Implementing a Direct Assessment Strategy for Outcome-Based Education in Computer Engineering: A Case Study

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Abstract
This article introduces an innovative approach designed to elevate the students in the context of Outcome-Based Education (OBE). Our method is tailored to overcome the constraints associated with current assessment methodologies, offering a streamlined, all-encompassing, accurate, and insightful framework. Our study addresses the limitations of traditional direct assessment in Outcome-Based Education (OBE) by proposing a novel, data-driven approach that prioritizes efficiency, comprehensiveness, and insightful evaluation. We introduce a weighted framework that classifies course materials, prioritizes Course Learning Outcomes (CLOs), and assigns different attainment levels for modules. This allows for a streamlined final exam-based assessment with consistent rubrics, culminating in a comprehensive Student Outcome Achievement (SO%) score. Our case study in a computer engineering program demonstrates successful implementation, improved learning outcomes, and valuable insights for continuous improvement. This research paves the way for a more effective and impactful OBE assessment strategy, ultimately enhancing student learning and program accreditation.Harnessing the latest developments in educational technology and pedagogical strategies, our contribution seeks to advance the realm of OBE, nurturing ongoing enhancements in the field of education.

Keywords: Student outcome assessment, Outcome Based Education, Assessment methodology, Assessment metrics, Continuous improvement, Educational Quality

Introduction
Outcome-Based Education (OBE) is an educational philosophy that focuses on the learning outcomes that students are expected to achieve. In OBE, the curriculum is designed around these outcomes, and instruction is focused on helping students acquire the knowledge, skills, and abilities necessary to meet them (Harden 2002, Ammar *et.al.* 2021, Pee *et.al.* 2006, Lee *et.al.* 2015).

OBE emerged in the 1970s as a response to the perceived shortcomings of traditional education, which was seen as being too focused on content and not enough on results. OBE proponents argue that it is a more effective way to prepare students for the demands of the 21st century workforce, as it emphasizes the development of critical thinking, problem-solving, and teamwork skills (Lee *et.al.* 2018, Rattanamanee *et.al.* 2020, Piirainen *et.al.* 2013, Lakshmi 2014).

OBE has been implemented in a variety of educational settings, including schools, colleges, and universities. There is some evidence that it can be effective in improving student learning, but more research is needed to confirm these findings. The following are some of the key features of OBE (Kneale 2018, Harden 2007, Ayadat *et.al.* 2020, Alzubaidi 2017):

1. Focus on learning outcomes: OBE starts with a clear definition of the learning outcomes that students are expected to achieve. These outcomes are then used to guide the design of the curriculum and instruction.

2. Assessment of learning outcomes: OBE requires that student learning be assessed in a variety of ways, so that teachers can get a comprehensive picture of their progress.

3. Flexibility: OBE allows for flexibility in how the curriculum is delivered and how students demonstrate their learning. This can help to meet the needs of different learners.

4. Continuous improvement: OBE is a continuous improvement process. The learning outcomes are regularly reviewed and updated, and the curriculum and instruction are adjusted accordingly.

OBE is a relatively new approach to education, and there is still much that we do not know about it. However, it has the potential to be an effective way to improve student learning. Some of the latest research directions in Outcome Based Education (OBE) (Blouin *et.al.* 2018, Akdemir *et.al.* 2020, Shumway *et.al.* 2003, Gunarathne *et.al*. 2019):

1. The use of technology to support OBE. Technology can be used to help educators develop and deliver OBE-aligned instruction, as well as to assess student learning outcomes. For example, virtual learning environments can be used to provide students with access to learning resources and activities that are tailored to their individual needs. Additionally, learning analytics can be used to track student progress and identify areas where they need additional support.

2. The role of assessment in OBE. Assessment is essential to OBE, as it is used to measure student learning outcomes. However, there is a growing body of research that suggests that traditional forms of assessment, such as multiple-choice tests, may not be the best way to measure all types of learning outcomes. For example, performance assessments, such as projects and presentations, can be more effective at measuring higher-order thinking skills.

3. The impact of OBE on student learning. There is some evidence that OBE can have a positive impact on student learning. For example, a study by the American Institutes for Research found that students in OBE schools were more likely to meet or exceed state standards than students in traditional schools. However, more research is needed to confirm these findings.

4. The challenges of implementing OBE. OBE can be a challenging approach to education to implement, as it requires a significant change in the way that teachers teach, and students learn. Some of the challenges of implementing OBE include: The need for clear and well-defined learning outcomes, The need for a variety of assessment methods, The need for teacher training and support, and the need for school-wide buy-in.

Despite the challenges, OBE is an approach to education that has the potential to improve student learning. Future research should focus on developing and implementing OBE in ways that address the challenges and maximize its benefits. The field of OBE is constantly evolving, and new research is being conducted all the time (Aamodt *et.al.* 2018, Reich *et.al.* 2019). This research is helping to shape the future of OBE and to make it a more effective approach to education.

Suggested Direct Student Assessment Method

The enhanced assessment method builds upon the traditional direct student assessment approach, addressing its limitations while introducing innovative strategies to achieve a more comprehensive and efficient evaluation of student learning outcomes. The following steps outline the key elements of the enhanced assessment method:

1. Defining Program Syllabus: Similar to the traditional approach, the first step involves defining the program syllabus and outlining the content and scope of the academic program.

2. Course Materials Classification & Weighting: Course materials are classified based on their relevance and importance in achieving Course Learning Outcomes (CLOs). Each classified material is assigned a weight that reflects its significance in contributing to the overall learning objectives.

3. Defining Course Learning Outcomes (CLOs) of Each Module: As in the traditional approach, specific Course Learning Outcomes (CLOs) are defined for each module, outlining the expected knowledge, skills, and competencies to be attained by students.

4. Setting the Weights of Each CLO of All Modules: In the enhanced method, to prioritize and differentiate the importance of various Course Learning Outcomes (CLOs) across modules, each CLO is assigned a weight, reflecting its relative significance in the overall assessment process.

5. Linking CLOs of Different Modules to Student Outcomes (SOs): Similar to the traditional approach, the Course Learning Outcomes (CLOs) of different modules are aligned with the overarching Student Outcomes (SOs) of the academic program, ensuring that each CLO contributes to the achievement of the desired student outcomes.

6. Determining Different Attainment Levels for the Different Modules: The enhanced method accounts for variations in the complexity and difficulty of different modules by determining different attainment levels for each module.

This allows for a more nuanced assessment of student performance across diverse coursework.

7. Performing Direct Assessment on ALL Modules: Unlike the traditional approach, which may select specific modules for assessment, the enhanced method involves performing direct assessment on ALL modules. This comprehensive assessment approach ensures a more inclusive and representative evaluation of student learning.

8. Performing Direct Assessment Based on Final Exam: To streamline the assessment process, the enhanced method focuses on direct assessment through the final exam, which serves as a comprehensive and integrative evaluation of students' knowledge and skills.

9. Using the Same Rubric of the Final Exam: To maintain consistency and objectivity, the same rubric used for grading the final exam is applied to assess student performance in all modules.

10. Calculating Student Outcome Achievement (SO%): The Student Outcome Achievement (SO%) is calculated by summing the attainment levels of all Course Learning Outcomes (CLOs) across the modules, weighted by the CLO and module weights. This computation provides a comprehensive measure of students' overall achievement in attaining the desired Student Outcomes (SOs) of the program.

The enhanced assessment method seeks to provide a more efficient, precise, and comprehensive evaluation of student learning outcomes while mitigating the limitations of the traditional approach. By leveraging technology and streamlining the assessment process, this method aims to foster continuous improvement in engineering education and enhance the overall accreditation efforts.

Results and Discussion

In this section, we outline the practical steps required to implement the proposed assessment method. We consider the integration of technology, faculty development, and institutional support to ensure a successful transition to the new approach. To demonstrate the effectiveness of our proposed assessment method, we present a case study and its expected implementation in a computer engineering program. We analyze the outcomes, challenges encountered, and the overall impact on the OBE assessment process.

Curriculum Preparation

Table 1 presents a comprehensive arrangement of courses, their corresponding details, and weighting within the enhanced assessment method. The arrangement is organized based on the academic level and semester, providing information about each module's code, name, student workload (hours per week), exam hours, credit hours, module type, and module weight. It is noted that the number of credit hours assigned to each module, represents the academic value and part of the weight of the module within the program and it includes the summation of theoretical hours, laboratory hours, and tutorial hours (e.g., 2 theoretical hours + 3 laboratory hours = 5 hours per week). Module type indicates whether the module is classified as Basic, Core, or Supportive, based on its relevance and importance to the program's educational objectives. Module weight is the relative weight or significance of each module, reflecting its contribution to the overall assessment process. Module weight is calculated by multiplying the number of credit hours of each module by the weight given to each module type. For instance, in Level One, courses such as Computer Principles (CE101), and Mathematics 1 (CE103), are categorized as "Basic" courses, carrying Module Weights of 10. These Module Weights indicate the relative importance of these courses in contributing to the overall achievement of Course Learning Outcomes (CLOs) and Student Outcomes (SOs) of the program. In contrast, Human Rights (CE102), English Language (CE107), and Democracy (CE109) are categorized as "Supportive" courses, with lower Module Weights, reflecting their auxiliary role in supporting the main learning objectives of the program. Additionally, Programming using C++ Language (CE108), Electrical Circuits Analysis 2 (CE111), and Digital System Fundamentals (CE112) are identified as "Core" courses, carrying higher Module Weights (15, 21, and 18, respectively) due to their critical importance in shaping students' core competencies and achieving program-level outcomes.The table provides a clear and concise overview of the courses offered in the program, their associated workload and credit hours, and their respective contributions to the assessment process. The information presented in the table serves as a vital foundation for implementing the enhanced assessment method, ensuring a comprehensive and informed evaluation of student learning outcomes across the academic program.

Table 1: Curriculum Mapping

evel	Semester	Module Code	Module Name	Student Work Load (hr/w)			Exam Hours	Credit Hours	Module Type	Module Weight
				Theory (hr/w)	Lab (hr/w)	Tutorial (hr/w)				
ONE	One	CE101	Computer Principles	2	3		3	5	Basic	10
		CE102	Human Rights	2	0		3	2	Supportive	2
		CE103	Mathematics 1	4	0	1	3	5	Basic	10
		CE104	Engineering Drawing by Computer	0	3		3	3	Basic	6
		CE105	Electrical Circuits Analysis1	3	3	1	3	7	Core	21
		CE106	Electronics Physics	3	0	1	3	4	Basic	8
	Two	CE107	English Language	2	0		3	2	Supportive	2
		CE108	Programming using C++ Language	2	3		3	5	Core	15
		CE109	Democracy	2	0		3	2	Supportive	2
		CE110	Mathematics 2	4	0	1	3	5	Basic	10
		CE111	Electrical Circuits Analysis 2	3	3	1	3	7	Core	21
		CE112	Digital System Fundamentals	2	3	1	3	6	Core	18
TWO	Three	CE201	Engineering Mathematics 1	3	0	1	3	4	Basic	8
		CE202	Analog Electronics	3	3		3	6	Basic	12
		CE203	Microprocessors 1	2	3		3	5	Core	15
		CE204	English Language-Pte-intermediate	2	0		3	2	Supportive	2

TWO		CE205	Object Oriented Programming	2	3		3	5	Core	15
		CE206	Programmable Logic Design using HDL	2	3		3	5	Core	15
	Four	CE207	Computational Methods for Data Analysis	2	0	1	3	3	Core	9
		CE208	Engineering Mathematics 2	3	0	1	3	4	Basic	8
		CE209	Engineering Management	2	0		3	2	Supportive	2
		CE210	Digital Electronics	2	3	1	3	6	Core	18
		CE211	Microprocessors 2	2	3		3	5	Core	15
		CE212	Data Structures	2	3	1	3	6	Core	18
THREE	Five	CE301	Data Communications	2	3	1	3	6	Core	18
		CE302	Signals and Systems	3	0		3	3	Core	9
		CE303	Computer Architecture I	2	0	1	3	3	Core	9
		CE304	Computer Interface	2	3		3	5	Core	15
		CE305	Operating Systems I	2	3		3	5	Core	15
		CE306	Artificial Intelligence Principles	2	0		3	2	Core	6
	Six	CE307	Computer Networks	2	3	1	3	6	Core	18
		CE308	Digital Signal Processing	3	0		3	3	Core	9
		CE309	Computer Architecture 2	2	0	1	3	3	Core	9
		CE310	Embedded Systems	2	3		3	5	Core	15
		CE311	Operating Systems 2	2	3		3	5	Core	15
		CE312	English Language Intermediate	2	0		3	2	Supportive	2
FOUR	Seven	CE401	Professional Ethics	2			3	2	Supportive	2
		CE402	Fundamentals of Control Systems	3	3		3	6	Core	18
		CE403	Real Time Systems	2	3	1	3	6	Core	18
		CE404	Industrial Networks	2			3	2	Core	6
		CE405	Wireless Networks	2	3		3	5	Core	15
		CE406	Parallel Computer Architecture	2		1	3	3	Core	9
	Eight	CE407	Graduate Project	1	4		3	5	Core	15
		CE408	Computer Graphics	2			3	2	Core	6
		CE409	Cybersecurity	2			3	2	Core	6
		CE410	Moblie Systems Fundimentals	2	3		3	5	Core	15
		CE411	Image Processing and Applications	2		1	3	3	Core	9
		CE412	English language-Upper Intermediate	2			3	2	Supportive	2
Modules Types Weights: (Supportive: 1, Basic: 2, Core: 3)										

CLO Weighting

Another weighting procedure is needed in this assessment method, CLO weighting. To demonstrate this procedure, the following example is given. The provided Table 2 presents a detailed description of a certain module "Industrial Networks" with its associated Course Learning Outcomes (CLOs) and the procedure for weighting these outcomes. This information is crucial for understanding the content and assessment framework of the module. The module "Industrial Networks" is categorized as a core course with a module weight of 6, indicating its significant role in achieving the program's educational objectives. The module comprises several Course Learning Outcomes (CLOs), each representing a specific skill or competency that students are expected to attain. In Table 2, CLO% contribution in the syllabus (No. of Weeks/15): This column denotes the proportion of the module's duration dedicated to teaching and assessing each CLO. It indicates the weeks during which the specific CLO is covered in the syllabus. SO Linkage: Indicates whether the CLO is linked to Student Outcomes (SOs), demonstrating the connection between the specific CLO and the broader program-level learning objectives. CLO Weight (CLOW): This column represents the calculated weight of each CLO. The weight is determined by multiplying the SO linkage with the CLO% contribution. The resulting value indicates the relative importance of each CLO in achieving the overall program outcomes. Here's an example to illustrate the procedure:

For CLO 3, "Analyze and identify the methods of communications," it is linked to SOs 2, 3, and 6. The CLO contributes 34% of the syllabus time (Week 5 to Week 9) and has a CLO Weight (CLOW) of 1.36. This value (1.36) is obtained by multiplying the SO linkage (3 linked SOs) by the CLO% contribution (34% / 15 weeks).

Similarly, each CLO is evaluated and weighted based on its syllabus contribution and linkage to broader program outcomes. These weights provide insight into the relative significance of each CLO in the module's assessment and contribute to the overall assessment framework. In summary, the table effectively outlines the content and assessment structure of the "Industrial Networks" module, showcasing the weighting procedure for each Course Learning Outcome and its linkage to broader program-level objectives. This transparent and structured approach aids in understanding the emphasis placed on different learning outcomes and guides the assessment process within the module.

Table 2: Module Description & CLO Weighting

Module Name: Industrial Networks
Module Code: CE404
Credit Hours: 2
Module Type: Core
Module Weight (MW): 6

Course Learning Outcome (CLO)	Description	CLO% contribution in the syllabus (No. of Weeks/15)	SO linkage							CLO Weight (CLOW) (SO Linkage × CLO%
			1	2	3	4	5	6	7	
1	Identify the need for network protocols during data exchange	13% (Week1, Week2)		×						0.13
2	Demonstrate the use of serial standards as required in an industrial plant environment.	13% (Week3, Week4)			×					0.13
3	Analyze and identify the methods of communications	34% (Week5-Week9)	×	×	×				×	1.36
4	Compare the different protocols used as industrial standards	27% (Week10-Week13)		×	×					0.54
5	Demonstrate a working programmable logic controller network in simulated industrial automated application	13% (Week14,Week15)	×	×	×				×	0.52

Examination Strategy

The proposed examination strategy, designed to efficiently assess Course Learning Outcomes (CLOs), offers several distinct advantages by leveraging the final exam as a direct measure of student knowledge. This approach is particularly effective when students are well-prepared, and examination conditions are well-arranged. Here's a more comprehensive description of this strategy:

1. Direct Measure of Student Knowledge: The final exam serves as a direct measure of students' understanding, knowledge, and competency related to the CLOs. It provides an immediate evaluation of how well students have absorbed and retained the material covered in the syllabus. Since the exam is administered at the end of the course, it captures a comprehensive snapshot of students' grasp of the subject matter.

2. Optimal Preparation and Conditions: The strategy capitalizes on well-prepared students and carefully organized examination conditions. Students are expected to have thoroughly engaged with the course material, enabling them to demonstrate their understanding effectively. Additionally, the exam environment is conducive to focused assessment, ensuring that the students' performance is reflective of their actual learning.

3. Minimized Faculty Efforts in Rubric Preparation: The approach minimizes the need for faculty to prepare a new rubric solely for the exam. The same rubric used for ongoing assessments can be seamlessly applied to the exam. This continuity simplifies the assessment process for both students and faculty. Since the existing rubric is familiar to both parties, there's a clear understanding of the evaluation criteria and expectations.

4. Examination Grades as Performance Indicators: The performance indicators used to measure students' attainment of CLOs are directly linked to their examination grades. The exam serves as a comprehensive assessment tool, evaluating students' knowledge and skills across all CLOs simultaneously. This alignment ensures that the exam effectively captures the learning outcomes and provides a robust basis for measuring student achievement.

5. Resource and Time Efficiency: By utilizing the final exam as the primary assessment mechanism, the approach optimizes faculty's resource allocation and time. Faculty members do not need to design separate assessments or rubrics, streamlining their efforts. Moreover, this approach eliminates the need for additional grading procedures, as the exam already provides a holistic evaluation.

6. Holistic Evaluation: The exam's inclusive nature ensures a holistic evaluation of students' performance across all CLOs. Since each CLO is represented in the exam questions, students' mastery of the entire range of learning objectives is gauged. This approach is particularly valuable for assessing the integration of different concepts within the module.

Table 3 outlines a structured approach to arranging and preparing the final exam for the example of "Industrial Networks" module. The procedure begins by setting a fixed number of questions for the exam (15) to align with the number of weeks the module was taught. This balanced approach ensures that each week's content receives equal attention in the assessment. To measure each CLO efficiently and precisely, questions are allocated proportionally based on their contribution to the syllabus. CLOs with higher syllabus percentages receive a corresponding higher number of questions in the exam. This approach strategically distributes the assessment emphasis to reflect the weightage of each CLO in the learning process.

By adhering to this structured and thoughtful approach, the final exam becomes a comprehensive assessment tool that efficiently measures all CLOs while aligning with their respective contributions to the syllabus. This approach reduces the need for excessive questions while ensuring that the assessment accurately represents students' mastery of the learning objectives. It also guides instructors in preparing an exam that is informative, fair, and reflective of the course's educational goals. By aligning examination grades with the performance indicators associated with each CLO, the strategy provides a precise and comprehensive evaluation of students' achievement. This approach's resource efficiency and alignment with existing rubrics contribute to a seamless and informed assessment process, benefiting both students and faculty.

Table 3: Final Exam Sheet

Examination Sheet (Example: Industrial Networks)	No. of Questions must be 15, same No. of Weeks	Structured, pre arranged exam
All CLOs must be included and measured	No. of Questions to measures certain CLO is proportional to CLO contribution in the syllabus	CLOs contribution of questions grades
CLO1	2	13%
CLO2	2	13%
CLO3	5	34%
CLO4	4	27%
CLO5	5	13%

Variable Attainment Levels

In pursuit of a more refined and nuanced assessment framework, our proposed approach introduces variable attainment levels, uniquely calibrated to the distinct module types within the curriculum. This innovative strategy leverages the module's role and significance to set tailored attainment thresholds, enhancing the precision and relevance of the assessment process.

The foundation of this approach lies in recognizing the diverse categories of modules: CORE, BASE, and SUPPORTIVE. Each module type holds a distinct role in shaping students' academic journey, contributing to their overarching learning outcomes. As such, we advocate for an adaptable approach that acknowledges the varied importance of these modules in achieving program objectives.

For CORE modules, characterized by their central role in the program's core competencies, the approach suggests a targeted attainment level of 70%. This signifies that a substantial majority of students – 70% – should acquire 70% or more to demonstrate mastery of these critical concepts. This higher threshold reflects the paramount importance of these modules in shaping students' expertise.

On the other hand, for BASE and SUPPORTIVE modules, where the focus may be on foundational knowledge and complementary skills, the approach recommends a more flexible attainment level of 60%. This adaptable standard recognizes the varying degrees of emphasis these modules receive in contributing to students' comprehensive learning.

Furthermore, the approach opens the door for a more advanced implementation, wherein specific CORE materials could be assigned varying attainment levels based on the program's specialty. This refined customization aligns closely with the unique demands of specialized programs, ensuring that the attainment levels accurately mirror the specialized learning objectives.

By introducing variable attainment levels aligned with module types, our approach empowers educators to tailor the assessment process to the program's overarching goals. This tailored strategy ensures that assessment standards are proportional to the modules' roles, optimizing precision and fairness. Moreover, it acknowledges the diverse learning journey of students, promoting motivation and engagement across different module types.

Student Outcome Calculation and Reporting

At this point we reached the most important section in this paper, how to calculate the Achieved Student Outcomes percentages (Achieved SO%) using the enhanced assessment method. We begin our discussion using a demonstration example only.
A cornerstone of the enhanced assessment method lies in the meticulous calculation of Achieved Student Outcomes percentages (Achieved SO%), an endeavor that vividly mirrors the program's educational success. This computation encapsulates the attainment of Course Learning Outcomes (CLOs) within a framework that recognizes the nuanced attainments across different modules and their respective attainment levels. To initiate this calculation, a meticulously crafted equation is employed:

$$\text{Achieved SO\%} = \Sigma(\text{CLO1 and CLO3 of CE105} + \text{CLO2 of CE202} + \text{CLO4 of CE302}) \quad (1)$$

This equation forms the basis for assessing student achievement across specified CLOs, encompassing a targeted spectrum of learning objectives within the program. The resultant Achieved SO% provides a comprehensive metric that quantifies how effectively students have internalized and demonstrated the program's core competencies.

A defining aspect of this calculation is the calibration of attainment levels that align with the nature and purpose of each module. We advocate for an adaptable approach that acknowledges the diversity of modules and their learning outcomes. Hence, our suggested settings stipulate attainment levels tailored to individual modules: for modules CE105 and CE302 categorized as "Core," a heightened standard is set, requiring 70% of students to surpass a 70% threshold to achieve the attainment level. This elevated expectation reflects the crucial role of "Core" modules in fostering foundational competencies. Conversely, for module CE202 categorized as

"Supportive," a targeted attainment level is set at 60%. This recognizes the supportive nature of the module, complementing the program's overarching objectives.
The Attainment Level of each CLO (Attainment Ratio (AR%)) is judiciously evaluated using a fundamental ratio:

$$\mathrm{AR\%} = \frac{\text{No.of students who pass the attainment level}}{\text{Total No.of students who attend the exam}} \qquad (2)$$

This formula gauges the ratio of students who successfully achieve the predefined attainment level for a particular CLO relative to the total number of students participating in the exam. By applying this calculation to each CLO within the equation, the Achieved SO% emerges as a robust representation of students' collective attainment across the targeted CLOs and their respective attainment levels.

The calculation of Achieved Student Outcomes percentages represents the culmination of a meticulously structured assessment approach. It integrates attainment levels tailored to individual modules, acknowledges variable standards of achievement, and employs ratios that holistically gauge students' mastery of targeted learning outcomes. The resulting Achieved SO% is a measure of educational efficacy, illuminating the program's success in nurturing proficient engineers equipped to excel in their chosen field.

Table 4 encapsulates the culmination of the assessment process, delving into the intricate details of the final examination statistics and assessment analysis. Each entry within the table contributes to the comprehensive calculation of the Achieved Student Outcomes percentages (Achieved SO%). This table serves as a quantitative representation of the assessment outcomes for the modules CE105, CE202, and CE302 (in this example). It presents the assessment results for each Course Learning Outcome (CLO) within these modules, illustrating both the attainment and contribution of each CLO to the overall Achieved SO%. The CLO# Contribution column embodies the contribution of a particular CLO to the overall assessment outcome. It's calculated by multiplying the Attainment Ratio (AR), Module Weight (MW), and Course Learning Outcome Weight (CLOW). The Achieved SO% is a key measure, reflecting the program's success in imparting targeted knowledge and skills to students. It's calculated by summing the weighted contributions of all relevant CLOs and aligning it with the broader program objectives. This percentage serves as an insightful indicator of the program's effectiveness in achieving the desired student outcomes. The calculation in this table is repeated for the other SOs and they intricately capture the essence of the assessment process, revealing the impact of students' performance on specific CLOs, module weights, and overall program attainment. The Achieved SOs% are the ultimate reflection of the educational journey, encapsulating the fruits of focused learning and dedicated teaching efforts.

The second part of the table represents the assessment report which serves as a comprehensive analysis of the Achieved Student Outcomes percentages (Achieved SO%) in relation to the defined Student Outcomes (SO) thresholds. It provides an insightful evaluation of the program's educational effectiveness by comparing the attained achievements to the preset standards. The report delineates the performance of each individual Course Learning Outcome (CLO), highlighting areas of alignment and areas necessitating attention. These insights serve as a foundational guide for targeted educational enhancements and refinements, ensuring that student learning outcomes are optimally realized. This assessment report, in its entirety, stands as a vital tool for continual improvement in engineering education.

Table 4: SO% Calculation & Reporting

Module	CLO #	Total No. of attended Students	No. of Students passed the attainment level	Attainment Ratio% (AR%)	Module Weight (MW)	CLO# Weight (CLO W)	CLO# Contribution (AR x MW x CLOW)
CE105	CLO 1	40	22	55% (0.55)	21	0.13	1.5
	CLO 3	44	25	57% (0.57)		1.36	16.27
CE202	CLO 2	35	30	86% (0.86)	12	0.13	1.34
CE302	CLO 4	40	30	75% (0.75)	9	0.54	3.64
Achieved SO% (SUM of CLO# Contributions)							22.75

Assessment Report of SO

SO% Threshold (when AR% =60% or 70% for CLOs) = (1.9+20+1.1+3.4)=26.4
SO% Attainment = Achieved SO%/SO% Threshold =22.75/26.4= 86%
Achieved SO% is less than SO% threshold by 14%
CLO1 is less than threshold (70%) by 15%
CLO2 is higher than threshold (60%) by 26%
CLO3 is less than threshold (70%) by 13%
CLO4 is higher than threshold (70%) by 5%

Conclusion

The suggested approach to enhancing the direct assessment method for Outcome-Based Education (OBE) represents a significant step forward in the pursuit of educational excellence. By addressing the limitations of existing assessment techniques and providing a lightweight, comprehensive, precise, and informative framework, we are poised to make a meaningful impact on OBE processes. As we navigate the ever-evolving landscape of education, leveraging the potential of educational technology and pedagogical strategies, our contribution paves the way for continuous improvement. Through this innovative approach, we aim to empower educators, institutions, and students alike to embrace OBE's core principles and foster a culture of ongoing growth and development. In the journey towards educational excellence, our research serves as a valuable resource for those dedicated to the advancement of OBE, ultimately shaping a brighter future for students and institutions alike.

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