# Categorized Laboratory Course Content Towards Better Attainment of Program Outcome

## Better Attainment of PO by categorization

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*Abstract— Enzyme Technology theory and laboratory course; usually offered at second year of undergraduate program in Biotechnology is one of the foundational courses. Traditionally laboratory component provides hands on experience to conduct experiment, immobilize enzyme and assay the enzyme samples. However the conventional pedagogy practiced till date, was unable to meet the metric goal set for certain program outcomes (PO). The lack in design of term-works at various levels, improper evaluation criteria and lack of rubrics could be the most contributing factors for poor attainment of PO.*

*To address this issue, we categorized the laboratory term works into four categories: demonstration, exercise, structured enquiry and open ended experiment. Term works were carefully designed to address major technical POs and some of professional POs. Evaluation criteria for each term work are mapped to Program outcome (PO), Outcome Element (OE) and Performance Indicator (PI). This helps us in assessing the attainment of POs more precisely. The students were expected to carry-out literature review and design the experiment, with due consideration to resources & feasibility. They carry out experiments, analyze and interpret the solution. The assessment of PO attainment through continuous internal evaluation reveals significant improvement in the achievement of program outcomes. To summarize the categorization of experiments, mapping evaluation criteria to PO, OE and PI, as well as rubrics designed for evaluation, improved the attainment of PO. The exercise also provides better learning experience among students.*

Keywords—**attainment; outcome based education; Biotechnology Engineering; Open ended laboratory.**

## I. INTRODUCTION

Outcome Based Education (OBE) is an education system with emphasis on outcome measurement rather than inputs of curriculum covered. Outcomes may include a range of knowledge, skills and attitudes. In order to obtain the desired outcomes, teaching components and activities should be well organized, planned and continuously improved [1, 2].

To comply with the ABET engineering criteria [3], a program must first formulate program educational objectives and then formulate a set of program outcomes (knowledge, skills, and attitudes the program graduates should have) that directly address the educational objectives and encompass certain specified outcomes (Outcomes 3a–3k, Table 1)

Table1: Program outcomes as defined by ABET

| Program must demonstrate that their graduates have: | |
|---|---|
| 3a | an ability to apply knowledge of mathematics, science and engineering |
| 3b | An ability to design and conduct experiments, as well as analyze and interpret data |
| 3c | An ability to design a system, component, or process to meet desired needs |
| 3d | An ability to function on multidisciplinary teams |
| 3e | An ability to identify, formulate, and solve engineering problems |
| 3f | An understanding of professional and ethical responsibility |
| 3g | An ability to communicate effectively |
| 3h | The broad education necessary to understand the impact of engineering solutions in global and societal context |
| 3i | A recognition of need for and an ability to engage in life long learning |
| 3j | A knowledge of contemporary issue |
| 3k | An ability to use the techniques, skills and modern engineering tools necessary for engineering practice. |

Enzyme Technology (ET) Laboratory course is one of the compulsory courses of Biotechnology Engineering Program. Each course and laboratory has course learning objectives. These objectives are mapped to the program outcomes of the department. Table 2 shows the Enzyme Technology Laboratory course outcomes linking them with the program outcomes of the department. Each program outcome (PO) is further detailed into outcome element (OE) and are numbered as 1,2,3… further each OE is structured into Performance Indicator (PI) and are depicted as capital alphabet. For example, program outcome –b" has three outcome elements, they are indicated as b1,b2, and b3. Further b1 has 3

performance indicators, then they are depicted as b1A,b1B,b1C. Similarly each program outcome is divided into various outcome elements and respective performance indicators.

Table 2: Mapping of course learning objectives to program outcomes.

Laboratory (Course) Title: **Enzyme Technology Lab**
Laboratory (Course) code: **BTL21**7 Semester: 4th

| **Course Learning Objectives-CLO** | **Program Outcomes** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **a** | **b** | **c** | **d** | **e** | **f** | **g** | **h** | **i** | **j** | **k** | |
| Design an experiment for determining enzyme activity and specific activity. | √ | √ | √ | √ | | | √ | | √ | | | |
| Work in a team for determining source and assay procedure. | | √ | | | | | √ | | | | | |
| Interpret the results of kinetic constants in presence and in absence of inhibitor. | | √ | | | | | | | | | | |
| Design immobilized enzyme to determine the kinetic parameters to meet desired needs. | | √ | | | | | | | | | | |
| Perform experiment to determine the purity and molecular weight of enzyme. | | √ | | | | | √ | | | | | |
| Design experiments to optimize and standardize parameters for enzyme assay | | √ | | | | | √ | | | | | |

The handling of Enzyme Technology Laboratory work has been improved from traditional way (passive learning) to problem based learning (student-centered learning) as described earlier [4, 5]. In order to meet and improve the attainment of the outcomes through Enzyme Technology Laboratory course, all the experiments in the laboratory course are categorized into demonstration, exercise, structured enquiry and open ended experiment (Table 3).

Table 3: Categorization of Enzyme Technology Laboratory.

| **Enzyme Technology Laboratory (BTL217)** | | |
|---|---|---|
| **Sl.No** | **Category** | **Experiment** |
| 1 | Demonstration experiment | Molecular weight determination by SDS PAGE and staining |
| 2 | Exercise experiments | 1. Determination of activity of amylase enzyme<br>2. Estimation of protein content of salivary amylase and specific activity<br>3. Determination of effect of temperature on enzyme activity.<br>4. Determination of effect of pH on enzyme activity.<br>5. Determination of effect of substrate concentration on enzyme activity. |
| 3 | Structured Enquiry | 1. Design an experiment to determine the kinetic parameters of immobilized enzyme.<br><br>2. Design an experiment to determine the effect of inhibitor on enzyme |
| 4 | Open ended experiment | 1. Design an experiment to determine selected enzyme activity from sample of interest and draw conclusions on obtained results. |

In demonstration experiments, students need to observe the conduction by the instructor and observe the results. In exercise experiment, students would be given with title of experiments, materials and also procedure, students need to conduct the experiment and analyze and interpret the data. In structured enquiry experiments, they will be provided with the title and materials, students need to design the procedure by referring to literature with due consideration of resource availability. They have to conduct, analyze and interpret the data. One of the modules in Enzyme Technology Laboratory course is open ended experiment (OEE). The main objective of open ended experiment is to develop an aptitude for: design of experiment, problem solving ability, perform experiment in team as member or leader, analyze and interpret the result. Present paper reports mainly on achievement of attainment of program outcome by open ended experiment. This paper depicts our experience to impart creativity and innovation in the curriculum by introducing categorization of experiments focusing more on categorization and its impact on attainment of PO.

## II. METHODOLOGY

In this section we present the procedure that is followed for assessment of program outcomes through open ended laboratory module.

### *A. Students*

Around fifty six students in pre-final year of undergraduate program were involved in this activity. The students were divided into twenty eight groups, each group containing two students. Each group was expected to understand the problem statement. Each group was expected to perform literature review to choose study parameters such as: source of enzyme, extraction buffer (concentration and volume), extraction method and method of assay. Student groups were supposed to prepare a report on the objectives, design of experiment, the necessary apparatus together with the methodology with due consideration to the availability of resources. It was a group laboratory assignment [6] where students had came out with an experiment related to a problem statement given to them. Each group had finalized the title and defined the objectives as well as listed-out all the requirements like chemicals, glassware and apparatus. Time slots were given to these groups for the completion of experimentation; after which each team submitted separate reports. However, the whole activity was monitored at each stage by the course instructor.

### *B. Assessment : Evaluation based on rubrics*

All the student groups were evaluated based on well defined rubrics presented in Table 4.

Table 4: Evaluation Rubrics

| Evaluation component | Parameter | PO | Weightage (%) |
|---|---|---|---|
| Analysis of Problem Statements | Review of literature | i | 18.75 |
| Develop/Implementation/design | Design a process | c | 25 |
| Conduct of experiment | Select, perform, tabulate | b,d | 25 |
| Result | Plot, calculate, analyze | b | 18.75 |
| Documentation | Record writing | g | 12.5 |

### *C. Mapping*

Each of the experiment was mapped to its outcome, outcome element and performance indicator and was evaluated accordingly.

Table 5: Mapping of PO, OE, PI for ET laboratory

| Category | PO | OE | PI | Weightage |
|---|---|---|---|---|
| Exercises | b,g,i | b2,b3,g1 | b2B,b2C,b3A,b3B,g1B, | 50% |
| Structured Enquiry | b,d,g,i | b2,b3,g1,i1 | b2B,b2C,b3A,b3B,g1B,i1A | 30% |
| Open Ended Experiment | b,c,d,g,i | b2,,b3,c3,g1,i1 | b2B,b2C,b3A,b3B,c3C,g1B,i1A | 20% |

### *D. Student feedback*

Student's feedback was taken after the completion of experimentation in the form of feedback in Lickert scale. Table 6 shows the questionnaires used to get the feedback.

Table 6: Feedback form

| Question No | Question |
|---|---|
| 1 | The lab enhanced your understanding of enzyme technology theory course. |
| 2 | Categorization of experiments has helped in enhancing your laboratory skills. |
| 3 | Through OEE, ability to design an experiment for the given problem statement has increased. |
| 4 | Through OEE, your ability to work in a team as a member or leader has increased. |
| 5 | In OEE, you were able to analyze and interpret obtained data /results.. |
| 6 | OEE helped you to think beyond syllabus. |

## III. RESULT AND DISCUSSION

### *A. Evaluation by Rubrics*

Experimental evaluation was based on the rubrics and the total marks for open ended experiment was divided as per rubrics so that the attainment of PO can be measured (Table 7). It can be observed that open ended experiment can address the PO-b, c, d, g and i. The assessment of the OEE in attaining POs of the program is depicted in Figure 1. It is observed that the open ended experiment resulted in the attainment of PO-b is 8.6, which indicates that the students could carry out the experiment conveniently, c- 9.4 and i-8.7 which indicate that the design of the process of experiments was properly done by referring to relevant literatures. This helped students to recognize the need for lifelong learning. Attainment of PO-d is 9.4, which indicates that the students could work in team as a member. Attainment of PO-g is 8.45, which indicates that students could able to present all the details of experiment, its documentation, analysis and conclusion in the form of report, including graphical representation.

Table 7: Student's score for various components of rubrics and attainment of program outcome.

| Evaluation component | Program Outcome | | | | |
|---|---|---|---|---|---|
| | b | c | d | g | i |
| Analysis of Problem Statements | | | | | 4.35 |
| Develop/Implementation/design | | 4.7 | | | |
| Conduct of experiment | 4.7 | | 4.7 | | |
| Results | 3.9 | | | | |
| Documentation | | | | 4.2 | |
| Average Attainment | 4.3 | 4.7 | 4.7 | 4.2 | 4.35 |
| In the scale of 10 | 8.6 | 9.4 | 9.4 | 8.4 | 8.7 |

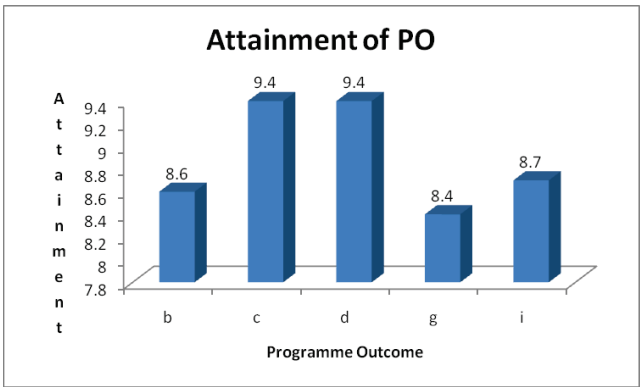


Figure 1: Attainment of PO by ET Laboratory course.

Similarly, the performance indicators were analyzed and attainment was calculated (Fig.2).
Initially, the students would have faced some difficulties because they were not familiar with such laboratory assignment. The need of open ended laboratory is emphasized to enhance independent learning and inculcating creativity and innovation of students [7].

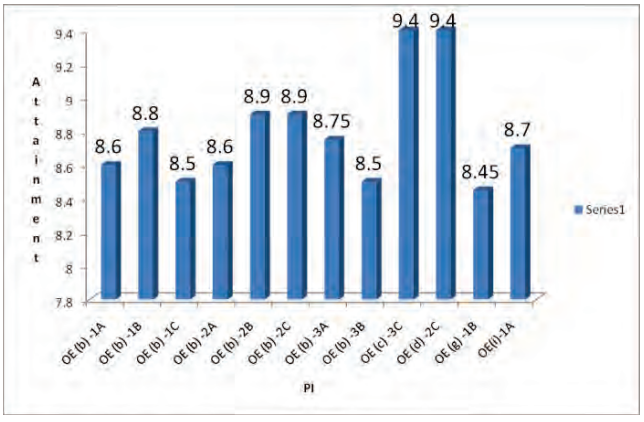


Figure 2: Attainment of PI by ET Laboratory course.

*B. Students feedback*

The feedback results obtained from the students were satisfactory. The graphical presentation depicts the response of each group to the questions asked. It is observed from Figure 3 that majority of students agreed that the laboratory activity had enhanced the understanding of the course in a better way. As the majority of students inclined their response towards enhancing the understanding, the success rate can be taken above 80 percent. In similar manner the response of each group with respect to questions is plotted. It can be seen that the open ended experiment has given them an opportunity to improve their laboratory skills, design and conduct experiments, analyze and interpret the data and work aptitude in a team. It is also clear that this module of categorization has helped students to think beyond the curriculum and to foster creativity and innovation during course study.

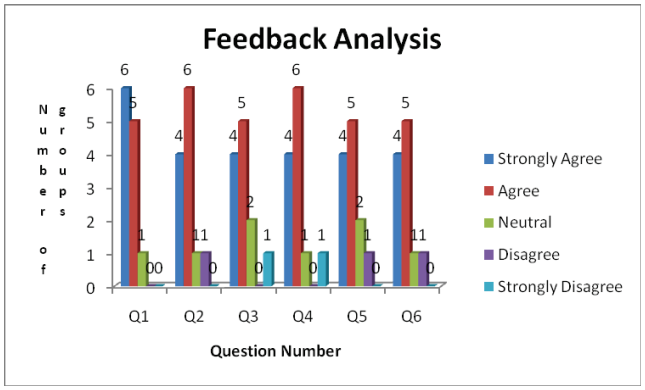


Figure 3: Response of students for Categorization

It can be seen that the students have become innovative in gathering variety of processes and methods to do within the topic scope. For example, the activity provided opportunity for them to select any enzyme from suitable source, suitable extraction buffer and procedure, suitable protocol for its assay; referring to the published scientific data and experimental manuals. The knowledge of extraction and assay of enzyme can be applied later in their career in the field of biotechnology. With this approach, student can be more open minded because there is no right and wrong method to accomplish the objectives, provided proper scientific temperament is maintained. This type of laboratory work prepares students to become more attentive, regular and properly plan their work. To perform the experiment, student should be exposed to this concept from the beginning. Intrinsic motivation occurs when student work on a task for their own satisfaction, interest, or challenge. When students prepare their OEE report, the course instructor can easily identify if it has been copied or not since every group should have a different method and also a unique result based on their choice of materials. This will make students more confident and independent in performing laboratory experiments [8].

## CONCLUSION

It is concluded that by categorization, the program outcomes have been achieved to a greater extent. It has given a platform for students to become more creative and innovative in academic initiatives. It also helped to develop and improve qualities such as team work, thinking ability, decision making, communication and lifelong learning. The above exercise also demonstrated student's ability for proper planning and execution of their project.

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