T.C.
İSTANBUL KÜLTÜR UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

DEVELOPING AN EXCEL-BASED EDUCATION MANAGEMENT SYSTEM FOR ENGINEERING PROGRAMS

MASTER'S THESIS

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1900001093

Department: Industrial Engineering

Program: Engineering Management

Supervisor: Assist. Prof. Okay Işık

JUNE 2025

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JUNE 2025

ACKNOWLEDGEMENT

Every journey has an ending, and as I reach the conclusion of this one, I would like to express my sincere gratitude to all those who supported me along the way.

First and foremost, I am deeply thankful to my family for their unwavering support throughout this journey. A special expression of gratitude goes to my brother and idol, Eng. Omar Yasin, whose constant encouragement and belief in me have been a source of strength and motivation.

I am also grateful to my friends, who stood by me during challenging times and offered their encouragement and kindness. I extend my appreciation to myself as well—for remaining resilient and committed, even during the most difficult moments.

I would like to express my heartfelt thanks to my advisor, Asst. Prof. Okay IŞIK, for his continuous guidance, support, and understanding throughout my studies. His mentorship played a crucial role in the completion of this thesis.

Additionally, I would like to thank my professors; Prof. FADİME YÜKSEKTEPE, Asst. Prof. ZEYNEP GERGİN, Asst. Prof. DUYGUN FATİH DEMİREL, Prof. AYŞE TÜLİN AKTİN, Prof. MURAT ERMİŞ, Res. Asst. OĞUZ EMİR, and Res. Asst. DİLEK AKBAŞ for their valuable teaching, insights, and inspiration throughout my academic journey.

To all who have contributed to this accomplishment—thank you.

20 June 2025 Hamza YASIN

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LIST OF SYMBOLS

POs	Program Outcomes
COs	Course Outcomes
LOs	Learning Outcomes' and 'Course Outcomes' are used interchangeably in academic contexts.
PO_j	Attainment of program outcome j
CO_i	Attainment of course outcome i
z	Index of an assessment (e.g., exam, quiz), where z = 1, 2, ..., Z
y	Index of a question within an assessment, where y = 1, 2, ..., Y
q_{yz}	Set of assessment questions y in assessment z
g_{yz}	Maximum grade (weight) for question y in assessment z
s_{yz}	Student's actual grade for question y in assessment j
ws_{yz}	Student's percentage grade (weighted score) for question y in assessment z
x_{iyz}	Support value from question y in assessment z to Course Outcome i
y_{ij}	Support value indicating the contribution of CO_i to PO_j

Üniversite : **İstanbul Kültür Üniversitesi**

Enstitü : **Lisansüstü Eğitim Enstitüsü**

Anabilim Dalı : **Endüstri Mühendisliği**

Programı : **Mühendislik Yönetimi**

Tez Danışmanı : **Dr. Öğr. Üyesi Okay Işık**

Tez Türü ve Tarihi : **Yüksek Lisans – Haziran 2025**

ÖZET

MÜHENDİSLİK PROGRAMLARI İÇİN EXCEL TABANLI BİR EĞİTİM YÖNETİM SİSTEMİ

Hamza YASIN

Modern mühendislik eğitiminde, müfredatların ABET ve MÜDEK gibi uluslararası akreditasyon standartlarıyla uyumlu hale getirilmesi, sistematik program planlaması, çıktı değerlendirmesi ve sürekli iyileştirme süreçlerini gerektirmektedir. Ancak, Program Çıktıları'nın (PÇ) Ders Çıktıları'yla (DÇ) eşleştirilmesi ve değerlendirme verilerinin toplanması gibi işlemlerin manuel olarak yürütülmesi, öğretim elemanları üzerinde ciddi bir iş yükü oluşturmakta ve sürecin tutarlılığı ile izlenebilirliğini olumsuz etkilemektedir.

Bu tez, PÇ-DÇ hiyerarşisini uyumlandırmayı ve veri odaklı değerlendirme yoluyla akreditasyon süreçlerini kolaylaştırmayı hedefleyen otomatik bir çerçeve önermektedir. Çerçeve üç aşamadan oluşmaktadır: (1) Program planlaması, müfredat genelinde PÇ'lerin stratejik olarak dağıtılması, (2) Ders ve ölçme planlaması, DÇ'leri hedefleyen değerlendirmelerin tasarlanması, (3) Ayrıntılı değerlendirme tasarımı, değerlendirme sürecinin program düzeyindeki beklentilerle uyumlu hale getirilmesi. Bu çerçevenin uygulanabilirliği için, dinamik DÇ-PÇ eşlemesi, sapma analizi ve otomatik raporlama gibi özelliklere sahip Excel-VBA tabanlı bir araç geliştirilmiştir. Bu araç, müfredat uyumunun gerçek zamanlı olarak izlenmesini sağlamakta ve planlama sürecinde düzeltici önlemlerin alınmasını kolaylaştırarak öğretim üyeleri arasındaki iş birliğini artırmaktadır.

İstanbul Kültür Üniversitesi'nde yürütülen bir vaka çalışması, çerçevenin değerlendirme doğruluğunu artırma, öğretim elemanlarının iş yükünü azaltma ve müfredat yönetimini

iyileştirme konularındaki etkinliğini ortaya koymuştur. Çalışma, akreditasyon uyumunu destekleyen ve mühendislik eğitiminde sürekli iyileştirmeyi teşvik eden pratik ve bütünleşik bir program değerlendirme yaklaşımı sunmaktadır. Önerilen çerçeve, çıktı temelli eğitime ve sürdürülebilir akreditasyon uygulamalarına bağlı kurumlar için tekrarlanabilir bir model niteliği taşımaktadır. Gelecekteki çalışmalar, bu yapının öğrenme yönetim sistemleriyle entegrasyonu, öngörüsel analizler için makine öğrenmesi kullanımı, disiplinlerarası uygulamalar ve veri odaklı karar alma süreçlerini iyileştirmeye yönelik optimizasyon teknikleriyle genişletilmesini ele alabilir.

Anahtar Kelimeler: Program Çıktıları, Ders Çıktıları, Çıktı Temelli Eğitim, Akreditasyon, Değerlendirme Planlaması, Excel-VBA

University	**: İstanbul Kültür University**
Institttute	**: Institute of Graduate Studies**
Department	**: Industrial Engineering**
Program	**: Engineering Management**
Supervisor	**: Assist. Prof. Okay Işık**
Degree Awarded and Date	**: MS – June 2025**

ABSTRACT

DEVELOPING AN EXCEL-BASED EDUCATION MANAGEMENT SYSTEM FOR ENGINEERING PROGRAMS

Hamza YASIN

In modern engineering education, aligning curricula with international accreditation standards (e.g., ABET, MÜDEK) requires systematic program planning, outcome assessment, and continuous improvement. However, manual processes for mapping Program Outcomes (POs) to Course Outcomes (COs) and collecting assessment data impose significant faculty burdens, often compromising consistency and traceability.

This thesis proposes an automated framework to streamline accreditation processes through structured PO-CO alignment and data-driven assessment. The framework consists of three phases: (1) program planning, strategically distributing POs across the curriculum; (2) course and assessment planning, designing CO-focused evaluations; and (3) detailed assessment design, ensuring alignment with program-level expectations. An Excel-VBA tool was developed to operationalize the framework, featuring dynamic CO-PO mapping, deviation analysis, and automated reporting. This enables real-time curriculum monitoring and corrective actions while enhancing faculty collaboration.

A case study at Istanbul Kültür University demonstrated the framework's effectiveness, showing improved assessment accuracy, reduced faculty workload, and better curriculum management. The study presents a practical, unified approach to program assessment, supporting accreditation compliance while fostering continuous improvement in engineering

education. The framework offers a replicable model for institutions committed to outcome-based education and sustainable accreditation practices. Future work may explore integration with learning management systems, machine learning for predictive analysis, multidisciplinary applications, and optimization techniques for data-driven decision-making.

Keywords: Program Outcomes, Course Outcomes, Outcome-Based Education, Accreditation, Assessment Planning, Excel-VBA

1. INTRODUCTION

In recent years, the evolving landscape of higher education, particularly within engineering disciplines, has underscored the necessity for rigorous, systematic approaches to the evaluation and management of educational outcomes. Accreditation bodies such as the Accreditation Board for Engineering and Technology (ABET) and the Association for Evaluation and Accreditation of Engineering Programs (MUDEK) have established comprehensive standards to ensure that engineering graduates possess the requisite knowledge, competencies, and skills to perform effectively in professional practice. Central to these standards is the adoption of Outcome-Based Education (OBE), a paradigm that represents a fundamental shift from traditional input-based models toward a results-oriented approach, wherein the attainment of predefined learning outcomes constitutes the principal metric of educational quality.

There are eleven program outcomes defined by MÜDEK, which serve as a foundational framework for engineering faculties, including those at Istanbul Kültür University. As an accreditation body, MÜDEK functions as a key stakeholder in the educational process, ensuring the quality and relevance of engineering education through these clearly established learning outcomes.

The transition to OBE necessitates the development and implementation of comprehensive assessment methodologies that go beyond conventional metrics such as the Grade Point Average (GPA), which—although indicative of general academic performance—are often insufficient in capturing the nuanced attainment of specific educational outcomes. This limitation highlights the importance of evaluating Program Outcomes (POs) as a central component of curriculum planning and design. Through the systematic alignment of Course Outcomes (COs) with broader POs, institutions can more accurately assess whether students are achieving the targeted competencies. Furthermore, such alignment facilitates curricular coherence, enables data-driven quality enhancement, and supports institutional accountability with respect to

accreditation requirements. A conceptual framework linking assessments, course outcomes, mission, and program outcomes can be seen in Figure 1.1 below.

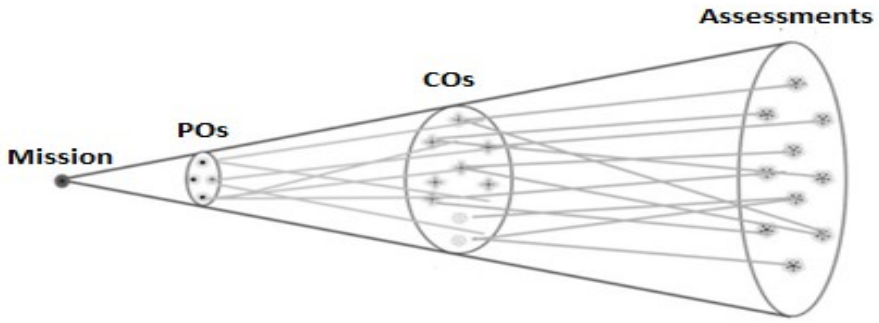


Figure 1.1. OBE Framework

The figure above illustrates that the OBE framework begins with the identification of clear educational goals. These goals are subsequently translated into specific POs, which are measurable and aligned with the intended learning objectives. The POs are further broken down into COs, which are specific to individual courses within the program. To assess the level of achievement of these outcomes, assessments are carefully designed and implemented. This systematic approach ensures that the educational objectives are clearly defined, measurable, and aligned with both program and course-level outcomes, thereby facilitating a structured and effective evaluation process.

The principal aim of this research is to develop and implement a structured, quantitative methodology for the assessment of Program Outcomes (POs) and Course Outcomes (COs) in engineering education. The fulfillment of this aim necessitates the achievement of the following specific objectives:

1. To develop a quantitative model for evaluating the attainment of POs and COs.
2. To establish a systematic linkage between CO assessments and broader program-level outcomes.
3. To inform the design and planning of academic programs and courses in alignment with defined POs.
4. To generate data-driven insights that support continuous improvement of engineering curricula and instructional practices.

This thesis addresses the following research questions:

Q1: How can Course Outcomes (COs) be systematically aligned with Program Outcomes (POs) within the framework of outcome-based education?
Q2: What types of assessment mechanisms can be employed to quantitatively evaluate the attainment of COs and POs?
Q3: How can the analysis of assessment data inform continuous curriculum improvement and ensure compliance with accreditation standards?

The first question clarifies the foundational relationship between course-level and program-level outcomes. The second question identifies appropriate assessment tools and methodologies for evaluating these outcomes. The third question examines the extent to which outcome data can guide institutional efforts aimed at quality assurance and continuous enhancement.

This study contributes to the academic discourse on outcome-based education by proposing a comprehensive, data-driven framework for the assessment of COs and POs in engineering programs. The framework integrates course-level assessments with program-level objectives and incorporates a continuous planning and evaluation mechanism to ensure coherence and alignment. By leveraging widely available tools such as Microsoft Excel and Visual Basic for Applications (VBA), the methodology supports efficient data analysis and reporting, thereby offering practical value for academic institutions seeking scalable solutions. The findings derived from this study are intended to inform the development of best practices in curriculum design, outcome evaluation, and accreditation preparedness in engineering education.

This research is focused on the assessment of educational outcomes in engineering programs, with specific emphasis on the systematic evaluation of Program Outcomes (POs) and Course Outcomes (COs). The methodology is applied to the Industrial Engineering Program at Istanbul Kültür University (IKU), thus grounding the study in a real-world academic context and ensuring alignment with applicable accreditation standards.

To address the stated research objectives and answer the corresponding research questions, the thesis is organized into five chapters:

- **Chapter 1 (Introduction)** outlines the context, objectives, research questions, significance, and scope of the study.
- **Chapter 2 (Literature Review)** provides an overview of existing assessment frameworks in engineering education, including their theoretical underpinnings, practical applications, and comparative analyses.
- **Chapter 3 (Methodology)** presents the proposed three-level assessment framework, detailing its components, implementation strategy, and mechanisms for continuous improvement.
- **Chapter 4 (Implementation)** describes the application of the methodology within the Industrial Engineering Program at IKU, including the assessment tools utilized and data analysis procedures using VBA and MS Excel.
- **Chapter 5 (Conclusion)** summarizes the main findings, articulates the contributions of the study, and offers recommendations for future research and application.

Through the development and application of a robust assessment framework, this research seeks to enhance the efficacy of outcome-based education in engineering and contribute to the broader goal of improving educational quality and graduate preparedness in the field.

2. LITERATURE REVIEW

With the significant development in scientific knowledge globally, it is important to implement advanced educational approaches like Science, Technology, Engineering, and Mathematics (STEM). A sample consisted of 22 science instructors was chosen from schools across Türkiye in the educational year 2021-2022 to emphasize their views regarding assessment and evaluation techniques used in STEM education. It was found that teachers are using both process and outcome-based methods to assess students. However, teachers faced challenges during the evaluation process due to either instructor-related issues or flaws within the education system. To overcome these challenges, institutions must guide measurement tools used during the evaluation process of STEM education (Karakaya & Yılmaz, 2022). Accreditation is a form of quality assurance for educational institutions to ensure that certain standards are being fulfilled while promoting excellence for engineering programs. These standards are translated into the defined Program Outcomes (POs) and assessment methodologies. Maintaining quality assurance in engineering education is crucial as it ensures the production of innovative and skilled engineers. However, with the rapid growth in the number of engineering students and institutions, ensuring quality has become a challenging task for authorities (Kohli, 2014).

2.1. Accreditation Board for Engineering and Technology (ABET)

To ensure that any educational organization is achieving the essential quality requirements in colleges and universities accreditation programs are established. As an example, a popular nonprofit organization called the Accreditation Board for Engineering and Technology (ABET) is certified with the ISO 9001 total quality management certification. ABET is committed to ensuring the quality of education in higher education programs in STEM educational fields. With the efforts and collaborations aiming to empower future generations of STEM disciplines; ABET's goal is to equip students with the necessary skills and knowledge to contribute to society for a more secure, more effective, inclusive, and sustainable world (ABET, 2021). Since 1932, ABET has served as the official accreditor of bachelor engineering degree programs in the United States and abroad. Currently, ABET accredits 2,000 engineering programs across over 350 institutions. Accreditation by ABET

necessitates adherence to a set of quality standards known as accreditation criteria. Throughout much of the latter half of the 20th century, ABET's accreditation criteria outlined all significant aspects of accredited engineering programs, including curriculum, faculty, and facilities. However, in the mid-1990s, there was a collective reassessment within the engineering community regarding the rigidity of these accreditation requirements. After a year of extensive dialogue, ABET introduced new and innovative accreditation criteria for engineering programs, known as Engineering Criteria 2000 (EC2000). EC2000 transitioned accreditation from focusing on inputs such as the curriculum taught, to outputs i.e., what students learn. The revised criteria outline 11 student learning outcomes (a-k) and mandate that programs evaluate and exhibit their students' proficiency in each of these areas (Lattuca, Terenzini, & Volkwein, 2004). Similarly, applying EC2000 requires institutions to design and plan their own curriculums along with assessment techniques aligned with the outcomes of each program. While ABET does not necessitate specific methodologies for the development and assessment process, it does require institutions to highlight the teaching techniques used to fulfill learning objectives defined as well as proof of assessment and ongoing improvement. This flexibility in developing programs enhances the ability to meet students' needs and demands, the current industry needs, and institutional goals and vision (Ventura, 2003).

After the academic year of 2017-2018, ABET updated some of the criterion introduced earlier in EC2000. The changes were mainly regarding Student Outcomes (SOs) criteria and the curriculum introduced in the 3rd and 5th criteria respectively. The original (a-k) SOs defined were summarized into (1-7) outcomes and mapped according to Table 2-1 below. The updated ABET accreditation criteria apply to all accredited engineering programs and are designed to encourage continuous improvement in the quality of engineering education. These criteria aim to ensure that engineering programs meet the evolving needs of their areas in a dynamic and competitive environment. Institutions seeking accreditation must clearly demonstrate that their programs satisfy the following criteria. Introduction and definitions providing updated guidance and context to align programs with current industry and educational standards. Curriculum changes by emphasizing integrating real-world problems and multidisciplinary approaches. Strengthened focus on practical application of knowledge, communication skills, teamwork, ethics, and lifelong

learning strategies. These changes aim to enhance the relevance and effectiveness of engineering education, ensuring that graduates are well-prepared to meet modern engineering challenges (ABET, 2017).

Table 2-1. ABET EAC mapping C3: A-K to C3: 1-7 **(ABET, 2017)**

Before 2019-20 cycle	**After 2019-20 cycle**
The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.	The program must have documented student outcomes that support the program's educational objectives. Attainment of these outcomes prepares graduates to enter the professional practice of engineering. Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.
(a) an ability to apply knowledge of mathematics, science, and engineering (e) an ability to identify, formulate, and solve engineering problems	1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	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
(d) an ability to function on multidisciplinary teams	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
(f) an understanding of professional and ethical responsibility (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (j) a knowledge of contemporary issues	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
(g) an ability to communicate effectively	3. an ability to communicate effectively with a range of audiences

(i) a recognition of the need for, and an ability to engage in life-long learning	7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	Implied in 1, 2, and 6

Recently, educational institutes are attempting to shift from Traditional Education (TE) to Outcome-Based Education system (OBE). Shafi et al. (2019), applied the concept of OBE on ABET accreditation criteria for Computer Science and Computer Information Systems departments. Various assessment methods were considered while linking assessment grades to the ABET criteria. The proposed system can be used to guide and assist institutions with computer programs for accreditation. Moreover, Zamir et al. (2022) tried to switch to an OBE system to evaluate it against TE system. OBE showed more advantages at Riphah International University (RIU). It was proved that OBE demonstrated guidance for students and tutors along with courses delivered.

A study of implementing OBE in Philippines at Batangas State University for Electronics Engineering program was discussed to breakdown motivations, processes, and challenges faced by the university while implementing OBE system. It was demonstrated that implementing OBE is the first step towards meeting requirements for higher-quality education. A key factor in successfully implementing OBE requires a clear framework communicated to stakeholders and the administration despite limited resources in the institution (Ronquillo & Ronquillo, 2014). Additionally, by linking Course learning outcomes (CLOs) to program learning outcomes (PLOs) through a bunch of performance indicators (PIs), an attempt to transform CLO-based education into PLO-based education was conducted. The results were used to establish a performance evaluation technique for ABET's seven students' outcomes. The proposed approach was found useful for all engineering programs looking to achieve accreditation requirements (Ghaly, 2019).

Additionally, according to Kalaani & Haddad (2014), an assessment process was designed to achieve ABET's criteria associated with Student Learning Outcomes (SLOs). Direct and indirect assessment methods were employed to gather data, and the collected data was used to evaluate the attainment of SLOs. Assessment tools that

outline specific criteria or standards against which student performance or work is evaluated. Three different standardized forms were developed and submitted to the assessment committee to produce a more efficient assessment and continuous improvement process (Kalaani & Haddad, 2014). University of Putra in Malaysia attempted a shift to an OBE system for engineering education to achieve accreditation from the Malaysian Engineering Accreditation Council (EAC). The engineering faculty in the university developed an automated system to assess and monitor program outcomes in a one-year study. The prescribed system was used to help academicians monitor the development of each program's outcomes that was taken into consideration for a continuous development system (Jaafar, et al., 2008).

2.2. Association for Evaluation and Accreditation of Engineering Programs (MÜDEK)

Other than ABET, another accrediting NGO based in Türkiye called the Association for Evaluation and Accreditation of Engineering Programs (MÜDEK) aimed at accrediting, evaluating, and informing engineering education programs across various disciplines to contribute to the enhancement of the quality of engineering education. MÜDEK was established in 2002 by the Council of Engineering Deans (MDK), consisting of deans of faculties providing engineering education in Türkiye and the Turkish Republic of Northern Cyprus (TRNC). It was formed as an independent platform named the Engineering Evaluation Board to develop and implement detailed programs for the evaluation of engineering undergraduate programs at these faculties. MÜDEK commenced the evaluation of engineering programs in 2003 and became an official association in 2007. In addition, MÜDEK is a member of both the European Network for Accreditation of Engineering Education (ENAEE) and the Washington Accord (WA) (MÜDEK, 2020).

MÜDEK employs a comprehensive set of nine criteria to assess and accredit engineering programs at the undergraduate level in Türkiye. These criteria are designed to ensure that engineering programs provide high-quality education aligned with national and international standards. A detailed explanation of each criterion is provided below:

2.2.1. Program Educational Objectives

This criterion focuses on the long-term achievements expected of graduates after they complete the program. These objectives typically describe what graduates are expected to attain within a few years of graduation, such as successful careers in engineering practice, further education, leadership roles, or societal contributions. Programs are required to define clear, measurable, and realistic educational objectives that are consistent with the mission of the institution and stakeholders' expectations.

2.2.2. Program Outcomes (POs)

Program outcomes are specific competencies that students are expected to acquire by the time of graduation. These include knowledge, skills, and attitudes related to engineering problem-solving, design, communication, teamwork, ethical responsibility, and lifelong learning. The outcomes must support the program's educational objectives and be measurable to ensure that students are adequately prepared for professional practice.

Although the Program Outcomes (POs) defined by MÜDEK were initially aligned with those established by ABET, MÜDEK did not revise its POs following ABET's subsequent updates to the outcomes for baccalaureate engineering programs. The current POs set and defined by MÜDEK are as follows in Table 2-2 below.

Table 2-2. POs set by MÜDEK at IKU **(İstanbul Kültür University, 2024)**

PO 1	**Application of Knowledge**: Ability to apply mathematics, science, and engineering principles to solve complex problems.
PO 2	**Problem Solving:** Skill in identifying, formulating, and solving complex engineering problems using appropriate methods.
PO 3	**Design Skills:** Ability to design systems or products that meet specific needs under real-world constraints.
PO 4	**Modern Tools Usage**: Competence in using modern engineering tools, techniques, and information technologies effectively.
PO 5	**Experimental Skills**: Ability to design experiments, collect and analyze data, and interpret results to address engineering challenges.

PO 6	**Teamwork and Independence**: Capability to work efficiently in individual, disciplinary, and multidisciplinary team settings.
PO 7	**Communication**: Proficiency in written and oral communication, including report writing and presentations, in at least one foreign language.
PO 8	**Lifelong Learning**: Awareness of the need for continuous learning and ability to follow scientific and technological advancements.
PO 9	**Ethics**: Understanding and adherence to ethical principles and professional responsibilities.
PO 10	**Professional Practice**: Knowledge of project, risk, and change management; awareness of entrepreneurship, innovation, and sustainable development.
PO 11	**Global and Societal Impact**: Awareness of the societal, environmental, and legal impacts of engineering practices and solutions.

2.2.3. Curriculum

The curriculum is assessed to ensure that it provides both breadth and depth in engineering and supporting disciplines. It must include a strong foundation in mathematics, science, and core engineering principles, as well as opportunities for design experience and practical application. Courses must be coherently structured and continuously updated to reflect advances in the field and the needs of industry and society.

2.2.4. Faculty Members

The faculty should possess adequate academic qualifications, professional experience, and teaching effectiveness. This criterion evaluates the sufficiency, competence, and development opportunities of the teaching staff. Faculty must be actively involved in curriculum development, student advising, and continuous improvement processes, and there should be a sustainable balance between teaching and research activities.

2.2.5. Students

This criterion evaluates the policies and procedures related to student admission, advising, progression, assessment, and support. It emphasizes the importance of

transparent and fair student evaluation mechanisms, active engagement in learning, and opportunities for personal and professional development. Student involvement in feedback processes and institutional governance is also considered.

2.2.6. Facilities

The institution must provide adequate physical infrastructure, including classrooms, laboratories, libraries, computing resources, and other educational tools necessary to support effective teaching and learning. The facilities must be safe, accessible, and regularly maintained. In addition, laboratory experiences should reinforce theoretical knowledge and develop hands-on skills.

2.2.7. Institutional Support and Financial Resources

This criterion assesses the adequacy and sustainability of financial and administrative support provided to the program. It includes budgetary allocation, staff support, and the availability of funds for faculty development, infrastructure maintenance, and equipment procurement. The institution must demonstrate a commitment to maintaining and improving the quality of the program.

2.2.8. Organization and Decision-Making Processes

The governance structure, administrative processes, and decision-making mechanisms of the program are examined under this criterion. It focuses on the roles and responsibilities of faculty, department leadership, and committees in academic and administrative matters. Effective communication, accountability, and stakeholder involvement in decision-making are essential elements.

2.2.9. Continuous Improvement

Continuous improvement involves the systematic assessment and enhancement of all aspects of the program. Programs must establish mechanisms for collecting and analyzing data on student performance, stakeholder feedback, and program outcomes. Based on this evidence, they must implement improvements to the curriculum, instruction, and other program elements in a documented and transparent manner.

2.3. Accreditation and Attainment

Miller (2016) introduced Miller Methodology, a streamlined approach designed to minimize the effort required in assessing student outcomes for ABET accreditation. This methodology involves a single faculty member gathering outcome data, which the entire program faculty then uses for the continuous improvement process. This approach aims to optimize faculty time while ensuring the credibility of student outcome data in the accreditation process. The methodology was applied during the 2015-2016 accreditation cycle for the Computer Science (CSCI) and Computer Engineering and Computer Science (CECS) programs at the Viterbi School of Engineering, University of Southern California. Both programs successfully achieved full accreditation from the ABET Computing Accreditation Commission, with the CECS program also receiving full accreditation from the ABET Engineering Accreditation Commission. Another study by Vanjale, Shelar, and Mane (2015) applied mathematical calculations to values taken from direct and indirect assessment tools to evaluate course outcome assessment and attainment. The results of the course outcome attainment are used by staff members to achieve POs and PEOs, thereby improving the overall teaching and learning process. Similarly, POs are covered in the curriculum through various teaching methodologies, including classroom teaching, laboratory experiments, seminars, and projects. Each course has specific Course Outcomes (COs), which are mapped to the Program Outcomes (POs). The attainment of COs is quantified by assessing students, with performance data analyzed using MS Excel. The methodology entails a detailed breakdown of the question paper, where each question is systematically mapped to a specific Course Outcome (CO) and its corresponding Program Outcome (PO). Continuous internal evaluation data is used to measure the attainment of COs and POs for a student group, with attainment levels adjustable based on course level and student efficiency. This structured approach ensures that engineering graduates possess a comprehensive skill set, enhancing their employability and global acceptance. Continuous assessment and data analysis play a critical role in maintaining and improving educational standards (Ramchandra, Maitra, & MallikarjunaBabu, 2014).

OBE is a performance-driven approach at the head of curriculum development, offers a compelling method for reforming and managing medical education. Unlike

traditional methods, which focus on the educational process, outcome-based education prioritizes the final product. However, several critical questions must be addressed in implementing outcome-based education, including defining the outcomes to be covered in the curriculum, determining assessment methods, and establishing implementation strategies (Harden, Crosby, & Davis, 1999). OBE has proven to be more effective and necessary when it comes to engineering education. However, there is no obvious way to evaluate the attainment of POs in engineering programs. Globally, Grade Point Average (GPA) is enough to determine the attainment of students' success from courses in TE. To meet modern educational demands a Web-based Academic Quality Assurance System (AQASYS) was developed. AQASYS aims to assist institutions in implementing educational standards, giving insights on quality parameters, analytics, and reports (Alfozan & Kadampur, 2021). Outcome-Based Education (OBE) emphasizes clearly defined learning outcomes that students are expected to demonstrate by the end of a course or degree program. It aligns curriculum design, teaching methods, and assessment strategies with professional competencies. The integration of OBE in engineering education is particularly essential due to the multidisciplinary skillset required to solve complex real-world problems. A structured OBE framework, aligned with the Washington Accord, has been successfully implemented in the undergraduate CSE program at IUB, serving as a model for academic institutions aiming for international accreditation and quality assurance (Syeed et al., 2022).

This research seeks to develop an engineering education management system that supports institutions in achieving accreditation and assists engineering faculties in designing and developing course materials based on the Outcome-Based Education (OBE) framework using MS Excel and VBA. The system provides insights into the individual attainment of Course Outcomes (COs) and Program Outcomes (POs), while ensuring that institutional resources remain aligned with the overarching vision and goals by planning and designing the outcomes, courses, and assessments accordingly. a summary of the litreature review is shown below in Table 2-3.

Table 2-3. Literature summary table

Authors	Per Student PO Attainment	Framework	Continuous Improvement	PO weights considered	Outcomes planning
Hongsuwan et al. (2022)	+	MS Excel	+	–	–
Karakaya & Yılmaz (2022)	–	–	–	–	–
Kohli (2014)	–	–	–	–	–
ABET (2021)	–	–	+	–	–
Lattuca, Terenzini, & Volkwein (2004)	–	–	+	–	–
Ventura (2003)	–	–	+	–	–
ABET (2017)	–	–	+	–	+
Shafi et al. (2019)	–	–	+	–	–
Zamir et al. (2022)	–	–	+	–	–
Ronquillo & Ronquillo (2014)	–	–	+	–	–
Ghaly (2019)	–	–	+	–	+
Kalaani & Haddad (2014)	–	–	+	–	–
Jaafar et al. (2008)	–	Automated system	+	–	+
MÜDEK (2020)	–	–	+	–	–
Miller (2016)	–	–	+	–	–
Vanjale, Shelar, & Mane (2015)	+	MS Excel	+	–	–
Harden, Crosby, & Davis (1999)	–	–	+	–	–
Alfozan & Kadampur (2021)	–	AQASYS (Web-based)	+	–	–
Syeed et al. (2017)	–	–	+	–	+
Ramchandra, Maitra, & Mallikarjunav Babu (2014)	+	–	+	–	–
This Study	**+**	**MS Excel & VBA**	**+**	+	**+**

The literature review summary presented in the table above highlights several previous studies and developments in the field of education management and outcome-based education. These efforts typically focus on either academic planning, such as curriculum design, course alignment, and scheduling, or on outcome attainment evaluation, such as assessing student learning outcomes, mapping course outcomes to program outcomes, and tracking achievement levels over time. However, what becomes apparent from the literature is that most existing approaches tend to treat these two aspects in isolation. In other words, while some systems are designed to help institutions plan and structure their academic programs, they often lack mechanisms to evaluate whether those plans are effectively leading to desired learning outcomes. Conversely, systems developed for assessment purposes rarely include features for forward-looking academic planning. This disconnect suggests that there has been limited or no research into a comprehensive, integrated framework that seamlessly merges both the planning phase (i.e., designing courses and programs with learning goals in mind) and the evaluation phase (i.e., measuring and analyzing the achievement of those goals through student outcomes). The absence of such an approach indicates a critical gap in the existing literature, and it points to the need for solutions that can bridge the two components in a cohesive and systematic way.

3. METHEDOLOGY

This study aims to develop a comprehensive assessment and management methodology for evaluating the attainment levels of Program Outcomes (POs) in alignment with the standards established by accrediting organizations such as the Accreditation Board for Engineering and Technology (ABET) and the Association for Evaluation and Accreditation of Engineering Programs (MUDEK). While Grade Point Average (GPA) is commonly used as a measure of student performance, this research adopts a three-level measurement strategy that incorporates course assessments, Course Outcomes (COs), and Program Outcomes (POs). A flowchart of the proposed methodology is presented in Figure 3.1. The flowchart illustrates that Outcome-Based Education (OBE) begins by identifying the required POs to be fulfilled at the end of the education period. These POs serve as a guide for designing courses that encompass the defined POs. Consequently, each course has COs that support some or all defined POs, and assessments are designed to cover the COs specified for that course.

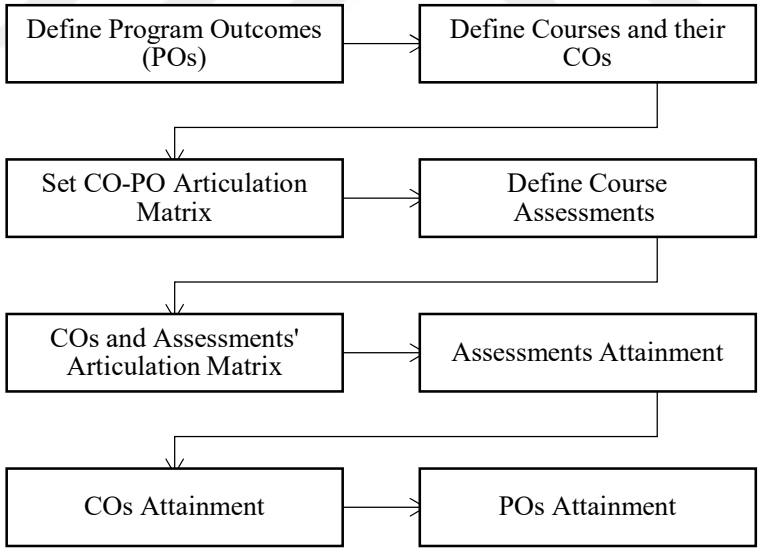


Figure 3.1. Program Outcomes attainment methodology flowchart

The proposed assessment framework utilizes various evaluation methods, including midterm and final examinations, projects, homework assignments, and presentations. To facilitate these assessments, Microsoft Excel and Visual Basic for Applications (VBA) are employed to streamline the calculation and analysis processes. There are three main stages in the methodology indicated as follows:

1. POs definition and their relative importances
2. Program Planning phase
3. POs and COs attainment calculation

3.1. Determining Program Outcomes

Graduate attributes established by the institution, in alignment with its educational mission, are articulated through POs. The starting point for OBE must be a clear definition of the outcomes that students are to achieve, and some effort must be made to indicate the priority of each of these outcomes which works as the direction of the institution (Lavanya & Murthy, 2022). The initial phase of OBE involves the identification of specific goals to be accomplished by the conclusion of the educational program. POs represent the key objectives of an engineering department. Consequently, course curricula are designed in alignment with these POs to ensure that students acquire the necessary knowledge and skills to achieve them. Typically, POs are established by accreditation bodies, which evaluate and accredit university departments based on the extent to which these POs are achieved and comprehensively addressed. This approach is implemented at the Istanbul Kultur University (IKU) Industrial Engineering Department, which adheres to the 11 POs defined by MUDEK, the accrediting institution at the start of the curriculum design process, it is important to decide how much energy will be allocated to each PO. Here, the term "energy" is a measure of how many and to what extent the courses will support the relevant PO after being weighed by its ECTS. This is a strategic issue and must be in line with the long-term plans of not only the institution offering education, but also the governing national higher education body.

3.2. Planning Phase

Studies such as Lavanya and Murthy (2022) and Turhan, Sengul, and Koyuncu (2015) have explored how to calculate the attainment of both COs and POs. However, the existence of significant discrepancies between the target and planned importance of program outcomes may indicate a misalignment with the strategic goals of the institution. These goals are ideally established by considering the institution's available resources and the needs of the environment it serves. The primary objective of this

study is to design a decision support system to assist program directors in identifying such deviations. This phase will provide real-time visibility into the contributions of individual courses toward the achievement of program outcomes. In cases where deviations from the target outcomes are detected, corrective actions will enable program directors to modify the curriculum during the planning phase, thereby addressing and mitigating these discrepancies. In this section, a proposed roadmap that

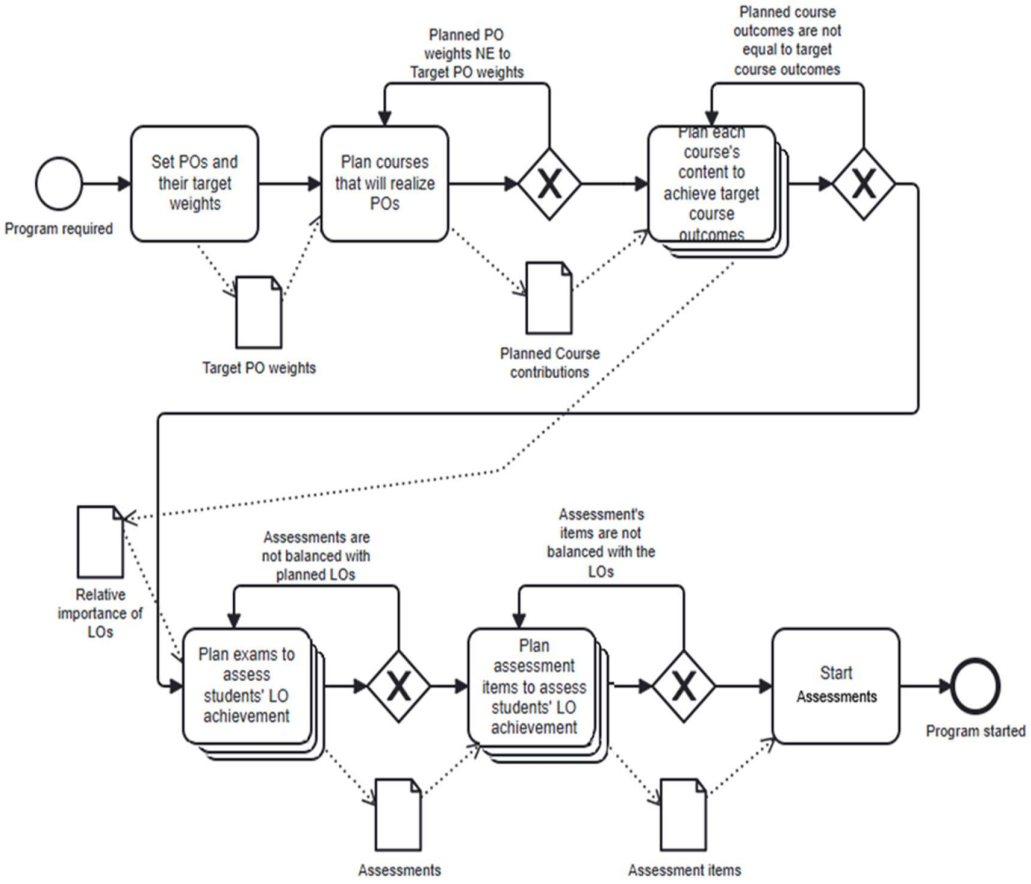


Figure 3.2 General flow of the proposed planning phase

will lead the education managers to an outcome-based education model where the program outcomes are planned and targeted in accordance with their respective priorities. Figure 3.2 outlines the general flow of the proposed planning method. As shown in the figure the initial step is to set POs and their target weights. All steps afterwards will continue iteratively to realize the POs, starting from course selection to assessments designed in each course. To simplify this iterative process, after each

step the target of the following step depends on the inputs set in the previous step as shown in Figure 3.3 below.

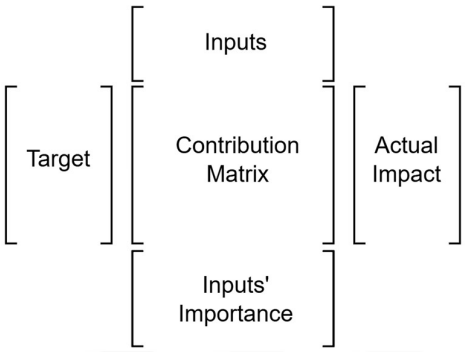


Figure 3.3. Overall planning methodology

As illustrated on the left-hand side of the figure above, the "target" column represents the desired outcomes the department aims to achieve, while the "inputs" column corresponds to the resources allocated to achieve these defined targets. The contribution matrix or articulation matrix, shown in the middle part of the figure, depicts how the inputs influence the expected targets.

To evaluate the alignment between resources and goals, the actual impact and the importance of each input are calculated by determining the total percentage of each row and column within the contribution matrix. The primary objective during this phase is to minimize the discrepancy between the actual impact weights and the target weights. This approach allows a more accurate assessment of how effectively the allocated resources are contributing to achieving the program's defined goals.

3.2.1. Program Planning

Program directors must select courses that will pave the way to achieve POs. Even if the POs are of equal importance, or some outcomes are of greater importance, it should be ensured that each outcome is targeted to the extent it deserves in terms of credit hours. The courses, their contents and durations must be adjusted in a manner that will meet the Target Program Outcome Weights. While calculating Planned PO weights, courses' ECTSs must be considered. There should not be significant differences when Target PO weights and Planned PO weights are compared. In case of discrepancies to address specific POs changing course content, duration, adding, or removing courses can be an approach. Optimization techniques can be useful to choose which course

combinations better minimize the deviations from target PO weights. In this regard, courses' importance can help program directors to facilitate the add-remove process. To address this as illustrated in Figure 3.3 previously, target weights will be POs weights, and inputs are courses defined in the curriculum as shown in Figure 3.4 below.

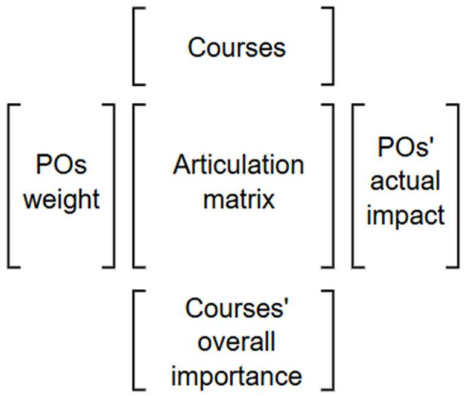


Figure 3.4. POs planning step

3.2.2. Course Content Planning

The planned Course Outcome (CO) weights serve as the target COs, which are further subdivided into detailed learning outcomes and aligned with specific course content. These are the objectives that students are expected to achieve upon the completion of the course. It is the responsibility of the course instructor to establish a clear link between course outcome weights and learning outcomes, ensuring that instructional activities and assessments align with the intended educational objectives.

A key consideration in this step is minimizing deviations between the planned and actual contributions of each course to the Program Outcomes (POs). Any significant discrepancies between the target PO contributions and the planned PO contributions should be addressed to maintain curriculum coherence and effectiveness. The outcome of this step is the determination of the relative importance of COs within each course, providing a structured framework for evaluating their impact on overall program achievement. As shown in Figure 3.5, the Course-to-PO target weights are derived from the PO planning step, specifically from the articulation matrix shown in Figure 3.4. This matrix defines how each course contributes to the achievement of various POs. Additionally, each course within the curriculum will have a unique CO planning

matrix, which further details the relationship between course content, learning outcomes, and program objectives. This structured approach ensures consistency and alignment between course-level outcomes and broader program goals.

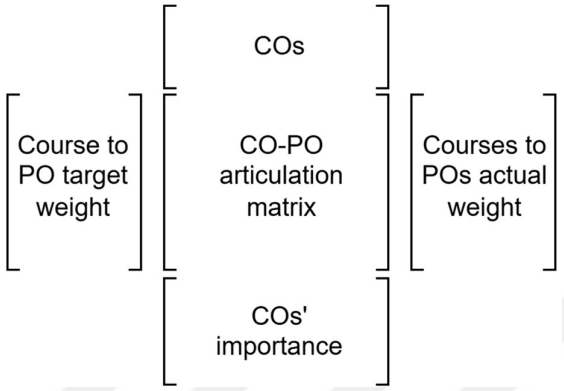


Figure 3.5. COs planning step

3.2.3. Planning the Assessments

Assessments can take various forms, with a primary focus on summative assessments, which are designed to evaluate student learning at the conclusion of a specific instructional period. These assessments commonly include quizzes, midterm examinations, final examinations, and project-based evaluations. The primary objective of assessment is to measure the extent to which students have achieved the predetermined learning outcomes.

At this stage, the planned Course Outcomes (COs) weights, established in the previous step, serve as the target weights for assessment design. To ensure alignment, assessments must be structured in accordance with the relative importance of each CO. It is recommended that an additional planning step be incorporated to systematically map assessments to COs, thereby ensuring that each learning outcome is addressed in proportion to its designated weight. Instructors are responsible for determining the contribution weights of assessments in accordance with their respective contributions to COs. Ideally, there should be minimal deviation between the target CO weights and the actual weights assigned through assessments. In cases where discrepancies arise, adjustments may be necessary. These adjustments may involve the modification of assessment formats, the inclusion or exclusion of specific assessments, or the restructuring of assessment components to ensure that COs are adequately addressed while maintaining alignment with the curriculum structure.

As illustrated in Figure 3.6, the relationship between assessments and COs is systematically determined to facilitate accurate outcome measurement. Given that each assessment comprises multiple components (e.g., individual questions), the subsequent step involves treating each assessment column's contribution as the target weight while designing specific assessment items. The outcome of this step is a structured framework that defines the overall significance of each assessment and quantifies its contribution to the achievement of COs. This structured approach enhances the validity and reliability of assessment methods, ensuring that student learning is comprehensively evaluated in alignment with program objectives.

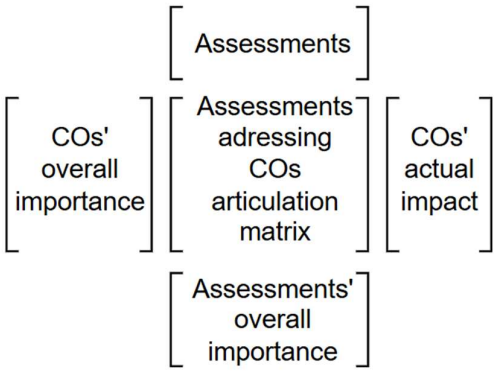


Figure 3.6. Assessments planning step

3.2.4. Planning Assessment's Components

The final step in the planning phase involves the design of individual assessment components and evaluation criteria. Each course may include multiple assessment components, such as examinations, projects, presentations, and other evaluative methods. Given the diversity of these components, each assessment comprises unique items that directly address the defined COs. Therefore, the design of these items must be strategically aligned with the learning objectives and overall educational goals of the course.

Like the preceding steps in the planning phase, the target weights of assessment items are derived from the articulation matrix that maps assessments to COs. Since multiple assessments contribute to CO attainment, this matrix serves as a reference to ensure that assessment items are proportionally distributed according to their relative importance. To achieve alignment with the target weights, assessment components may be modified by adding, removing, or redesigning specific elements to enhance

their effectiveness in measuring CO achievement. This marks the final step of the planning process. Upon approval of this step, the course structure is finalized, ensuring that all assessments are designed in accordance with the institution's strategic goals. This structured approach guarantees that the course effectively contributes to student learning and aligns with broader program objectives, thereby enhancing the overall quality and coherence of the educational framework. As shown in Figure 3.7 below the last planning step is constructed as follows where the inputs in this step are obtained from the normalized column of the desired assessment to COs articulation matrix shown in Figure 3.6 previously.

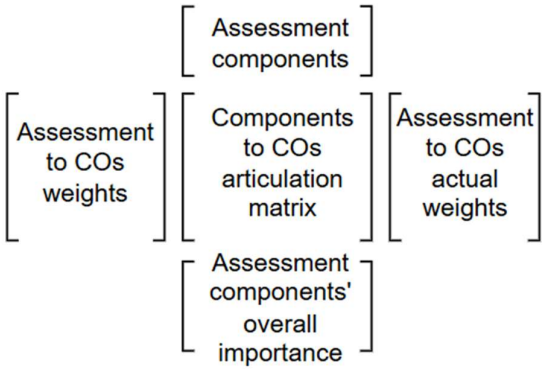


Figure 3.7. Assessment components planning step

3.3. Course Outcomes Attainment

The initial phase after planning involves defining the Course Outcomes (COs), which serve as a framework for designing assessments administered by instructors throughout the semester. It is assumed that all assessments within a course comprehensively address the specified COs. At Istanbul Kultur University (IKU), the current practice assigns a value of 1 to an assessment question if it aligns with a particular CO, and a value of 0 if it does not. However, alternative methodologies can be employed to determine the relative weighting of each assessment question. For example, in Quality Function Deployment (QFD) (Singh & Rawani, 2018) a four-level scale is commonly used, as illustrated in Table 3-1 below.

Table 3-1. QFD support scale

Value	Support Degree
0	No relationship
1	Weak relationship
3	Moderate relationship
9	Strong relationship

After constructing the Question-CO matrix for all assessments, the student percentage scores for each assessment question are multiplied by the corresponding correlation values. The summation of these products yields the final attainment level for each CO. This cumulative value is then divided by the total of the Question-CO column values to determine the percentage attainment of each CO. As explained in Table 3-2 below.

Table 3-2. CO attainment sample calculation matrix for a single student

Assessment z	Questions' weighted max. grade	Student's grades	Student's grades percentage	Course Outcomes (CO) $i = 1,2,\dots,I$
$\begin{bmatrix} q_{yz} \\ \vdots \\ q_{Yz} \end{bmatrix}$	$\begin{bmatrix} g_{yz} \\ \vdots \\ g_{YZ} \end{bmatrix}$	$\begin{bmatrix} s_{yz} \\ \vdots \\ s_{YZ} \end{bmatrix}$	$\begin{bmatrix} ws_{yz} \\ \vdots \\ ws_{YZ} \end{bmatrix}$	$\begin{bmatrix} x_{iyz} & \cdots & x_{Iyz} \\ \vdots & \ddots & \vdots \\ x_{iYZ} & \cdots & x_{IYZ} \end{bmatrix}$
			CO_i % attainment	$\frac{\sum_{j=1}^{J}\sum_{y=1}^{Y} ws_{yj} * x_{iyj}}{\sum_{j=1}^{J}\sum_{y=1}^{Y} x_{iyj}}$, , $\forall i$

In the table above, Assessment z is the defined set of assessments in a course where $z = 1,2,\dots,Z$. Each assessment has a set of questions represented as q_{yz} where y is the number of questions defined in assessment z ($y = 1,2,\dots,Y$). Similarly, questions' weighted max. grade is the set of maximum grades that can be obtained from each question shown as g_{yz}. Student's grade and percentage grade are the attained grades by the students from questions indicated as s_{yz} and ws_{yz} respectively. Lastly, there are I defined COs where $i = 1,2,\dots,I$ and x_{iyz} is the support value from question part y and assessment z to Course Outcome i.

moreover, the maximum contribution for each CO_i is determined by summing the corresponding column in the articulation matrix, which represents the contribution of each assessment component to COs. The attainment for each CO_i is subsequently

calculated as the sum product of the students' grade percentages with the associated COs. Finally, the percentage attainment for each CO_i is obtained by dividing the CO_i attainment by the CO_i maximum contribution for all values of i.

3.4. Program Outcomes Attainment

Following the calculation of each Course Outcome (CO) attainment, the next step is to determine the contribution of each CO to the relevant Program Outcomes (POs) within the course. To facilitate this process, a CO-PO relationship workbook was developed for all core Industrial Engineering courses, mapping the extent to which each CO supports each PO. This mapping matrix. is acquired from IKU's course-program outcomes matrix webpage as shown in Figure 3.8 below.

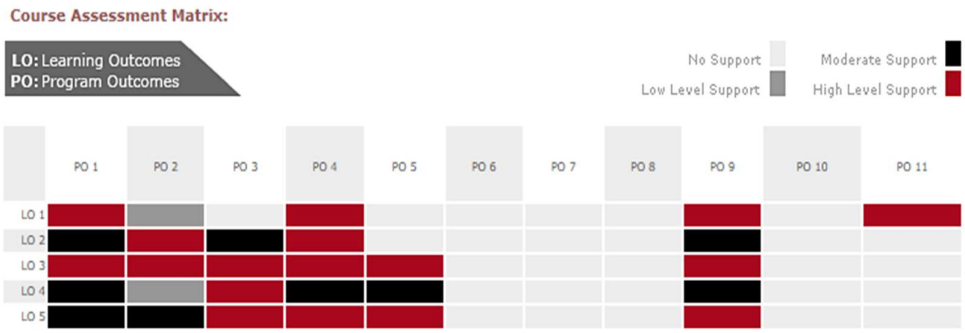


Figure 3.8. Quality Engineering (IE8406) at Istanbul Kultur University course-program outcomes articulation matrix **(Istanbul Kultur University, 2024)**

The figure above indicates that the institution at IKU defined four levels of correlation between COs and POs in Quality Engineering course, as illustrated in Table 3-3 below.

Table 3-3. CO-PO support values.

Value	Support Degree
0	No Support
1	Low Level Support
2	Moderate Support
3	High Level Support

The attainment of POs can be determined by multiplying the CO's attainment percentages by the corresponding support values in the PO correlation column and

summing the results, as illustrated in Table 3-4 below. The below matrix is consisted of i rows representing the number of COs defined for the course that can vary from one course to another, and j number columns representing POs defined by ABET used by the engineering faculty at IKU where $j = 1,2,\dots,11$.

Table 3-4. PO attainment calculation for a single student

CO_i attainment	CO-PO articulation matrix
$\begin{bmatrix} CO_i \\ \vdots \\ CO_I \end{bmatrix}$	$\begin{bmatrix} Y_{ij} & \cdots & Y_{iJ} \\ \vdots & \ddots & \vdots \\ Y_{Ij} & \cdots & Y_{IJ} \end{bmatrix}$
PO_j attainment %	$\frac{\sum_{i=1}^{I} CO_i * Y_{ij}}{\sum_{i=1}^{I} Y_{ij}}$, $\forall j$

The table above illustrates how COs attainment, derived from the previous step, is utilized to determine PO attainment for the course under consideration. Here, Y_{ij} represents the support values linking CO_i to PO_j where j is the number of identified program outcomes. The attainment of each PO_j is calculated by taking the sum of the products of CO_i and Y_{ij}, then dividing this result by the sum of Y_{ij} for the corresponding PO_j.

To account for varying course weights, the PO_j scores are further adjusted by multiplying them with the European Credit Transfer and Accumulation System (ECTS) credits assigned by the department. Finally, the overall PO attainment across multiple courses is computed by taking the average of the attained PO_j values.

4. IMPLEMENTATION

To implement the proposed methodology on a dataset of students from Istanbul Kultur University (IKU), Microsoft Excel serves as an effective tool that can be customized to manage student data through various objects, such as workbooks, worksheets, and cells. To efficiently manipulate these objects, Visual Basic for Applications (VBA) is utilized to develop a system that processes inputs, attributes, and parameters, integrating them to assess whether students have achieved the intended Program Outcomes (POs) and Course Outcomes (COs).

Visual Basic for Applications (VBA) is a programming language environment designed to facilitate task automation, function creation, calculation execution, and spreadsheet interaction within Microsoft Excel (Dessislava, 2012). Built upon the foundation of the Visual Basic language, Visual Basic for Applications (VBA) offers a user-friendly interface that is simpler to grasp compared to its parent language. This accessibility makes VBA an asset for enhancing Office applications (McFedries, 2004). With a user base exceeding 4 million, VBA is widely regarded as the predominant programming language worldwide, particularly esteemed for crafting enterprise applications, intricate web systems, and robust database applications (Siebold, 2000). VBA stands as a versatile tool that grants substantial capabilities upon spreadsheet modeling. It is indispensable for finance professionals who depend on Microsoft Excel for their operations (Naraghi, 2008). In this study several macros were used for the purpose of finding an overall PO average for a single student from different courses or the overall PO average of all students recorded. The model is consisted of three main workbooks named as “Macros”, “Summary”, and “CO-PO”.

4.1. Macros Workbook

The Macros workbook is used to record biodata of courses and students. There are certain inputs required to initiate the process. After opening the Macros workbook, a sheet named “Support” will be found as shown in

Figure 4.1 below. A brief description of the required steps is as follows:

4.1.1. Initialize the Workbook:

The Macros Workbook requires the input of essential parameters, which are prominently highlighted in green for user clarity. These parameters include the course code (e.g., IE8406), the total number of students enrolled in the course, and details about the assessments, such as the number of exams, projects, and their respective weightings. Upon completing these entries, the workbook is automatically renamed to reflect the course code (e.g., IE8406_Grades.xlsx) and saved in a designated folder specified by the instructor. To maintain consistency, all course-related workbooks must be stored in the same directory. Additionally, the system prompts the user to provide the file path of the CO-PO (Course Outcome–Program Outcome) Workbook. This step retrieves critical metadata, including the official course name, number of course outcomes, and the ECTS (European Credit Transfer and Accumulation System) credits assigned to the course as illustrated in

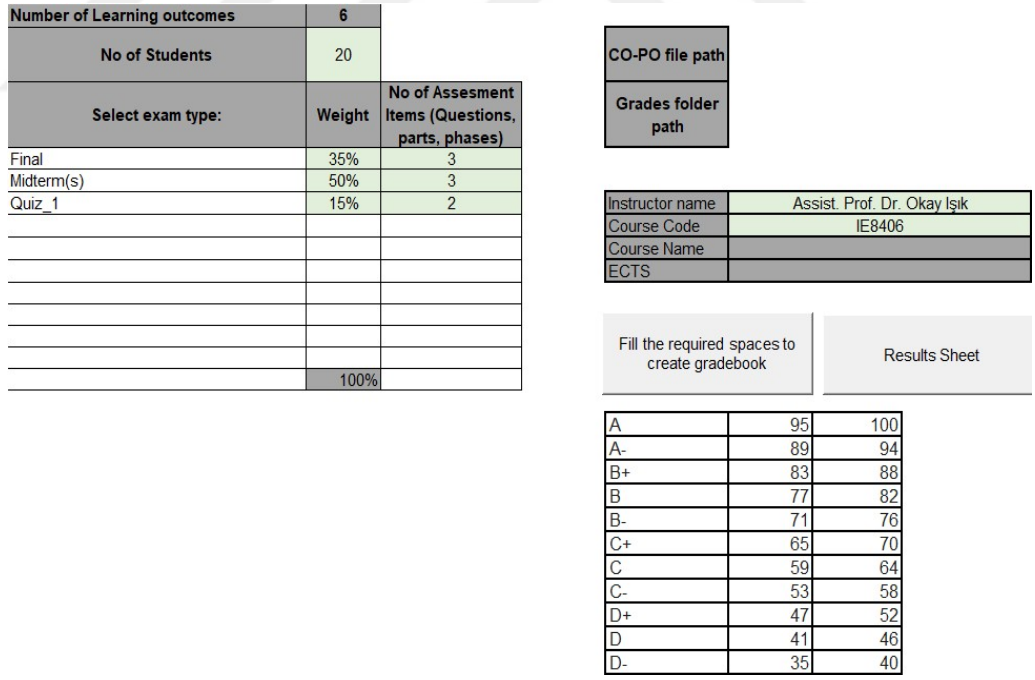


Figure 4.1 below.

Figure 4.1. IE8406 Support worksheet interface

4.1.2. Generating Assessment Sheets

The system automatically generates assessment sheets corresponding to each evaluation method specified during initialization (e.g., Midterm Examination, Final Examination). Each assessment sheet contains three mandatory data entry components that must be completed by the instructor.

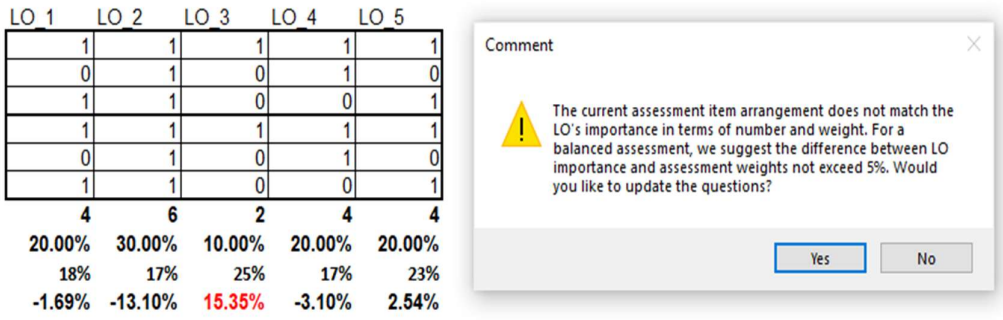
First, instructors are required to input the complete list of enrolled students, including both student names and identification numbers. Second, the corresponding grades for each student must be recorded for all assessment components. Finally, a correlation matrix must be completed to establish the quantitative relationship between individual assessment questions and the predefined Course Outcomes (COs). This structured approach ensures comprehensive data collection while maintaining alignment between assessment instruments and intended learning outcomes. The automated generation of assessment sheets standardizes the evaluation process across courses and instructors, while the correlation matrix provides the necessary foundation for subsequent learning outcome analysis as shown in Figure 4.2 below.

			Question-LO Relations			
		LO_1	1	0	1	
		LO_2	1	1	1	
		LO_3	1	0	0	
		LO_4	1	1	0	
		LO_5	1	0	1	
		Question max grade	50	25	25	
		Question Weight				
SN	ID	Name	Q_1	Q_2	Q_3	Total
1	Student 1	Student1_Name	50	25	25	
2	Student 2	Student2_Name	16	24	5	
3	Student 3	Student3_Name	28	5	0	
4	Student 4	Student4 _Name	8	12	14	
5	Student 5	Student5_Name	36	16	24	
6	Student 6	Student6_Name	22	9	14	
7	Student 7	Student7_Name	4	10	3	
8	Student 8	Student8_Name	33	1	23	
9	Student 9	Student9_Name	5	18	0	
10	Student 10	Student10_Name	33	3	4	

Figure 4.2. Sample assessment's input worksheet

4.1.3. Generating the Results Sheet

Navigating to the Support Sheet and clicking the "Results" button will be required to provide the CO-PO file path to retrieve the correlation matrix between Course Outcomes (COs) and Program Outcomes (POs). A sheet named “Q_LO” will be generated to obtain the questions and COs mapping matrix and calculates each CO weight to control weather the assessment are designed parallel to the CO-PO matrix importance, if the difference between the two exceeds 5% a warning message will be signaled as shown in Figure 4.3 below.



LO_1	LO_2	LO_3	LO_4	LO_5
1	1	1	1	1
0	1	0	1	0
1	1	0	0	1
1	1	1	1	1
0	1	0	1	0
1	1	0	0	1
4	**6**	**2**	**4**	**4**
20.00%	**30.00%**	**10.00%**	**20.00%**	**20.00%**
18%	**17%**	**25%**	**17%**	**23%**
-1.69%	**-13.10%**	**15.35%**	**-3.10%**	**2.54%**

Figure 4.3. Q_LO mapping

The figure above shows that CO 3 should be given more importance or design questions addressing CO 3 to balance the assessments’ questions as discussed in the continuous improvement section. Afterwards, a comprehensive grading sheet will be generated, summarizing and calculating all the information entered in the previous steps. The results sheet will include the following for a single course:

1. Students' course total grades shown in Figure 4.4
2. COs attainment shown in Figure 4.5
3. POs attainment shown in Figure 4.6

Student Name	Student ID	Midterm(s) Q_1	Midterm(s) Q_2	Midterm(s) Q_3	Final Q_1	Final Q_2	Final Q_3	Total
MAX	1111.00	50.00	25.00	25.00	50.00	25.00	25.00	100.00
Student1_Name	Student 1	50.00	25.00	25.00	50.00	25.00	25.00	100.00
Student2_Name	Student 2	34.00	4.00	24.00	9.00	22.00	14.00	53.50
Student3_Name	Student 3	39.00	22.00	9.00	38.00	18.00	11.00	68.50
Student4 _Name	Student 4	33.00	5.00	3.00	41.00	24.00	20.00	63.00
Student5_Name	Student 5	44.00	6.00	5.00	7.00	23.00	24.00	54.50
Student6_Name	Student 6	27.00	9.00	21.00	44.00	8.00	2.00	55.50

Figure 4.4. Students' course total grades

Student Name	Student ID	LO_1	LO_2	LO_3	LO_4	LO_5
MAX	1111.00	1.00	1.00	1.00	1.00	1.00
Student1_Name	Student 1	1.00	1.00	1.00	1.00	1.00
Student2_Name	Student 2	0.60	0.57	0.43	0.48	0.60
Student3_Name	Student 3	0.59	0.66	0.77	0.79	0.59
Student4 _Name	Student 4	0.60	0.59	0.74	0.66	0.60
Student5_Name	Student 5	0.55	0.56	0.51	0.55	0.55
Student6_Name	Student 6	0.59	0.50	0.71	0.53	0.59

Figure 4.5. COs attainment

Student Name	Student ID	PO_1	PO_2	PO_3	PO_4	PO_5	PO_6	PO_7	PO_8	PO_9	PO_10	PO_11
MAX	1111.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00
Student1_Name	Student 1	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00
Student2_Name	Student 2	0.53	0.53	0.51	0.54	0.50	0.00	0.00	0.00	0.53	0.00	0.60
Student3_Name	Student 3	0.68	0.68	0.70	0.67	0.70	0.00	0.00	0.00	0.67	0.00	0.59
Student4 _Name	Student 4	0.64	0.65	0.65	0.64	0.67	0.00	0.00	0.00	0.64	0.00	0.60
Student5_Name	Student 5	0.54	0.54	0.54	0.54	0.53	0.00	0.00	0.00	0.54	0.00	0.55
Student6_Name	Student 6	0.59	0.59	0.59	0.59	0.62	0.00	0.00	0.00	0.59	0.00	0.59

Figure 4.6. POs attainment

4.2. CO-PO Workbook

To use the Macros workbook, certain attributes for each course must be obtained. These attributes are pre-constructed and stored in the CO-PO workbook. General information, such as the course and ECTS, is located on the first sheet as shown in Figure 4.7 below. Each course offered in the Industrial Engineering program has its own separate sheet within this workbook named by course codes, containing the CO-PO correlation matrix.

code	name	ECTS	Num CO
IE1601	Engineering Graphics	5	5
IE1001	Introduction to Computing	6	6
IE2602	General Chemistry	5	11
IE2401	Introduction to Industrial Engineering	3	6
IE2002	Introduction to Programming	5	5
IE3101	Introduction to Probability	6	5
IE3501	Economics	4	5

Figure 4.7. CO-PO workbook "Courses" worksheet

The source of the articulation matrix is from the IKU Academic Package website (İstanbul Kültür University, 2024) for the Industrial Engineering Program. Therefore, from the course code entered in the "Support" worksheet the code opens the "CO-PO" workbook and maps the for the course required worksheet and obtains the correlation matrix shown in Figure 4.8 below.

Quality Engineering
IE8406

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11		
LO 1	3	1	0	3	0	0	0	0	3	0	3	13	18%
LO 2	2	3	2	3	0	0	0	0	2	0	0	12	17%
LO 3	3	3	3	3	3	0	0	0	3	0	0	18	25%
LO 4	2	1	3	2	2	0	0	0	2	0	0	12	17%
LO 5	2	2	3	3	3	0	0	0	3	0	0	16	23%

Figure 4.8. CO-PO workbook, IE8406 Quality Engineering CO-PO worksheet

4.3. Summary Workbook

The Summary Workbook is used at the end to calculate average Program Outcomes (PO) achieved by students across different courses saved in the folder designated by the Macro Workbook. This workbook views the overall average PO for all students or find the individual average for a specific student by searching using their student number or name. This workbook can be seen as the database for all students and courses taken into consideration in the calculation. Moreover, the code iteratively opens all the courses saved in the file obtaining all the courses gradebooks then searches for the POs results and aggregates all scores in one table inside the "Summary" workbook. As shown in Figure 4.9 below, some arbitrary courses were recorded from the IE department at IKU to illustrate how the courses entered from the "Macros" workbook are aggregated in one single table. Under the first column called Student ID, a student with number "1111" plays as the maximum possible PO contribution from a single course. Afterwards, another tool in MS Excel is used to analyze the database constructed called PivotTable. A PivotTable is a versatile tool for calculating, summarizing, and analyzing data, enabling the identification of comparisons, patterns, and trends effectively (Microsoft 365, 2025). A PivotTable is constructed to analyze the attainment of each PO as needed. Pivot tables can be modified as required by the instructor using filters for different attributes such as Student's number, course code, and instructor name. Figure 4.10 below shows the PivotTable constructed from the database shown Figure 4.9 below.

Student ID #	Course Name	Course Code	ECTS	Instructor Name	Num LO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
1111	Operations Research II	IE5202	7	Instructor 1	6	7.00	7.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Student 1	Operations Research II	IE5202	7	Instructor 1	6	5.65	5.65	0.00	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Student 2	Operations Research II	IE5202	7	Instructor 1	6	3.99	3.99	0.00	3.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Student 3	Operations Research II	IE5202	7	Instructor 1	6	3.41	3.41	0.00	3.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1111	Simulation Modelling	IE7203	6	Instructor 2	6	0.00	5.14	5.14	5.14	5.14	5.14	5.14	0.00	0.00	0.00	0.00
Student 1	Simulation Modelling	IE7203	6	Instructor 2	6	0.00	5.07	5.07	5.07	5.07	5.06	5.07	0.00	0.00	0.00	0.00
Student 2	Simulation Modelling	IE7203	6	Instructor 2	6	0.00	3.26	3.29	3.29	3.29	3.42	3.32	0.00	0.00	0.00	0.00
Student 3	Simulation Modelling	IE7203	6	Instructor 2	6	0.00	3.23	3.25	3.25	3.25	3.34	3.23	0.00	0.00	0.00	0.00
1111	Quality Engineering	IE8406	5	Instructor 2	5	5.00	5.00	5.00	5.00	5.00	0.00	0.00	0.00	5.00	0.00	5.00
Student 1	Quality Engineering	IE8406	5	Instructor 2	5	4.03	4.02	4.04	4.03	4.05	0.00	0.00	0.00	4.03	0.00	4.04
Student 2	Quality Engineering	IE8406	5	Instructor 2	5	2.57	2.56	2.64	2.55	2.62	0.00	0.00	0.00	2.55	0.00	2.37
Student 3	Quality Engineering	IE8406	5	Instructor 2	5	3.15	3.15	3.23	3.09	3.37	0.00	0.00	0.00	3.12	0.00	2.80

Figure 4.9. "Database" worksheet in the "Summary" workbook

Student Number	(All)	Values	
Course Code	(All)	PO 1	0.581
Instructor Name	(All)	PO 2	0.708
		PO 3	0.538
		PO 4	0.704
		PO 5	0.538
		PO 6	0.323
		PO 7	0.360
		PO 8	0.208
		PO 9	0.411
		PO 10	0.273
		PO 11	0.405

Figure 4.10. PivotTable and filters

In Figure 4.10 above the values shown are calculated as follows in Equation 1 below,

$$Overall\ PO_j = \frac{\sum_i^I ECTS_i * PO_{ij}}{\sum_i^I ECTS_i} \quad ,\forall j \qquad (1)$$

Single PO_j values are previously explained in Table 3-4. Therefore, in Equation 1 above, PO_{ij} represents the contribution to PO_j from course i, where I represents the set of courses aggregated in the database worksheet. The equation can be used for a single student if more than one student is considered, the equation then will be changed by aggregating PO contribution from different students for the same course.

Finally, a radar chart can be utilized to visually represent the level of Program Outcome (PO) attainment for an individual student or an entire cohort. In this representation, a value of 1 indicates the highest possible level of attainment, while a value of 0 represents the lowest. This graphical approach provides a clear and comparative overview of performance across multiple POs as illustrated in Figure 4.11 below. In addition, an automated dashboard giving insights on POs attainment percentage can be seen in Figure 4.12 below

The charts below illustrate that the student in question can prioritize selecting future courses or allocating resources toward PO 1, 2, and 4. Similarly, this approach can be applied by the institution when planning which courses to offer or how to structure them.

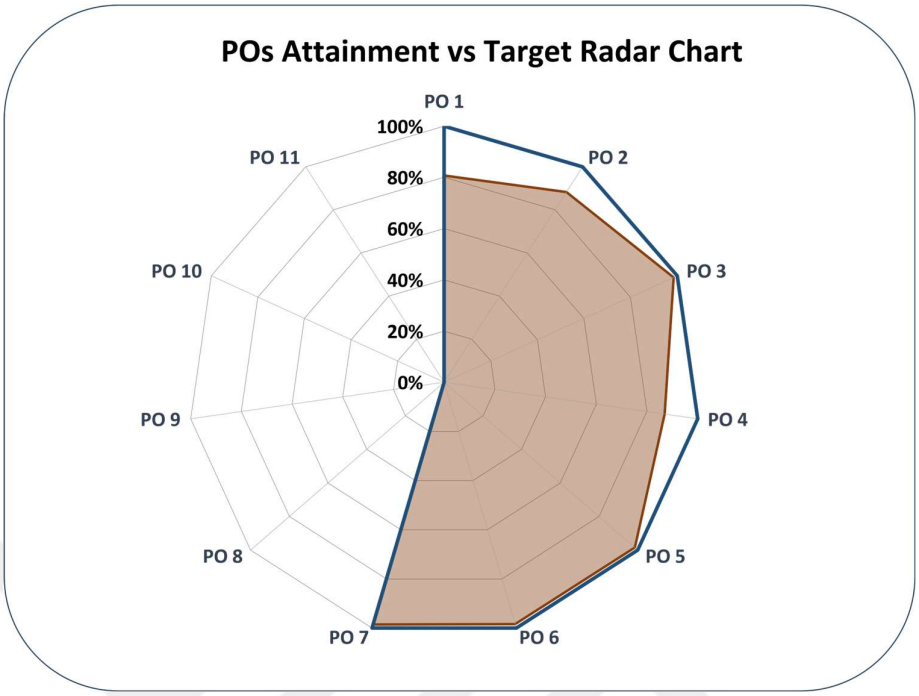


Figure 4.11. A sample student PO attainment radar chart

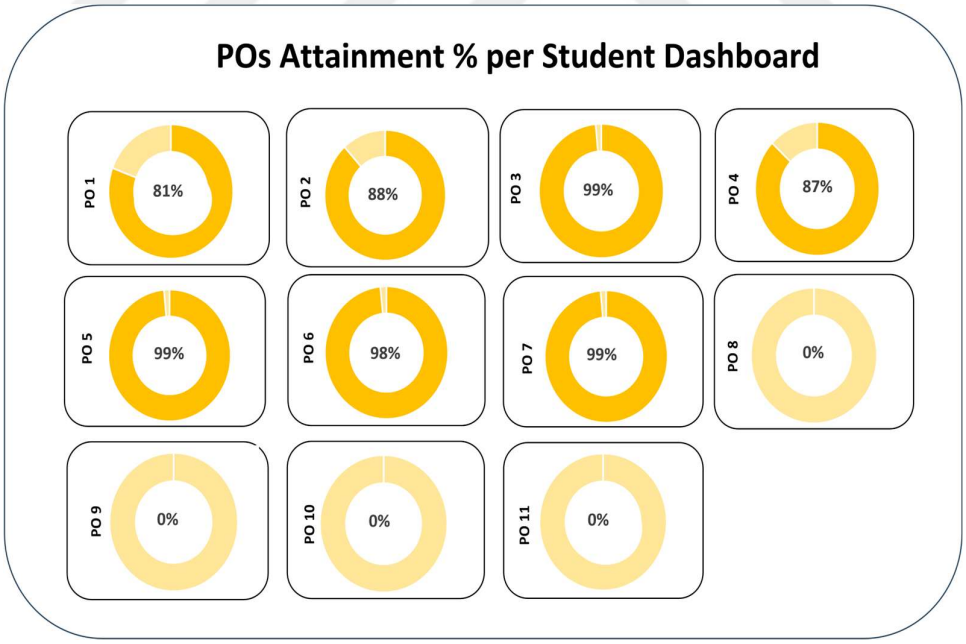


Figure 4.12. Sample student POs attainment dashboard

5. CONCLUSION

This study has presented a comprehensive methodology for assessing and managing learning outcomes in engineering education through the development of an Excel-based management system. The research addressed the critical need for systematic outcome evaluation in alignment with international accreditation standards, particularly those set by MÜDEK.

The proposed three-tier assessment framework successfully integrates course-level evaluations with program-level outcomes, demonstrating significant improvements over traditional assessment methods. Key findings indicate that:

1. The automated Excel-VBA system provides an efficient and reliable solution for calculating Course Outcome (CO) and Program Outcome (PO) attainment, reducing manual workload while improving accuracy.
2. The suggested continuous planning mechanism ensures proper alignment between course content, assessments, and program objectives, facilitating accreditation compliance.
3. The case study implementation at Istanbul Kültür University validated the system's effectiveness in identifying curriculum gaps and supporting data-driven decision making for continuous improvement.

The study contributes to the field of engineering education by developing a quantitative model for outcome assessment, providing a practical tool to support accreditation documentation, and establishing a comprehensive framework aimed at enhancing curriculum quality. These contributions offer both theoretical and practical value, supporting continuous improvement efforts in engineering programs.

While the current system focuses primarily on engineering programs, the underlying methodology demonstrates strong potential for adaptation to other disciplines that utilize outcome-based assessment. Future research could explore the integration of the model with institutional learning management systems, the application of machine learning techniques for predictive analysis, the expansion of its use to multidisciplinary program assessment other than engineering, and the incorporation of optimization techniques to support data-driven decision making and improve outcome attainment.

Limitations of the study include the system's dependency on properly structured input data and the need for faculty training in its implementation. Another limitation of this study is that the articulation matrices were constructed based on the perspectives of individual instructors, which may result in misalignments between course content and the intended learning outcomes. However, these challenges do not diminish the system's value as an effective tool for outcome assessment in higher education.

In conclusion, this research provides academic institutions with a practical, scalable solution for implementing outcome-based education. The developed system not only supports accreditation requirements but also enhances the quality of engineering education by ensuring graduates acquire the necessary competencies for professional practice. The findings underscore the importance of systematic outcome assessment in maintaining educational excellence and meeting evolving industry demands.

This work establishes a foundation for further development of automated assessment tools in higher education, contributing to the ongoing advancement of quality assurance in engineering programs worldwide.

REFRENCES

ABET. (2017, April 1). *ABET Accreditation Changes 2018-2019 Accreditation Policy and Procedure Manual.* Retrieved from ABET Web site: https://www.abet.org/accreditation/accreditation-criteria/accreditation-changes/

ABET. (2021, April 4). *About ABET*. Retrieved from ABET Web site: https://www.abet.org/about-abet/

Alfozan , A., & Kadampur, M. A. (2021). System Design and Case Study Reporting on AQASYS: A Web-based Academic Quality Assurance System. *(IJACSA) International Journal of Advanced Computer Science and Applications*, vol. 12, No. 7.

Dessislava, P. A. (2012). Introduction to Visual Basic for Applications. *Encyclopedia of Financial Models*. doi:10.1002/9781118182635.efm0115

Ghaly, S. M. (2019). Optimization of Quality Assessment and Evaluation Approach for Engineering Program Accreditation. *2019 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1267-1274). Dubai: IEEE.

Harden, R. M., Crosby, J. R., & Davis, M. H. (1999). AMEE Guide No. 14: Outcome-based education: Part 1 An introduction to outcome-based education. *Medical Teacher*, Vol. 21, No. 1.

Istanbul Kultur University. (2022, July 02). *Istanbul Kultur University: Accreditation*. Retrieved from Istanbul Kultur Univesity Web site: https://fef.iku.edu.tr/en/accreditation

Istanbul Kultur University. (2024, April 23). *Academic Package Course Program outcomes matrix: Istanbul Kultur University*. Retrieved from Istanbul Kultur University Web site: https://akademikpaket.iku.edu.tr/EN/ects_bolum.php?m=1&p=13&f=4&r=0&ects=matris

İstanbul Kültür University. (2024). *Course - Program Outcomes Matrix*. Retrieved from Industrial Engineering Main Page :

https://akademikpaket.iku.edu.tr/EN/ects_bolum.php?m=1&p=13&f=4&r=0&ects=matris

Jaafar, M., Nordin, N., Wagiran, R., Aziz, A., Noor, M., Osman, M., . . . Abdulaziz, F. (2008). Assessment Strategy for an Outcome Based Education.

Kalaani, Y., & Haddad, R. J. (2014). Continuous Improvement in the Assessment Process of Engineering Programs. *roceedings of the 2014 American Society for Engineering Education Southeast Section Conference* (p. 43). Macon: ASEE.

Karakaya, F., & Yılmaz, M. (2022). Teachers' views on assessment and evaluation methods in STEM education: A science course example. *Journal of Pedagogical Research*, 61-71. doi:https://doi.org/10.33902/JPR.202213526

Kohli, N. (2014). Role of Accreditation in Engineering Education. *2014 IEEE International Conference on MOOC, Innovation and Technology in Education (MITE)* (pp. 157-159). Patiala, India: IEEE Xplore.

Lattuca, L. R., Terenzini, P. T., & Volkwein, F. J. (2004). Engineering Change: A Study of the Impact of EC2000. *International Journal of Engineering Science Vol. 20, No. 3*, 318-328.

Lavanya, C., & Murthy, J. N. (2022). Assessment and Attainment of Course Outcomes and Program Outcomes. *Journal of Engineering Education Transformations*, Volume 35 , No. 4.

McFedries, P. (2004, March 9). Absolute Beginner's Guide to VBA. Que Publishing.

Microsoft 365. (2025). *Excel Help & Training*. Retrieved from Create a PivotTable to analyze worksheet data: https://support.microsoft.com/en-us/office/create-a-pivottable-to-analyze-worksheet-data-a9a84538-bfe9-40a9-a8e9-f99134456576

MÜDEK. (2020, April 18). *MÜDEK Briefly*. Retrieved from MÜDEK Web site: https://www.mudek.org.tr/en/hak/kisaca.shtm

Naraghi, M. H. (2008). VBA/EXCEL: An Alternative Computer Programming Tool for Engineering Freshman. *ASME 2005 International Mechanical Engineering Congress and Exposition* (pp. 315-322). Florida: ASME.

Ramchandra, S., Maitra, S., & MallikarjunaBabu, K. (2014). Method for estimation of attainment of program outcome through course outcome for outcome based education. *2014 IEEE International Conference on MOOC, Innovation and Technology in Education (MITE)* (pp. 7-12). Patiala: IEEE.

Ronquillo, D. G., & Ronquillo, T. A. (2014). Implementing Outcomes-Based in Electronics Engineering of Batangas State University: Motivations, Processes, Challenges. *2014 IEEE International Conference on Teaching, Assessment and Learning for Engineering* (pp. 423-428). Wellington: IEEE.

Shafi, A., Saeed, S., Bamarouf, Y. A., Iqbal, S. Z., Min-Allah, N., & Alqahtani, M. A. (2019). Student Outcomes Assessment Methodology for ABET Accreditation: A Case Study of Computer Science and Computer of Computer Science and Computer Information Systems Programs. *IEEE TRANSACTIONS ON EDUCATION*, VOL. 65, NO. 4.

Siebold, D. (2000). *Visual Basic Developer's Guide to SQL Server.* Sybex Inc.

Singh, A. K., & Rawani, A. M. (2018). Application of quality function deployment for the prioritization of National Board of Accreditation quality parameters. *Quality Assurance in Education*, 127-139.

Syeed, M. M., Shihavuddin, A., Uddin, M. F., Hasan, M., & Khan, R. H. (2017). Outcome Based Education (OBE): Defining the Process and Practice for Engineering Education. *IEEE Access*, vol. 10, pp. 119170-119192. doi:10.1109/ACCESS.2022.3219477

Ventura, J. (2003). Accreditation Criteria for Engineering Programs – Implementing EC-2000 Criteria. *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition* (pp. 8.230.1-8). Tennessee: American Society for Engineering Education.

Zamir, M. Z., Abid, M. I., Fazal, M. R., Qazi, M., & Kamran, M. (2022). Switching to Outcome-Based Education (OBE) System, a Paradigm Shift in Engineering Education. *IEEE Transactions on Education*.

APPENDICES

APPENDIX A

```
Option Explicit
Public No_Of_Sheets_to_be_Added As Integer
Public Sheet_Name As String
Public i, NumStd, SN, NumLO, numCol, j, k, Q, numQ As Integer
Public startCell As Range
Public lastRow As Long, lastCol As Long
Public ws As Worksheet
Public POA As Range
Sub Start()
Call courseinfo
Call CreateWorksheetsUpdate(Sheets("Support").Range("A4:A13"))
Call RenameAndMoveWorkbook
End Sub
Sub CreateWorksheets(Names_Of_Sheets As Range)
NumLO = Worksheets("Support").Range("B1").Value
NumStd = Worksheets("Support").Range("B2").Value
No_Of_Sheets_to_be_Added = Names_Of_Sheets.Rows.Count
For i = 1 To No_Of_Sheets_to_be_Added
Sheet_Name = Names_Of_Sheets.Cells(i, 1).Value
' Only add sheet if it doesn't exist already and the name is longer than zero characters
If (Sheet_Exists(Sheet_Name) = False) And (Sheet_Name <> "") Then
Set ws = Worksheets.Add
ws.Name = Sheet_Name
ElseIf Sheet_Name <> "" Then
Set ws = Worksheets(Sheet_Name)
End If
' Create headers of the sheets
numQ = Worksheets("Support").Cells(i + 3, 3).Value
With ws
.Cells(1, 4).Value = "Question-LO Relations"
.Cells(NumLO + 4, 1).Value = "SN"
.Cells(NumLO + 4, 2).Value = "ID"
.Cells(NumLO + 4, 3).Value = "Name"
.Cells(NumLO + 2, 3).Value = "Question max grade"
.Cells(NumLO + 3, 3).Value = "Question Weight"
End With
' Create LO rows
For j = 1 To NumLO
ws.Cells(j + 1, 3).Value = "LO_" & j
Next j
' Create SN
For k = 1 To NumStd
ws.Cells(k + NumLO + 4, 1).Value = k
Next k
ws.Cells(NumLO + 4, numQ + 4).Value = "Total"
' Create question rows
For Q = 1 To numQ
ws.Cells(NumLO + 4, 3 + Q).Value = "Q_" & Q
Next Q
With ws
.Columns("A:Z").EntireColumn.AutoFit
```

```
.Columns("B").ColumnWidth = 10
.Columns("D").ColumnWidth = 4
End With
Set startCell = ws.Cells(NumLO + 4, 1)

lastRow = NumLO + NumStd + 4
lastCol = numQ + 4
ws.Range(startCell, ws.Cells(lastRow, lastCol)).Borders.Weight = xlThin
ws.Range(ws.Cells(1, 3), ws.Cells(lastRow, lastCol)).Borders.Weight = xlThin
Next i
ws.Cells(NumLO + 4, numQ + 4).Value = "Q_1"
End Sub
Function Sheet_Exists(WorkSheet_Name As String) As Boolean
Dim Work_sheet As Worksheet
Sheet_Exists = False
For Each Work_sheet In ThisWorkbook.Worksheets
If Work_sheet.Name = WorkSheet_Name Then
Sheet_Exists = True
Exit Function
End If
Next Work_sheet
End Function
Sub ProtectWorkbookStructure()
Dim wb As Workbook
Set wb = ThisWorkbook
' Protect the workbook structure
wb.Protect Password:="12345", Structure:=True
MsgBox "Workbook structure is now protected.", vbInformation
End Sub
Sub RenameWorkbook()
Dim newFileName As String
' Get the new file name from cell F8
newFileName = ThisWorkbook.Sheets("Sheet1").Range("F8").Value
' Rename the workbook
ThisWorkbook.SaveAs newFileName
' Optionally, update the workbook name in Excel
ThisWorkbook.Name = newFileName
End Sub
Sub Q_LO()
Dim X As Integer
Dim numQ As Integer, NumLO As Integer, j As Integer
Dim ws As Worksheet
Dim targetRange As Range
Dim pasteRange, COW, lastRow As Range
Dim code As String
Dim col As Long
Dim thresh As Range
code = Worksheets("Support").Range("F7").Value
Worksheets("Q_LO").Select
' Clear previous content in Q_LO sheet
Worksheets("Q_LO").Cells.Clear
Call RemoveAllBorders
' Set up the number of LOs
NumLO = Worksheets("Support").Range("B1").Value
For j = 1 To NumLO
Worksheets("Q_LO").Cells(2, j + 2).Value = "LO_" & j
```

```
Next j
' Loop through the worksheets
For X = 1 To Worksheets.Count - 3
Set ws = Worksheets(X)
numQ = Application.WorksheetFunction.XLookup(ws.Name,
Worksheets("Support").Range("A4:A13"), W
orksheets("Support").Range("C4:C13"))

Set targetRange = ws.Range("D2").Resize(NumLO, numQ)
targetRange.Copy
Worksheets("Q_LO").Range("C2000").End(xlUp).Offset(1, 0).Resize(numQ, NumLO).Select
Selection.PasteSpecial Paste:=xlPasteAll, Transpose:=True
Call thickoutsideborders
Next X
Call normalization
Call OpenWorkbook
With Workbooks("CO-PO.xlsm").Worksheets(code)
Set COW = .Range(.Cells(4, 14), .Cells(4, 14).End(xlDown))
COW.Copy
End With
Workbooks("Macros").Activate
Worksheets("Q_LO").Range("C2000").End(xlUp).Offset(1, 0).Select
Selection.PasteSpecial Paste:=xlPasteAll, Transpose:=True
'Workbooks("CO-PO.xlsm").Close
For col = 1 To NumLO
Worksheets("Q_LO").Cells(3, 2 + col).End(xlDown).Offset(1, 0).Value = Worksheets("Q_LO").Cells
(3, 2 + col).End(xlDown).Value - Worksheets("Q_LO").Cells(3, 2 + col).End(xlDown).Offset(-1, 0).Value
Worksheets("Q_LO").Cells(3, 2 + col).End(xlDown).NumberFormat = "0.00%"
Worksheets("Q_LO").Cells(3, 2 + col).End(xlDown).Font.Bold = True
Next col
Worksheets("Q_LO").Range("A1").Select
Call CheckLastRowValues
End Sub
Sub CheckLastRowValues()
Dim ws As Worksheet
Dim rng As Range
Dim lastRow As Long
Dim cell As Range
Dim threshold As Double
Dim exceeds As Boolean
Dim response As VbMsgBoxResult
' Set worksheet and range
Set ws = Worksheets("Q_LO") ' Change as needed
Set rng = ws.Range(ws.Range("C3").End(xlDown), ws.Range("C3").End(xlDown).End(xlToRight)) '
Define
your range
' Find last row with data in the range
threshold = 0.05
' Check if any value in the last row exceeds the 5% limit
exceeds = False
For Each cell In rng
If cell.Value > threshold Then
exceeds = True
Exit For
End If
Next cell
```

```
For Each cell In rng
If cell.Value > threshold Then
cell.Font.Color = RGB(255, 0, 0)
End If
Next cell
' If any value exceeds the threshold, prompt the user
If exceeds Then
response = MsgBox("The current assessment item arrangement does not match the LO's importance
in terms of number and weight. For a balanced assessment, we suggest the difference between LO
importa
nce and assessment weights not exceed 5%. Would you like to update the questions?",
vbExclamation + vb
YesNo, "Comment")
ws.Activate

' Exit the sub if the user selects "Adjust" (Yes)
If response = vbYes Then End
End If
End Sub
Sub normalization()
Dim pasteRange, normalizationRange, sumrow As Range
Dim cell As Range
Dim sumResult, total As Double
Dim col As Long
Dim ws As Worksheet
Dim NumLO As Integer
NumLO = Worksheets("Support").Range("B1").Value
Set ws = ThisWorkbook.Sheets("Q_LO")
With Worksheets("Q_LO")
Set pasteRange = .Range("C3", .Cells(.Cells(.Rows.Count, "C").End(xlUp).row, .Cells(3, .Column
s.Count).End(xlToLeft).Column))
End With
pasteRange.Select
lastRow = pasteRange.Rows.Count
For col = 1 To pasteRange.Columns.Count
sumResult = Application.WorksheetFunction.Sum(pasteRange.Columns(col))
ws.Cells(lastRow + 3, col + 2).Value = sumResult
ws.Cells(lastRow + 3, col + 2).Font.Bold = True
Next col
Set sumrow = Worksheets("Q_LO").Range("C2000").End(xlUp).Resize(1, NumLO)
total = Application.WorksheetFunction.Sum(sumrow)
For col = 1 To NumLO
Worksheets("Q_LO").Cells(3, 2 + col).End(xlDown).Offset(1, 0).Value = Worksheets("Q_LO").Cells
(3, 2 + col).End(xlDown).Value / total
Worksheets("Q_LO").Cells(3, 2 + col).End(xlDown).NumberFormat = "0.00%"
Worksheets("Q_LO").Cells(3, 2 + col).End(xlDown).Font.Bold = True
Next col
End Sub
Sub RemoveAllBorders()
Dim ws As Worksheet
Set ws = Worksheets("Q_LO")
ws.Cells.Borders(xlEdgeLeft).LineStyle = xlNone
ws.Cells.Borders(xlEdgeTop).LineStyle = xlNone
ws.Cells.Borders(xlEdgeBottom).LineStyle = xlNone
ws.Cells.Borders(xlEdgeRight).LineStyle = xlNone
ws.Cells.Borders(xlInsideVertical).LineStyle = xlNone
```

```
ws.Cells.Borders(xlInsideHorizontal).LineStyle = xlNone
End Sub
Sub thickoutsideborders()
Selection.Borders(xlDiagonalDown).LineStyle = xlNone
Selection.Borders(xlDiagonalUp).LineStyle = xlNone
With Selection.Borders(xlEdgeLeft)
.LineStyle = xlContinuous
.ColorIndex = 0
.TintAndShade = 0
.Weight = xlMedium
End With
With Selection.Borders(xlEdgeTop)
.LineStyle = xlContinuous
.ColorIndex = 0
.TintAndShade = 0
.Weight = xlMedium
End With
With Selection.Borders(xlEdgeBottom)
.LineStyle = xlContinuous
.ColorIndex = 0

.TintAndShade = 0
.Weight = xlMedium
End With
With Selection.Borders(xlEdgeRight)
.LineStyle = xlContinuous
.ColorIndex = 0
.TintAndShade = 0
.Weight = xlMedium
End With
With Selection.Borders(xlInsideVertical)
.LineStyle = xlContinuous
.ColorIndex = xlAutomatic
.TintAndShade = 0
.Weight = xlThin
End With
With Selection.Borders(xlInsideHorizontal)
.LineStyle = xlContinuous
.ColorIndex = xlAutomatic
.TintAndShade = 0
.Weight = xlThin
End With
End Sub
Sub results()
Dim X As Integer, SN As Integer
Dim ws As Worksheet
Dim numQ As Integer, NumStd As Integer
Dim k, numCol As Integer, Q As Integer
Dim resWs As Worksheet
Dim w, totalgrade As Double
Dim examRange, pasteRange, y, max, StuGrade, MaxGrade As Range
Call Q_LO
Set resWs = Worksheets("Results")
resWs.Select
NumStd = Worksheets("Support").Range("B2").Value
numCol = Application.WorksheetFunction.Sum(Worksheets("Support").Range("C4:C13"))
```

```
NumLO = Worksheets("Support").Range("B1").Value
' Initialize headers and clear previous results
With resWs
.Cells.ClearContents
.Cells(4, 1).Value = "Student"
.Cells(4, 2).Value = "SN"
.Cells(2, 2).Value = "Exam Weight"
.Cells(3, 2).Value = "Question Weight"
End With
For X = 1 To Worksheets.Count - 3
Set ws = Worksheets(X)
numQ = Application.WorksheetFunction.XLookup(ws.Name,
Worksheets("Support").Range("A4:A13"), W
orksheets("Support").Range("C4:C13"))
w = Application.WorksheetFunction.XLookup(ws.Name, Worksheets("Support").Range("A4:A13"),
Work
sheets("Support").Range("B4:B13"))
With resWs
Set max = .Cells(5, 1)
max.Value = "MAX"
max.Offset(0, 1).Value = 1111
' Write question headers
For Q = 1 To numQ
.Cells(4, 2000).End(xlToLeft).Offset(0, 1).Value = "Q_" & Q
.Cells(4, 2000).End(xlToLeft).Offset(-3, 0).Value = ws.Name
.Cells(4, 2000).End(xlToLeft).Offset(-2, 0).Value = w
.Cells(4, 2000).End(xlToLeft).Offset(-1, 0).Value = ws.Cells(3 + NumLO, 3 + Q).Value

max.End(xlToRight).Offset(0, 1).Value = ws.Cells(NumLO + 2, Q + 3).Value
Set MaxGrade = max.End(xlToRight).Offset(0, numCol + 1)
MaxGrade.Value = ws.Cells(NumLO + 2, Q + 3).Value * w
MaxGrade.Offset(0, numCol).Value = MaxGrade.Value / MaxGrade.Value
Next Q
' Write student numbers and results
For SN = 1 To NumStd
.Cells(5 + SN, 1).Value = ws.Cells(SN + NumLO + 4, 3).Value ' Assuming student numbers
are in column B starting at NumLO + 4 rows
.Cells(5 + SN, 2).Value = ws.Cells(SN + NumLO + 4, 2).Value ' Assuming student numbers
are in column B starting at NumLO + 4 rows
For Q = 1 To numQ
Set y = .Cells(5 + SN, 1).End(xlToRight).Offset(0, 1)
y.Value = ws.Cells(4 + NumLO + SN, 3 + Q).Value ' Assuming results start from colu
mn D, numLO+4 row
Set StuGrade = y.Offset(0, numCol + 1)
Set MaxGrade = max.End(xlToRight).Offset(0, numCol - numQ + Q + 1)
If y.Offset(-2 - SN, 0).Value = 0 Then
StuGrade.Value = (y.Value * w)
StuGrade.Offset(0, numCol).Value = StuGrade.Value / MaxGrade.Value
Else
StuGrade.Value = (y.Value * w * y.Offset(-1 - SN, 0).Value)
StuGrade.Offset(0, numCol).Value = StuGrade.Value / MaxGrade.Value
End If
Next Q
Next SN
End With
Next X
```

```
With resWs
.Cells(4, 1).Offset(0, numCol + 2) = "Total"
For SN = 1 To NumStd + 1
Set y = .Cells(4 + SN, 1).End(xlToRight).Offset(0, 1)
y.Value = Application.WorksheetFunction.Sum(.Range(y.Offset(0, 1), y.Offset(0, numCol)))
Next SN
End With
Call DeletefailedStudents
Call matrixmult
Workbooks("CO-PO.xlsm").Close
Call decimalPlace
resWs.Columns.AutoFit
End Sub
Sub matrixmult()
Dim exams, LOA, results, cell, examW, QW, y, weightedGrade, PO_grade, LOs As Range
Dim normalizationRange, PO_matrix, col, row, PO_sumrow As Range
Dim resWs, LO_matrix, ws As Worksheet

Dim X, LO, PO, SN As Integer
Dim w As Double
Dim z As Long
Dim numCol, NumStd, ECTS As Integer
Dim code As String
NumLO = Worksheets("Support").Range("B1").Value
NumStd = Worksheets("Support").Range("B2").Value
code = Worksheets("Support").Range("F7").Value
Set resWs = Worksheets("Results")
Set LO_matrix = Worksheets("Q_LO")
ECTS = Range("F9").Value
numCol = Application.WorksheetFunction.Sum(Worksheets("Support").Range("C4:C13"))
resWs.Select
With resWs
Set examW = .Range(.Range("C2"), .Range("C2").End(xlToRight))
Set QW = .Cells(.Cells(3, 3).row, .Cells(3, 3).Offset(0, numCol).Column)
Set exams = .Range(.Cells(5, 3), .Cells(5, 3).End(xlDown).Offset(0, numCol - 1))
Set results = .Cells(5, 3).Offset(0, numCol * 2 + 1).Resize(NumStd + 1, numCol)
End With
results.Select
LO_matrix.Select
With LO_matrix
Set LOs = .Range(.Cells(3, 3), .Cells(3, 3).Offset(numCol - 1, 0).End(xlToRight))
LOs.Select
Set y = .Range(.Cells(3, 3).End(xlDown), .Cells(3, 3).End(xlDown).End(xlToRight)).Offset(-3, 0)
y.Select
End With
resWs.Select
Set LOA = resWs.Cells(5, 3).End(xlToRight).Offset(0, 1).Resize(NumStd + 1, NumLO)
LOA.Select
LOA.Value = Application.WorksheetFunction.MMult(results, LOs)
For SN = 1 To NumStd + 1 'to calculate LOs attainment
For LO = 1 To NumLO
LOA.Cells(SN, LO).Value = LOA.Cells(SN, LO).Value / y.Cells(1, LO).Value
LOA.Cells(SN, LO).NumberFormat = "0.00%"
Next LO
Next SN
For LO = 1 To NumLO
```

```
LOA.Cells(1, LO).Offset(-1, 0).Value = "LO_" & LO
Next LO
'Call OpenWorkbook
With Workbooks("CO-PO.xlsm").Worksheets(code)
Set PO_matrix = .Cells(4, 2).Resize(NumLO, 11)
Set PO_sumrow = .Range(.Cells(4, 2).End(xlDown), .Cells(4, 2).End(xlDown).End(xlToRight))
End With
Set POA = resWs.Range("A5").End(xlToRight).Offset(0, 1).Resize(NumStd + 1, 11)
POA.Value = Application.WorksheetFunction.MMult(LOA, PO_matrix)
For PO = 1 To 11
POA.Cells(1, PO).Offset(-1, 0).Value = "PO_" & PO

Next PO
For SN = 1 To NumStd + 1
For PO = 1 To 11
If PO_sumrow.Cells(1, PO).Value <> 0 Then
POA.Cells(SN, PO).Value = POA.Cells(SN, PO).Value / PO_sumrow.Cells(1, PO).Value
Else
POA.Cells(SN, PO).Value = 0
End If
POA.Cells(SN, PO).NumberFormat = "0.00%"
Next PO
Next SN
Set PO_grade = resWs.Range("A5").End(xlToRight).Offset(0, 1).Resize(NumStd + 1, 11)
PO_grade.Value = POA.Value
For Each weightedGrade In PO_grade
weightedGrade.Value = weightedGrade.Value * ECTS
Next weightedGrade
For PO = 1 To 11
PO_grade.Cells(1, PO).Offset(-1, 0).Value = "WPO_" & PO
Next PO
End Sub
Sub OpenWorkbook()
Dim file, resultString As String
' Set the path to the workbook you want to open
If IsEmpty(Range("F2").Value) Then
file = InputBox("Please paste CO-PO file path", "File Path")
resultString = Replace(file, """", "")
Range("F2").Value = resultString
Workbooks.Open (resultString)
Else
Workbooks.Open (Range("F2").Value)
End If
End Sub
Sub decimalPlace()
Dim ws As Worksheet
Dim cell As Range
Dim decimalPlaces As Integer
Set ws = Worksheets("Results")
decimalPlaces = 2
For Each cell In ws.UsedRange
' Check if the cell contains a number
If IsNumeric(cell.Value) Then
cell.NumberFormat = "0." & String(decimalPlaces, "0")
End If
Next cell
```

```
End Sub
Sub RenameAndMoveWorkbook()
Dim newFileName As String
Dim newFilePath, FilePath As String

Dim oldFileName As String
' Get the new file name from cell F7
newFileName = ThisWorkbook.Sheets("Support").Range("F7").Value
' Validate the new file name
If newFileName = "" Then
newFileName = InputBox("Please enter course code")
Range("F7").Value = newFileName
Exit Sub
End If
' Add file extension if necessary (e.g., ".xlsm")
If Not Right(newFileName, 5) = ".xlsm" Then
newFileName = newFileName & ".xlsm"
End If
If IsEmpty(Range("F3").Value) Then
' Prompt user to input the new file path
newFilePath = InputBox("Please paste gradebooks folder path", "File Path")
Range("F3").Value = newFilePath
' Check if the path contains quotation marks and remove them
If InStr(newFilePath, """") > 0 Then
newFilePath = Replace(newFilePath, """", "")
End If
' Ensure the path ends with a backslash
If Right(newFilePath, 1) <> "\" Then
newFilePath = newFilePath & "\"
End If
' Get the current workbook's full path (including the name)
oldFileName = ThisWorkbook.FullName
' Save the workbook with the new file name and new location
On Error Resume Next ' Prevents crashing if there's an error
ThisWorkbook.SaveAs Filename:=newFilePath & newFileName
On Error GoTo 0 ' Reset error handling
' Display a message confirming the operation was successful
MsgBox "Workbook renamed and moved successfully!"
Else
FilePath = Range("F3").Value
' Check if the path contains quotation marks and remove them
If InStr(FilePath, """") > 0 Then
FilePath = Replace(FilePath, """", "")
End If
' Ensure the path ends with a backslash
If Right(FilePath, 1) <> "\" Then
FilePath = FilePath & "\"
End If
' Get the current workbook's full path (including the name)
oldFileName = ThisWorkbook.FullName
' Save the workbook with the new file name and new location
On Error Resume Next ' Prevents crashing if there's an error
ThisWorkbook.SaveAs Filename:=FilePath & newFileName
On Error GoTo 0 ' Reset error handling
' Display a message confirming the operation was successful
MsgBox "Workbook renamed and moved successfully!"
```

```
End If
End Sub
Sub courseinfo()

Dim ws As Worksheet
Dim wb As Workbook
Call OpenWorkbook
Set wb = Workbooks("CO-PO.xlsm")
Set ws = wb.Worksheets("Courses")
'Course Name
Range("F9").Value = Application.WorksheetFunction.XLookup(Range("F7"), _
ws.Range(ws.Range("A2"), ws.Range("A2").End(xlDown)), _
ws.Range(ws.Range("C2"), ws.Range("C2").End(xlDown)))
'Course ECTS
Range("F8").Value = Application.WorksheetFunction.XLookup(Range("F7"), _
ws.Range(ws.Range("A2"), ws.Range("A2").End(xlDown)), _
ws.Range(ws.Range("B2"), ws.Range("B2").End(xlDown)))
'Course NUM LO
Range("B1").Value = Application.WorksheetFunction.XLookup(Range("F7"), _
ws.Range(ws.Range("A2"), ws.Range("A2").End(xlDown)), _
ws.Range(ws.Range("D2"), ws.Range("D2").End(xlDown)))
wb.Close
End Sub
Sub DeletefailedStudents()
Dim total, TotalCol, cell As Range
Dim numCol As Integer
Dim F, X As Integer
X = 0
F = Range("F26").Value
numCol = Application.WorksheetFunction.Sum(Worksheets("Support").Range("C4:C13"))
Set total = Worksheets("Results").Cells(4, 1).Offset(0, numCol + 2)
Set TotalCol = Worksheets("Results").Range(total.Offset(1, 0), total.Offset(1, 0).End(xlDown))
For Each cell In TotalCol
If cell.Value < F Then
cell.EntireRow.Delete
X = X + 1
Else
End If
Next cell
'exclude the number of failed studets from total #of stu in the Support sheet
Range("B2").Value = Range("B2").Value - X
End Sub
Sub test()
Dim code As String
Dim PO_matrix As Range
Dim NumLO As Integer
NumLO = 5
code = "IE1601"
With Workbooks("CO-PO.xlsm").Worksheets(code)
' Fully qualify the Cells object with the worksheet reference
Set PO_matrix = .Cells(4, 2).Resize(NumLO, 11) ' Define the range

PO_matrix.Select
End With
End Sub
Sub CreateWorksheetsUpdate(Names_Of_Sheets As Range)
```

```
NumLO = Worksheets("Support").Range("B1").Value
NumStd = Worksheets("Support").Range("B2").Value
No_Of_Sheets_to_be_Added = Names_Of_Sheets.Rows.Count
For i = 1 To No_Of_Sheets_to_be_Added
Sheet_Name = Names_Of_Sheets.Cells(i, 1).Value
' Skip if the sheet already exists or the name is empty
If Sheet_Exists(Sheet_Name) Or Sheet_Name = "" Then
Debug.Print "Skipping sheet: " & Sheet_Name ' Optional for debugging
GoTo SkipSheet
End If
' Add new worksheet
Set ws = Worksheets.Add
ws.Name = Sheet_Name
' Create headers of the sheets
numQ = Worksheets("Support").Cells(i + 3, 3).Value
With ws
.Cells(1, 4).Value = "Question-LO Relations"
.Cells(NumLO + 4, 1).Value = "SN"
.Cells(NumLO + 4, 2).Value = "ID"
.Cells(NumLO + 4, 3).Value = "Name"
.Cells(NumLO + 2, 3).Value = "Question max grade"
.Cells(NumLO + 3, 3).Value = "Question Weight"
End With
' Create LO rows
For j = 1 To NumLO
ws.Cells(j + 1, 3).Value = "LO_" & j
Next j
' Create SN
For k = 1 To NumStd
ws.Cells(k + NumLO + 4, 1).Value = k
Next k
ws.Cells(NumLO + 4, numQ + 4).Value = "Total"
' Create question rows
For Q = 1 To numQ
ws.Cells(NumLO + 4, 3 + Q).Value = "Q_" & Q
Next Q
With ws
.Columns("A:Z").EntireColumn.AutoFit
.Columns("B").ColumnWidth = 10
.Columns("D").ColumnWidth = 4
End With
Set startCell = ws.Cells(NumLO + 4, 1)
lastRow = NumLO + NumStd + 4
lastCol = numQ + 4
ws.Range(startCell, ws.Cells(lastRow, lastCol)).Borders.Weight = xlThin
ws.Range(ws.Cells(1, 3), ws.Cells(lastRow, lastCol)).Borders.Weight = xlThin
SkipSheet:
Next i

End Sub
```

APPENDIX B

```
Sub SumCellValuesInFolder()
Dim FolderPath As String
Dim WorkbookName As String
Dim CellAddress, cell, summary, SNID As Range
Dim CurrentWorkbook As Workbook
Dim CellValue As Double
Dim TotalSum, TotalECTS As Double
Dim FileExtension, CourseName, CourseCode, InstName As String
Dim SN As Double
Dim NumLO, NumCol, ECTS, i, j, x As Integer
Range("B3:S1048576").ClearContents
FolderPath = Range("A1").Value
' Define the file extension
FileExtension = "*.xlsm"
' Check if the path contains quotation marks and remove them
If InStr(FolderPath, """") > 0 Then
FolderPath = Replace(FolderPath, """", "")
End If
' Ensure the path ends with a backslash
If Right(FolderPath, 1) <> "\" Then
FolderPath = FolderPath & "\"
End If
' Get the first workbook in the folder
WorkbookName = Dir(FolderPath & FileExtension)
' Loop through all workbooks in the folder
Do While WorkbookName <> ""
' Open the workbook
Workbooks.Open (FolderPath & WorkbookName)
Set CurrentWorkbook = ActiveWorkbook
With CurrentWorkbook
NumCol = Application.WorksheetFunction.Sum(.Worksheets("Support").Range("C4:C13"))
NumLO = .Worksheets("Support").Range("B1").Value
SN = .Worksheets("Support").Range("B2").Value
ECTS = .Worksheets("Support").Range("F9").Value
CourseName = Worksheets("Support").Range("F8").Value
CourseCode = Worksheets("Support").Range("F7").Value
InstName = Worksheets("Support").Range("F6").Value
Set CellAddress = .Worksheets("Results").Cells(5, NumLO + NumCol * 3 + 11 + 4).Resize(SN + 1,
11)
Set SNID = .Worksheets("Results").Cells(5, 1).Resize(SN + 1, 2)
SNID.Copy
Range("B10000").End(xlUp).Offset(1, 0).PasteSpecial Paste:=xlPasteValues
For x = 1 To SN + 1
Range("D10000").End(xlUp).Offset(1, 0).Value = CourseName
Range("E10000").End(xlUp).Offset(1, 0).Value = CourseCode
Range("F10000").End(xlUp).Offset(1, 0).Value = ECTS
Range("G10000").End(xlUp).Offset(1, 0).Value = InstName
Range("H10000").End(xlUp).Offset(1, 0).Value = NumLO
Next x
CellAddress.Copy
Range("I10000").End(xlUp).Offset(1, 0).PasteSpecial Paste:=xlPasteValues
End With
Sheet1 - 2
' Close the workbook without saving
```

```
CurrentWorkbook.Close SaveChanges:=False
' Get the next workbook
WorkbookName = Dir
Loop

End Sub
```