Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 2, 2185 – 2192

Implementation of Outcome-Based Education for Engineering Accreditation Exercise

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Abstract

With the globalisation of engineering education, Outcome-Based Education (OBE) is inevitable. By effective implementation of OBE, institutions can acquire and sustain accreditation. To implement OBE successfully, measures of achievement for Programme Outcomes (POs) and Course Outcomes (COs) are important. Monitoring the achievement of POs at different stages of the programme is important. This article investigates the importance of rubrics as an assessment instrument in measuring and achieving POs through COs by the Faculty of Engineering and Computer Technology (FECT), Asian Institute of Medicine, Science and Technology University (AIMST) in Malaysia. As a case study the POs achieved by one cohort of students are analysed to validate this research.

Keywords: POs, COs , Continuous Quality Improvement (CQI), OBE, Rubrics, Accreditation

1. Introduction

OBE is focused on accomplishing better results regarding information, knowledge, perspectives and conduct at the end of the programme. OBE consist of educating with this in mind and putting out the associated effort. This involves a standard strategy for identifying the attainment of POs and benchmarking these against the POs targeted. OBE centres (Basri et al., 2004) on graduating students who demonstrate proficient practice and requires evidence of the ways in which the programme bestows degrees, as opposed to concentrating on the procedures to accomplish the results, despite the fact that this might be similarly significant. OBE insists upon determination of course outcomes as the first step in designing the curriculum, and enables self-assessment of learners to measure their progress towards attaining the outcomes. OBE is a very clear system, from programme planning to the declaration of assessment results. Figure 1 explains the general flow of OBE implementation for accreditation. OBE approaches (Zhang & Fan, 2020) can advance the stability of students to communicate effectively in the workplace.

Accreditation is formal acknowledgment of the nature of an educational program by an outside, autonomous organization which conducts an unprejudiced appraisal based on specific measures of evaluation. Accreditation parameters are used to measure the minimum requirements of the programme. It is a procedure that confirms and improves programme value, whereby a programme in an endorsed institution is fundamentally evaluated at regular intervals, to check that the programme is continuing to fulfill and surpass-guidelines recommended by the authorizing body. Accreditation confirms that the scholarly purpose of the school is really sought after and is adequately accomplished, and that the school has shown its ability to guarantee the viability of the instruction. Engineering institutions in Malaysia are following guidelines issued by Engineering Accreditation Council (EAC) and the Board of Engineers in Malaysia (BEM) affiliated with Washington Accord (WA). The WA is a global alliance among various nations who have been responsible for authorizing undergrad science qualification programs, since 1989. Malaysia became as a provisional signatory to WA in 2003 (*Washington Accord*, n.d.). Whether we wish it or not, international accreditation for professional courses is mandatory (Gurukkal, 2018).

[Insert Figure 1]

Programme Educational Objectives (PEOs) are an explicit proclamation that is congruent with the strategic mission and vision of the organization, meets with the approval of programme partners, and predicts the expected professional accomplishments of graduates three to five years after graduation, according to the EAC manual 2020 (Engineering Accreditation Counciil, n.d.). PEOs are discrete statements of POs which are measurable, performance indicators that address specific graduate competencies. PEO statements can contain key attainments, such as professional Engineer, project management professional, senior engineer, research and development etc., that are expected after a few years of employment. Further, (Tshai et al., 2014) stated that "partners such as the higher education institution, executive associations and regulatory bodies, faculty, examiners from outside, graduated students, Industry Advisory Panel (IAP), and employers have to be involved in framing PEO statements".

POs depict what learners are required to know, and the options for reaching graduation. These identify with the skills and knowledge that learners must master, through the programme, and there are twelve POs to be achieved by the student, as stated in the EAC manual 2020(Engineering Accreditation Counciil, n.d.) . POs directly map the courses and link the PEOs, whose measurement must be realistic and reflective of the performance of the class. The scientific methodology (Shanableh, 2014) can be without much of a stretch, modified in a spreadsheet that can automatically estimate the different pointers, contrast the outcomes and cut-off points set by the client, and create a synopsis report with proper tables and figures.

COs are explanations that portray what undergraduates are required to know and have the option of performing or accomplishing at the end of a course. COs identify the minimum achievements required for success in the course. COs should aim to develop higher order skills in each domain of learning. COs are linked to specific POs and thus serve as direct evidence of the achievement of each PO. The COs are essentially announcements of specific results described (Rajak et al., 2019) by the topic master and are imparted to different partners, and a leading group of investigators, therefore, affirms these announcements into the programme. Further, 360 action verbs for writing student CO statements in higher education have been provided by San Diego State University (SDSU) Centre for Teaching and Learning, 2004 (Learning, 2004) . The COs evaluation criteria include undergraduate learning results for the program, decide activities used to accomplish results through educational planning, decide techniques for appraisal, gather evidence, and close the circle (Premalatha, 2019).

A rubric is a coherent set of criteria for student work that describes levels of performance.
Rubrics allow the faculty to convey clearly the standards for student success and also encourag e comprehensive feedback to students. If areas of success and weakness are highlighted in an essay, students can more readily grasp the reasoning behind the evaluation of their work. Rubrics are used to evaluate a relatively complex assignment, laboratory reports, essays, and research- based projects. Different types of rubrics are as below:

- Holistic rubric: - Used for quick, overall snapshot of student achievement
- Analytic rubric:- Used for more detailed feedback about relative strength and weakness, and to assess complex skills.
- General rubric- Used to evaluate the rationale, skills and products that are different for each student.
- Task-specific rubric - Used to assess knowledge and consistency scoring

A rubric creation (Bishop et al., 1969) also encourages reflection upon the curriculum in a way that leads to positive enhancements. CQI in an academic institution refers to any faculty- or instructional-improvement process that unfurls logically, does not have a fixed or pre-ordained endpoint, and is supported over expanded timeframes. According to (Vlăsceanu et al., 2004), excellence in undergraduate and postgraduate studies is complicated, contextualised, and multifaceted. CQI is significant in the accomplishment of a faculty's instructional objectives. CQI includes a couple of stages as follows:

- Plan: Reconsider the faculty's existing plan with an additional plan if required for further improvement.
- Implement: Execute the modified plan
- Monitor and Audit: Quantify and examine the accomplishments of the objectives set; consider gaps based on the logic of the existing and additional plan
- Improve: Achieve improvement or build up an additional plan dependent on achieving targets and the appropriateness of the existing and additional plan.

2. Design and Methodology

The educational plan and curricular frame work must reflect the main theme of the programme, delivery mode, learning strategy and evaluation processes. The said plan and design must be aligned towards the achievement and measurement of POs. A fair educational plan will incorporate all specialized and non-specialized features expected in the POs, and there will be a link between the core components and electives of the program. This link should contain all programme expectations (POs) with industrial and practical design experience stated by EAC.

A programme needs to contain the required depth of knowledge in the field of specialization for all the courses listed. From time to time, a consultation is warranted to meet any new skill requirements of industry via IAP, to give an appropriate industrial career to the students. This can be achieved and implemented in courses such as industrial training and integrated design project. The course sequence and the number of hours of study for each course are also very important. Educational programme commonly alludes to the information and abilities that undergraduates are expected upon to gain during the course.

A curriculum includes the following points (Idachaba, 2018):

Course Outcomes the graduates are expected to meet:

- The components and modules to be taught
- The coursework and tasks to be given to the graduates
- The list of reference and text books, non-conventional delivery, presentations, and readings used in the syllabus;
- The exams, valuations, and other methods used to evaluate graduate learning

The FECT engineering degree program courses are categorized as shown the Table 1. This covers the wide area of their respective disciplines as specified by the regulatory authorities. (EAC, BEM affiliated with WA standard).

The educational planners need to comprehend the genuine importance and significance of the announcements of PEOs, POs, and COs, while considering (Priya Vaijayanthi & Raja Murugadoss, 2019) the educational plan. The syllabus, method of delivery and assessment criteria are the 3 transcendent mainstays of engineering education and the previous one sets the foundation for all other OBE procedures.

[Insert Table 1]

All the above points need to be included in the curriculum, keeping in mind that minimum standards need to be maintained because they are essential for accreditation.

Every CO can have all three components or a verb with the condition, or a verb with the standard. Three samples are provided below.

[Insert Table 2]

The attributes in the CO statements should be measurable and observable in three domains namely cognitive, psychomotor, and affective. Thus, it is better to avoid verbs such as understand, know, practice, make, etc., which cannot be measured.

Sample 1: Design a FIR filter using the Butterworth algorithm with MATLAB and Simulink R2019a.

Sample 2: Design a FIR filter using the Butterworth algorithm.

Sample 3: Design a FIR filter using any open-ended signal processing software.

The choice of CO depends on POs to be tested and accordingly teaching and assessment methods are decided as indicated in the Table 2.

2.2 Measurement of Cos

Assessment is a measure of performance which drives student learning, whereas evaluation is an interpretation of assessment. CO evaluation starts from the beginning and lasts to end of the semester as per the course schedule approved by the faculty. Assessment evaluations (formative and summative) of particular COs are aggregated and achievements are expressed in percentage. The summative instruments should be designed to ensure that all students are required to pay attention to the attainment of all COs. A Table of Test Specification (TTS) showing cognitive questions, their taxonomy level, and allocated marks need to be planned or designed before implementation of lecture. This is generally followed for written exams which eases the vetting process. A sample TTS is shown in the Figure 2. From Figure 2 it can be seen that the marks allocated for each topic in the mid-semester examination is based on the number of hours spent in teaching and learning. Thus, the questions are distributed according to the teaching and learning hours and cognitive levels as per CO planning. TTS helps in measuring the COs even at different cognitive levels. Measured CO achievements have to be recorded and it will serve as CQI input for the next cycle, in addition to PO measurement and analysis.

[Insert Figure 2]

2.3 Measurement of POs through COs

COs must be mapped to POs so that no assessment of POs or COs for a single task overlaps. This is explained in the Table 3 which justifies the importance of one-to-one CO/PO mapping.

[Insert Table 3]

Further it also eases our PO attainment calculations. The order in which the courses are taught, and the course outcomes for any given programme with appropriate teaching and learning methodologies, ensure the achievement of all the POs with desired expertise. To give opportunity to improve the achievement of POs, learners should be given four chances in a four-year engineering programme. Proper planning of PO and CO mapping has to consider the above point while designing the curriculum. The extent to which weightages of POs are measured for a particular COs are slight (20%), moderate (30%), and substantial (50%). A matrix in Figure3 shows the aggregate of weightages of individual POs for different courses. The overall achievement of POs for whole programme can be calculated using the equation 1.

[Insert Figure 3]

$PO_n = \frac{\sum_{k=1}^{N} C_K}{\sum_{k=1}^{n} P_K}$ Where N= Number of Courses, n= Number of POs (1)

This also helps the programme owners to assess or fine-tune the weightages (if required) of POs prior to implementation of the curriculum.

2.3 PO Mapping with WA Attributes

To ensure all the fundamentals required for the programme innovatively WA developed three attributes namely Knowledge Profile (WK), Complex Engineering Activities (CEA), and Complex Problem Solving (CPS). These attributes have to be checked through proper rubrics for each assessment.

WK has eight subsets attributes such as natural science (WK1), mathematics (WK2), engineering fundamentals (WK3), specialist knowledge (WK4), engineering design (WK5), engineering practice (WK6), comprehension (WK7), and research literature (WK8). For example, if design criteria are tested, WK3 should be included, this is linked with PO3.

CEA has five subset attributes such as range of resources (EA1), level of interactions (EA2), innovation (EA3), consequences to society and the environment (EA4), familiarity (EA5), For example while testing the communication with reference to innovative ideas EA3can be included, which is linked with PO10.

CPS has seven subset attributes, such as depth of knowledge required (WP1), range of conflicting requirements (WP2), depth of analysis required (WP3), familiarity of issues (WP4), extent of applicable codes (WP5), extent of stakeholder involvement and level of conflicting requirements (WP6), and interdependence (WP7). While assessing PO1 and 2, WP1 is tested along with any one or more from WK3-WK8, depending on the degree of knowledge. The sample of PO, WK-CEA-CPS is shown in Figure 4.

[Insert Figure 4]

2.4 Significance of Bloom's Taxonomy

In 1956, Benjamin Bloom headed a gathering of instructive analysts who built up a characterisation framework for levels of thinking abilities and learning conduct. The taxonomy framework they made is frequently alluded to as sprouts Bloom's categorisation. The word scientific classification implies arrangements or structures. Bloom's scientific categorisation order as indicated by six levels of thinking degrees of a multifaceted nature and is shown in Figure 5(a) (Center, n.d.). During the 1990, Lorin Anderson (Center, n.d.) and a team of thinking analysts refreshed the Blooms categorization. The corrections they made are minor, nonetheless, they do have a critical effect on how individuals utilize the Bloom's classification as shown in Figure 5(b) (Center, n.d.).

[Insert Figure 5a&b]

The purposes of Bloom's are follows (P.Armstrong, 2018):

- ➢ Course aims are critical to build up in an academic exchange with the goal that lecturer and students should realize same inspiration behind that skill.
- ➢ Setting targets helps with clarifying objectives for lecturer and students.
- ➢ Through the plan of objectives make lecturers to do the following.
- "strategy and carry fitting supervision";
- "Plan substantial assessment responsibilities and procedures"; and
- "Confirm that supervision and evaluation are lined up with the goals."

One of the most challenging tasks for a lecturer is setting exam papers so that they assess all the levels of knowledge, based on cognitive level C1 – C6. In a same way the assessment strategy is also equally challenging to measure achievement. In this context, (Timakova & Bakon, 2018) explained about evaluation scheme as below.

- Small exam questions with a 40% evaluation designation,
- Application exam questions (less clear exam questions with 40-50% of evaluation scheme,
- 20-30% of high level (C4-C6) Bloom's exam questions

This makes us, confirm and accept the Bloom's level of achievement of student without any confusion.

Bloom's scientific classification has been demonstrated to be a useful recommended structure (Draga Vidakovic, Jean Bevis, 2004) for producing short answers, compound decision, coordinating and summary type questions which test students' knowledge in different levels of Bloom's activities.

FECT, AIMST University, carefully designed each semester question paper to achieve the lower order to higher order thinking skills. The faculty design the question paper with following stipulated rules:

- All year of the questions must be prepared with 20-35% higher Bloom's level which is C5. Percentage may vary depends upon the year of study and course.
- For pre-final and final year question paper must be prepared with 5-10% from higher blooms level which is C6.

The choice of the above scale is set by faculty with approval from all stakeholders such as External Examiner (EE), and Faculty Quality and Academic Curriculum Committee (FQACC). The quality of exam question papers is properly verified by the vetting committee which is coordinated by the exam coordinator with the guidance of Head of Department (HOD). The following points are to be tested and verified by the vetting committee.

- Question papers are designed in line with the syllabus and aligned as per the COs/POs.
- Question papers are set with appropriate Bloom's levels as framed in TTS.

- Marking schemes are in place.
- Any final exam questions are checked for non-repetition from other mode of assessments in the same semester.

Therefore, faculty is able to ensure and confirm the quality of COs, POs alignment in question papers and Bloom's taxonomy level as well. This will aid institutions to get accreditation from the board.

3. Results and Discussions

3.1 COs Achievement

After the assessment tools are implemented, evaluations are done by the course coordinator to achieve of COs for a particular course. A sample of the COs achievement is shown in Figure 5 and clearly itemised the formative (40%) and summative (60%) attainment. Figure 5 discuss how formative and summative assessments are tested to achieve three COs through Mid Sem (Mid-Semester Examination), Group Assign (Group Assignment), Laboratory Reports (Lab Marks), and Final Exam.

CO1: Explain various power semiconductor devices with their characteristics.

CO2: Explore the operation and performance parameters of converters, Inverters and Dc-Dc Converters, AC voltage controller and Electrical Drives applications.

CO3: Function effectively in the operating team of Electrical Drives application.

CO1 is tested through Mid Sem (15%), CO2 is tested through Final Exam (60%) with laboratory exercises (15%), CO3 is tested for group work through group assignment (15%) which is linked with PO1, PO2, and PO9 respectively. All the assessments are done with proper rubrics through criteria which reflect WA profiles and PO attributes as well. Total assessments are 100% and the last column in Figure 6 shows achievement of the COs. As this course has one-to-one mapping, CO achievement is also PO achievement. Similarly, the achievements (CO and PO) of each course offered in one semester are submitted to the programme coordinator by the course coordinator. Each PO's allocation of marks is tested through the courses and shown in Figure 3. Achievement of the CO sheet is prepared in Microsoft XL sheet using the formulae embedded in the software.

[Insert Figure 6]

Achievement of COs are categorised as Good, Satisfactory, and Poor. The achievements category and targets are fixed from feedbacks from various stakeholders such as IAP, EE (Extremal Examiner) and FCC (Faculty Curriculum Committee). As per Figure 7, achievements of COs are tabled and compared with previous cycle achievements and appropriate remedial steps are taken to fill the gap, in case the achievement is lower than targeted. If the achievement is above or equal to the targets, the next high-level target is to be fixed, to ensure continuous quality improvement. The lecturer who takes the same course in the forthcoming semester should implement this feedback. Thus, the CQI loop is closed.

[Insert Figure 7]

3.2 POs Achievement

As stated earlier, the PO achievement is to be calculated at the end of the programme. Yet the goal can be easily achieved by monitoring and discussing its accomplishments at the end of each semester and giving feedback to the faculty from the programme coordinator or HOD. To discuss the PO attainment, a sample PO achievement of a cohort is considered. Every year's achievement is shown in the Figure 8 -11, which help us to monitor, whereas, Figure 8a represents the achievement of the entire programme. Achievement of POs are categorised as

- Very poor <50%,
- Poor 50-59%,
- Satisfactory60-69%,
- Good > 70%

It is fixed from feedback from various stakeholders such as IAP, EE and Faculty Curriculum Committee (FCC). In the example, PO2 is tested in almost all semesters, and PO11 is tested only in last two semesters which reflects the poor planning. The Figure 8(a) shows PO achievements at the end of the programme (Year 4 Semester 2) and attainment of POs are above 70%, which is categorised as a good scale except forPO3 and PO6. Achievement of PO3 and PO6 is neither poor nor very poor, but it is at the satisfactory level. Therefore, the overall batch PO achievement is satisfactory and good at the end of the programme. The achievements of POs are tabled and discussed with all the stakeholders and feedback taken for further improvements. Testing of POs has to be planned strategically, and all the POs should be tested at least four times in a program. However, testing of the same PO for every semester or testing of a PO for only one semester is to be avoided. This gives the student a fair and equal opportunity to improve their achievement.

Implementations of teaching, learning and assessment tools have shifted considerably with the Covid - 19 scene. This also made educational planners revise the process of learning from face-to-face to online mode. Vigil is required to monitor the courses which are handled by part-timers with reference to the quality documentation work. Programme independent POs (PO6 - PO12) which are away from technical aspects have to be paid equal attention , since this POs measurement and testing requires more effort and dedication than program dependent POs.

[Insert Figure 8-11]

4. Conclusion

Utilizing a proper design of COs conforming the POs of EAC-Malaysia to the WA profile, enable us to monitor and measure. This article reports an overview to gauge the success level of COs and POs from the four-year degree course needed for graduation from the AIMST University Electrical & Electronic Engineering programme. The results have demonstrated that graduates have seen the accomplishment of most POs to be over the expected level. One sample of course COs achievement is discussed and all the attainments are at a satisfactory level, CQI is also discussed for further achievements. Using these results, appropriate suggestions are recommended within the guidelines framed by EAC which is affiliated to WA.

Thus it can be concluded that implementation of OBE involves following steps to succeed in the accreditation exercise.

- Planning of PO/CO mapping,
- Proper documentation
- Proper teaching and learning assessments
- Appropriate tools to measure the COs/POs
- A good stakeholder's team to comment monitor and guide the attainment.
- A dedicated team which takes the whole process of accreditation as a challenge will be an added advantage to secure a high accreditation.

The procedures that are discussed in this research work need not be ideal. By suitable feedback mechanisms and effective implementation of CQI tools, better results can be achieved in accreditation.

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