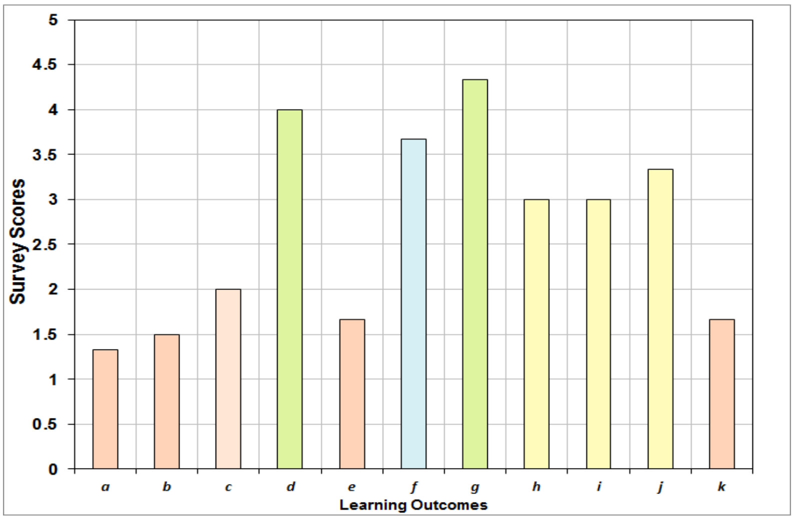

Figure 5: Scores of employer's survey about student learning outcomes

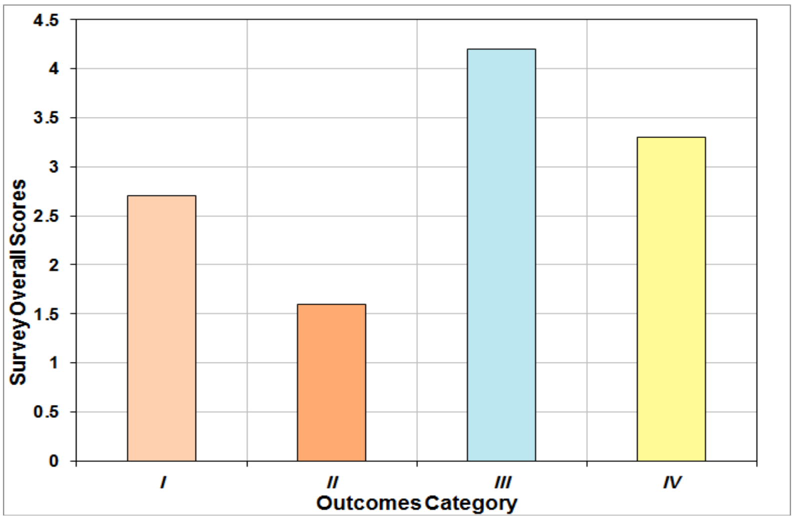

Figure 6: Overall scores of employer per outcomes category

Survey to CE faculty

For the same purpose, a survey was conducted with faculty members from the CE program as well as faculty members from other departments who were involved in the delivering of CE courses such as senior design projects and internships. The results obtained are summarized in Table 6 and presented in Figures 7 and 8.

Generally, Figures 7 and 8 show a similar trend to those observed in the senior-exit students' survey. However, compared to the results of the students, the thresholds of all learning outcomes scores are somewhat lower. In the exception of the partial score recorded for outcome *h*, the results of the faculties' judgment concerning the different learning outcomes can be grouped into two levels or categories: *i*)- Average performance (including learning outcomes *f*, and *ii*)-performance below average (including learning outcomes *a* to *e*, *g*, *j* and *k*).

Similarly to students' survey, the lowest scores were obtained for learning outcomes *a*, *b* and *c*, confirming that students have some difficulties concerning cognitive skills (i.e. difficulties in applying basic mathematical and scientific concepts that underlie the modern field of CE, and designing/conducting experiments and analyzing/interpreting experimental data). Moreover, the overall score for category III is also below average, but well above fair which could be considered admissible for a technical program.

Finally, the few comments recorded from faculty members interact well with those recorded from senior exit students, notably, concerning computer skills. Furthermore, observation about student achievement on the outcomes is consistent with students' performance (e.g. GPA) as expected.

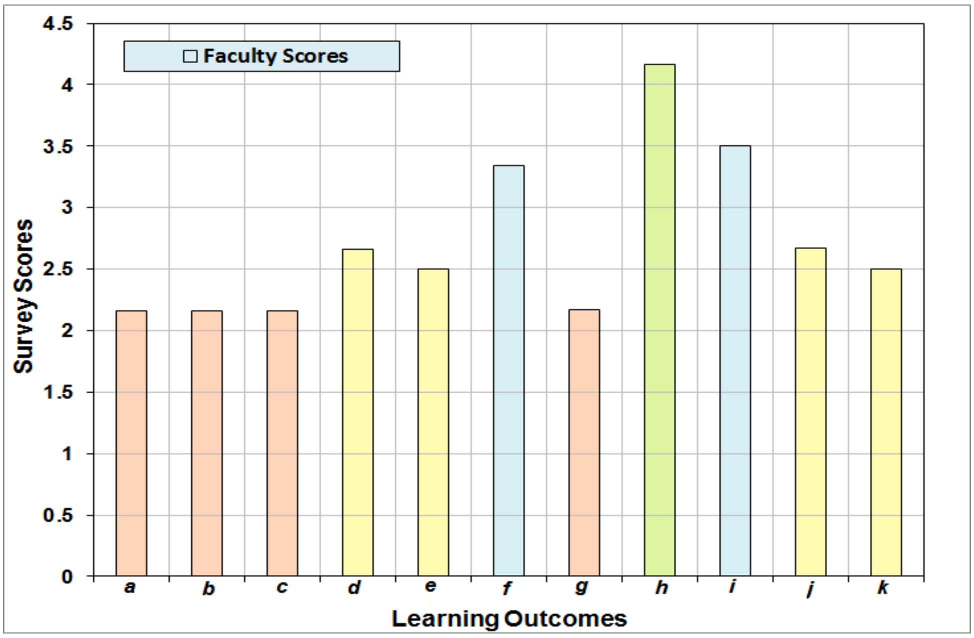

Figure 7: Scores of faculty survey about student learning outcomes

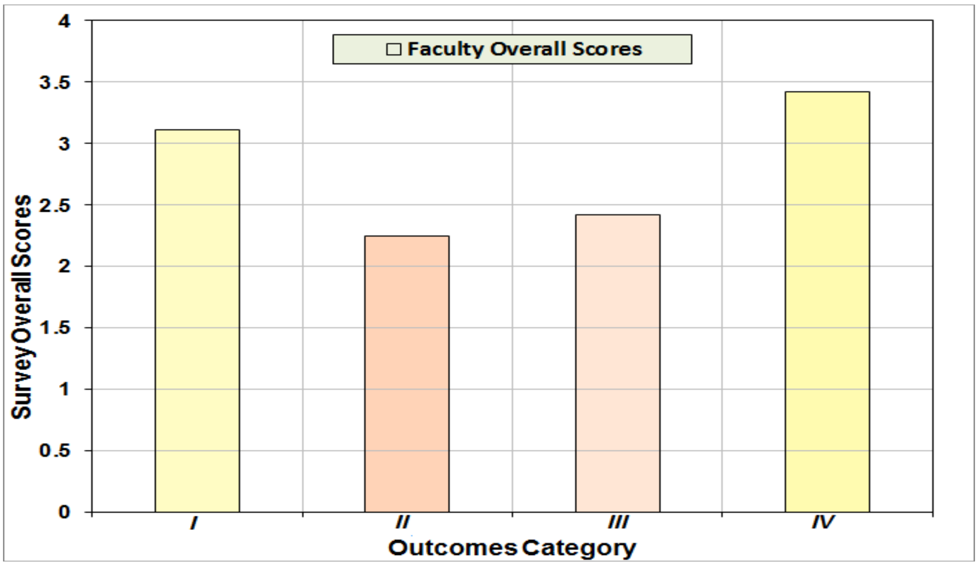

Figure 8: Overall scores of faculty per outcomes category

Table 5: Results of survey for Employer about student learning outcomes

	Outcomes Category	**LO**	**Students' Appreciation (%)**						**Partial**	**Overall**
			S(5)	M(3)	F(2)	W(1)	N(0)	UT	**Scores**	**Scores**
		h		100.0					3.0	2.7
I	Knowledge Skills	*i*	33.3	33.3	33.3				3.3	
		k			66.7	33.3			1.7	
		a			33.3	66.7			1.3	1.6
		b			50.0	50.0			1.5	
II	Cognitive Skills	*c*		33.3	33.3	33.3			2.0	
		e			66.7	33.3			1.7	
	Communication & Information	*d*	50.0	50.0					4.0	4.2
III	Tech. Skills	*g*	66.7	33.3					4.3	
	Interpersonal Skill &	*f*	33.3	66.7					3.7	3.3
IV	Responsibility	*j*		100.0					3.0	

S = strong, M = medium, F = fair, W = weak, N = none, UT = unable to tell& LO = Learning outcomes

Table 6: Results of faculty survey about student learning outcomes

	Outcomes Category	LO	Faculty Appreciation (%)						Partial Scores	Overall Scores
			S(5)	M(3)	F(2)	W(1)	N(0)	UT		
		h	66.6	16.7	16.7				4.16	
I	Knowledge Skills	*j*		66.7	33.3				2.67	3.11
		k		66.6	16.7	16.7			2.50	
		a		50	33.3			16.7	2.16	
		b		33.3	50	16.7			2.16	2.25
II	Cognitive Skills	*c*		50	33.3			16.7	2.16	
		e		50	50				2.50	
	Communication &	*d*		66.7	33.3				2.66	
III	Information Tech. Skills	*g*		16.7	83.3				2.17	2.42
	Interpersonal Skill &	*f*	33.4	33.3	33.3				3.34	
IV	Responsibility	*i*	50	16.6	16.7	16.7			3.50	3.42

S = strong, M = medium, F = fair, W = weak, N = none, UT = unable to tell & LO =

Figures 9 and 10 shows the average score of the whole constituent responses based on ABET and PMU CE outcomes, respectively. ABET Outcome *c* (*an ability to design a system, component, or process to meet desired needs*) has the lowest score relative to the other 10 outcomes. Also, based on the CE outcomes category, cognitive skill (Category II) has the lowest performance relative to the other three categories (Figure 10). As was discussed before, the cognitive skill is related to ability of students to apply the science and engineering concepts into design of actual CE components and systems.

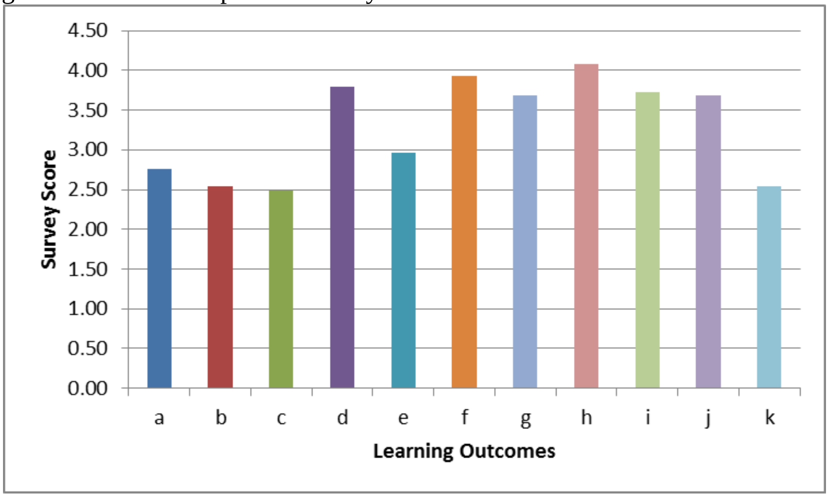

Figure 9: Average scores for learning outcomes

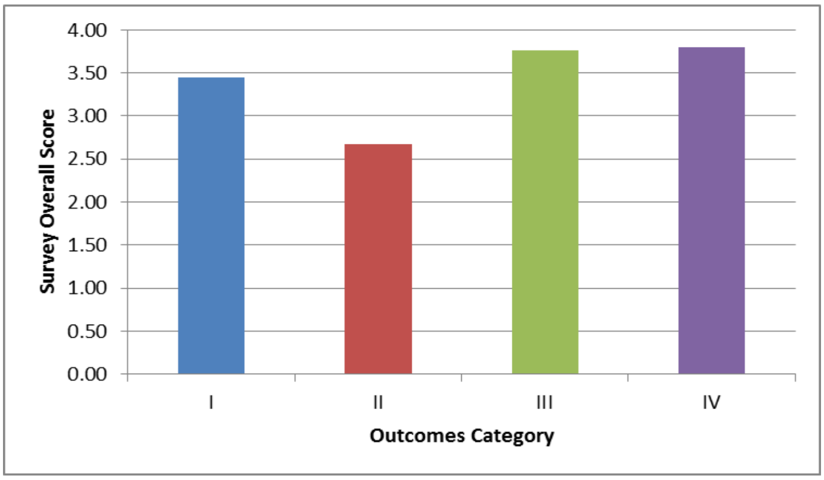

Figure 10: Average scores for outcomes category

This requires that students are supported with strong analysis and synthesis that are developed through conducting experiments, solving, designing and constructing components or systems and utilizing necessary engineering tools. Major causes for lack of cognitive skills could include: limited amount of time for students exposed to the actual engineering practices and resources such as laboratory experimentation, field experience observation, and case studies for actual problem solving. The issue is normally compounded with weak background students have in math and sciences. Typical results regarding cognitive skill issues were also experienced by academic institutions across the Gulf countries including Saudi Arabia [36-37].

In general to address this issue, teaching strategy and assessment at all course levels that are described in course specifications should be improved and aligned properly with the LOS [38]. Also, alignment of basic math courses with CE design courses needs to be revisited. Smooth transition between lower and upper math course needs to be reinforced.

Based on these observation and analysis, the CE curriculum has been upgraded recently to accommodate few of those issues. Amongst the key changes that have already been approved by the university curriculum council at PMU and will be operated in the next academic cycle, are as follow [7]: adding more hours for the capstone design project at the senior year and splitting it into two semesters, splitting introduction to engineering course into two semesters, adding more laboratory based courses including engineering drawing and lower level mechanics and computational based laboratories.

During a capstone project, students are required to undertake an entire design project; this process includes the developing a project idea and a proposal, collecting necessary data for the completion and implementation of the project, completing the design for the project, and preparing the final report. Students and faculty both reported that a regular semester period is not enough time to complete such projects effectively. As such, the learning objectives from the project are not adequately met. Therefore, it was proposed that Capstone Design Projects are divided into a period spanning across two semesters, which gives student the opportunity to develop the project idea, proposal, and collect data during the first semester. Then, complete the project design and formulate the final report during the second semester. Furthermore, this time extension allows students more time to interact with faculty and local industries while working on their Capstone Design Projects giving them hands-on experiences and realistic ideas that fit the current market needs.

Similarly, more laboratory based courses and the splitting of introduction to engineering courses allows student ample chance to thoroughly gain the necessary knowledge and skills needed for the successful attainment of program LOS. Especially since introduction to engineering courses are general courses that span over several engineering areas and concepts; students need to be able to conceptualize knowledge gained in those courses throughout the entire duration of their programs of study.

Conclusion and Implications

The purpose of this article was to measure and assess the quality of teaching and learning in a CE program at a relatively new university in the Kingdom of Saudi Arabia. The study utilized a survey designed to measure the level of achievement of program learning outcomes, which was administered to all program constituents including students, alumni, faculty, and employers.

The survey analysis results suggest that CE students achieved above average on most skills addressed in the program learning outcomes, however, their achievement with regard to cognitive skills was below average and needed to be improved. To address these issues, an expert panel of CE faculty and Curriculum Development experts was initiated for the purpose of reviewing the current curriculum in order to improve students' achievement of program learning outcomes; several program changes were proposed in order to address this issue.

While such research is usually performed for or by accreditation agencies, the study methodology and findings provide an in-depth experience for development of CE program in a developing country as well as the tools to evaluate the program performance towards enhancing the program's educational outcomes to meet national and international accreditation requirements. Furthermore, findings of this study provide future program developers, especially in developing countries, with a case study that emphasizes the importance of continuous measurement of the achievement of program learning outcomes.

Finally, further research is needed through redistribution of the survey after a few years in order to measure the effectiveness of the proposed changes and to assist in further program enhancements to guarantee that all program learning outcomes are achieved to the highest levels. Moreover, replication of this study in several other institutions can further validate the survey instrument used in this study, as well as the findings of this study.

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