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Evaluation of Student Learning Outcomes for Civil Engineering Program

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***Abstract*— Assessing students' understanding of curricular content at both the course and program levels relies heavily on student learning outcomes. Yet, a major obstacle in this process is the need to establish consistent and impartial evaluation methods. This paper aims to address this issue by proposing an assessment method to evaluate student learning outcomes within a civil engineering program. The primary focus of this study is on formative direct assessment, which will serve as a key parameter for analyzing and improving teaching and learning practices in the department. By presenting and utilizing the findings from the direct assessment, the study seeks to foster continuous enhancements in the educational processes to ensure better student outcomes and understanding in the field of civil engineering.**

***Keywords*— Civil Engineering; Course Learning Outcomes; Evaluation; Student Outcomes.**

***JEET Category*—: Practice**

I. INTRODUCTION

Student outcomes, also known as program learning outcomes or educational outcomes, are specific statements that define the knowledge, skills, and competencies students are expected to achieve by the end of an educational program. These outcomes serve as benchmarks for assessing student performance and academic achievements. By clearly articulating what students should know and be able to do, student outcomes guide curriculum development, teaching methods, and assessment strategies, ensuring a focused and effective learning experience. Institutions use student outcomes to evaluate the success of their educational programs and make continuous improvements to enhance student learning and overall academic quality.

The evaluation of students' learning outcomes is a critical aspect of educational assessment, ensuring that students attain the expected knowledge, skills, and capabilities within their respective disciplines. In the context of higher education, this evaluation involves measuring the extent to which students meet the stated learning outcomes and objectives of their courses or programs. Various assessment methods, such as examinations, assignments, projects, and performance evaluations, are employed to gauge students' proficiency in the desired areas (Angelo & Cross, 1993; Banta, Lund, Black, & Oblander, 1996; Popham, 2008). These evaluation processes play a pivotal role in guiding curriculum improvements, enhancing teaching practices, and ultimately, ensuring the quality of education and students' academic success (Suskie, 2004; Brown & Knight, 1994).

Learning outcomes in engineering education have become a key area of focus in recent years, aiming to ensure that engineering graduates possess the necessary knowledge and skills to excel in their professional careers. These outcomes serve as a set of well-defined statements that articulate the specific competencies expected of engineering students upon completing their programs. Assessment of learning outcomes in engineering involves evaluating students' abilities in problem-solving, critical thinking, technical proficiency, teamwork, and communication, among other essential skills (Crawley et al., 2007).

In higher education, there is a growing emphasis on clearly defined learning goals, as outlined in frameworks like the European Qualifications Framework (EQF). It has become evident that there is a need for effective ways to measure actual learning achievements (Caspersen, Frølich & Muller, 2017), a requirement highlighted by the Bologna Process and EQF in Europe, as well as increasing accountability trends globally (Stensaker & Sweetman, 2014).

Assessing what students have learned is considered crucial for evaluating the quality of educational institutions and programs. Douglass, Thomson, and Zhao (2012) argued that there is a global interest in precisely measuring learning outcomes to gauge the effectiveness of higher education institutions. They noted, "Government ministries, accrediting agencies, the media, and critics of higher education all seek a universal tool to measure learning outcomes, making comparisons across institutions, regions, and even countries" (Caspersen J, 2017). Various assessment techniques, such as performance-based exams, projects, lab work, internships, and capstone design projects, are employed to measure students' achievements in meeting the learning outcomes. This data-driven assessment process plays a crucial role in continuous

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improvement efforts, allowing engineering programs to align their curricula with industry demands, technological advancements, and emerging trends. By incorporating up-to-date research and industry feedback into the definition and evaluation of learning outcomes, engineering education can effectively prepare graduates for the challenges and opportunities of the modern engineering landscape. Moreover, the regular review and refinement of learning outcomes ensure that engineering programs remain relevant and responsive to the changing needs of society and the global workforce.

Educational institutions employ diverse assessment methods, such as problem-based learning, design projects, fieldwork, internships, and laboratory work, to measure students' achievements in meeting the learning outcomes. The continuous evaluation and refinement of these outcomes play a vital role in shaping civil engineering curricula to meet the demands of an evolving industry and address emerging societal challenges. Technology and the Internet have been extensively covered in the literature, serving as a channel for both direct and indirect evaluation as well as a tool for determining the extent to which students met learning objectives. (Mark A. Minott, 2023). According to El Marsafawy et al. (2022), learning outcomes are evaluated using learning management systems (LMS), such as Moodle, Blackboard, and Canvas. LMS was also used by authors like Rani (2020) to evaluate learning objectives. The online Learning Outcomes Assessment Management System (LOAMS), developed and implemented at UAEU, is highlighted by Ibrahim et al. (2022). While it provides a centralized approach to outcomes assessment, some faculty—particularly those less familiar with digital tools—require additional training and support.

Learning outcomes in civil engineering education have garnered increasing attention, aiming to ensure that graduates are equipped with the necessary knowledge and skills to excel in their professional careers. These outcomes serve as specific statements outlining the competencies expected of civil engineering students upon completing their academic programs. The assessment of learning outcomes in civil engineering involves evaluating students' abilities in various areas, including project management, transportation engineering, environmental engineering, geotechnical engineering, and structural analysis.

This study's main focus is on formative direct assessment, which will be used as a crucial metric to evaluate and enhance the department's teaching and learning strategies. Through the presentation and use of the results obtained from the direct assessment, the research aims to promote ongoing improvements in teaching procedures to guarantee improved student performance and comprehension in the area of civil engineering.

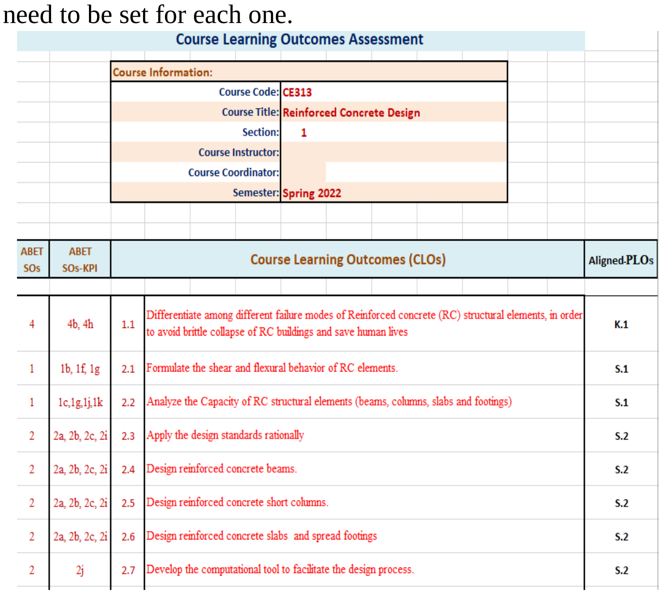
II. Student Outcomes

The Civil Engineering Department has adopted ABET Student Outcomes (SO) '1-7' (see Table I), which all Civil Engineering program students are expected to achieve before graduation. These outcomes refer to the essential skills and knowledge that students in engineering programs should acquire during their education. These outcomes typically encompass a range of abilities, such as problem-solving, technical competence, teamwork, and ethical considerations.

TABLE I
CE "1" TO "7" STUDENT OUTCOMES (SOs)

SOs Id	Student Outcomes (SOs) Description
1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
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.
3	An ability to communicate effectively with a range of audiences.
4	An ability to recognize 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.
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.
6	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

ABET sets these outcomes to ensure that graduates are well-prepared to enter the engineering profession with a strong foundation in various areas, fostering their ability to tackle real-world challenges and contribute effectively to the field of engineering. Throughout the program, the students study various courses to develop these skills. Nevertheless, in order to make all student outcomes measurable and applicable to the Civil Engineering curriculum, performance measures would need to be set for each one.


Course Learning Outcomes Assessment

Course Information:

Course Code:	CE313
Course Title:	Reinforced Concrete Design
Section:	1
Course Instructor:	
Course Coordinator:	
Semester:	Spring 2022

ABET SOs	ABET SOs-KPI	Course Learning Outcomes (CLOs)		Aligned-PLOs
4	4b, 4h	1.1	Differentiate among different failure modes of Reinforced concrete (RC) structural elements, in order to avoid brittle collapse of RC buildings and save human lives	K.1
1	1b, 1f, 1g	2.1	Formulate the shear and flexural behavior of RC elements.	S.1
1	1c,1g,1j,1k	2.2	Analyze the Capacity of RC structural elements (beams, columns, slabs and footings)	S.1
2	2a, 2b, 2c, 2i	2.3	Apply the design standards rationally	S.2
2	2a, 2b, 2c, 2i	2.4	Design reinforced concrete beams.	S.2
2	2a, 2b, 2c, 2i	2.5	Design reinforced concrete short columns.	S.2
2	2a, 2b, 2c, 2i	2.6	Design reinforced concrete slabs and spread footings	S.2
2	2j	2.7	Develop the computational tool to facilitate the design process.	S.2

Fig. 1. SO-CLO mapping for a specific course

III. Essential Elements of SO Assessment & Evaluation

Student outcomes (SOs) are routinely assessed and evaluated

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using a variety of techniques. This section of the study details these procedures as well as the outcomes that show how closely the SOs were met. Several fundamental components are necessary for the assessment and evaluation processes to function effectively. To make it easier for the reader to understand the entire procedure, it must be described. The following describes these crucial components.:

A. Course Learning Outcomes

All direct evaluations of SOs are based on course learning outcomes or CLOs. "Course Learning Outcomes," or CLOs, are a collection of outcomes specific to each course. The skills that must be acquired by the end of the course are outlined in the CLOs. Each course's CLOs are designed to be as brief and non-overlapping as feasible, while yet covering the course's prescribed syllabus. The curriculum committee is in charge of updating and changing the course descriptions (CLOs) by the course coordinators' suggestions. The CLOs are covered in the syllabus and given to students at the beginning of the semester in the Civil Engineering program. Fig. 1 displays a typical collection of CLOs for the course CE313 Reinforced Concrete Design.

B. Linking the CLOs with the SOs

The SOs that are obtained as a result of achieving the Course Learning Outcomes (CLOs) are connected to each course's CLOs. This suggests that a student's achievement in a given CLO corresponds to a skill in the pertinent SOs. We include a CLO if it materially aids in achieving a skill associated with an SO; otherwise, we exclude it. On the other hand, this enhancement has been scheduled for the future in light of the experiences with the ongoing procedures. A typical CLO-SO map for CE313 Reinforced Concrete Design is shown in Fig. 1

Since the CLO-SO-KPI mapping links SOs to the CLOs of different core courses, if the CLOs are satisfied with the necessary degree, the relevant SOs are also assumed to be satisfied with the required degree. This suggests that monitoring the achievement and contentment of CLOs over a range of courses is the most crucial aspect of our SO assessment procedure. Following the conversion of the CLO satisfaction data into SO-KPI satisfaction data, the SO score is determined by averaging the SO-KPIs. The main concept of the SO assessment procedure is illustrated in Fig. 2.

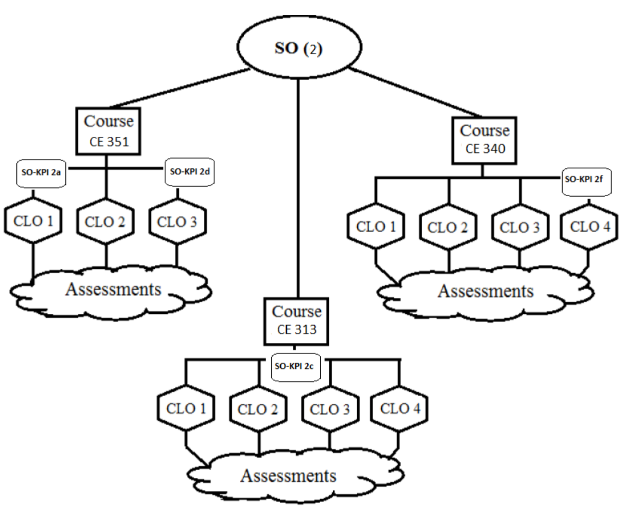

Fig. 2. The SO assessment linked to CLO assessment

C. SO Key Performance Indicators (SO-KPI)

According to ABET criteria 3, SOs are rather broad. They are so generic that any kind of engineering program has the same set of requirements. More detailed statements based on these SOs are required for a given program to assess the student's achievement. The Civil Engineering program's SO Key Performance Indicators (SO-KPI) were created with this goal in mind. Fig. 3 displays a common set of KPIs for SOs (1-2) as an example.

D. Courses Considered for Evaluation

Throughout the duration of the program, students in the Civil Engineering department gain the skills required by the compulsory SOs through a variety of courses. These courses cover a wide range of topic areas and are offered by different departments at different institutions. The assessment and evaluation provided here show that the attainment of Student Outcomes (SOs) is limited to the core courses of the program, which are managed by the Civil Engineering Department, including the Graduation Project.

The following courses are excluded from consideration in the SO evaluation processes:

- Courses that fulfill the requirements of the university
- Courses taught by other departments
- Courses available as electives for the Civil Engineering program

It must be underlined once more that all of the aforementioned courses, which are not considered when assessing the attainment of SOs, unquestionably enhance the skills associated with SOs. The following are the primary reasons why it is preferred to leave the above out of the assessment of SO attainment:

(1) As previously said, we shall show that all of the SOs have completed the necessary number of core courses in civil engineering to reach the necessary satisfaction level. As a result, evaluation of skills acquired in other compulsory courses and elective courses is not necessary.

1	**an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics**
1a	Identified mathematical and scientific terms appropriately in a given complex engineering problem
1b	Applied mathematical and scientific principles to formulate complex engineering problems
1c	Solved complex engineering problems using the concepts of integral calculus, differential calculus or linear algeb
1d	Applied knowledge of basic or natural sciences* to address engineering problems.
1e	Translated academic theory into engineering applications.
1f	Identified the relevant key issues or variables and formulated the problems in main technical areas of civil engineering**
1g	Used appropriate resources needed to solve complex engineering problems.
1h	Understood the problem as a whole and how various parts of the problem are related to each other.
1i	Recognized the need for multiple or alternate solutions.
1j	Analyzed alternative solutions to complex engineering problems.
1k	Used relevant computer applications or software necessary for modern engineering practice.
	*Natural sciences may include materials science, geology, biology and environmental science.
	**Technical areas of civil engineering include structural, geotechnical, environmental, transportation, water resources, construction, and surveying.
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**
2a	Recognized desired needs of an engineering system, component, or process.
2b	Identified realistic constraints in the categories noted in the outcome statement.
2c	Applied structural engineering and scientific principles to design a system, component, or process.

Fig. 3. Key Performance indicators (KPIs) for Student Outcomes

(2) Since the department does not oversee the administration of these courses, we may not be able to fully execute the improvement plans, and we may not have complete control over them to get accurate satisfaction data.

(3) Because not every student takes the same electives, it is preferred to omit the department's elective courses from the assessment of SO achievement. Because the SOs earned in different elective courses vary, the SOs earned in these courses do not accurately reflect the ability of all students. But just like with core courses, we also collect data for these elective courses.

(4) All of the SOs are covered, if not equally, by the program's core courses, which are utilized to evaluate SO attainment. Fig. 4 displays a list of all core courses aligned with the relevant SOs by using KPIs. The KPIs considered for the assessments in particular courses are shown in Fig. 5. Each KPI, associated with a SO, is assessed, and the average of these KPIs determines the overall score for the SO.

E. KPI Satisfaction Criterion

The "KPI Satisfaction Criterion" is a crucial component of the SO assessment and evaluation procedure. It outlines the proportion of students who, as indicated by their percentage of marks in each SO-KPI, must reach a particular level of proficiency. Each rubric contains a set of Key Performance Indicators (KPIs) with the following scoring/rating system.

1 = Unsatisfactory (no evidence of work towards the outcome)

2 = Developing (work that does not meet expectations for a CE candidate)

3 = Proficient (work that meets expectations for a CE candidate)

4 = Excellent (work that exceeds expectations for a CE candidate)

If the satisfaction level for a SO in a course is lower than the Satisfaction Criterion (specified by the department), it will trigger the alarm for the instructor, and a “Course Continuous Improvement Plan” (CCIP) must be written and implemented by the instructor.

The target satisfaction criterion of KPI is now stated as follows:

% of students with score of '3 & 4' $\geq$ 70% and/or % of students with score of '1' $\leq$ 10%

F. SOs Satisfaction Criterion

The SO Satisfaction Criterion is considered met when the achievement of Student Outcomes (SOs) reaches a threshold of 70%. This threshold ensures that at least 70% of the SO-KPIs are successfully achieved. If the satisfaction rate falls below this threshold, it indicates a need for improvements in the teaching strategies to better support student’s understanding.

G. CLO-SO Assessment Excel Application

The department decided to use the Excel application dashboard to achieve the following goals:

- To reduce the amount of time and effort that the instructor must spend organizing the course file and gathering data.
- To make the data gathered more dependable.
- To enable the department to examine and evaluate all courses within a week of receiving the data files from the teachers by enabling error-free processing of vast amounts of data.
- To get the faculty's input on several matters that could enhance the CLO and SO attainments.
- To recognize any problematic courses and implement corrective action.
- To give the department chairman and the ABET coordinator the opportunity to review the SO/CLO attainments and "Loop-closing" at the end of each semester or year.

IV. Assessment Processes Summary

The assessment processes can be divided into two categories, direct and indirect measurement, to measure the level of achievement of Student Outcomes (SOs).

Through a variety of procedures, the accomplishment of SOs is continuously examined and appraised. The assessment method itself is always being enhanced. As of right now, the system has attained a very high degree of sustainability and stability, and the department has been successful in reducing the amount of time that instructors must spend organizing their course materials and doing data analysis. It is important to remember the following two points to comprehend the assessment processes:

(1) Reliance on a small number of "SO-based" questions in a subset of courses proved ineffective for the direct assessment procedure. All key courses must have complete data to make decisions that will enhance things. We allow the instructor to concentrate on the CLOs for accurate assessment of the course CLOs because they are more focused on the "Course Learning Outcomes" (CLOs) and naturally plan to assess the CLOs of the course and consider students' attainment of the CLOs of the course as the major responsibility. The SO-KPI can then be evaluated with CLO-based data using the previously mentioned course map.

(2) The foundation of the Formative Assessment's philosophy is the understanding that students' skills at graduation represent their capacities, not only the skills they have shown in certain courses. All prerequisite core courses serve as a means for students to achieve the SOs. As a result, students' progress toward achieving SOs is indicated by the data from the Formative Assessments, which serve as a representation of the caliber of instruction and learning.

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Course Code	Course Name	Student Outcomes						
		1	2	3	4	5	6	7
CE210	Civil Engineering Materials	1b 1d			4g		6a 6c	
CE213	Civil Engineering Materials Lab.	1a		3b 3c	4c	5a	6b 6c	
CE221	Engineering Surveying	1a 1b 1c		3a 3b 3c	4c	5a 5b	6b 6c 6d	
CE211	Solid Mechanics	1a 1b 1c 1e 1j						
CE231	Fund. of Env. Engineering	1a 1b 1d 1e 1f 1h 1i	2a 2g		4e 4g 4h			
CE241	Fluid Mechanics	1a 1b 1c 1d 1f	2c 2f					
CE251	Geology for Engineers	1d						
CE310	Concrete Properties	1d 1j	2i	3a 3b 3c	4f 4g 4i 4j		6a 6b 6c	
CE311	Structural Engineering	1a 1b 1c 1d 1e 1f 1h 1i 1j						7a 7b
CE313	Reinforced Concrete Design	1b 1c 1f 1g 1k	2a 2b 2c 2i 2j		4b 4h			
CE321	Transportation Engineering	1b 1j	2a 2e		4e 4f 4g		6c 6e	
CE322	Transportation Engineering Lab.	1g 1h		3a 3b 3c	4c 4g	5a 5b	6a 6b	
CE331	Environmental Eng. Processes	1a 1b 1d	2a 2b 2g 2h 2i		4f 4g			
CE332	Environmental Engineering Lab.	1a 1b 1d 1f		3a 3b 3c	4c	5a 5b	6b 6c 6d 6e 6f	
CE340	Water Resources Engineering	1b 1c 1i 1k	2f 2h	3a 3b				
CE344	Water Resources Engineering Lab.			3a 3b	4c	5a	6b 6c	
CE351	Geotechnical Engineering	1b 1d 1f 1g 1h			4f		6c	
CE352	Geotechnical Engineering Lab.			3b	4c	5a	6b 6c	
CE411	Steel Structures	1c 1f 1g 1h 1i 1j	2a 2b 2c 2i		4f			
CE421	Transportation Facility Design		2a 2e		4e 4f 4g		6c 6e	
CE422	Civil Engineering Systems	1b 1c 1f 1j 1k	2h 2j					7a
CE451	Foundation Engineering	1d 1g	2a 2d				6c	7a 7b
CE461	Construction Eng & Mgnt	1c	2a	3e	4a			7b
CE462	Const. Contracts & Specs.	1e	2a	3d	4a			7a
CE491	Graduation Project-I	1a 1b 1c 1d 1e 1f 1g 1h 1i 1j 1k	2a 2b 2c 2d 2e 2f 2g 2h 2i 2j	3a 3b 3c 3d 3e	4c 4d 4f 4i 4j	5a 5b		7a 7b
CE492	Graduation Project-II	1a 1b 1c 1d 1e 1f 1g 1h 1i 1j 1k	2a 2b 2c 2d 2e 2f 2g 2h 2i 2j	3a 3b 3c 3d 3e	4c 4d 4f 4i 4j	5a 5b	6c	7a 7b
GE201	Statics	1a 1b 1c 1k						
GE302	Prof. Ethics for Engrs.				4a 4b 4c 4d			
GE399	Engineering Training			3a 3b 3c 3d 3e	4c			

Fig. 4. Mapping between courses and SOs by using KPI

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
2a	Recognized desired needs of an engineering system, component, or process.
Where Enabled:	CE231 CE313 CE321 CE331 CE411 CE421 CE451 CE461 CE462 CE491 CE492
Where Assessed:	CE451
When Assessed:	
Assessed By:	
2b	Identified realistic constraints in the categories noted in the outcome statement.
Where Enabled:	CE313 CE331 CE411 CE491 CE492
Where Assessed:	CE331
When Assessed:	
Assessed By:	
2c	Applied structural engineering and scientific principles to design a system, component, or process.
Where Enabled:	CE241 CE313 CE411 CE491 CE492
Where Assessed:	CE313
When Assessed:	
Assessed By:	
2d	Applied geotechnical engineering and scientific principles to design a system, component.
Where Enabled:	CE451 CE491 CE492
Where Assessed:	CE451
When Assessed:	
Assessed By:	
2e	Applied transportation engineering and scientific principles to design a system, component.
Where Enabled:	CE321 CE421 CE491 CE492
Where Assessed:	CE421
When Assessed:	

Fig. 5. Course-KPI mapping

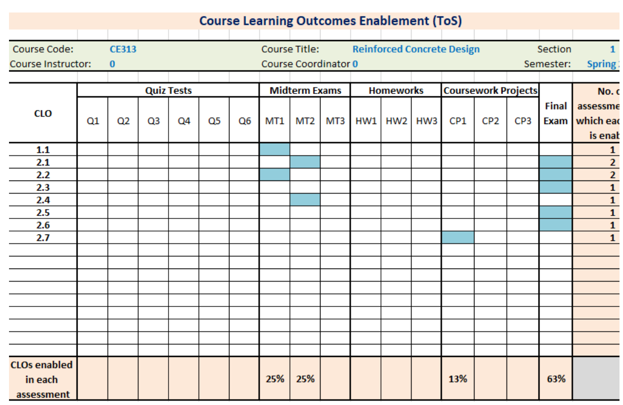

Fig. 6. Assessment-CLO mapping for a specific course

The students' graduation projects from the last year serve as examples of the SOs. Numerous SOs are addressed in the graduating projects. Because of this, we refer to the evaluation of the graduation project as a "summative assessment."

In Table II, these procedures are outlined. To provide the reader with a rapid overview of the processes, a brief description of each step is provided after the table. The subsequent sections contain the specifics of these procedures.

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TABLE II
SUMMARY OF SO-ASSESSMENT PROCESS

SO Assessment Process	Type	Frequency	Data Collected By
Formative assessment	Direct	Every Semester	Instructor
Summative Assessment	Direct	Every Semester	Advisor and Project committee

A. Formative Assessment

The instructor gathers course assessment data for each course in an established format. All necessary analysis and assessment data are generated by the CLO_Assessment Excel application. Additionally, it generates a few tables that are needed to finish the course file. The Accreditation Committee examines and assesses the combined results. The CLO_Assessment Excel application handles all data processing, which has been verified by cross-referencing its results with calculations performed manually in two distinct college departments. Therefore, data entry and collection are critical to ensuring the dependability of the direct course assessment and evaluation system. The next parts outline the information that the instructor will gather throughout the whole semester.

B. Assessment Plan

A SO assessment plan for the courses they are teaching must be developed and shared with the students within the first week of instruction. This is the initial requirement for all instructors. This plan aims to make students more aware of the SOs that are important to the course and to remind the faculty of the significance of SO assessment. This aids the instructor in considering relevant SOs when creating an evaluation for CLOs. Additionally, it assists students in focusing on the skills they will need to have when they graduate.

C. Assessment Contribution Data

The following features define an assessment for data input to an Excel sheet:

- The name that the instructor assigns to the assessment
- the raw marks that are utilized to grade it
- Actual marks out of 100 that the assessment receives toward the final grade

D. CLO Marks Allocation Data

Monitoring the CLO marks allocation data is a crucial step in the procedure. The marks given to each question and the CLO that each question addresses must be specified by the instructor for each assessment. Certain assessments, such as quizzes, only cover one CLO; however, other assessments, such as the final exam and other exams (like the "Mid-term" test), have questions covering multiple CLOs.

However, if an assessment is a “Multiple CLO Assessment”, the questions in the exam are linked with different CLOs. In this instance, it is necessary to record the grades that students receive for every question that is part of each CLO. In these situations, gathering the data can be a little tiring for the instructor, but there's no other way to find out how the students are doing in a specific CLO, which then indicates how they're doing in the corresponding SOs. Fig. 6 illustrates the mapping between assessments and Course Learning Outcomes (CLOs) for a specific course. The CLO is aligned with SO-KPI, which will be used to evaluate the corresponding Student Outcome (SO).

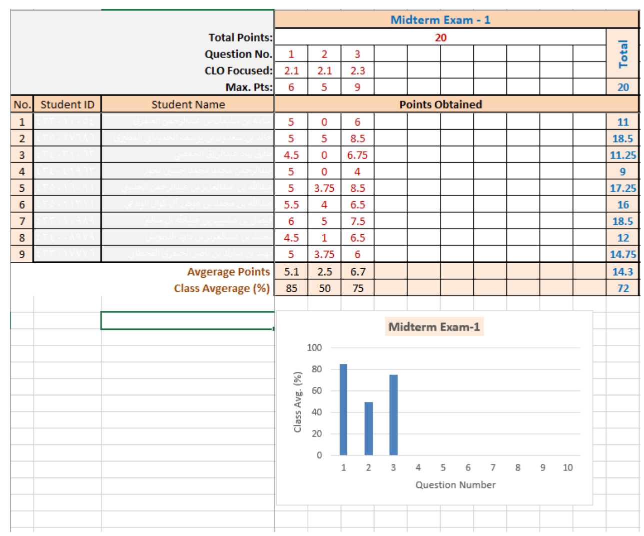
E. Assessment Data

Among the records that a teacher constantly keeps are the learner's assessment scores. The CLO-wise recording of assessment marks is required by the Civil Engineering Program Evaluation and Assessment system. The data input for the assessment data is shown in Fig. 7. It's noteworthy to note that as soon as the instructor enters the data, the analysis of the two types appears quickly. Through these analyses, the instructor can make necessary adjustments to improve the learning outcomes by staying updated on the student's performance.

F. Evaluation of SO Attainment through Core Courses

The CLO_Assessment Excel application analyzes the assessment data that has been gathered for each course. Two kinds of outcomes are obtained

1) CLO Satisfaction Results: The Excel program examines each examination to ascertain the proportion of students who meet the CLO satisfaction threshold. An example of CLOs data is shown in Fig. 8.



		Midterm Exam - 1			
	Total Points:	20			
	Question No.	1	2	3	Total
	CLO Focused:	2.1	2.1	2.3	
	Max. Pts:	6	5	9	20
No.	Student ID / Student Name	Points Obtained			
1		5	0	6	11
2		5	5	8.5	18.5
3		4.5	0	6.75	11.25
4		5	0	4	9
5		5	3.75	8.5	17.25
6		5.5	4	6.5	16
7		6	5	7.5	18.5
8		4.5	1	6.5	12
9		5	3.75	6	14.75
	Avgerage Points	5.1	2.5	6.7	14.3
	Class Avgerage (%)	85	50	75	72

Fig. 7. Data input for assessment

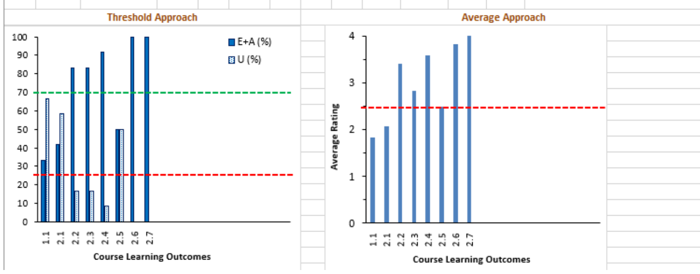
2) SO Satisfaction Results: SO-KPI satisfaction is conducted via the Excel application and calculates the proportion of students who meet the program satisfaction criteria for the applicable SO-KPI for the course. After getting the result of SO-KPIs, SO is calculated as an average of these SO-KPIs. A typical example of SO-2 is shown in Fig. 9, displaying the average of KPIs used for the assessment of this Student Outcome.

Course Learning Outcomes Assessment Summary

Course Code: CE313 Course Title: Reinforced Concrete Design Sectior 1

Course Instructor: 0 Semester: Spring 2023

CLO	Relation to ABET SOs	Relation to ABET SOs-KPI	Avg. Rating	E (%)	A (%)	M (%)	U (%)	E+A (%)	Summary Analysis	Action Plan to improve the performance
1.1	4	4b, 4h	1.8	17	17	0	67	33	Action needed	Re-assessment of students with weak CLOs or weak SOs aft
2.1	1	1b, 1f, 1g	2.1	25	17	0	58	42	Action needed	Providing students with solutions of problems related to pa
2.2	1	1c,1g,1j,1k	3.4	75	8	0	17	83	Outcome achieved	
2.3	2	2a, 2b, 2c, 2i	2.8	17	67	0	17	83	Outcome achieved	
2.4	2	2a, 2b, 2c, 2i	3.6	75	17	0	8	92	Outcome achieved	
2.5	2	2a, 2b, 2c, 2i	2.5	50	0	0	50	50	Action needed	Providing students with solutions of problems related to pa
2.6	2	2a, 2b, 2c, 2i	3.8	83	17	0	0	100	Outcome achieved	
2.7	2	2j	4.0	100	0	0	0	100.0	Outcome achieved	



Rating Criterion: *Excellent, E ≥75 (4), Adequate, A=65-74% (3), Minimal, M=60-64% (2), Unsatisfactory, U<60% (1)*

Outcome Achieved: *Students with Excellent+Adeqaute performance ≥ 70% and unsatisfactory perfromance ≤ 25%*

Fig. 8. CLO Satisfaction Results

Assessment Summary

Academic Year:2021-2022

Student Outcome (2) or PLO (S.2)	Average Score (Out of 4)	% of students with score "1"	% of students with score "3 & 4"	KPI Result
2a	3.60	0.00	100.00	Achieved
2b	3.78	0.00	100.00	Achieved
2c	3.43	0.00	71.40	Achieved
2d	3.31	0.00	76.90	Achieved
2e	3.00	0.00	100.00	Achieved
2f	3.85	0.00	92.30	Achieved
2g	3.07	6.70	73.30	Achieved
2h	3.20	0.00	80.00	Achieved
2i	3.58	8.30	91.70	Achieved
2j	3.57	7.10	92.90	Achieved
SO(2)	3.44	2.21	87.85	ACHIEVED

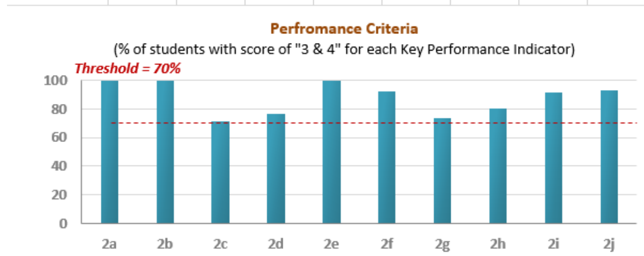


Fig. 9. SOs Satisfaction Results

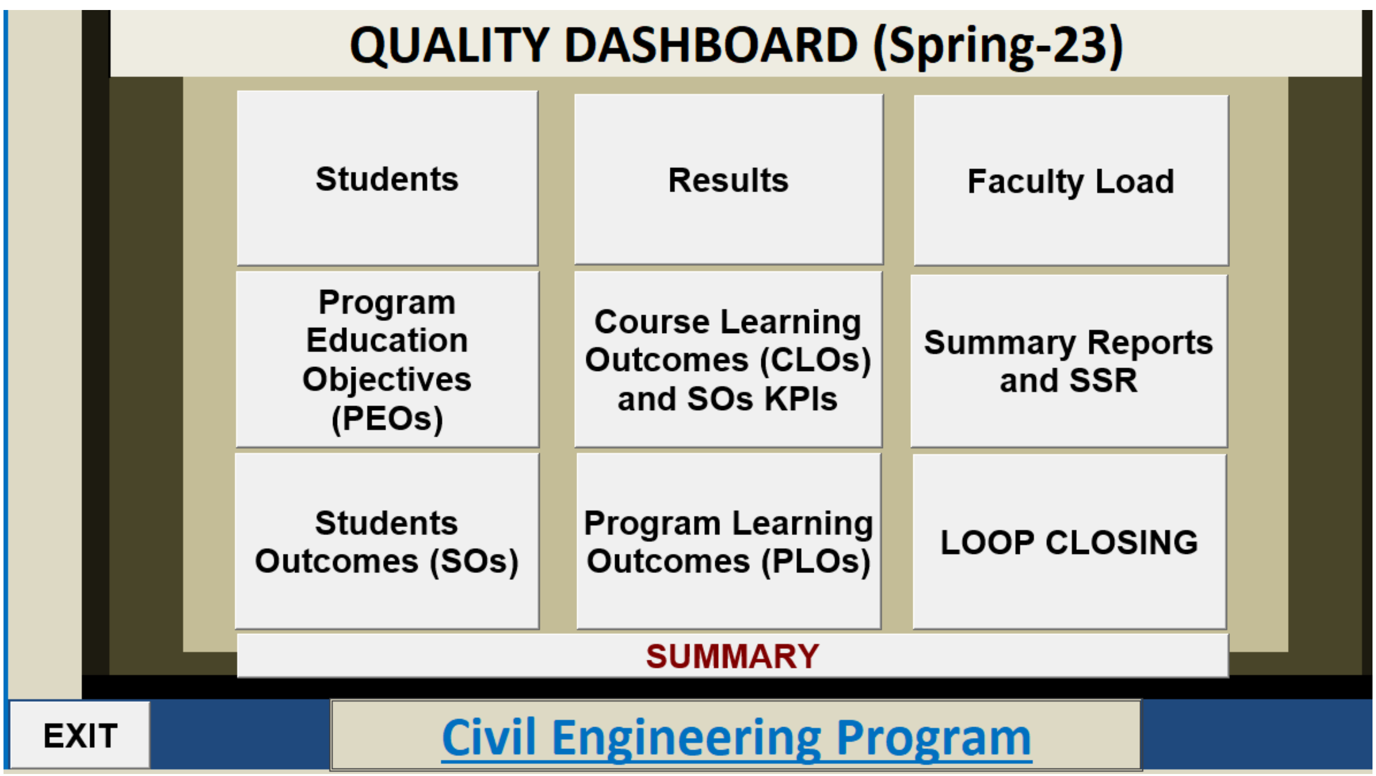


Fig. 10. Quality dashboard for visualization

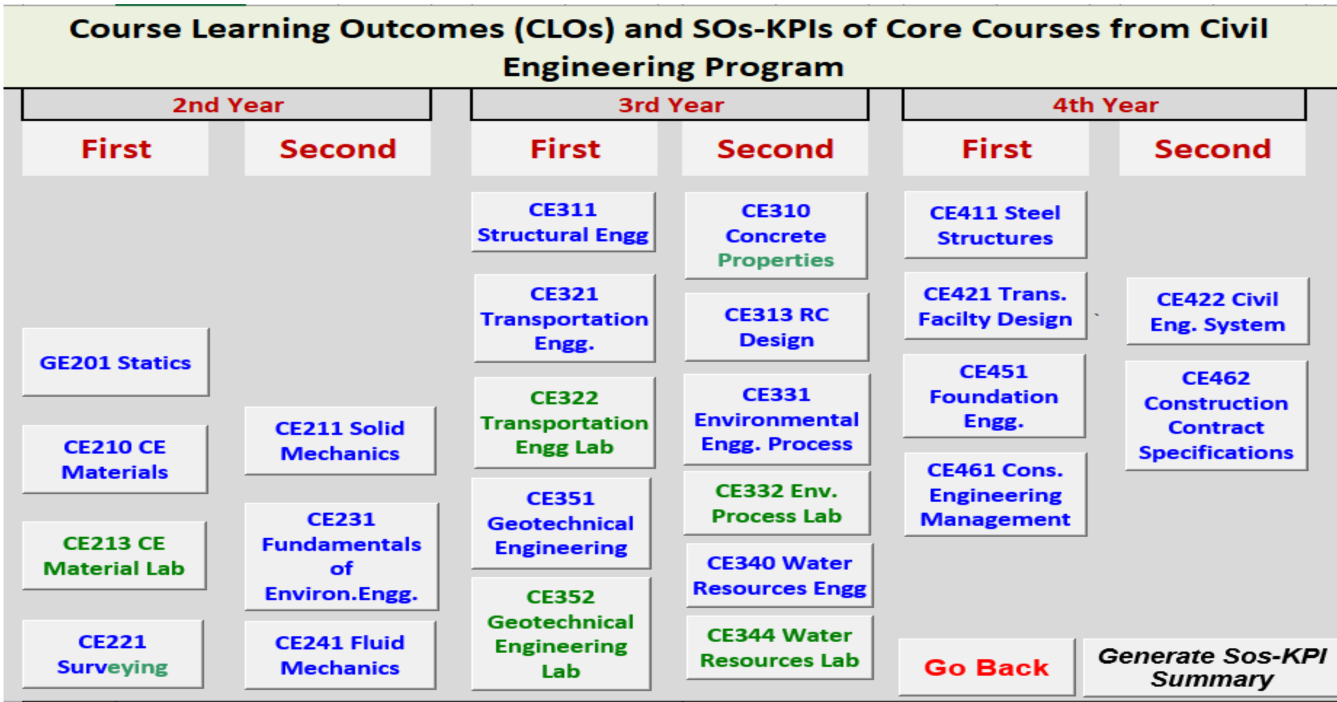


Fig. 11. Visualization of CLOs for all courses

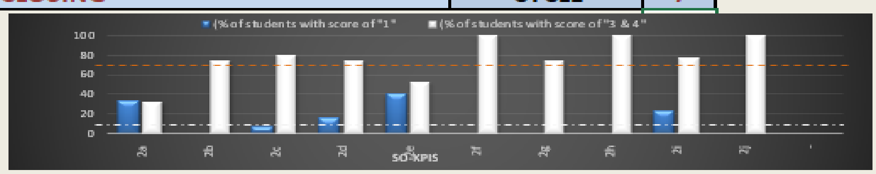
Student Outcomes, Civil Engineering Department, IMSIU | **Go Back**

LOOP CLOSING | **CYCLE** 7

SO-ID: 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

Save Report



KPI-Code	KPI-Statement	Results from CYCLE-6 (10, 70)	At the start of the semster, was an improvement plan avaialble that addressed this SO-Kpi?	Who was responsible for implementing the improvement plan?	Was the improvement plan implemented while teaching this course?	How good was the improvement in SO-KPI satisfaction?	Results from CYCLE-7 (10, 70)	Was the loop closed?	Action Plan for Next Cycle
2a	Recognized desired needs of an engineering system, component, or	0 , 100	No	Not Applicable	Not Applicable	Satisfaction went down,Satisfaction	33.33 , 33.33	NO	Required
2b	Identified realistic constraints in the categories noted in the outcome statement.	0 , 100	No	Not Applicable	Not Applicable	Satisfaction criterion was met	0 , 75	Yes	-
2c	Applied structural engineering and scientific principles to design a system, component, or process.	0 , 71.4	No	Not Applicable	Not Applicable	Satisfaction criterion was met	6.7 , 80	Yes	-
2d	Applied geotechnical engineering and scientific principles to design a system, component.	0 , 76.9	No	Not Applicable	Not Applicable	Satisfaction criterion was almost achieved	16.7 , 75	Yes	-
2e	Applied transportation engineering and scientific principles to design a system, component.	0 , 100	No	Not Applicable	Not Applicable	Satisfaction went down,Satisfaction criterion was not met	40 , 53.3	NO	Required
2f	Applied water resources engineering and scientific principles to design a system, component or process.	0 , 92.3	No	Not Applicable	Not Applicable	Very good. Satisfaction criterion was met	0 , 100	Yes	-
2g	Applied environmental engineering and scientific principles to design a system, component or process.	6.7 , 73.3	No	Not Applicable	Not Applicable	Satisfaction criterion was met	0 , 75	Yes	-
2h	Considered technically feasible alternative solutions, compared the alternative solutions, and recommended one of the solutions.	0 , 80	No	Not Applicable	Not Applicable	Very good. Satisfaction criterion was met	0 , 100	Yes	-
2i	Recognized practical significance of design outcome or result.	8.3 , 91.7	No	Not Applicable	Not Applicable	Satisfaction criterion was almost achieved	23.1 , 76.9	Yes	-
2j	Developed practical tools" to solve engineering problems.	7.1 , 92.9	No	Not Applicable	Not Applicable	Very good. Satisfaction criterion was met	0 , 100	Yes	-
-	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

Satisfaction Criterion: % of students with score of '3 & 4' ≥ 70% and % of students with score of '1' ≤

Fig. 12. Loop closing for continuous improvement plan

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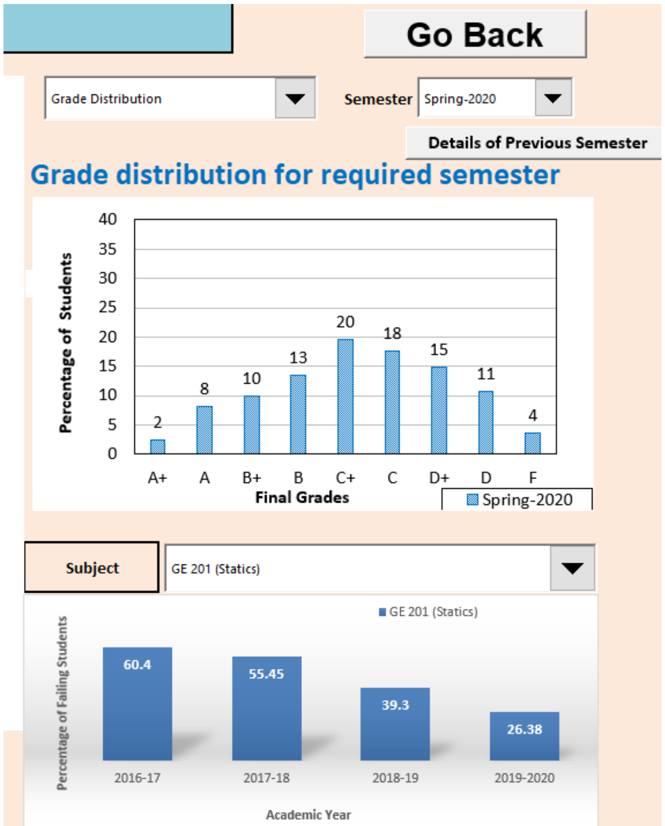

Fig. 13. Grade distribution for the required semester

V. Data Visualization and Analysis for Course Assessments by Excel Application Dashboard

The procedure begins with the submission of all data input files to the coordinator. An Excel application, developed by the author, is then used to visualize various components of the data. Fig. 10 displays the main menu of the Excel application, which offers features including student grade variation with semesters, faculty workload tracking, program educational objectives, summary reporting, grade visualization, Course Learning Outcome (CLO) assessments across all courses, and loop-closing mechanisms for continuous improvement. Fig. 11 highlights all the core courses in the program, with green indicating lab courses, blue representing theory courses, and a combination of green and blue signifying courses that integrate both lab and theory components. Clicking on any course button displays the corresponding Course Learning Outcomes (CLOs) assessment, Student Outcome-Key Performance Indicators (SO-KPIs) result, and their associated action plans. This comprehensive system provides a clear representation of data visualization and analysis for all courses within the program framework. Additionally, Fig. 12 demonstrates the loop-closing mechanism for the continuous improvement plan. By clicking the “Results” button in the main menu, the Civil Engineering program's results are displayed (See Fig. 13). Users can select a specific semester to view the grade distribution and identify critical courses with high failure percentages. Additionally, the application provides a comparison of failure percentages for the selected semester against previous semesters, offering valuable insights for analysis.

VI. Impact of Implementation

After the implementation of the Excel-based CLO-SO assessment tool, a significant reduction in student failure rates was observed. Specifically, the failure percentage decreased from 55.45% in the semester before implementation (Spring 2017–18) to 26.38% post-implementation (2019–2020), as shown in Fig. 13. This improvement reflects better curriculum alignment, early identification of learning gaps, and more targeted instructional strategies facilitated by the tool’s structured assessment framework. Additionally, the time required to prepare course files has been reduced from approximately 3 hours to just 1 hour, demonstrating the Excel Application’s effectiveness in streamlining documentation and reporting processes.

VII. Limitations and Future Work

The Excel Application requires manual data entry, which is common across most assessment tools currently used in the market. While this process demands faculty time and attention, it allows for flexibility and control over the data.

A key advantage of the Excel Application is its compatibility with institutional Learning Management Systems (LMS) like Blackboard. Because the Excel Application follows the same formatting standards as the LMS gradebook, assessment results can be easily downloaded from Blackboard and uploaded into the Excel Application, or vice versa. This streamlined data exchange reduces the risk of errors and simplifies the assessment workflow.

However, despite this compatibility, direct automated integration between the Excel Application and LMS platforms is not yet available, and achieving full automation remains a future objective to further enhance efficiency.

Concluding Summary

Through a meticulous mapping of Course Learning Outcomes (CLOs) against Student Outcomes (SOs), the development process ensured a cohesive and well-aligned curriculum. These mapping tables played a pivotal role in thoroughly reviewing and updating the curriculum while also serving as a valuable tool in the assessment processes of CLOs and Student Outcomes (SOs). As a result, this process fostered a culture of continuous improvement and academic excellence within the Civil Engineering program.

The newly developed Excel sheet for Student Outcomes (SO) and Course Learning Outcomes (CLO) assessment represents a valuable and efficient tool for evaluating the alignment and attainment of learning objectives within our academic programs. This tool streamlines the assessment process, providing a structured framework to assess the extent to which CLOs are aligned with the desired Student Outcomes (SOs). By using this Excel sheet, faculty members and academic administrators can easily track and analyze the performance of each CLO against the corresponding Student Outcomes (SO), gaining valuable insights into the effectiveness of our curriculum and teaching methodologies.

Furthermore, the Excel sheet allows for a systematic and data-driven approach to measuring student achievements, providing quantitative evidence of learning outcomes, and enabling evidence-based decision-making to enhance the educational experience. The Excel Application facilitates continuous improvement efforts, as faculty can identify areas for potential refinement and make informed adjustments to the curriculum to better align with program goals and industry demands. Overall, the Excel sheet for CLO and Student Outcomes (SO) assessment serves as a valuable resource to ensure that our academic programs remain relevant, rigorous, and aligned with the institutional mission and goals. Its user-friendly interface and comprehensive data analysis capabilities empower our faculty and administration to maintain high academic standards, fostering a culture of excellence and innovation in teaching and learning at our institution.

Moreover, the Excel Application provides quantitative insights that support accreditation requirements while significantly reducing the administrative burden associated with outcomes assessment. This approach serves as a practical, scalable, and cost-effective model that can be replicated by other ABET-accredited programs seeking to streamline their assessment processes. While a direct comparison with commercial assessment platforms was not conducted due to limited access, the Excel Application's flexibility, ease of customization, and lack of licensing requirements make it particularly suitable for programs operating under budgetary or technical constraints.

Note: All kinds of data and Excel spreadsheets will be provided on Demand

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