A Micro-level Assessment Methodology for attaining Programme Outcomes through UnderGraduate Engineering Projects

P. Karthikeyan[1], A. M. Abirami[2], M. Thangavel[3]

[1,2,3] Department of Information Technology, Thiagarajar College of Engineering, Madurai, TamilNadu
[1] karthikit@tce.edu
[2] abiramiam@tce.edu
[3] thangavelmuruganme@gmail.com

Abstract: The Programme Outcomes (PO) of students are measured after the completion of every Under Graduate (UG) programme. Contributions of engineering projects on programme outcomes are significantly more when compared with other courses. The final year projects are evaluated by rubrics at different stages. The projects may fall in different categories; mapping of each project with PO needs to be carried out based on the nature of the problem and its solution. Hence, there exists a need for micro-level assessment and evaluation processes for projects. It is really a challenging process to define the set of activities needed for this. In this paper, a micro-level assessment methodology for attaining programme outcomes through UG Engineering Projects has been proposed and implemented. The process is defined in alignment with the ADDIE instructional design model and recommended to have different phases like plan, design, implement, evaluate and assessment. Project-PO mapping guidelines are prepared and used in the assessment process. This study explores the attainment level of different POs for each student and analyzes how the project helps in the attainment of Graduate Attribute (GA) for each individual. This paper discusses the detailed processes that have been carried out for the project course and how these processes help in the PO attainment level for two different batches of BTech IT students. The results of PO attainment prove that the proposed process would help in the attainment of PO, hence the Graduate Attribute level of each student.

Keywords: Engineering Project Review Process, Programme Outcome Attainment, Project PO Mapping, Project PO Attainment Calculation, Project Review Rubrics

Corresponding Author
P. Karthikeyan, Department of Information Technology,
Thiagarajar College of Engineering, Madurai.
karthikit@tce.edu

1. Introduction

UG Engineering programmes define their Programme Outcomes (POs) in accordance with the 12 Graduate Attributes (GAs) defined by the Washington Accord and recommended by National Board of Accreditation (NBA), India. Each programme designs their curriculum to cater to the attainment of these POs and GAs. There exists a need to establish a suitable procedure for the calculation of PO attainment for the project course. It helps in the assessment of knowledge, skill and attitude of each student in respect to the required PO/GA target level. List of Programme Outcomes for an Engineering programme is given in Annexure 1.

Engineering curriculum includes many programme core and elective courses, which are mapped to the POs through Course Outcomes (COs). Each course may be mapped to 6-10 POs, not to all POs. Project courses have the greatest potential of solving real time problems by learners, which improves the quality and quantity of learning significantly. Project course is carried out in the final semester of B.Tech IT curriculum as a group activity. Project courses can be done by mentoring of institute faculty or by outside organization experts with monitoring of institute faculty. The processes involved in the project courses are: forming project student batches, identifying problem statements, allocating projects and faculty to student batches, schedule for mentoring and evaluation for assessment, and, rubrics for assessment. Continuous internal assessment in the name of project review has been conducted for periodical monitoring. Summative external assessments have been conducted at the end of the semester with demonstration of the work done, presentation and project report. The features of project course include: (i) challenging learners to all the relevant affective and cognitive levels of learning (ii) engaging learners actively with new knowledge (iii) interacting well among learners, faculty and society for real time problem solving (iv) having a good system for assessment, feedback, and grading and (v) incorporating experiences which can help for the attainment of professional outcomes.

The twelve POs are grouped under three categories namely Knowledge, Skill and Attitude domains. The Project course is mapped to all 12 POs; it helps in measuring PO attainment, thereby enabling to measure the attainment levels in three different domains. In order to address POs through the project course, (i) project guidelines must include the necessity of POs, (ii) student performance tracking in project course must assess the problems in addressing POs, (iii) project rubrics must include parameters related to POs, and, (iv) rubrics must be explained to the students before assessment. Generally, the final semester examination results declare whether the students get passed or failed in the project course with the marks (or grade); it does not describe the details of PO attainment. It is the responsibility of the programme to analyse the attainment level of the project course using its continuous assessment and evaluation marks. This study

explores different processes that are followed to understand the real implications of the project course for each student.

The research question is framed as follows: Does the Project help the individual to attain the required Graduate Attribute level? This paper focuses on the PO attainment calculation procedure for the project course of BTech Information Technology (IT) programme. The paper is organized as follows: section 2 explains the related work done in this problem domain, section 3 describes the proposed methodology, section 4 discusses the results and section 5 concludes the paper.

2. Literature Survey

In this section, the existing processes related to programme outcome attainment methods of project course and the research gap have been discussed. Abdul et. al. (2012) proposed programme outcome assessment model using the direct and indirect assessment methods including the sub-criteria measurement for certain POs like Communication. Noor et. al. (2011) used indirect assessment methods like surveys from parents, alumni, and employers to measure the attainment of programme educational objectives and programme outcomes for Civil Engineering students. Tshai et. al. (2014) conducted a study to measure the effectiveness of Outcome Based Education (OBE) in the Department of Mechanical, Materials and Manufacturing Engineering at the University of Nottingham Malaysia Campus, Malaysia. They formulated an assessment process by getting stakeholders inputs for evaluating the POs/PEOs and for continual quality improvement. Gowrishankar et. al. (2017) detailed the assessment procedure for POs/PEOs and how the continual quality improvement includes the changes in the curriculum development process.

Hamimi et. al. (2011) and Azrul et. al. (2011) used the direct and indirect assessment techniques to assess the attainment level of Programme outcomes through the specific courses. Ramchandra et. al. (2014) proposed a method for the calculation of attainment of Course Outcomes (COs), and hence the attainment of Programme Outcomes (POs). They focussed on the CO mapping at the question level for continuous internal evaluation and thereby assessing the efficiency of students through different courses. Balasubramani et. al. (2017) discussed the process of PO attainment through CO attainment level of the sample course Building Enterprise Application and explained how different COs supported PO attainment. Mark et. al. (2018) demonstrated that was an improvement in PO attainment, if courses use modern tools than the other courses, as those courses would improve psychomotor and affective domain skills of students.

Roslan et. al. (2009) implemented Project Based Learning so as to improve the soft skills and professional qualities of students as part of Outcome Based Education in the University of Malaya. Ignacio et. al. (2010) proposed project based learning for the final year undergraduate students and explained how collaborative learning facilitated improvements in the professional skills. Stuart et. al. (2011) explained their experience of offering PBL to their first year students and proposed more design projects for future offerings. to them. Kyungmoon et. al. (2014) used ARCS model for implementing Project Based Learning for their students and assessed the projects using Instructional Materials Motivational Scale (IMMS); their findings showed that women students were lacking in all motivational categories and all students were having lower confidence levels.

Chowdhury (2015) investigated the relationship among the learning style of students, teaching approaches of instructors, and the role of smart technologies while implementing PBL to the students for their project work; the survey results showed that there existed a lack of collaborative learning skills among the students. Jacek (2016) recommended Project Based Learning with experiential learning and reflective writing would make the graduate role ready for industries and meet the industry demands. Karthikeyan et. al. (2016) proposed the assessment model for evaluating the IT programme using the direct and indirect assessment method strategies and the course outcome attainment levels. JanseVan et. al. (2019) used Project Based Learning methodology to inculcate 21st century competencies required for IT graduates. They recommended having PBL in the early stages of curriculum and encourage the students to get involved in reflective writing so as to promote their self-learning attitude.

From the literature, it has been understood that much of the focus is given to the CO/PO attainment calculation process at programme level; no work discussed about this procedure for the project course exclusively. Project is the only course where each student may be given individual attention and the PO attainment can be measured efficiently. Hence, it becomes necessary to document the procedure and share it with the academic community. The study explained in this paper would help all the programmes (not only BTech IT programme) for their Self-Assessment Report (SAR) preparation for their NBA assessment process.

3. Methodology

In this paper, the ADDIE (Analyse-Design-Develop-Implement-Evaluate) model, an instructional design model, has been used as the basis for developing the processes for the project course. The activities like framing guidelines, students team formation, rubrics design and project guide assignment are done as part of the ADDIE phases, the project implementation is done in ADDIE phase and the project evaluation and assessment are done in ADDIE phase. The following subsections explain the processes and the PO attainment calculation methodology.

A. Process

The study explores the programme outcome attainment of the project course of two batches of students of BTech IT programme, consisting of 250 students. The project

implementation by each team is evaluated by the faculty team using the rubrics in three different stages. Fig. 1 explains the overall framework of the proposed methodology.

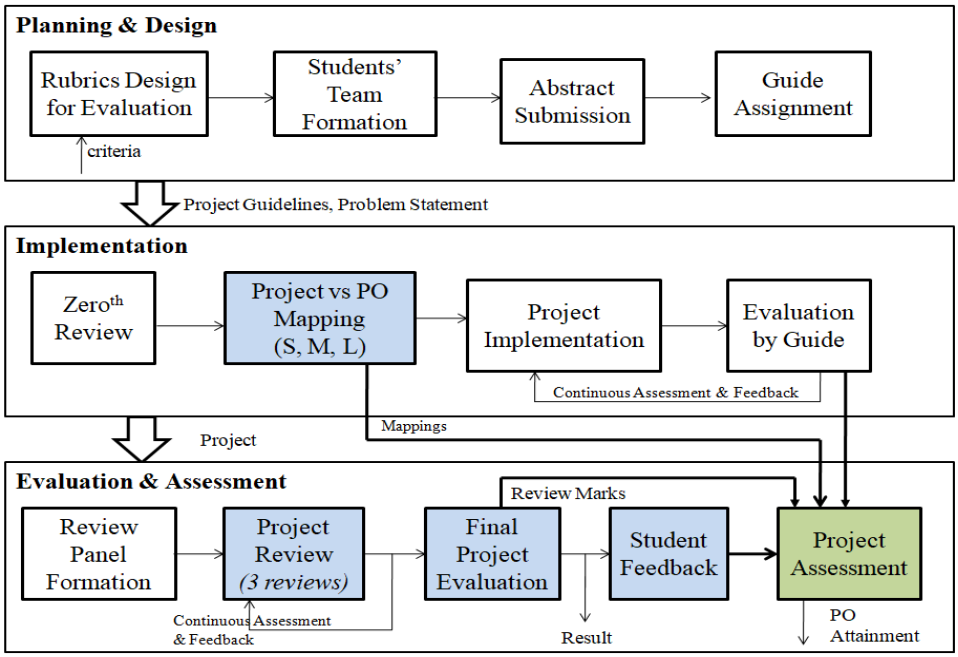

Fig. 1 Framework for PO Attainment Calculation for Project Course

Rubrics are framed in alignment with the 12 POs. Based on the problem selected by the student teams, the project guides are assigned to each team. Table 1 shows a list of POs addressed in each review and the details are shown in Annexure 2.

Table 1. Mapping of Rubrics Criteria with POs

Reviews	PO Mapping with Criteria in Rubrics	PO Mapping with Continuous Assessment by Guide
Review 1	PO1, PO2, PO6, PO7, PO8, PO10, PO11	Objectives (PO6), Plan (PO11), Discussion (PO2), Results (PO1), Attendance (PO8)
Review 2	PO1, PO2, PO3, PO5, PO7, PO8, PO9, PO10, PO11, PO12	Objectives (PO1), Plan (PO11), Discussion (PO2), Results (PO3), Attendance (PO8)
Review 3	PO1, PO3, PO4, PO8, PO10, PO11, PO12	Objectives (PO1), Plan (PO11), Discussion (PO4), Results (PO3), Attendance (PO8)

The Zeroth review is conducted by the project guide; each project is mapped to 12 POs and given weights like S, M and L (S-strong, M-medium, L-Low). Prior to mapping, all project guides are given facilitation for mapping with POs. Table 2 shows the guidelines that may be used for mapping each project with 12 POs to ensure uniformity in the process. Table 2 shows only 'S' mapping; the project guides may take the decision to give 'M' or 'L' mappings. For example, usually the industry internship projects may not be at 'Evaluate' level (PO4). These projects may be given 'M' mapping for PO4.

Table 2. Guidelines for PO Mapping for the Project

Project Type	Programme Outcomes	Mapping
Institute Projects (done at own Institute or at IITs/NITs)	PO1, PO5, PO8, PO9, PO10, PO11, PO12	Strong (S)
Institute Projects (done at own Institute or at IITs/NITs)	PO2 , PO3, PO4	Strong (S)
Industry Internship Projects	PO1, PO5, PO8, PO9, PO10, PO11, PO12	Strong (S)
Industry Internship Projects	PO2 , PO3	Strong (S)
Projects solution useful to Society	PO6	Strong (S)
Projects understand the impact of Environment and the Society and provide sustainable solutions	PO7	Strong (S)

Project design and implementation is continuously monitored by project guides with necessary discussions and directions towards achieving the project objectives. Project review panel is formed with expertise from different domains of computer science and information technology. The project is reviewed in three different stages and the progress is evaluated by the panel members. Final project viva voce is conducted; student feedback is obtained for the project course. The assessment for the project is carried out using the statistical methods and the actual PO attainment is calculated for the batch of students through this project course.

B. Attainment Calculation

Two different measures can be determined from the result data of the project course - course outcome and programme outcome attainments. Project is considered as a course (like any other course), and each PO is considered as a course outcome. The course outcome attainment is calculated as follows: each course has two targets, namely Expected Proficiency (EP) and Expected Level of Attainment (ELA). These targets are set using the results of previous batches of students of the Programme. For the project course, these targets are set as EP 90% and above, and ELA 60% and above. It means that 60% of students have to score 90% and above in the Project course. The course outcome attainment is determined by:

$$q = \frac{p * 100}{z} \qquad \text{(Equation 1)}$$

where 'p' is the number of students scored above EP and 'z' is the number of students registered for the course. If q is greater than ELA, then the corresponding PO is attained; else analysis has to be done and an improvement plan needs to be prepared for the next batch of students.

PO attainment through the project course is calculated using the weights given to each project. Let xi be the mapping (weights) for POi for a project and yi be the score of the individual student for POi, where i varies from 1 to 12. Here, yi includes the rubrics based consolidated review score given by the panel members for each student/team, evaluated against each PO. Let z be the total number of students registered for the project course in a Programme. Two different approaches may be adopted for the calculation of PO attainment:

Method 1:

$$POi = \frac{xi*yi}{3z} \qquad \text{(Equation 2)}$$

Method 2:

$$POi = \frac{xi*yi}{sum\ of\ weights} \qquad \text{(Equation 3)}$$

Method 1 expects that all mappings have to be 'strong' whereas method 2 uses the weighted average method, as shown by equations 2 and 3 respectively. The differences in values and their interpretation are discussed in the next section.

4. Results and Discussions

In this paper, the results of the project course of two different final year BTech IT students have been considered. The continuous assessment marks of two batches, namely 2015-19 (Batch 1) and 2016-20 (Batch 2) have been used for this study. Table 3 shows the PO mapping and the weights for a sample project.

Table 3. PO Mapping for Sample Project

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
S	S	S	M	S	S	L	S	S	S	S	S
3	3	3	2	3	3	1	3	3	3	3	3

The contribution of this sample project to PO4 is given as 'M' as it does not involve complex experiments; and PO7 is given as 'L' as it is a pure software application project and it does not have any impact to environment. Rubrics-based review marks are consolidated for each project for each review. The contribution of each project towards each PO is then calculated based on the mapping shown in Table 1 and Annexure 2.

Considering the project work as a course, the course outcome attainment has been calculated, using the Equation (1), and is shown in Fig. 2. Here weights (i.e. PO mappings) are not used. PO attainment values for POs like PO1, PO5, PO6, PO8 and PO12 are greater than 60 for both the batches; hence these POs are attained. However, the programme has to analyse and prepare an action plan for improving the knowledge POs such as PO2, PO3, and PO4, whose attainment is lesser than 60. Few POs like PO5, PO6 and PO9 for the Batch 1 have greater attainment than the Batch 2.

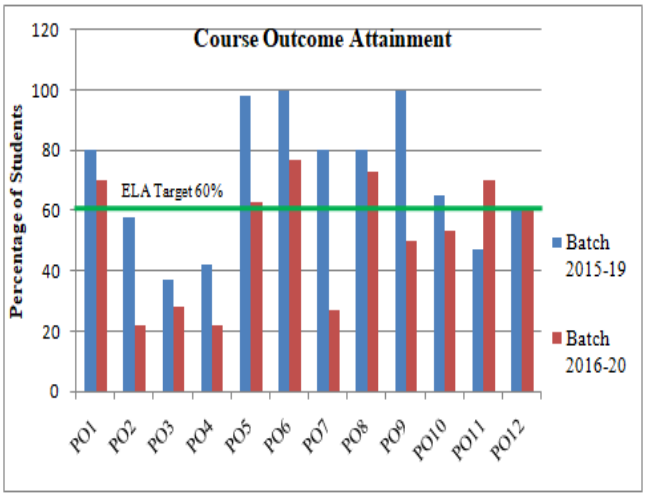

Fig 2. Course Outcome Attainment for Project

Few POs like PO2, PO3, PO4 and PO7 show poor attainment value for the batch 2 when compared with the batch 1. The review panel has been given guidance prior to evaluation of the batch 2 projects. This add-on activity in the project evaluation process avoids awarding random marks to all team members of the project. The panel evaluates strictly and awards marks only if the individual in the team answers queries, participates in the project development, and so on.

The Table 4 shows the total marks given for each PO in each review, which includes the evaluation of both review panel and project guides. For the review 1, the project team would do literature review and hence more weightage is given to PO2. The communication and project management skills are given focus in all three reviews.

Table 4. Mark split-up in Reviews for each PO

PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
Review 1	8	20				8

Review 2	8	4	12		4	
Review 3	8		12	16		
Total Marks	24	24	24	16	4	8
PO	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Review 1	4	4		8	8	
Review 2	4	8	4	8	8	4
Review 3		8		8	4	4
Total Marks	8	20	4	24	20	8

Tables 5(a), 5(b), 5(c) and 5(d) show the calculation summary of review marks of a sample project. The marks given by the review team are consolidated for each review and mapped to respective POs, as shown in Table 1 and Annexure 2.

Table 5 (a). Review 1 marks vs PO Mapping

PO	PO1	PO2	PO6	PO7	PO8	PO10	PO11
Total	**8**	**20**	**8**	**4**	**4**	**8**	**8**
Stud #1	7.33	14.67	7.33	3.67	4.00	6.33	7.00
Stud #2	6.33	13.67	7.33	3.67	3.00	6.33	7.00
Stud #3	6.33	13.67	7.33	3.67	3.00	6.33	7.00

Table 5 (b). Review 2 marks vs PO Mapping

PO	PO1	PO2	PO3	PO5	PO7
Total	**8**	**4**	**12**	**4**	**4**
Stud #1	6.0	4.0	8.0	2.0	3.0
Stud #2	6.0	4.0	8.0	2.0	3.0
Stud #3	6.0	2.0	7.0	2.0	3.0
PO	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Total	**8**	**4**	**8**	**8**	**4**
Stud #1	6.0	2.5	4.0	6.0	2.0
Stud #2	6.0	2.5	4.0	6.0	2.0
Stud #3	5.0	2.5	4.0	6.0	2.0

Table 5 (c). Review 3 marks vs PO Mapping

PO	PO1	PO3	PO4	PO8	PO10	PO11	PO12
Total	**8**	**12**	**16**	**8**	**8**	**4**	**4**
Stud #1	6.33	7.67	11.00	7.00	7.33	3.00	3.00
Stud #2	6.33	7.67	11.00	7.00	7.33	3.00	3.00
Stud #3	6.33	7.67	11.00	7.00	7.33	3.00	3.00

Table 5 (d). Consolidated Review Marks vs PO Mapping

PO	PO1	PO2	PO3	PO4	PO5	PO6
Total	**24**	**24**	**24**	**16**	**4**	**8**
Stud #1	19.67	18.67	15.67	11.00	2.00	7.33
Stud #2	18.67	17.67	15.67	11.00	2.00	7.33
Stud #3	18.67	15.67	14.67	11.00	2.00	7.33
PO	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Total	**8**	**20**	**4**	**24**	**20**	**8**
Stud #1	6.67	17.00	2.5	17.67	16.00	5.00
Stud #2	6.67	16.00	2.5	17.67	16.00	5.00
Stud #3	6.67	15.00	2.5	17.67	16.00	5.00

The values shown in Table 5(d) are then converted to percentage, which in turn multiplied with weights of the project, as given in Table 3. PO attainment values are calculated as described by method 1 or method 2.

A. Discussion 1:

POs like PO1, PO8, PO11 and PO12 are addressed in all 3 reviews and their progress is shown in Fig. 3. The attainment of PO11 is low for the Batch 1 in all 3 reviews. An initiative has been taken for the Batch 2 in order to improve this PO.

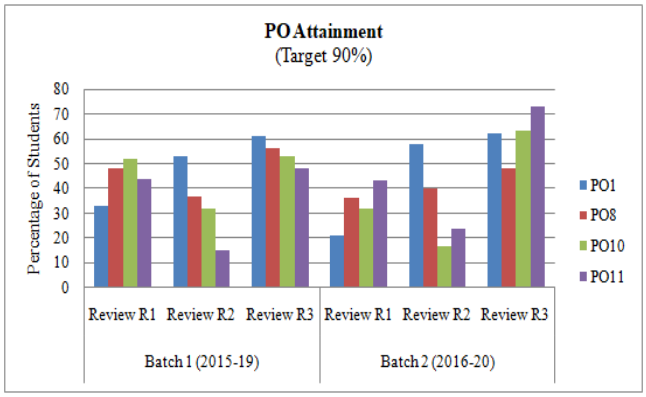

Fig 3. Progress in PO attainment in Three Reviews

At the beginning of the project course, all students were given orientation on the project management topics like project charter preparation, risk management, and progress monitoring by the team leader, which helped in the better attainment values.

B. Discussion 2:

Figures 4(a) and 4(b) show the PO attainment values of two batches Batch 1 and Batch 2, calculated by using the Equations (2) and (3), which includes direct and indirect PO attainment values. Direct PO attainment includes continuous assessment (weight 60%) and final viva voce examinations (30%). Feedback is obtained from the students for the project course and is used for the indirect PO assessment (10%).

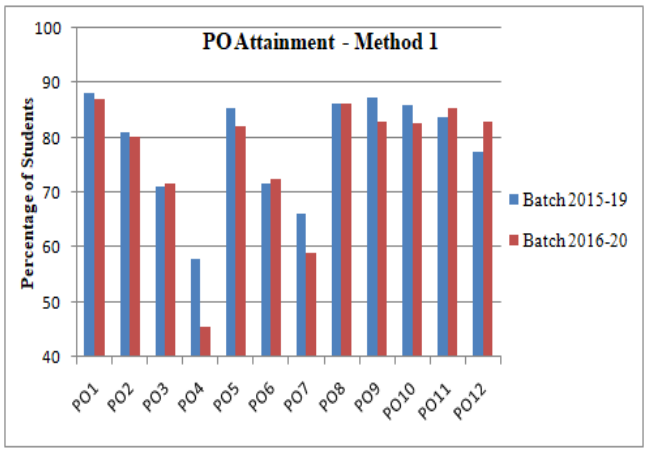

Fig 4 (a). PO Attainment by Method 1

NBA proposes Method 1 for PO attainment calculation, as this method identifies the gap between the target and the actual values. Method 1 exhibits an ideal case and it expects all projects have to be strongly mapped 'S' to all POs. Fig. 4(a) shows that PO1, PO2, PO5, PO8, PO9, PO10, and PO11 attained > 80% whereas PO3, PO4, PO6 and PO7 have lesser than 80%. Major reason could be that few projects may not be mapped 'S' to these POs, hence the poor values.

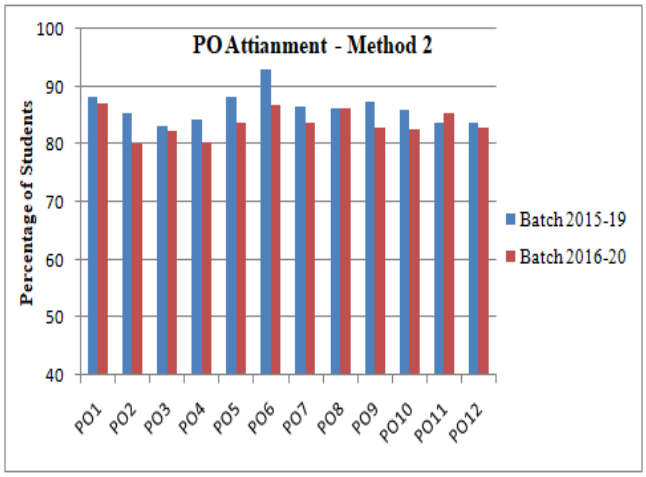

Fig 4 (b). PO Attainment by Method 2

However, Fig. 4(b) shows greater than 80% for all POs. If the programme adopts Method 2 for their PO attainment calculation, the real scenario would not be captured and the corrective action may not be planned precisely. Hence, adopting Method 1 would exhibit the actual status of project teams and helps the programme for better planning for the subsequent batches.

C. Discussion 3:

Figures 5(a) and 5(b) show the PO attainment values of Regular and Internship projects for two batches Batch 1 and Batch 2, calculated by using the Equation (2), which includes direct and indirect PO attainment values.

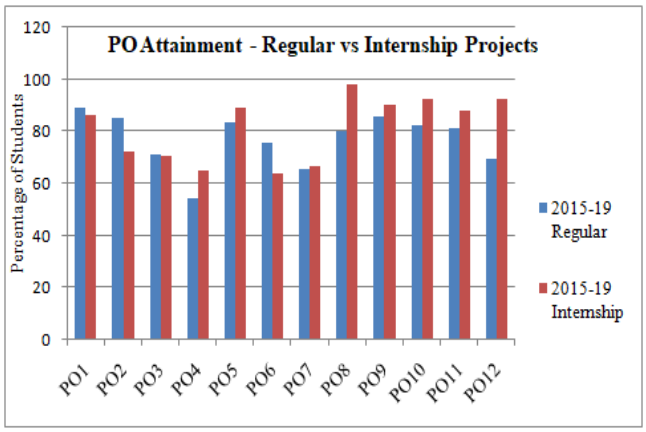

Fig 5 (a). PO Attainment – Regular vs Internship Projects for Batch 1

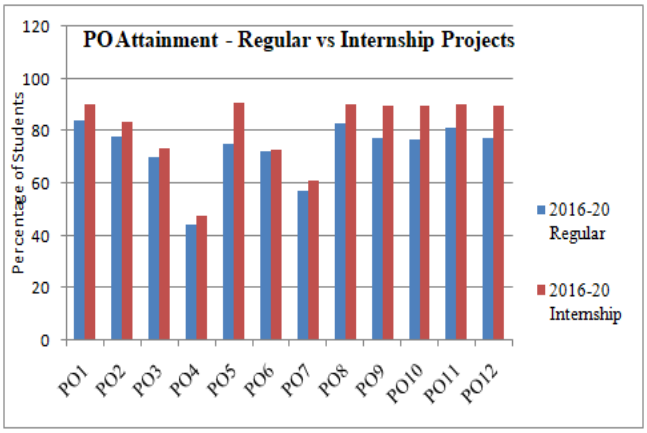

Fig 5 (b). PO Attainment – Regular vs Internship Projects for Batch 1

Fig. 5(a) shows that internship projects PO attainment is mostly higher than regular projects. Fig. 5(b) shows that internship projects PO attainment is higher than regular projects. So, regular projects guidelines need to be revised for improving PO attainment.

5. Conclusions

PO attainment calculation has been done with appropriate guidelines for the project course of UG programme. In this work, a micro-level assessment methodology for attaining programme outcomes of Projects has been proposed and implemented. A systematic process has been implemented using ADDIE model structure. Mapping of projects and POs are done initially and the proposed methods applied for two batches of students. The obtained results help to identify the action for improvement specific to each POs. In particular, the POs of personal and interpersonal skills have been measured properly through systematic methods. Hence the proposed process for the project course implementation will significantly improve the PO attainment method with micro-level assessments.

Acknowledgement

We acknowledge the Academics Process team of TCE for sharing the project rubrics for each review with the Programme for Project assessment and evaluation.

Annexure 1

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety,

and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. 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.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long 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.

Annexure 2

Programme Outcomes	Review 1	Review 2	Review 3
PO1 - Engineering Knowledge	• Application of engineering principles and concepts	• Application of engineering principles and concepts	• Application of engineering principles and concepts
PO2 – Problem Analysis	• Identification & definition of problem • Literature Review and Identification of alternate solutions • Project statement and objectives with Project Specifications and Constraints • Problem Solving Approach		
PO3 – Design and Development of Solutions		• Mathematical Modeling and analysis • Methodology	• Mathematical Modeling and analysis • Methodology
PO4 – Conduct Investigation of complex problems			• Project outcomes • Interpretation of Results • Conclusions and recommendations
PO5 – Modern Tool Usage		• Use of computer aided tools	
PO6 – Engineer and Society	• Social Relevancy		
PO7 – Environment and Sustainability	• Impact on environmental consideration	• Impact on environmental consideration during development	
PO8 - Ethics		• Ethics	• Ethics
PO9 – Individual and Team Work		• Team work	
PO10 - Communication	• Content & Organization • Delivery Skill	• Content & Organization • Delivery Skill	• Content & Organization • Delivery Skill
PO11 - Project Management and Finance	• Task Management and Costing		
PO12 – Life Long Learning		• Self Learning	• Self Learning

References

Abdul, W. M. and Azami, Z. (2012) Programme Outcomes Assessment Models in Engineering Faculties, Asian Social Science, 8(16), 115-121.

Azrul, A. M., Riza, A. A. R., Rashid, A., Fatihah S. and Suraya, S. (2012) Measurement and Evaluation of Program Outcomes in the Civil Engineering Courses, Procedia - Social and Behavioral Sciences, 60, 333 – 342.

Balasubramani, R. and Niranjan, N.C. (2017) Attainment of Programme Outcomes through Course Outcomes In Outcome Based Education: A Case Study, Journal of Engineering Education Transformations, 31(2), 26-30.

Chowdhury, R. K. (2015) Learning and teaching style assessment for improving project-based learning of engineering students: A case of United Arab Emirates University, Australasian Journal of Engineering Education, 20(1), 81-94.

Gowrishankar, K., Nithiyananthan, K. and Priyanka, R. (2017) Implementation And Assessment of Outcome Based Education in Engineering Education, International Journal of Pure and Applied Mathematics, 117(17), 217-228.

Hamimi, F. A. W., Afida, A., Wan, M. D., Hafizah, H., Aini, H. and Siti, S. M. (2011) Program Outcomes Measurement and Assessment Processes, Procedia Social and Behavioral Sciences, 18, 49–55.

Ignacio, R., Adolfo, C., José, M. D. And José L. Y. (2010) Project–based learning in engineering higher education: two decades of teaching competences in real environments, Procedia - Social and Behavioral Sciences, 2 (2), 1368-1378.

Jacek, U. (2016) A project-based learning approach in an engineering curriculum, Global Journal of Engineering Education, 18 (2), 119-123.

JanseVan, J. T. R. and Roelien, G. (2019) Reflecting on the use of project-based learning for 21st century competencies in an IT extended programme, Proceedings of the 10th Annual UNISA ISTE conference on Mathematics, Science and Technology Education, South Africa.

Karthikeyan, P., Uma, K. V., Abirami, A. M. and Thangavel, M. (2016) Efficient Assessment Methods for Improving the Programme Outcomes of Undergraduate-Information Technology Programme in India, in Proceedings of IEEE 4th International Conference on MOOCs, Innovation and Technology in Education (MITE), 351-356.

Kyungmoon, J., Olga, J. and Han, D. G. (2014), Project-Based Learning in Engineering Education: Is it motivational?, International Journal of Engineering Education, 30(2), 438-448.

Mark, O., Saravanan, K., Shaharin, A. S., Puteri, S. M. and Alfonso, U. (2018) A Comparative Analysis of Attainment of Program Outcomes for Courses with and without the Use of Modern Tools, MATEC Web of Conferences, 225, doi:10.1051/matecconf/201822506022

Noor, E. A. B., Kamaruddin, A. T., Othman, J., Shahrom, M. Z., Fatihah, S., Anuar, K., Siti, A. O. and Shanmugam, N.E. (2011) An Evaluation of Programme Educational Objectives and Programme Outcomes for Civil Engineering Programmes, Procedia - Social and Behavioral Sciences, 18, 56-64.

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

Roslan, H. and Mokhtar, A. M. D. (2009) Implementing Outcome Based Education Using Project Based Learning at University Malaya, European Journal of Scientific Research, 26 (1), 80-86.

Stuart, P. and Wayne, H. (2011), An evaluation of a project-based learning initiative in engineering education, European Journal of Engineering Education, 36 (4), 357-365.

Tshai, K.Y., Ho, J. Y., Yap, E. H. and Ng, H. K. (2014) Outcome-based Education – The Assessment of Programme Educational Objectives for an Engineering Undergraduate Degree, Engineering Education, 9(1), 74-85.