# Assessment and attainment of Course Outcomes and Program Outcomes

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***Abstract*—One of the important element of outcomes based education (OBE) is establishment and attainment of program outcomes (POs) and course outcomes (COs). At Department of Mechanical Engineering, Rajarambapu Institute of Technology, OBE has been implemented since academic year 2011-12. Based on the feedback of alumni and employers program educational objectives (PEOs) have been established. Program educational objectives are the career and professional achievements of the graduates of the program after 3 to 5 years of graduation. POs are designed considering graduate attributes (GAs) recommended by National Board of Accreditation (NBA), and feedback of alumni and employer. POs are the knowledge and skills, student of the program should demonstrate at the completion of the program. Based on the POs courses of the curriculum have been finalized. Next COs were written for each course of the program. COs are the knowledge and skills, the student should demonstrate upon completion of the course. These COs and POs are assessed to determine their achievement or attainment. Based on the attainment of COs and POs improvements are made in teaching methods, assessment methods, curriculum etc. A method has been developed for this purpose. This paper illustrates this method. Both, direct and indirect methods of assessment are used. Microsoft excel based system has been developed to process the data. Assessment and achievement of COs and POs is done for each individual student as well as for entire class. The results of assessment and achievements are used for improvements in teaching, assessment and curriculum.**

***Keywords—outcomes based education; program educational objectives; program outcomes; course outcomes; rubrics; graduate attributes.***

## I. INTRODUCTION

Outcomes based education (OBE) is starting with a clear picture of what is important for students and then organizing curriculum, delivery and assessment to achieve the same [1]. Recently, National Board of Accreditation has made it mandatory to implement OBE to become eligible for accreditation. Outcomes based model of accreditation requires evidence of assessment and achievement of course outcomes (COs) and program outcomes (POs) to feed a quality improvement process. It is sophisticated and hard to evaluate as it requires a lot of responsibility and risk in the hands of the program leaders. Outcome based model is „Learner centric', rather than the traditional „Teacher Centric' [2]. Outcomes with reference to educational program are the competencies, skills, knowledge, proficiency a student should demonstrate at the time of graduation [1]. In educational terms these outcomes are of two types:

i) Program outcomes.

ii) Course outcomes.

POs are the clear statements of what student should know and be able to do at the end of the program. They are to be in line with the graduate attributes of NBA. POs transform the program educational objectives (PEOs) into specific student performance and behaviors that demonstrate student learning and skill development [2]. COs are clear statements of what knowledge student gains and what skills he/she is able to demonstrate upon completion of a course.

In this paper a method which is used for the assessment and attainment of COs and POs, implemented at the Department of Mechanical Engineering, Rajarambapu Institute of Technology (RIT) is discussed. COs are mapped with POs. Assessment and attainment of COs is used for assessment and attainment of POs. The results of assessment and attainment of COs and POs are used for improvement of teaching methods, assessment methods and revision of curriculum.

## II. MAPPING OF COS WITH POS

Implementation of the OBE starts with writing vision and mission of the institute. Vision is a picture of the future you seek to create, described in the present tense, as if it were happening now. It shows where we want to go, and what we will be like when we get there. Mission statement defines what an institution is, why the institution exists, and its reason for being. It defines what we are here to do together [2]. Next define the vision and mission of the department. The vision and mission of the department should be correlated with the mission and vision of the institution. Further, mission and vision of the department is to be more focused on the theme area of the Department.

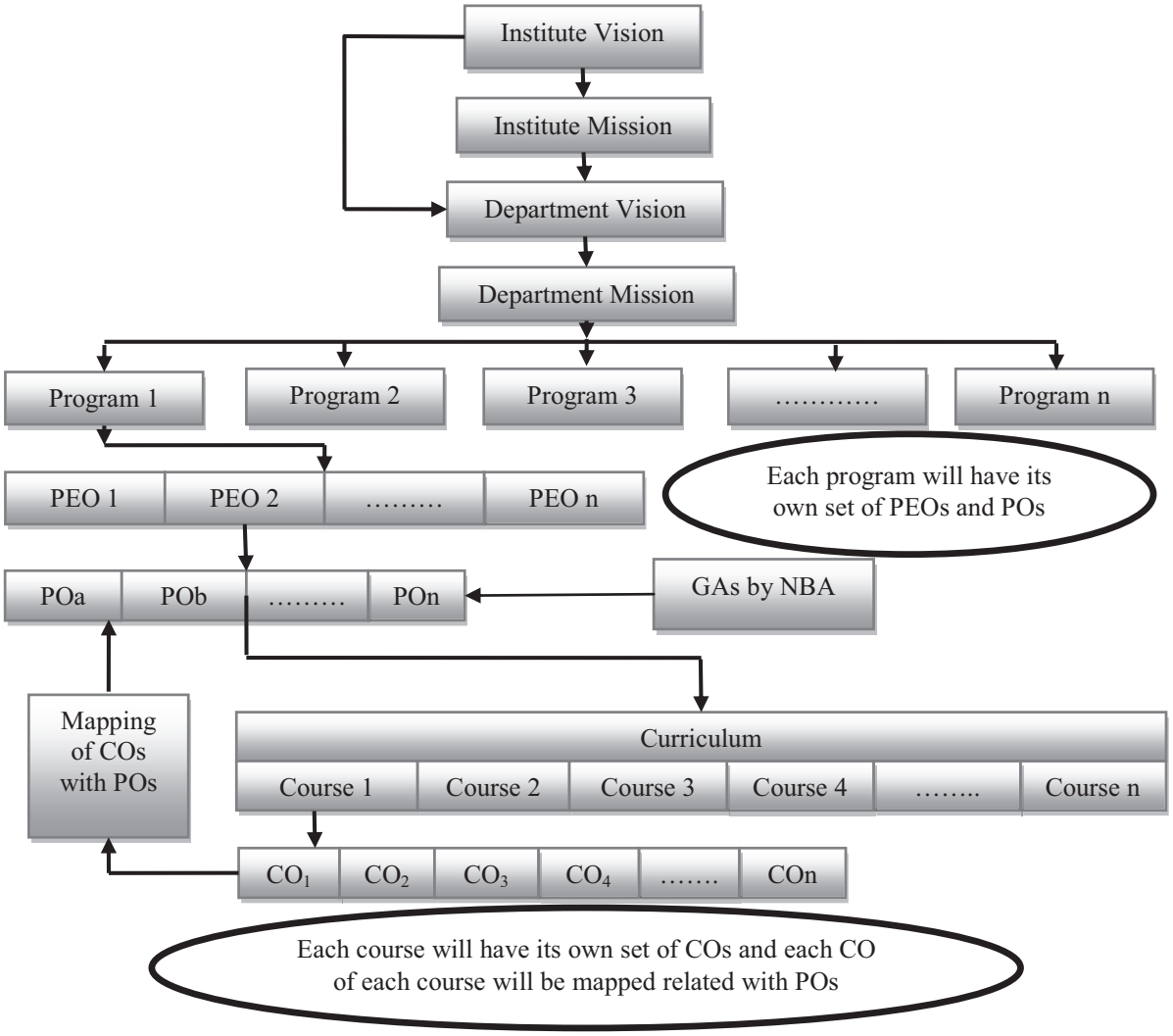


Fig. 1 OBE framework

**Mapping of COs with POs**

**Course: ME309 - Manufacturing Engineering, T. Y. B. Tech. (Mech.) Sem. I**

2 Strong correlation  1 Weak correlation  No Correlation

| Class | Course Code and Name | Course Learning Outcomes (CLOs) | Program Outcomes | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | a | b | c | d | e | f | g | h | i | j | k | l | m |
| M. Tech. (CAD/CAM/CAE) | MCC504 Advanced Industrial Automation and Robotics | 1. Explain the Mechanism of chip formation. | | 1 | | | 2 | | | | | | | | |
| | | 2. Select the process parameters, cutting tools etc. for given machining application. | 1 | | | | 2 | | | | | | | | |
| | | 3. Investigate the effect of various parameters such as process variables, cutting tool materials etc. on the performance of machining. | | 1 | | | 2 | | | | | | | | |
| | | 4. Identify and define various elements of tool geometry of single and multi point cutting tools. | 1 | | | | | | | | | | | | |
| | | 5. Design the press tools | | | 2 | | | | | | | | | | |

Fig. 2 Mapping COs of ME309: Manufacturing Engineering course with POs.

These vision and mission may be created based on the SWOT (Strength, Weakness, Opportunity and Threat) analysis. A mission statement might include a brief history and philosophy of the academic program, the type of students to be served, the academic environment and primary focus of the curriculum, faculty roles, the contributions to and connections with the community, the role of research, and a stated commitment to diversity and nondiscrimination [2].

Once the vision and mission of the Institute and Department are finalized, define the separate set of PEOs for each program offered by the Department. The Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments of the graduates of the program after 3 to 5 years of graduation. PEOs should be measurable, appropriate, realistic, time bound and achievable.

Based on the PEOs, feedback of employers and alumni and input given by Department Advisory Board, POs for each individual program are defined. Program Outcomes (POs) describe what students should know and be able to do at the end of the program. They are to be in line with the graduate attributes of NBA. POs are to be specific, measurable and achievable. POs transform the PEOs into specific student performance and behaviors that demonstrate student learning and skill development.

Next logical step in implementation of OBE is design of curriculum. Curriculum is designed such that it addresses all the POs. Curriculum is a set of courses. For each course in a curriculum COs are defined. Course Outcomes (COs) are clear statements of what a student should be able to demonstrate upon completion of a course. They should be assessable and measurable knowledge, skills, abilities or attitudes that students attain by the end of the course [3].

All courses in a particular program would have their own course outcomes. These course outcomes are designed based on the requirement of the program outcomes (POs). Each course outcomes are mapped to a relevant PO. It is ensured, through this mapping that all POs are addressed in the curriculum. These COs are useful to:

- convey performance expectations to the students.
- select/design suitable teaching method
- select/design suitable assessment method

Fig. 2 shows the mapping of COs of ME309: Manufacturing Engineering course with POs.

## III. Assessment Of COs and POs

Assessment and evaluation play vital role in OBE. Effective assessment methods would be helpful in improving the student learning. In particular to the learning process, assessment is the systematic collection and analysis of information to improve student learning. In OBE, assessment is one or more processes, carried out by the institution, that identify, collect, and prepare data to evaluate the achievement of program outcomes and course outcomes.

At Department of Mechanical Engineering, RIT, for the assessment of COs, both, direct and indirect assessment tools are used. Direct assessment tools include i) In Semester Evaluation (ISE). ISE includes class test, assignments, quizzes, group discussions, term papers, online tests, open book tests etc. ii) Mid semester Examination, MSE, test conducted approximately at the middle of semester, for grading the performance of the students and iii) End Semester Examination, ESE, test conducted at the end of semester, for grading the performance of the students. Indirect assessment tools include Course End Survey, CES. It is ensured by each course faculty that all the COs of the particular course are addressed through these evaluations.

Just before the start of new semester, each course faculty prepares a course file for the course(s) allotted to him/her. Course file consists of course plan, lecture notes, COs, mapping of COs with POs, assignments, handouts etc. Course faculty also decides the teaching methods to be used to achieve the COs and assessment tools to be used for determining attainment of COs. Fig. 3 shows CO – Assessment type matrix and mapping of COs with question bits. These are used as direct assessment component of COs.

Based on the performance of the students in these examinations/evaluations attainment of COs is calculated for each individual student as well as for the entire class. Table 1 shows the example of CO attainment using direct assessment tools.

Table 1: Example CO direct attainment score

| Class Average | 65 | 54 | 54 | 83 | 55 | 63 |
|---|---|---|---|---|---|---|
| Student's PRN | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
| 1325001 | 83 | 35 | 56 | 100 | 44 | 70 |
| 1324002 | 78 | 33 | 34 | 47 | 41 | 64 |
| 1323003 | 66 | 66 | 56 | 47 | 98 | 68 |
| 1322004 | 76 | 59 | 83 | 69 | 65 | 69 |
| 1321005 | 79 | 52 | 63 | 99 | 65 | 69 |
| 1320006 | 55 | 37 | 68 | 97 | 63 | 67 |
| 1319007 | 74 | 73 | 55 | 99 | 76 | 57 |
| 1318008 | 81 | 44 | 39 | 98 | 53 | 38 |
| 1317009 | 71 | 56 | 74 | 99 | 54 | 69 |
| 1316010 | 59 | 82 | 83 | 87 | 76 | 70 |
| 1315011 | 29 | 32 | 9 | 71 | 9 | 54 |
| 1314012 | 64 | 66 | 59 | 99 | 70 | 76 |
| 1313013 | 82 | 82 | 82 | 100 | 21 | 43 |
| 1311015 | 23 | 44 | 12 | 98 | 64 | 57 |
| 1310016 | 41 | 52 | 37 | 59 | 48 | 70 |
| 1309017 | 61 | 58 | 56 | 83 | 64 | 68 |
| 1307019 | 75 | 43 | 51 | 69 | 8 | 64 |
| 1306020 | 80 | 58 | 60 | 75 | 64 | 56 |

| Name of Faculty: B. R. Jadhav | | | | Class: T. Y. B. Tech. (Mech.) sem. I | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO Weightage(By faculty) | | | | Course: Me309 - Manufacturing Engineering | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | CO and Question bit mapping M - M - ESESE, E | | | | | | | | | | | | | | | | | | | | | | | |
| | ISE | MSE | ESE | Total Out of 100% | | M1a | M1b | M2a | M2b | M3a | M3b | M3c | M3d | E1a | E1b | E2a | E2b | E3a | E3b | E3c | E4a | E4b | E4c | E5a | E |
| | | | | | Max. Marks | 6 | 10 | 8 | 8 | 6 | 6 | 6 | 6 | 8 | 10 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | |
| CO1 | 10 | 60 | 30 | 100 | | Y | | | | | | | | | | | | | | | | | | | |
| CO2 | 10 | 90 | 0 | 100 | | | Y | | | Y | | | | | | Y | | | | | | | | | |
| CO3 | 10 | 0 | 90 | 100 | | | | Y | Y | | Y | | | | Y | | Y | | | | | | | | |
| CO4 | 10 | 45 | 45 | 100 | | | | | | | | Y | | Y | | | | | | | | | | | |
| CO5 | 10 | 0 | 90 | 100 | | | | | | | | | Y | | | | | Y | Y | Y | | | | | |
| CO6 | 10 | 0 | 90 | 100 | | | | | | | | | | | | | | | | | | Y | Y | | |
| CO7 | 10 | 0 | 90 | 100 | | | | | | | | | | | | | | | | | Y | | | | |
| CO8 | 10 | 0 | 90 | 100 | | | | | | | | | | | | | | | | | | | | | |
| CO9 | 10 | 0 | 90 | 100 | | | | | | | | | | | | | | | | | | | | | |
| CO10 | 10 | 0 | 90 | 100 | | | | | | | | | | | | | | | | | | | | Y | |

Fig. 3 Screenshot of example of CO – Assessment type matrix and mapping of COs with question bits

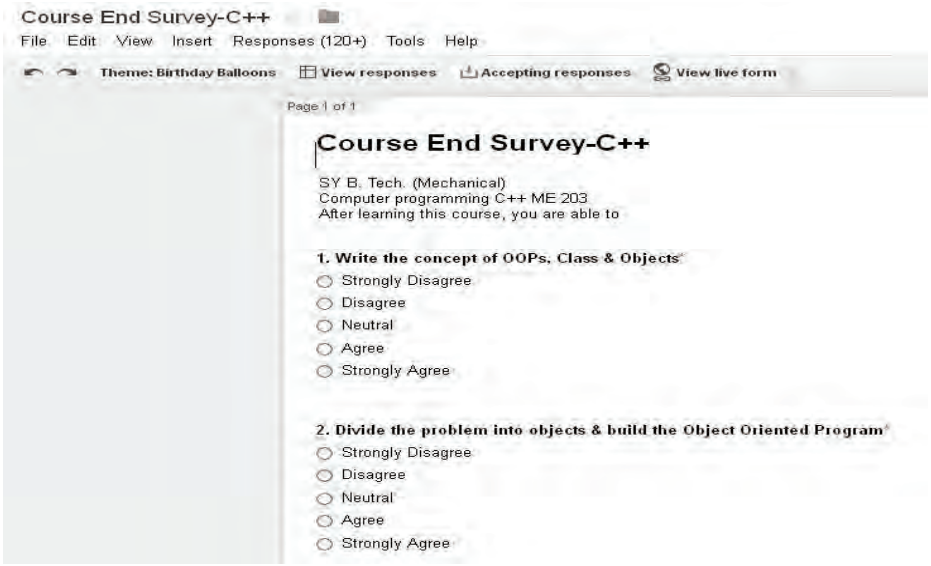


Fig. 4 Screenshot of example of couse end survey form

| PRN of the student | Explain the Mechanism of chip formation | Select the process parameters, cutting tools etc. for given machining application | Investigate the effect of various parameters such as process variables, cutting tool | Identify and define various elements of tool geometry of single and multi | Design the press tools for punching, blanking operations. | Define and differentiate jigs and fixtures. | Recognize the importance of jigs and fixtures in mass production | Design the jigs for given component. | Design the fixture for given component. | Explain NC and CNC and DNC of machine tools |
|---|---|---|---|---|---|---|---|---|---|---|
| 1006077 | 7.50 | 7.50 | 7.50 | 7.50 | 5.00 | 7.50 | 5.00 | 5.00 | 5.00 | 5.00 |
| 1006082 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 |
| 1006088 | 7.50 | 7.50 | 7.50 | 10.00 | 10.00 | 10.00 | 10.00 | 7.50 | 10.00 | 10.00 |
| 1011001 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 5.00 | 10.00 | 10.00 | 10.00 |
| 1011013 | 7.50 | 7.50 | 7.50 | 5.00 | 5.00 | 7.50 | 7.50 | 7.50 | 2.50 | 7.50 |
| 1011025 | 7.50 | 7.50 | 7.50 | 10.00 | 10.00 | 7.50 | 7.50 | 5.00 | 5.00 | 7.50 |
| 1011026 | 7.50 | 2.50 | 2.50 | 2.50 | 2.50 | 7.50 | 7.50 | 7.50 | 7.50 | 2.50 |
| 1011028 | 7.50 | 5.00 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 2.50 |
| 1011083 | 10.00 | 7.50 | 10.00 | 10.00 | 7.50 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| 1011204 | 7.50 | 5.00 | 5.00 | 7.50 | 10.00 | 7.50 | 5.00 | 7.50 | 7.50 | 10.00 |
| 1011210 | 7.50 | 7.50 | 2.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 |
| 1011220 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 5.00 | 10.00 | 10.00 | 10.00 | 7.50 |
| 1011303 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 | 7.50 |

Fig. 5 Screenshot of example of course end survey of ME309: Manufacturing Engineering course. Point scores are: strongly agree – 10.00, agree – 7.50, neutral – 5.00, disagree – 2.50 and strongly disagree – 0.00

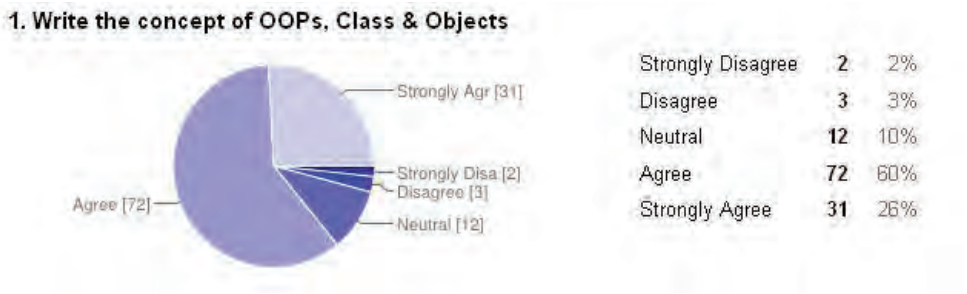


Fig. 6 Screenshot of example of summary of result of course end survey generated using Google app.

| Course Outcome | CO Attainment (Direct) | CO Attainment (Indirect) | CO Attainment (Consolidated) | PO a |
|---|---|---|---|---|
| To identify & investigate the stability of spinning bodies due to gyroscopic effect. | 79 | 81 | 80 | 159 |
| To apply the theoretical knowledge to balance the rotary and reciprocating systems. | 74 | 81 | 76 | 152 |
| To apply different principles to convert physical vibratory system into a mathematical model. | 55 | 75 | 61 | 122 |
| To recognize the suitable method for minimizing or elimination the vibration from the system. | 63 | 78 | 67 | 134 |
| To identify the effect of external excitation on the system and effect of dampers to control the system vibration. | 44 | 78 | 54 | 54 |
| To recognize the whirling speed conditions of shaft and methods to eliminate it. | 64 | 76 | 68 | 135 |
| Differentiate the modes of heat transfer with appropriate governing laws and explain importance of thermal conductivity , heat transfer coefficient, etc. | 68 | 80 | 72 | 144 |

Fig. 7 Screenshot of example of attainment of CO and partial attainemnt of PO

Course end surveys are used as the indirect assessment component of CO. Course end surveys cover the entire COs plus few questions related to classroom environment. Course end surveys are collected online using Google app forms. Fig. 4 shows screen shot of example of course end survey form. Fig. 5 shows screenshot of example of course end survey. Fig. 6 shows screenshot of example of summary of results of course end survey automatically generated using Google app. Evaluation of these assessments results are used for continuous improvement in teaching methods, assessment methods and curriculum. For the final CO score ($CO_{Attainment\ (consolidated)}$) 70% weightage is given to direct assessment and 30% to indirect assessment. Eq. 1 is used to calculate the $CO_{Attainment(consolidated)}$.

$$CO\ Attainment\ (Consolidated) = CO\ (Direct) * 0.7 + CO\ (Indirect) * 0.3 \quad (1)$$

For the purpose of assessment, POs have been split into two categories: Technical PO and Professional PO. POs which can be assessed through grading of the students are Technical POs, whiles POs which could not be assessed through grading of the students are Professional POs. Attainment of technical POs is determined using attainment of COs based on their correlation. Rubrics have been developed for the attainment of professional POs. Attainment of professional POs is not covered in this paper. First, the partial attainment of each PO through each CO is determined using the Eq. (2).

$$\text{POa Attaiment(COn)} = \text{COn Attainment} * \text{Strength of correlation of COn with POa} \quad (2)$$

Final attainment of each PO is calculated using Eq.(3).

$$POa\ (Attainment) = \frac{\sum POa\ Attaiment\ (COn)}{\sum Correlation\ strengt\ of\ all\ COs\ mapped\ to\ POa} \quad (3)$$

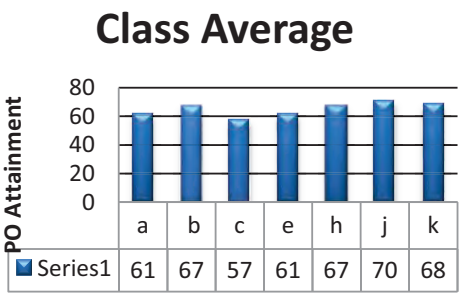


Fig. 8 Attainment of technical POs for entire class

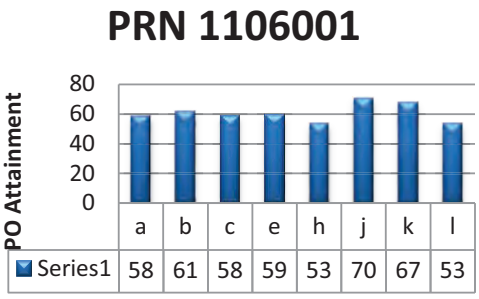


Fig. 9 Attainment of technical POs for individual student.

Fig. 7 shows the screenshot of example of attainment of CO and partial attainment of POa through individual COs mapped with POa. A system has been developed using Microsoft Excel for processing the data. System is capable of generating the reports on attainment of COs and POs for entire class as well as for individual students. If attainment of COs and POs is calculated as class average and not for individual student then there is possibility of producing some inferior graduates and it goes unnoticed. If the class average attainment of any specific PO is say 60, there is possibility that attainment of this PO for some students in class might be below 40 as well. This goes unnoticed if PO attainment for each individual student is not calculated. Therefore there is risk of producing inferior graduates.

This system has been implemented in Department of Mechanical Engineering, Rajarambapu Institute of Technology, Rajaramnagar, Maharashtra state. It has been observed that system is saving lot of faculty time and is useful for precise calculation of attainment of COs and POs.

## IV. Conclusion

A method and MS Excel based system has been developed for determining the attainment of COs and POs. System generates the report on the attainment of COs and POs for each individual student in the class as well as class average. This system is very useful as it saves faculty's time, generates reports on attainment of COs and POs.

Attainment of COs and POs are used for continuous improvement in teaching methods, assessment methods and curriculum.

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