A Holistic Design Tool to Evaluate Learning Outcome Attainment Levels in Engineering Education Programmes

Mohammed Muazzaz[1] and Velu Vengadeshwaran[2]

Abstract

The International Engineering Alliance (IEA) plays a vital role in promoting the mobility of the engineering professionals through recognizing the locally accredited Engineering programmes in its signatory countries. This is achieved through various accords and agreements within the signatory countries to ensure internationally recognized standards are met. The Washington Accord, Sydney Accord and Dublin Accord provide the necessary guidelines to implement the required competencies for Professional Engineering, Engineering Technologist and Engineering Technicians standards respectively through effective outcome-based education. The Engineering Programmes offered at Villa College Maldives are designed to fully adhere to the Washington Accord standards in order to ensure the attainment of the graduate attributes.

This paper outlines a dedicated outcomes-based education (OBE) tool which was designed to correlate the module learning outcomes to the programme learning outcomes. It was developed to ensure that all of the assessments implemented in the programme appropriately measure the attainment of the Complex Engineering Problems, Knowledge Profiles and the Engineering Activities as per the IEA accord standards. This paper provides the technical details of the design, different types of reports generated and the techniques adopted in the proposed OBE Tool for the measurement of the attainment of the learning outcomes of the course, programme and learning outcomes achievement of the students.

Keywords: engineering teaching; engineering graduate attributes; outcomes-based course design and assessment; outcomes-based education tool

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Introduction

Engineering plays a vital role in the economic development of a country, meeting the technological advancements needs and services to the society. Engineers are expected to find creative, innovative, and technologically advanced solutions to resolve complex engineering problems. This requires a comprehensive amount of both theoretical and applied engineering knowledge, practical hands-on skills, socio-cultural, management and financial awareness and abilities. In general, engineering graduates are expected to possess the specialization-based engineering knowledge, problem analytical skills, design and development knowledge to find solutions for complex engineering problems, well-versed in modern tools, with adequate knowledge on sustainability and environment, work ethics, and lifelong learning habits required of a professional engineer.

Engineering education as such is classified into three categories or tracks based on level of qualification such as Diploma (for Technicians), Engineering Technologist Degree (for Technologists) and the Professional Engineering Degree (for Engineers). The International Engineering Alliance (IEA) is a global organization that drafts and approves the graduate attributes and the professional competencies for the Engineering Profession that have to be fulfilled by the Universities offering Engineering Education qualifications (International Engineering Alliance, 2021). The IEA consists of members from twenty-nine countries with forty-one jurisdictions across seven international agreements. In order to maintain the international standards benchmark for the engineering education at various levels of competencies and for the mutual recognition of engineering qualifications, the members of IEA sign various agreements such as Washington Accord, Sydney Accord and Dublin Accord corresponding to Engineer, Engineering Technologist and Engineering Technician respectively.

The Washington Accord (WA) provides the required graduate attributes and professional competencies for the Professional Engineering Track, whereas the Sydney Accord (SA) is for the Engineering Technologist Track and the Dublin Accord (DA) is for the Engineering Technician Track. The latest version of IEA graduate attributes and professional competencies was released in September 2021 (International Engineering Alliance, 2021).

The accreditation regulatory bodies of engineering qualifications adopt outcome-based education as the strategy to measure attainment of the Graduate Attributes and Profession Competencies (GAPC). The signatories of the accords recognize each other's graduates of the accredited engineering qualifications. This facilitates the mobility of graduates for further studies and employment across the signatory countries.

Graduate attributes are clearly defined statements on the expected qualities of professionalism appropriately arranged to the competency levels for the various grades of engineering such as Engineer, Engineering Technologist and Engineering Technician. The Engineering Programme at bachelor's degree level is required to produce graduates able to apply knowledge of mathematics, science, computing and engineering fundamentals and an engineering specialization as specified in WK1-WK4 respectively to develop solution to complex engineering problems.

It is imperative for the accrediting authorities of the signatories to ensure that all of the engineering qualifications are effectively being implemented based on outcome-based education (OBE) in order to ensure that the graduates of these programmes possess the desired graduate attributes and professional competencies (Tshai, K. Y et al., 2014). Outcome based education is a proven academic strategy for effective teaching and learning, dynamic assessments and continuous quality improvement (CQI) activities.

The Graduate Attributes and Professional Competencies of the International Engineering Alliance (IEA) is adopted as the international standard for accrediting engineering education by the professional bodies across various signatory countries. It is developed based on outcome-based education with distinctive competencies together with their educational underpinnings which include common range and contextual definitions. It highlights the Range of Problem Solving, Range of Engineering Activities and the Knowledge Profiles.

The attributes of range of problem solving are depth of knowledge required, range of conflicting requirements, depth of analysis required; familiarity of issues; extent of applicable codes; extent of stakeholder involvement; and conflicting requirement, interdependence, consequences and judgement. The attributes of range of engineering activities are preamble; range of resources; level of interactions, innovation, consequences to society; & the environment and familiarity. The attributes of the knowledge profile are understanding of natural sciences; conceptually-based Mathematics; engineering fundamentals; specialist knowledge; engineering design; engineering practice; role of engineering in society; and research literature.

The implementation of the outcome based education is through the establishment of systematic correlation between the programme learning outcomes to the courses offered under the programme in order to ensure that all of the graduate attributes are attained by each and every student by graduation. For accreditation of engineering programmes, evidence is required to prove that the graduating students possess the required theoretical knowledge and practical abilities.

The objective of this paper is to present a tool designed and developed based on the IEA Standard for utilization in the Engineering programmes offered at Villa College, Maldives. The paper presents a technique to directly measure programme learning outcomes using an outcome-based education tool. The outputs of the OBE Tool generate the percentage attainment of each Programme Learning Outcome (PLO) every semester and the progressive growth of overall attainment through spider charts.

Outcomes based Attainment in Engineering Education

The accreditation standards for engineering education programmes outline the outcomes of the engineering curriculum that has to be attained in order to ensure the institution of higher learning meets the minimum standard stipulated in the IEA Accords. The engineering programme's learning outcomes have to be in line with the graduate attributes and the professional competencies (GAPC) statements and the vision and mission of the Institution of Higher Learning (IHL). The OBE strategy adopted by the IHL should ensure that the graduates of the engineering programme possess all of the desired graduate attributes and professional competencies on graduation.

In this paper, we have chosen to adopt Washington Accord (WA) attributes and competencies mainly because the Engineering Programmes offered at Villa College Maldives are professional engineering track programmes. Once the Villa College engineering programmes are accredited by the signatory institutions, the Villa College Engineering Graduates will be assessed on the Washington Accord standards and demonstrate equivalence of competence. This will allow them to pursue higher studies and to work abroad.

OBE Tool Design Strategy

The block diagram of the design strategy for the outcomes-based education proposed by K.Y. Tshai et al (2014) was used to design the OBE Tool for the programme and is highlighted in the Figure 1.

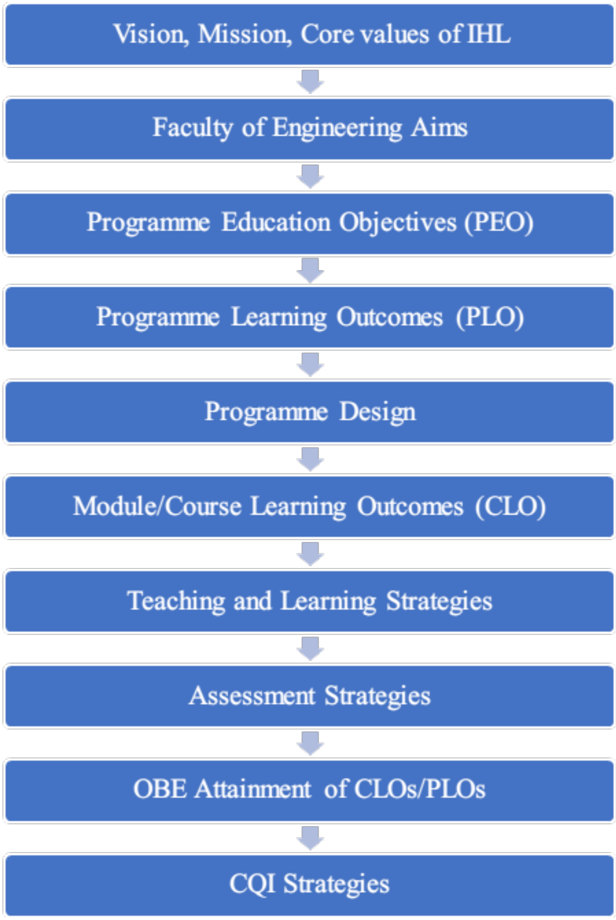


Figure 1: Block diagram of OBE Design Strategy

The Graduate Attributes and the Professional Competencies (GAPC)

The knowledge and attitude profiles of the Washington Accord are classified into eight categories from WK1 toWK8. The characteristics of complex engineering problems are classified into seven categories WP1-WP7. The range of complex engineering activities or projects is classified into five categories EA1-EA5. The Graduate Attributes and the Professional Competencies (GAPC) stipulated in the IEA standard version 2013 is listed in Table 1 (International Engineering Alliance, 2021).

Table 1: The Graduate Attributes and the Professional Competencies (GAPC)

No	Differentiating Characteristic	Engineering Graduate
1	Engineering Knowledge:	WA1: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to the solution of complex engineering problems.
2	Problem Analysis Complexity of analysis	WA2: Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences. (WK1 to WK4)
3	Design/ development of solutions: Breadth and uniqueness of engineering problems i.e. the extent to which problems are original and to which solutions have previously been identified or codified	WA3: Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (WK5)
4	Investigation: Breadth and depth of investigation and experimentation	WA4: Conduct investigations of complex problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
5	Modern Tool Usage: Level of understanding of the appropriateness of the tool	WA5: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations. (WK6)
6	The Engineer and Society: Level of knowledge and responsibility	WA6: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems. (WK7)

7	Environment and Sustainability: Type of solutions	WA7: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts. (WK7)
8	Ethics: Understanding and level of practice	WA8: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice. (WK7)
9	Individual and Team work: Role in and diversity of team	WA9: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
10	Communication: Level of communication according to type of activities performed	WA10: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	Project Management and Finance: Level of management required for differing types of activity	WA11: Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12	Lifelong learning: Preparation for and depth of continuing learning.	WA12: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Knowledge Profiles, Complex Engineering Problems and Complex Engineering Activities

The IEA GAPC documents also provide the details of various categories of the knowledge Profiles, Complex Engineering Problems and the Complex Engineering Activities to be addressed as shown in Table 2 (International Engineering Alliance, 2021).

Table 2: Knowledge Profile, Complex Engineering Problems and Engineering Activities of Washington Accord

Knowledge Profile	Complex Engineering Problems	Complex Activities
WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline	WP1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamentals-based, first principles analytical approach	EA1: Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies)
WK2: Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline	WP2: Involve wide-ranging or conflicting technical, engineering and other issues	EA2: Require resolution of significant problems arising from interactions between wide ranging or conflicting technical, engineering or other issues,
WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline	WP3: Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models	EA3: Involve creative use of engineering principles and research-based knowledge in novel ways.
WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.	WP4: Involve infrequently encountered issues	EA4: Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation
WK5: Knowledge that supports engineering design in a practice area	WP5: Are outside problems encompassed by standards and codes of practice for professional engineering	EA5: Can extend beyond previous experiences by applying principles-based approaches

WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline	WP6: Involve diverse groups of stakeholders with widely varying needs	
WK7: Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability	WP 7: Are high level problems including many component parts or sub-problems	
WK8: Engagement with selected knowledge in the research literature of the discipline		

Engineering Programmes at Villa College Maldives

The Engineering programmes offered at Villa College adhere to the specifications stipulated in the WA GAPC; and follow an outcomes-based programme design, teaching and assessment method. This ensures that each student achieves the attributes and competencies expected of a professional engineering training programme. The Faculty of Engineering and Information Technology offers three Bachelor Degrees of Engineering programmes of four years duration, namely Bachelor of Mechanical Engineering (Honours), Bachelor of Mechatronics Engineering (Honours) and Bachelor of Electrical and Electronics Engineering (Honours).

Programme Learning Outcomes (PLOs)

The Programme learning outcomes (PLOs) of the Villa College Engineering Programme adopts the graduate attributes and professional competencies verbatim from the WA standards. The Programme Learning Outcomes of the Bachelor of Mechanical Engineering (Honours) is shown in Table 3 (International Engineering Alliance, 2021).

Table 3: Programme Learning Outcomes of Mechanical Engineering Programme

PROGRAMME LEARNING OUTCOMES (PLOs) OF BACHELOR OF MECHANICAL ENGINEERING (HONS)
PLO1: Engineering Knowledge- Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to the solution of complex engineering problems;
PLO2: Problem Analysis- Identify, formulate, conduct research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1 to WK4);
PLO3: Design/Development of Solutions- Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations (WK5);
PLO4: Investigation – Conduct investigation of complex engineering problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions;
PLO5: Modern Tool Usage- Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations (WK6);
PLO6: The Engineer and Society- Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7);
PLO7: Environment and Sustainability- Understand and evaluate the sustainability and impact of professional engineering work in the solutions of complex engineering problems in societal and environmental contexts. (WK7);
PLO8: Ethics- Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice (WK7);
PLO9: Individual and Teamwork- Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings;
PLO10: Communication- Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions;

PLO11: Project Management and Finance- Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments;
PLO12: Lifelong Learning- Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Design & Mapping of Modules to PLOs

The modules of each programme were carefully identified in different sectors of knowledge profiles corresponding to the respective engineering discipline based on the feedback from various stakeholders. Detailed benchmarking was done with reputed international universities in United Kingdom, Australia, Canada, Malaysia, and India to ensure that the modules are appropriate to the engineering programme discipline. The modules were then mapped and correlated to the corresponding PLOs to ensure that the modules provide the necessary knowledge, analytical and practical skills and the needed experiences to achieve the programme learning outcomes on graduation.

Module/Course Learning Outcomes (MLOs/CLOs)

Adequate benchmarking was done in the design and development of the programme modules. The course learning outcomes were designed at appropriate complexity and speciality level using the Blooms Taxonomy hierarchies. Appropriate formative and summative assessments were used to measure the course learning outcomes to ensure the students had the required theoretical knowledge, practical skills, attitudes and awareness of safety and sustainability expected.

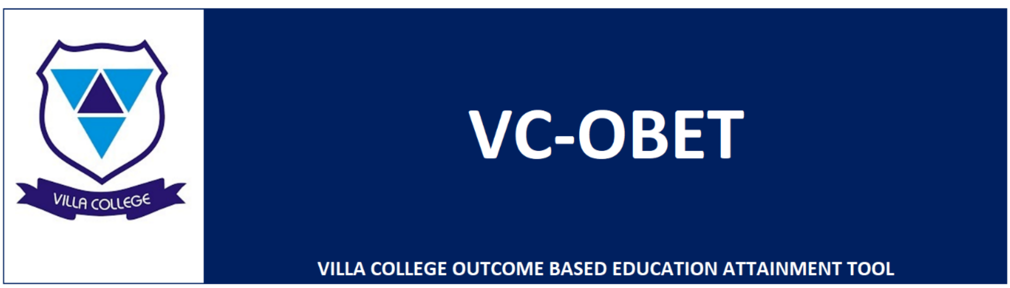


Figure: Villa College OBE Tool

The Villa College OBE Tool (VC-OBET) was subsequently developed to track the programme's implementation of outcome-based education. The tool was primarily designed to track the attainment of students' GAPCs, with the added ability to ensure that modules are fully addressing the PLOs listed in Table 3. The tool was developed in Microsoft Excel and includes detailed instructions on how it is to be used on the first sheet.

CLO Number	Course Learning Outcomes	PLO Map
CLO 1	Comprehend and apply the fundamentals of workplace safety standards	PLO 6
CLO 2	Select and apply appropriate Causation Models to investigate safety incidents	PLO 4
CLO 3	Comprehend and apply the fundamentals of workplace safety and health risk management	PLO 11
CLO 4	Comprehend and apply the fundamentals of conceptual Engineering ethics and resolve problems throu	PLO 8
CLO 5	Comprehend and practice the key aspects of "trust and reliability" and be responsible for "Risk and Lia	PLO 8

Figure 2: PLO - CLO mapping table

The module's Course Learning Outcomes (CLOs) are to be initially mapped to Programme Learning Outcomes (PLOs) in a table as shown in Figure 2. One PLO can be selected for each CLO via a drop-down menu. While a CLO may address more than one PLO, a limit to mapping to one PLO was made to prevent overcomplication of the tool.

Mark Distribution By Assessment Type						
Final Total (Percentage Marks)						100
Module Learning Outcomes	Test	Assignment	Quiz	Practical	Final Exam	Total
Total Assessment Marks	25	50	25	30	100	
CLO 1	5	7			6	18
CLO 2	10	8			12	30
CLO 3	10	6			12	28
CLO 4		4			10	14
CLO 5					10	10
Total Weightage By Assessment Type	25	25	0	0	50	

Figure 3: Mark Distribution table

The percentage marks for each CLO are then entered, split into the assessments that they are graded in. The total mark for each assessment is also to be filled in. Figure 3 shows an example in which the test (i.e., mid-semester exam) is out of 25 marks, and contributes to 25% of the module. 5% of the module is based on CLO 1 from the test, and 10% each for CLO2 and CLO3 from the test. Note that when the assessment marks differ from the percentage contribution of the assessment on the module, the CLOs are to be entered by percentage contribution of the module. A check is made to ensure the summed percentage contribution to the module equals 100, which is highlighted in green when true and in red if the value differs.

Input of Student List

Student List		
Name	StudentID	Status
Ahmed Ali	S2100027	Active
Ahmed Hussain	S2100028	Inactive
Ali Arif	S2101037	Active

Figure 4: Student list example (note: names and IDs are anonymised)

The student list, with the data shown in Figure 4 is then added to the tool. The full format of the table is identical to the student list available via Villa College's Student Management System (SMS) enabling the list to be copied and pasted in quickly for different purposes within the college.

Student Marks

The last step in which manual entry of data is required is entering in student marks. Each set of assessment marks obtained by the student are to be keyed-in correspondingly to the CLO allocations for the particular assessment.

Student Name	Student Number	Test CLO 1	Test CLO 2	Test CLO 3	Assignment CLO 1	Assignment CLO 2	Assignment CLO 3	Assignment CLO 4	Final Exam CLO 1
		5	10	10	14	16	12	8	12
Ahmed Ali	S2100027								
Ahmed Hussain	S2100028								
Ali Arif	S2101037								

Figure 5: Marks Entry Table Example

A table for marks entry (Figure 5) is populated with the student list as well as the assessments based on the information added in the previous steps. The assessment marks are split by CLOs for each assessment. The 2nd row of the headers displays the total marks, automatically split, and calculated for each

CLO/assessment combination. These calculated values allow the marks from the assessments to be directly inputted, reducing the likelihood of calculation errors. Inactive students are highlighted to further ease the marking process.

This table could also be used to automatically calculate the marks allocation for each assessment's total marks when writing question papers. Conversely, historical marks from before using this system are recommended to be added by evenly distributing marks for each assessment between the respective CLOs,

Module Analytics

Once student marks are entered, total assessment marks are generated to allow detailed analysis of marks attained by each student, and by each cohort.

Student Name	Student Number	Grade	Total	Test	Assignment	Final Exam	Test CLO 1	Test CLO 2	Test CLO 3	Assignment CLO 1
							5	10	10	14
Ahmed Ali	S2100028	HD	96.3%	100.0%	93.3%	96.0%	100.0%	100.0%	100.0%	93.3%
Ahmed Hussain	S2100807	DN	78.0%	80.0%	88.0%	72.0%	80.0%	80.0%	80.0%	88.0%
Ali Arif	S2100027	CR	74.3%	96.7%	76.7%	62.0%	96.7%	96.7%	96.7%	76.7%

Figure 6: Student Results Table

Figure 6 shows the results summary for all of the students which are automatically generated. Percentage marks for each assessment is estimated, along with the grade and total percentage. The percentage marks for each CLO can also be checked for each assessment.

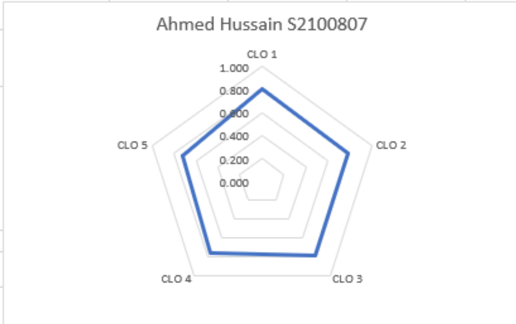
Student Name	Student Number	Total	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	PLO 4	PLO 6
			18	30	28	14	10	30	18
Ahmed Ali	S2100028	96.3%	96.1%	96.6%	96.9%	95.2%	96.0%	96.6%	96.1%
Ahmed Hussain	S2100807	78.0%	80.4%	78.9%	78.3%	76.6%	72.0%	78.9%	80.4%
Ali Arif	S2100027	74.3%	77.3%	77.5%	77.5%	66.2%	62.0%	77.5%	77.3%

Figure 7: CLO and PLO Breakdown

Figure 7 shows percentage attainment for students split only into CLOs and PLOs. This can help to identify if students are struggling with attaining specific learning outcomes, which may not be immediately noticeable if marks are only split by assessment. The weighted marks for each CLO and PLO are displayed on the second header row.

Equivalent tables with weighted marks are also available for each assessment.

Search Term	Ahmed Hussain
	Student Name



Search Results

Student Name	Student Number	Total	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	PLO 4
Ahmed Hussain	S2100807	0.780	0.804	0.789	0.783	0.766	0.720	

Figure 8: Results Search Example

A search function has been added to find specific students based on either name or student ID as shown in Figure 8. On selecting the student, the respective per unit CLO attainment will be displayed with the aid of a spider chart as shown in Figure 8.

Grade Distribution By Assessment Type						
Grade	Total	Test	Assignment	Quiz	Practical	Final Exam
Fail (FF)	0	0	0	0	0	0
Pass (PP)	2	3	1	0	0	9
Credit (CR)	8	8	7	0	0	5
Distinction (DN)	8	4	5	0	0	3
High Distinction (HD)	3	6	8	0	0	4
Total	21	21	21	0	0	21
Number Passed	21	21	21	0	0	21
% Passed	100.0%	######	100.0%	0.0%	0.0%	100.0%

Grade Distribution By CLO								
Grade	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5			
Fail (FF)	0	0	0	0	0			
Pass (PP)	1	1	2	3	9			
Credit (CR)	8	8	7	10	5			
Distinction (DN)	9	9	9	4	3			
High Distinction (HD)	3	3	3	4	4			
Total	21	21	21	21	21	0	0	0
Number Passed	21	21	21	21	21	0	0	0
% Passed	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%

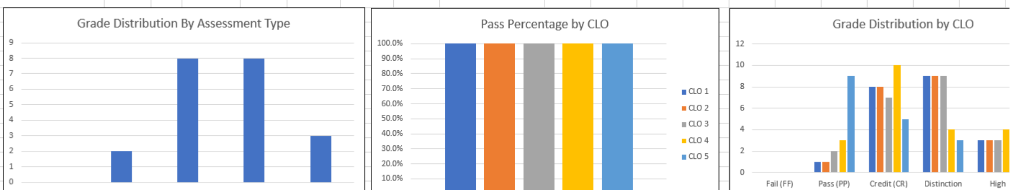


Figure 9: Module Results Analytics

Lastly, overall module trends can be viewed on the analytics page. Pass rates, and grade distribution for each assessment, and each CLO are listed and displayed in graphs, as shown in Figure 9.

Programme Analytics

The tool has the additional feature to estimate the Programme level attainment for each student progressively semester wise. The tool collates the results of multiple modules to track the PLOs assessed over the course of the programme.

Module Code	Module Name	Credits	% Credits	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 10	PLO 11
COMP1007	Computer Programming	12	18.2%	1.2	3.6	5.4	1.2	0	0	0	0	0	0.6
ENGI1001	Electrical and Electronics Principles	12	18.2%	2.16	2.76	2.16	3.36	1.56	0	0	0	0	0
ENGI1002	Engineering Drawing and Graphics	12	18.2%	1.2	0	8.4	0	2.4	0	0	0	0	0
ENGI1003	Engineering Mathematics 1	10	15.2%	0	10	0	0	0	0	0	0	0	0
ENGI1004	Occupational Safety and Ethics	10	15.2%	0	0	0	3	0	1.8	0	2.4	0	2.8
ENGI1005	Environment and Sustainable Engineering	10	15.2%	2	0	0	0	0	0	2.5	1.5	2	2
Total		**66**		**6.56**	**16.36**	**15.96**	**7.56**	**3.96**	**1.8**	**2.5**	**3.9**	**2**	**5.4**

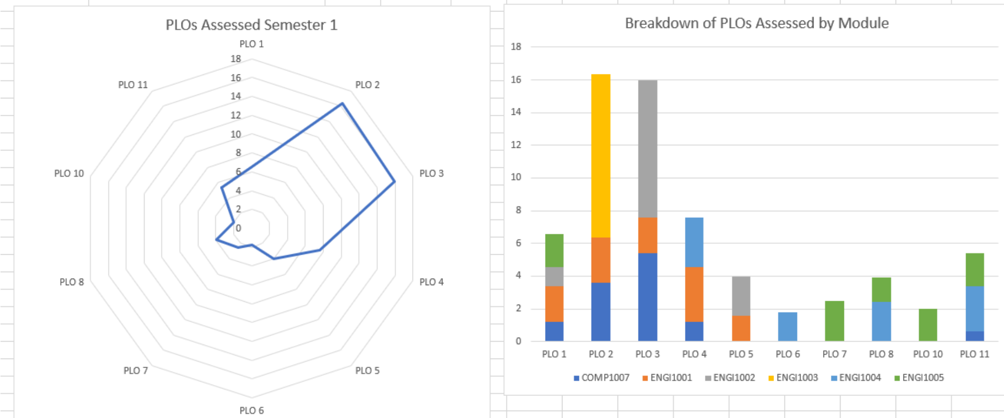


Figure 10: Collation of Module Information

Figure 10 shows the distribution of credits by PLO by splitting the credits of each module based on the CLO/PLO mapping from section 3.1. Note how this shows that PLO 2 and 3 have the greatest priority in semester 1, with PLOs 9 and 12 not being addressed significantly. This tool allows such disparities to be reviewed, and help ensure that by the end of the programme, all PLOs have been addressed to a satisfactory standard.

Student Name	Student ID	Programme	PLO 1	PLO 2	PLO 3	PLO 4
Ahmed Ali	S2100027	83.8%	90.7%	79.8%	85.4%	90.4%
Ahmed Hussain	S2100028	81.4%	86.5%	80.5%	78.1%	84.0%
Ali Arif	S2101037	84.3%	92.7%	87.6%	83.1%	84.7%

Figure 11: Attained Percentage per PLO

Figure 11, similarly to Figure 7, displays percentage attainment of PLOs based on marks attained from all modules. The percentages are based on the marks input for each module as well as the information collated as shown in Figure 10.

Grade Distribution by PLO											
	Programme	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 10	PLO 11
Fail (FF)	0	0	0	1	0	0	0	0	0	0	0
Pass (PP)	0	0	0	3	0	0	1	0	1	0	0
Credit (CR)	4	0	2	0	0	1	8	3	10	1	6
Distinction (DN)	17	3	16	16	16	9	9	16	10	15	14
High Distinction (HD)	0	18	3	1	5	11	3	2	0	5	1
Total	21	21	21	21	21	21	21	21	21	21	21
Number Passed	21	21	21	20	21	21	21	21	21	21	21
% Passed	100.0%	100.0%	100.0%	95.2%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

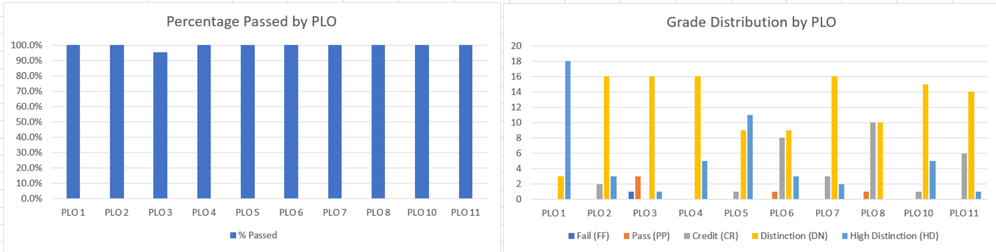


Figure 12: Programme Results Analytics

Search Term	Ahmed Hussain
	Student Name

#	Student Name	Student ID	Programme	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 10	PLO 11
Best	Maximum Credits		66	6.56	16.36	15.96	7.56	3.96	1.8	2.5	3.9	2	5.4
Match	Attained Credits		53.71082	5.67392	13.16692	12.4596	6.35148	3.129	1.4472	2.12	3.0783	1.8	4.4844
#	Student Name	Student ID	Programme	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 10	PLO 11
2	Ahmed Hussain	S2100028	81.4%	86.5%	80.5%	78.1%	84.0%	79.0%	80.4%	84.8%	78.9%	90.0%	83.0%

Figure 13: Programme Level Student Result Search

Figure 12 shows the programme level analytics, similar to Figure 9. Figure 13 shows the programme level counterpart to course level analytics shown in Figure 8. The latter allows for creation of radar graphs based on PLOs for use in showing the GAPCs attained by the students for use in individual student reports. Graphs with percentage results, as well as based on "credits attained" are generated. In this case "credits attained" refers to the percentage marks obtained on each PLO multiplied by the number of credits allocated.

We found that the proposed techniques of assessing the individual CLOs and the corresponding PLOs for each module works well and the outputs generated by OBE Tool measures directly the attainment of the graduate attributes and professional competencies stipulated in the IEA standard for each graduating student. Spider charts are produced as evidence for the attainment of PLOs.

Conclusion

This paper demonstrates some of the potential benefits of using outcome based education and development of related tools to enable easier, more thorough tracking of both programme content, and student performance within programmes. VC-OBET tool has the capabilities to measure the attainment of learning outcomes at student level, module level and at programme level. The analytical output of the VC-OBET will be used in the Continual Quality Improvement (CQI) meeting to close the loop. This VC-OBET tool is designed to ensure that all of the graduates of the engineering programme possess the required graduate attributes and professional competencies as per the Washington Accord standards. On top of being able to ensure that the Villa College engineering programmes will meet standards set by international accreditation bodies for Engineering qualifications, it is the belief of the authors that the use of these tools can be further expanded to other higher education departments to implement outcomes based education programmes and to enhance the quality of the programmes offered.

REFERENCES

Tshai, K. Y., Ho, J. H., Yap, E. H., & Ng, H. K. (2014). Outcome-based education–the assessment of programme educational objectives for an engineering undergraduate degree. Engineering Education, 9(1), 74-85.

Ho, J. H., Tshai, K. Y., & Yap, E. H. (2013, November). Students' Attainment of Programme Objectives (POs) for the Mechanical Engineering Undergraduate Degrees at the University of Nottingham Malaysia Campus (UNMC).

Killen, R. (2000, January). Standards-referenced assessment: Linking outcomes, assessment and reporting. Proceedings of the Annual Conference of the Association for the Study of Evaluation in Education.

Magee, C. L. (2003). Needs and possibilities for engineering education: one industrial/academic perspective.

Albalooshi, F. A. (2013). Graduate Attributes for Higher Education and Their Development in Bahrain. International Education Studies, 6(9), 23-30.

International Engineering Alliance (IEA) (2013, June) Graduate Attributes and Professional Competencies. http://www.ieaagreeements.org

International Engineering Alliance (IEA) (2021, June) Graduate Attributes and Professional Competencies. https://www.ieagreements.org/assets/Uploads/Documents/IEA-Graduate-Attributes-and-Professional-Competencies-2021.1-Sept-2021.pdf

Engineering Accreditation Council. Board of Engineers. Malaysia (2020). Engineering Programmes Accreditation Standard 2020. https://www.eac.org.my/web/document/EAC%20Standard%202020_approved%20BEM19April2020%20upload%2015June2020.pdf

Jaafar, M. S., Nordin, N. K., Wagiran, R., Aziz, A., Noor, M. J. M. M., Osman, M. R., Noorzaei, J. & Abdulaziz, F. N. A. (2008, July). Assessment strategy for an outcome based education. In International Conference on Engineering Education.

Zhu, X., Xu, F., & Jiang, Z. (2021, May). Study on Engineering Educational Accreditation Based on Outcome Based Education philosophy. In 7th International Conference on Humanities and Social Science Research (ICHSSR 2021) (pp. 1211-1215). Atlantis Press.