Implementation of Some Program Outcomes (POs) Prescribed by NBA for B.Tech. Degree Programs

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Abstract: In India, accreditation of various technical degree and diploma Programs is done by National Board of Accreditation (NBA). NBA defines Program Outcomes (POs) as, "Program outcomes are narrower statements that describe what students are expected to know, and be able to do by the time of graduation. These relate to the skills, knowledge and behaviours that students acquire during the Program." NBA prescribes twelve (12) POs to be achieved by all B.Tech. Degree graduates. POs 1 to 5 usually match directly with courses prescribed by various institutions and universities. However, POs 6 to 12 related to "The Engineer and Society, Environment and Sustainability, Ethics, Individual and Team Work, Communication, Project Management and Finance, Life-long Learning" respectively, usually do not match directly with the courses prescribed. This paper translates these POs to Course Outcomes (COs), so that these COs can be achieved by using these or similar COs in some of the prescribed courses; thus achieving these POs by the end of the Program. If there are some gaps, these can be filled by 'beyond curriculum' inputs and activities and extra and co-curricular activities by the institutions.

Universities and institutions revising their programs are expected to take into consideration, achievement of these POs by graduates from various B.Tech. degree Programs. Most of the examples considered in this paper are generic in nature and will be applicable for all engineering degree Programs.

Keywords: Accreditation, Course Outcomes (COs), National Board of Accreditation, Program Outcomes (POs)

1. INTRODUCTION

National Board of Accreditation (NBA) in its present form came into existence as an autonomous body with effect from 7th January 2010, with the objective of "Assurance of Quality and Relevance of Education, especially of the Programs in professional and technical disciplines, i.e., Engineering and Technology, Management, Architecture, Pharmacy and Hospitality, through the mechanism of accreditation of programs offered by technical institutions." [1]

Over the years major shift has taken place in accreditation philosophy. Initially accreditation used to be mainly based on resources available in the institutions. Now the focus is on 'outcome based accreditation'.

In the current NBA accreditation documents [2, 3] Program Outcomes (POs) expected from engineering under-graduate degree Programs are specified. Students graduating from these Programs are expected to achieve these by the end of the Programs.

In General Manual of Accreditation available on NBA website [1, 2]; Program Outcomes are defined as, "Program outcomes are narrower statements that describe what students are expected to know, and be able to do by the time of graduation. These relate to the skills, knowledge and behaviours that students acquire in their matriculation through the program."

At present NBA prescribes 12 Program Outcomes (POs) to be achieved by graduates of all under-graduate engineering degree programs. In addition, it is recommended that each degree program may have 2 to 4 Program Specific Outcomes (PSOs).

General Manual of Accreditation available on NBA website [1, 2] also defines Course Outcomes (COs) as," Course Outcomes are narrower statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behaviour that students acquire in their matriculation through the course."

In this context, another term Program Educational Objectives (PEOs) is also defined as "Program Educational Objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve." Usually it is expected that these accomplishments will be obtained after four-

five years of graduation.

In an institutional setting; there are prescribed courses which could be theoretical courses and practical & sessional courses. In addition, there usually are beyond curriculum courses. In addition, there are always extra and co-curricular activities in which students are expected to participate.

Relationships between PEOs, POs and COs can be stated as (1) and (2) below:

POs = ∑ [Individual Course Outcomes (COs) + COs for Beyond curriculum courses + COs for Extra and Co-curricular activities]
(1)

PEOs = ∑ POs + Practical experience of 4 to 5 years
(2)

Above relationship implies that sum total of COs from various courses; prescribed and beyond curriculum and extra and co-curricular activities result in achievement of POs by graduating students. PEOs are expected to be achieved after four to five years of graduation.

2. OBJECTIVES OF PAPER

This paper primary looks at engineering under-graduate degree Programs. When one looks at prescribed POs, one finds that there are POs which can normally be achieved during various courses in a Program. However, one finds some POs for which changes in teaching-learning methods, strategies and learning opportunities will possibly have to be explored so that those POs can be achieved.

The objectives of this paper are:

(a) To isolate those POs which are difficult to achieve in normal classroom situations.
(b) To translate the above POs into Course Outcomes (COs) so that these COs can be achieved in prescribed courses. Gaps can be filled by beyond curriculum inputs and activities, as well as extra and co-curricular activities.

3. PROGRAM OUTCOMES (POs) AS PRESCRIBED BY NBA & POs TO BE CONSIDERED FOR THIS STUDY

POs as prescribed by NBA for an undergraduate degree program in engineering degree program are classified under following headings [3, 4] with a rubric as "Engineering Graduates will be able to"

1. Engineering Knowledge
2. Problem Analysis
3. Design/development of solutions
4. Conduct investigations of complex problems
5. Modern tool usage
6. The engineer and society
7. Environment and sustainability
8. Ethics
9. Individual and team work
10. Communication
11. Project management and finance
12. Life-long learning

4. LITERATURE REVIEW

Banthiya [5] published a study about PEOs and POs for undergraduate degree program in Mechanical Engineering. In this study (a) to (k) POs as suggested by NBA in 2009 were considered. These POs were matched with existing syllabus of B.Tech. Mechanical Engineering of Rajasthan Technical University (RTU). Results of this study related to POs similar to above POs from 6 to 12 are as follows:-

(i) PO (f) which related to understanding of professional and ethical responsibilities which is similar to present PO 8 had very small weight in theory courses, and had average weight in practical and sessional courses.
(ii) PO (g) which was concerned with communication and which is similar to present PO 10, had 'below average' weight in theory courses. It had slightly higher weightage in practical and sessional courses because of laboratory report writing and oral tests.
(iii) PO (h) about understanding of impact of engineering solutions which is slightly similar to present PO 7 had practically zero weights in theory as well a practical and sessional courses.
(iv) PO (i) related to life-long learning which is similar to present PO 12 was showing above average weight where library/internet usage seemed essential. Otherwise, it showed 'to a certain extent', on the basis of assumption that students would do self-learning.

Another study conducted by Banthiya, Chaudhary and Agrawal [6] looked at Graduate Attributes (GAs) as prescribed by NBA and formulation of POs based on these GAs. The wording of GAs prescribed at that time is almost same as POs prescribed by NBA at present. In this study RTU syllabus of B.Tech. Mechanical Engineering prescribed at that time was matched with GAs/COs. Results of this study relevant to the present study are given below:

(i) POs 6, 7 & 8 had very little weightage in courses prescribed.
(ii) PO 9 was having a fairly good weightage on the assumption that proper processes would be

followed during practical and sessional courses as well as extra and co-curricular activities.

(iii) PO 10 had average weightage.

(iv) PO 11 had very low weightage.

(v) PO 12 had comparatively low weightage.

Based on the findings of these studies, it can be said that POs 6 to 12 which are of general nature would usually match a few courses only. This is obvious from the statements of these POs also, because these do not relate to any specific areas of content in engineering curricula. Thus in this study, focus is on POs 6 to 12.

5. PROGRAM OUTCOMES (POs) AND COURSE OUTCOMES (COs) FOR POS 6 TO 12 AND IMPLEMENTATION STRATEGIES

It is not possible to achieve completely a Program Outcome in a single course. Due to this it is worthwhile to rewrite POs in the form of Course Outcomes (COs) so that such COs can be adopted/adapted in various courses. Similar exercise was done in [6]. In that paper various graduate attributes (GAs) suggested at that time were expressed as sample Program Outcomes.

In this paper POs 6 to 12 have been translated into Sample COs. The result of this translation is given in later sections of this paper. These COs are called sample COs, as the translation may differ from person to person. Also these COs are generic in nature and will be applicable in most of the courses in various engineering disciplines with slight changes depending on the course or activity. Many of the COs given here have already been given in [6]. In this paper, suggested implementation strategies for the sample POs have also been given.

In the statement of the POs as given in later Sections, the verb is **underlined** to show to what level that PO has to be achieved by the graduating students.

6. PO 6, SAMPLE COS FOR PO 6 AND SUGGESTED IMPLEMENTATION STRATEGIES

PO6: Graduating students will be able to

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.

Sample CO 6.1: Students will be able to

'Understand and apply societal, health, safety, legal and cultural issues falling in the domain of engineering profession' [6].

Suggested Implementation Strategies for CO 6.1

1. If a course related to these or similar issues exist in the curriculum, 'understanding' and 'applying' levels can be achieved. Alternatively these issues may be discussed as a 'beyond curriculum' input. This will achieve 'understanding' level. For apply level strategies 2, 3, 4, 5 or similar strategies may be used.
2. In the 'Design' and 'Project work', students be required to implement these issues.
3. In the 'field trip', 'industrial visit', 'practical training', students be required to see application of these issues, and mention specifically in their reports.
4. Students may be required to visit / work with an NGO and study these issues.
5. Students may join NSS or similar programmes and work in these areas.

Sample CO 6.2: Students will be able to

'Appreciate responsibilities of an engineer at different levels' [6].

Suggested Implementation Strategies for CO 6.2

1. If a course related to this exists, lecture discussion on this can be arranged.
2. Guest lectures can be arranged from renowned engineers from the industry and field for achieving this outcome.
3. Student seminars can be arranged on this aspect.
4. During industrial visits and practical training, this outcome be set for achievement by students.

Sample CO 6.3: Students will be able to

'Appreciate Code of Conduct for members by ASME, IEEE, Institution of Engineers (India), or any other professional organization with a focus on societal, health, safety, legal and cultural issues.'

Suggested Implementation Strategies for CO 6.3

1. Code of Conduct of related professional organizations be discussed in classes, and students be required to follow the code while they are in the institute. A record of this may also be kept.
2. Questions may be asked related to the Codes, especially from student members of professional organizations.

Sample CO 6.4: Students will be able to

'Appreciate Code of Conduct prescribed by the department for them.'

Suggested Implementation Strategies for CO 6.4

1. If Code of Conduct exists in the department, students need to be explained and promises taken from them usually in writing that they will follow the same.
2. If a Code of Conduct does not exist, it may be worthwhile to develop it. Codes of

professional organizations and institutional rules and regulations may be referred for developing the Code.

3. If a Code of Conduct exists in the department, it is necessary that faculty and staff follow the points relevant to them in the code, before asking the students to follow it.

7. PO 7, SAMPLE COS FOR PO 7 AND SUGGESTED IMPLEMENTATION STRATEGIES

PO 7: Graduating students will be able to

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.

Sample COs 7.1, 7.2 & 7.3: Students will be able to

7.1 'Understand environment related issues relevant to engineers.'

7.2 'Understand sustainable development and its need' [6].

7.3 'Understand the impact of engineering solutions on society and environment' [6].

Suggested Implementation Strategies for COs 7.1, 7.2 & 7.3

1. If a course related to these issues – 'environment'. 'sustainable development ' and 'impact of engineering solutions on society and environment ' exists, 'understanding' level can be achieved by this course.
2. If there is no course, these issues can be discussed by a 'beyond curriculum' course.
3. Issues raised are extremely important and students can be encouraged to take these issues during seminars.

8. PO 8, SAMPLE COs FOR PO 8 AND SUGGESTED IMPLEMENTATION STRATEGIES

PO 8: Graduating students will be able to

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

Sample COs 8.1 & 8.2: Students will be able to

8.1 'Appreciate responsibilities and norms of engineering practice' [6].

8.2 'Understand and apply ethical principles in different situations'.

Suggested Implementation Strategies for COs 8.1 & 8.2

1. If a course related to ethics is part of the curriculum, 'understanding' and 'application' levels can be achieved as a result of inputs in the course.
2. Alternatively, 'beyond curriculum' inputs can be arranged and students tested on achievement of these outcomes, especially by discussion on case studies related to 'ethical principles related to engineering profession'.
3. Guest lectures can also be planned for achieving these outcomes.

Sample CO 8.3: Students will be able to

8.3 'Commit to professional ethics during professional life.'

Suggested Implementation Strategies for CO 8.3

1. Commitment is a long drawn process. In the institutional setting, efforts can be focused on inculcating commitment to various norms viz. attendance norms, laboratory and laboratory report norms, seminar and seminar report norms, industrial training and industrial training report norms, project and project report norms etc. Records of these could be maintained by concerned faculty members.
2. For example, laboratory report norms may state date of submission, 'discussion/ comments/ conclusions' to be written down by individual students and 'follow up' norms, after evaluation has been done by concerned faculty. If a student does follow up, extra credit can be given to the concerned student.
3. Project norms may specify that the work will be of students only, though they may take assistance from different sources with due recognition, and all in the group will contribute in the project work.

9. PO 9, SAMPLE COs FOR PO 9 AND SUGGESTED IMPLEMENTATION STRATEGIES

PO 9: Graduating students will be able to

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

Sample CO 9.1: Students will be able to

9.1 'Work effectively as a member of a team or leader of a team in the departmental teaching-learning situations e.g. laboratory work, project work, industry visits, industry tour.'

Suggested Implementation Strategies for CO 9.1

1. In the department setting, various situations arise where teams are / can be formed. Faculty members can form teams with rotating leadership, especially in laboratory setting. Rotating leadership means that in

laboratory student groups, leadership of the group will be pre-decided and it will rotate e.g. if a group consists of 4 students A, B, C and D; in the first week A will be leader of the group, next week B will be the leader and leadership will change every week within the group. Even assessment can be done for this outcome.

2. Project work is a situation where group work and leadership can be inculcated and assessed also.
3. Mini project work or problem solving experiences can be undertaken as part of laboratory work in groups.
4. Students need to be encouraged to participate in project competitions by ASME, SAE, IEEE and other internal and external organizations.

Sample CO 9.2: Students will be able to

9.2 'Work effectively as a member and/or leader of a team in different settings e.g. organizing seminars & conferences / organizing and participating in extra and co-curricular activities in the department. '

Suggested Implementation Strategies for CO 9.2

1. Opportunities for organizing and participating in seminars, conferences, competitions, courses etc. are becoming fairly common. Students need to be encouraged to organize and participate in such events.
2. It has been observed that some students attain fairly high capability in software, robotics, automotives and even course related competence; they may be encouraged to organize programs for other students.

Sample CO 9.3: Students will be able to

9.3 'Work effectively as a member or a leader of a multi-disciplinary team at the institution level extra and co-curricular activities.'

Suggested Implementation Strategies for CO 9.3

1. Ample opportunities exist in the institutional setting where multi-disciplinary teams are formed. Some of these are: organizing and participating in competitions of all kinds, debates, quizzes, discussions, exhibitions, cultural events (e.g. music, dance and drama), social work, blood donation, games and sports etc.
2. Students need to participate in events of their choice.
3. Students need to be encouraged to undertake competitive projects or regular projects requiring multi-disciplinary inputs. Inter-disciplinary collaboration will have to be developed for this purpose.

10. PO 10, SAMPLE COs FOR PO 10 AND SUGGESTED IMPLEMENTATION STRATEGIES

PO 10: Graduating students will be able to

Communication: Communicate effectively on complex engineering activities with the engineering community and with the 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.

Sample COs 10.1 & 10.2: Students will be able to

10.1 'Express in writing and orally in English correctly.'

10.2 'Answer questions in writing or orally on prescribed reading material ...'

Suggested Implementation Strategies for COs 10.1 & 10.2

1. Usually there are prescribed theory and practical courses on 'communication skills', in most of the curricula. Focus in these courses need to be in writing and speaking correct English.
2. Students may be encouraged to form self-help groups for speaking correct English. Such groups may have one or two students who have studied in English medium schools.
3. Students may be encouraged to read newspapers, magazines and good general books, including fiction and make brief presentations of what they have read to the whole class or to other group members. Such books may be made available in departmental libraries.

Sample COs 10.3, 10.4, 10.5 & 10.6: Students will be able to

10.3 'Prepare and present appropriate Power Point Presentations (PPTs) in various courses, seminars, industrial training and project work presentations.'

10.4 'Make oral presentations in different situations, including with or without PPTs.'

10.5 'Listen to presentations and report back about understanding of the presentations in seminars, practical training, project work, conferences and guest lectures.'

10.6 'Listen to viva voce questions asked in various laboratory and sessional courses and answer the same properly.'

Suggested Implementation Strategies for COs 10.3, 10.4, 10.5 & 10.6

1. PPTs have become an important media for presentations. It is necessary that students learn to prepare and make power point presentations.
2. Departmental faculty must ensure that by the end of the program, all students get ample

opportunities to prepare and make power point presentations. This will also ensure communicating orally with the peers, listening to their queries and responding to the same.

3. Departmental faculty may have small oral presentations from students in their laboratory courses. These presentations may relate to the theory of the experiments / results / discussion of results etc.
3. Listening is an important communication skill. Students need to practice it and show that they have become good listeners.
4. Habit of taking notes has to be inculcated in the students during various presentations, so that they can reproduce what transpired. Assessments can be done for seminar presentations, industrial training presentations, guest lectures etc. from the perspective of listening by the peers. They may even be sometimes permitted to see their notes of presentations during assessment.
5. Viva voce in various laboratory and sessional courses must also be looked from the perspective of listening of what is being asked and what is being replied.

Sample COs 10.7: Students will be able to

10.7 'Prepare proper tables, figures and graphs for various reports (laboratory, visits, training, project etc.).'

Suggested Implementation Strategies for CO 10.7

1. Any report e.g. laboratory, project, seminar, industry visits, practical training is likely to contain tables, figures and graphs. It is necessary that the skill of preparation of tables, figures and graphs is inculcated in students in various laboratory courses. They need to be encouraged to draw tables, figures and graphs of different types on their own.
2. Usually in Laboratory Manuals; tables, figures and what graphs are to be drawn are given. Exercises may be planned in some laboratory experiences where decision about these is left to the students.
3. In Mechanical Engineering, there are situations where students are exposed to semi-log and log-log graphs, and they need to learn to draw as well as read and interpret such graphs. In other disciplines also similar opportunities arise.

Sample COs 10.8 & 10.9: Students will be able to

10.8 'Prepare engineering drawings.' [.6]

10.9 'Read engineering drawings, for the purpose of giving proper instructions.' [6]

Suggested Implementation Strategies for COs 10.8 & 10.9

1. Engineering drawing being language of engineers, sufficient practice need to be given in preparing drawings. Drawings initially may be drawn by the usual process but at later stages AUTOCAD drawn drawings may be prescribed. Also in laboratory and similar courses, some drawings may necessarily be prescribed to be drawn by AUTOCAD.
2. Skill of reading drawings need to be achieved by students. For this proper exercises have to be designed by the faculty and given to the students in drawing class as well as other pertinent courses e.g. Workshop practice, Manufacturing laboratory, Civil Engineering Construction Technology.

Sample CO 10.10: Students will be able to

10.10 'Give and receive clear instructions orally and/or in writing during laboratory work, industrial training, project work, organization of various co and extra-curricular activities, including seminars and conferences. '

Suggested Implementation Strategies for CO 10.10

1. Various situations arise when instructions are given to students orally and/or in writing. Habit of checking will have to be developed in students, if they don't follow the instructions.
2. Assignments can be planned in laboratories and other situations to see that students have understood the instructions. Ambiguity in instructions has to be avoided.
3. In laboratory work, if rotating leadership strategy is being adopted, leader has to give instructions and other members have to follow the instructions.
4. In Project Work, faculty member concerned may give written or oral instructions on 'Project Diary' and check whether instructions have been followed.
5. In Project Work, leader may give instructions to the members about their responsibilities and do work allotment. This may be noted in the Project Diary.

Sample CO 10.11: Students will be able to

10.11 'Write appropriate reports for problem solving exercises in laboratories, sessionals or other situations / design problems / seminars / industry visits / practical training / project work etc.'

Suggested Implementation Strategies for CO 10.11

1. Proper instructions, preferably in writing supported by oral presentation are necessary by concerned faculty about how reports are

to be written in different situations. Faculty has to ensure that instructions given have been followed.

2. Some reports of laboratory experiences may be assigned in such a way that these come closer to real life situations e.g.
   (a) From an Assistant Engineer in field to his next person in hierarchy i.e. Executive Engineer
   (b) From an Assistant Engineer in field to Chief Engineer
   (c) From Executive Engineer to Managing Director or CEO of the Company.

11. PO 11, SAMPLE COs FOR PO 11 AND SUGGESTED IMPLEMENTATION STRATEGIES

PO 11: Graduating students will be able to

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.

Sample CO 11.1: Students will be able to

11.1 'Understand project management principles.' [6]

Suggested Implementation Strategies for CO 11.1

1. If a course on 'Project Management Principles' exist in the curriculum, this outcome can be achieved during that course.
2. If such a course does not exist in the curriculum, a short course can be planned and delivered during project classes. This has been successfully done by Mechanical Engineering faculty of SKIT, Jaipur.

Sample CO 11.2: Students will be able to

11.2 'Apply project management principles in different situations, especially during industry visits and tours, and project work.' [6]

Suggested Implementation Strategies for CO 11.2

1. Project management principles need to be implemented by students during their project work. Project diary of students need to reflect this application of project management.
2. Project management principles can also be implemented during industry visits and similar activities which have known start and end points in time.

Sample CO 11.3: Students will be able to

11.3 'Apply project management principles in organizing extra and co -curricular activities, seminars and conferences.' [6]

Suggested Implementation Strategies for CO 11.3

1. Project management principles can also be applied during organizing extra and co - curricular activities, seminars, conferences and other activities.
2. Concerned students may be encouraged to make notes of planning, implementation, monitoring and evaluation of the activity.

12. PO 12, SAMPLE COs FOR PO 12 AND SUGGESTED IMPLEMENTATION STRATEGIES

PO 12: Graduating students will be able to

Life-long learning: Recognise the need for, and have the preparation and ability **to engage** in independent and life-long learning in the broadest context of technological change.

Sample COs 12.1 & 12.2: Students will be able to

12.1 'Appreciate the need of independent and lifelong learning.'

12.2 'Understand methods to prepare for independent and lifelong learning.'

Suggested Implementation Strategies for COs 12.1 & 12.2

1. Lecture discussion on need and preparation for independent and lifelong learning may be arranged by the institute / departments from First year itself.
2. As the student progresses, this outcome needs to be emphasized by the departments and departments need to encourage students to go for independent and lifelong learning.

Sample CO 12.3: Students will be able to

12.3 'Use various methods for preparing for independent and lifelong learning.'

Suggested Implementation Strategies for CO 12.3

1. Exercises can be planned and implemented for library search for various topics using books, technical journals, internet etc. This can be done under 'seminar' and 'project' courses. Such courses are usually part of curriculum for various programs.
2. Number and type of documents consulted in seminars and project work could be a good measure for achieving this outcome.
3. As a participant, students have to ensure that they have understood what was presented.

13. CONCLUDING REMARKS

This paper looked at POs 6 to 12 related to The Engineer and Society, Environment and

Sustainability, Ethics, Individual and Team work, Communication, Project management and Finance, and Life-long learning respectively; as prescribed by NBA for accreditation of B.Tech. degree programs in all branches of engineering & technology. These POs usually do not match directly with any prescribed courses, until and unless some courses are prescribed by universities matching some of these POs. These POs have been translated into sample Course Outcomes (COs). These or similarly translated COs can be matched with prescribed courses in a program. However, strategies need to be suggested to teachers so that they make efforts to achieve these COs and thus POs in their courses. Due to this implementation strategies have also been suggested in this paper for various sample COs.

Gaps, if remaining can be filled by beyond curriculum content delivery or other strategies.

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