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Theme-based Minor Project Implementation for Basic Skill Enhancement in Biotechnology

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Abstract: Biotechnology being an inter-disciplinary domain, demands an adequate theoretical knowledge of allied subjects, good hands-on skill-sets, along with an ability to integrate biology with engineering for the graduates to be industry-ready. In this context, theme-based mini and minor academic projects for V and VI semester respectively were designed and implemented for under-graduate students of Biotechnology. The objectives of the mini project were 1) To equip the students with basic skill-sets and impart the culture of Good Laboratory Practices (GLP) & Standard Operating Procedures (SOP)and 2) to impart basic microbiological and biochemical skill-sets. In continuation of mini project, students have to harness the capabilities of skills learnt in mini project to translate in to an industrially viable product, hence fermentation skills play an important role. In this perspective, the objectives of minor project weredeveloped to impart the students with 1) basic fermentation skills at laboratory level 2) SOP of analytical instruments and 3) statistical analysis of the results. The minor project was implemented with the theme "Submerged Fermentation and Optimization of Process Parameters for Production of Industrially important Biomolecules". A multi-level rubrics-based assessment was followed to measure the stated learning outcomes. The attainment was highest (9.5) for PI 9.1.2, which indicated good team work and show lowest (7.0) for PI 13.2.1, which shows scope for improvement for improvement in area of verification and calibration of equipment. It was concluded that the theme-based projects were effective in experiential learning for the students which plays a key role in bridging the gap between industry and academia.

Keywords: Skill-sets, Standard Operating Procedures (SOP), Good Laboratory Practices (GLP).

1. Introduction

Recent developments in genetics and molecular biology have excited world-wide interest in biotechnology. The ability to manipulate DNA has already changed our perceptions of medicine, agriculture and environmental management. Scientific breakthroughs in gene expression, protein engineering and cell fusion are being translated by a strengthening biotechnology industry into revolutionary new products and services. The sector is capital intensive, demands long window periods for product and process realization and relies heavily on trained manpower in terms of domain knowledge and hands-on skill-sets. The methodically trained human resource, with an ability to integrate biology with engineering skills like substantial manufacturing capabilities, design skills and economic aspectsis crucial for any industry for its optimum performance (Society of Biological Engineers). Hence, the academic institutions are expected to play a key role in

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enabling the students to make them industry-ready and bridge the gap (Dahms, 2001).

In this regard, the present exercise of implementing a minor project for undergraduate students of Biotechnology was undertaken to impart knowledge and skill sets related to fermentation process. The broad objective of the activity was to enhance the fundamental skill-sets of the students from industry perspective and handle subsequent academic projects (Capstone), Research Experience for Undergraduate (REU) with minimal hand-holding.

In project-based learning, students engage in meaningful problems that are likely to arise in real working environments. A project-based classroom allows students to investigate questions and explanations, discuss their ideas, and try out new ideas. Project-based learning is considered an alternative to paper-based, rote memorization and teacher-led classrooms. Proponents of project-based learning cite numerous benefits to the implementation of these strategies in the classroom including a greater depth of understanding of concepts, broader knowledge base, improved communication and interpersonal/social skills, enhanced leadership skills, increased creativity, and improved writing skills. (Marx et al., 2004; Rivet&Krajcik, 2004; William & Linn, 2003).

The minor project for VI semester was implemented with the theme "Submerged Fermentation and Optimization of Process Parameters for Production of Industrially important Biomolecules". The objectives of minor project are 1)Media & inoculum preparation and media sterilization 2) SOP of analytical instruments 3) Fermentation studies for biomolecules production 4) Study of effect of parameters on biomolecules production 5) Estimation of kinetic parameters and6) Statistical analysis of the results.

2. Methods

A. Design of the Minor Project

The Minor project was designed taking into consideration the inputs from industry stake-holders, alumni and departmental faculty members. The recommendations of Society of Biological Engineers (SBE) and American Society of Microbiology (ASM) were taken into account while designing the contents of the project.The project was of 6-credits and was carried out in a group of 4 students. The group dynamics followed a pattern of selecting the students belonging to different levels of CGPA in each group.A total of eleven groups were formed.

B. Execution of minor project

Minor project was implemented for VI semester biotechnology students with a perspective of orienting them to fermentation process and application of basic statistical tools for the results obtained. Accordingly the theme "Submerged Fermentation and Optimization of Process Parameters for Production of Industrially important Biomolecules" was framed with the objectives mentioned earlier.

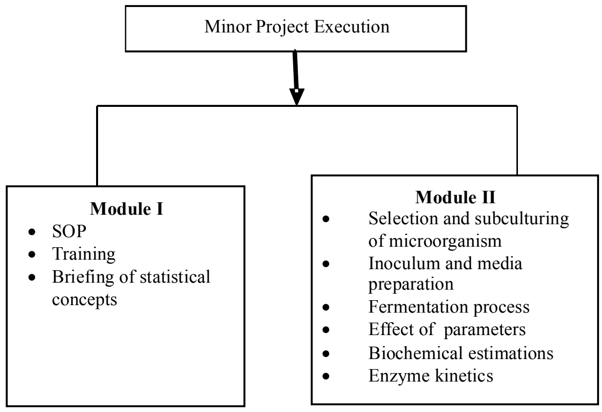


Fig.1 Modules of Minor Project

The minor project was comprehensively designed so as to include end-to-end activities needed for a typical bioprocess technology. The project was a continuation of the mini project wherein the microorganisms isolated were used as inoculum for the execution of the minor project. Selected isolates were subjected for submerged fermentation for the production of industrially important metabolites (enzymes). A one factor at a time (OFAT) approach was followed with four process parameters (inoculum size, media pH, nitrogen and carbon sources) each at three levels. The minor project was implemented in two modules as represented in fig.1.

In module-I, training was given to students on 1) Standard Operating Procedures (SOP) of analytical instruments like Spectrophotometer, Centrifuge, Microscope, Tangential Flow Filtration, Ultra filtration, Rotary Evaporator, Ultrasonicator, SDS and Lyophilizer 2) Criteria for media & inoculum development and 3) Statistical analysis of results.

In module-II,the skill sets targeted were sub-culturing of microorganisms, inoculum preparation, establishment of submerged fermentation process (Shake flask studies), sampling, biochemical estimation & kinetics studies of biomolecule. Analysis of the results was performed using basic statistical methods likeCorrelation & Regression, Analysis of variation (Variance & Standard Deviation), Coefficient of Variation, Hypothesis testing,ANNOVA and Turkey test.

C. Assessment of Minor Project

The assessment of the project was done in four phases comprising of guide and review committee.A detailed Calendar of Activities (CoA) was provided and followed for timely, smooth and hassle-free execution of the project amongst the different project groups.

1) Phase I: In the first phase, written examination of 50 Marks was conducted on SOP and statistical analysis. In this review the assessment parameters considered were result analysis skills (PI Code 4.3.2) and SOP skills of analytical instruments (PI Code: 13.2.1).

2) Phase II: During second phase, students were asked to operate and demonstrate the usage of analytical instruments by random picking. The assessment parameters considered were "Use appropriate analytical instruments/software tools to carry-out the experiments"(PI Code: 4.1.3) and"Perform calibration and verification for obtaining accurate and reproducible data" (PI Code: 13.2.1). Rubrics for second phase considered for assessment as follows,

Table 1. Rubrics for phase II assessment

PI addressed	Inadequate (up to 25%)	Average (up to 50%)	Admirable /Good (up to 75%)	Outstanding (up to 100%)
Analytical instruments Usage (4.1.3)	*Did not use appropriate analytical instruments to carry -out the experiments	*Used appropriate analytical instruments with no knowledge.	*Used appropriate analytical instruments with partial knowledge.	*Used appropriate analytical instruments with complete knowledge.
Calibration and verification (13.2.1)	*Did not Perform calibration and verification of the instruments. *Did not obtain accurate and reproducible data.	*Performed calibration and verification of th e instruments with no knowledge. *Obtained accurate and reproducible data.	*Performed calibration and verification of the instruments with partial knowledge. *Obtained accurate and reproducible data.	*Performed calibration and verification of the instruments with complete knowledge. *Obtained accurate and reproducible data.

3) Phase III: In third phase, overall progress of minor project was assessed by considering following rubrics parameterslike use appropriate procedures, tools and techniques to collect and analyze data (PI Code: 4.3.2), Critically analyze data for trends and correlations, stating possible errors and limitations (PI Code: 4.3.3), Apply contemporary engineering tools and models to analyze and interpret the results (PI Code: 2.4.2), Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal (PI Code: 9.1.2).Rubrics for third phase considered for assessment as follows,

Table 2. Rubrics for phase III assessment

PI addressed	Inadequate (up to 25%)	Average (up to 50%)	Admirable /Good (up to 75%)	Outstanding (up to 100%)
Techniques to collect and analyze data (4.3.2)	Did not use appropriate procedures, tools and techniques to collect and analyze data	Used procedures, tools and techniques to collect and analyze data without understand.	Used appropriate procedures, tools and techniques to collect and analyze data with partial understanding	Used appropriate procedures, tools and techniques to collect and analyze data with proper understanding.
Analyze data for trends and correlations (4.3.3)	Did not critically analyze data for trends & correlation and state the possible errors and limitations	Critically analyzed the data for trends & correlations, Without stating any possible errors and limitations	Critically analyzed the data for trends & correlations, and did not state all the possible errors and limitations	Critically analyzed the data for trends & correlations, and also stated all the possible errors and limitations
Engineering tools and models to analyze and interpret the results (2.4.2)	Did not apply engineering tools and models to analyze and interpret the results	Applied engineering tools and models to analyze and interpret the results without understanding the tools	Applied engineering tools and models to analyze and interpret the results with partial understanding of the tools	Applied engineering tools and models to analyze and interpret the results with complete understanding of the tools.
Effective team Work, to accomplish a goal. (9.1.2)	Team showed poor cohesion, interaction & respect. Tasks were NOT completed.	Team showed average cohesion, interaction & respect. Did not share the tasks equally and utilize abilities of each member. Tasks were completed on time with satisfactory results.	Team showed good cohesion, interaction & respect. Moderately shared the tasks and few members carried out the work. Tasks were completed on time and with good results.	Team showed great cohesion, interaction respect. Shared the tasks equally and utilizing abilities of each member. Tasks were completed on time and with great results.

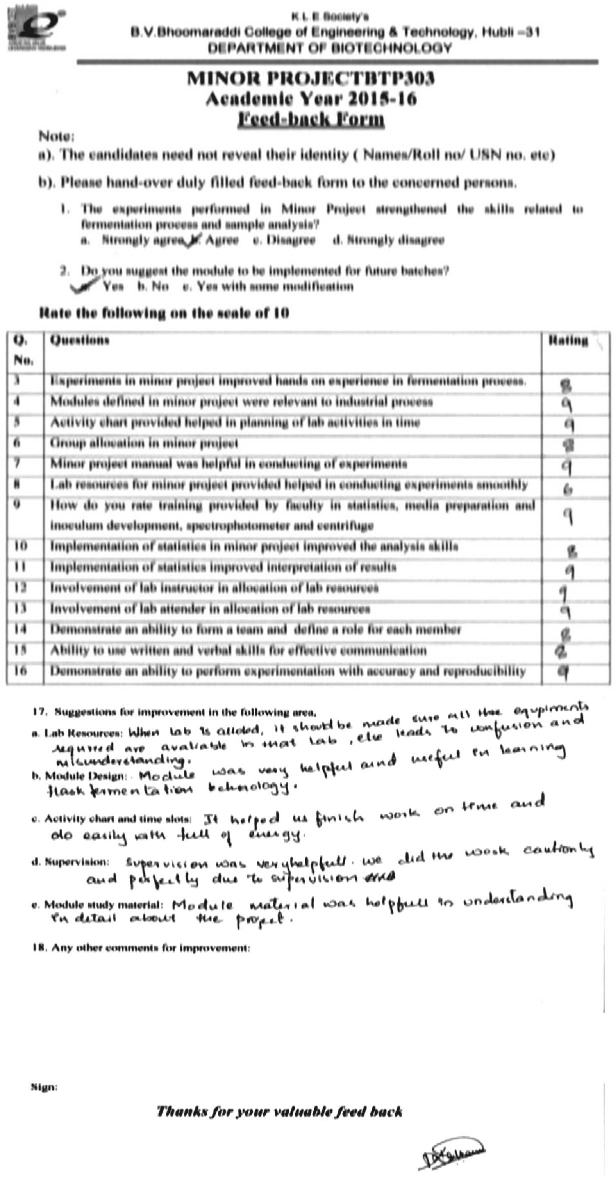
4) Phase IV: In fourth phase, final assessment was done by project review committee to assess following rubric parameters; Develop clear understanding of the results and correlate to defined objectives (PI Code: 2.4.4), Correlate the experimental outcomes with underlying theoretical concepts and principles (PI Code: 4.1.4), Produce clear, well-constructed, and well- supported written engineering documents(PI Code: 10.1.2), Deliver effective oral presentations (PI Code: 10.2.2), Use a variety of media effectively to convey a message in a document or a presentation (PI Code: 10.3.2).Rubrics for fourth phase considered for assessment as follows,

Table 3. Rubrics for phase IV assessment

PI addressed	Inadequate (up to 25%)	Average (up to 50%)	Admirable /Good (up to 75%)	Outstanding (up to 100%)
Results correlated to defined objectives (2.4.4)	Did not develop clear understanding of the results and correlated it to defined objectives	Developed partial understanding of the results and correlated to defined objectives	Developed partial understanding of the results and correlated to the defined objectives	Developed clear understanding of the results and correlated to the defined objectives
Correlation of experimental outcomes with theoretical concepts (4.1.4)	Did not correlate the experimental outcomes with underlying theoretical concepts and principles	Correlated experimental outcomes with underlying theoretical concepts and principles but with few mistakes.	Correlated few experimental outcomes with underlying theoretical concepts and principles without any mistakes	Correlated all the experimental outcomes with underlying theoretical concepts and principles without any mistakes
well-constructed, and well-supported report (10.1.2)	Report contains many distracting mistakes, generally difficult to follow and poorly organized. Figures, tables and graph are hard to understand, and are not adequate to link to text.	Report is generally clear, distracting errors and flow make it difficult to follow at times and organization of report is weak. Figures, tables and graph are hard to understand, are not all linked to text. .	Report is logical and easy to read, may contain a few errors causing minimal reader distraction and organized strongly. All figures, tables and graphs can be understood and are linked to text.	Report is virtually error-free, and clearly organized with excellent transitions. All figures, tables and graphs are easy to understand, and are clearly linked to the text.
Effective oral presentations (10.2.2)	Student mumbles, incorrectly pronounces, and speaks too quietly for a majority of members to hear. Inadequate knowledge No alignment with the objectives	Student's voice is low incorrectly pronounces. Audiences have difficulty in hearing. Average knowledge of subject. Intermittent deviation from objectives	Students' voice is clear. pronounces most Words correctly. Most Audiences can hear. Moderate correlation of the contents with topic.	Student uses a clear voice and correct, precise pronunciation. All audiences' can hear. Very Good correlation of contents with the topic.
Effective usage of media (10.3.2)	Use a variety of media effectively to convey a message in a document or a presentation	Use a variety of media effectively to convey a message in a document or a presentation	Use a variety of media effectively to convey a message in a document or a presentation	Use a variety of media effectively to convey a message in a document or a presentation

D. Feed Back

A formal anonymous feedback of the students was collected to identify the gaps and scope for further improvement in terms of resources, group dynamics, and support from teaching and non-teaching staff, learning curve (experiments, written and oral). Sample copy of feedback of student is as shown in fig 2.



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DEPARTMENT OF BIOTECHNOLOGY

MINOR PROJECTBTP303
Academic Year 2015-16
Feed-back Form

Note:
a). The candidates need not reveal their identity (Names/Roll no/ USN no. etc)
b). Please hand-over duly filled feed-back form to the concerned persons.

1. The experiments performed in Minor Project strengthened the skills related to fermentation process and sample analysis?
a. Strongly agree b. Agree c. Disagree d. Strongly disagree

2. Do you suggest the module to be implemented for future batches?
a. Yes b. No c. Yes with some modification

Rate the following on the scale of 10

Q. No.	Questions	Rating
3	Experiments in minor project improved hands on experience in fermentation process.	8
4	Modules defined in minor project were relevant to industrial process	9
5	Activity chart provided helped in planning of lab activities in time	9
6	Group allocation in minor project	8
7	Minor project manual was helpful in conducting of experiments	9
8	Lab resources for minor project provided helped in conducting experiments smoothly	6
9	How do you rate training provided by faculty in statistics, media preparation and inoculum development, spectrophotometer and centrifuge	9
10	Implementation of statistics in minor project improved the analysis skills	8
11	Implementation of statistics improved interpretation of results	9
12	Involvement of lab instructor in allocation of lab resources	9
13	Involvement of lab attender in allocation of lab resources	9
14	Demonstrate an ability to form a team and define a role for each member	8
15	Ability to use written and verbal skills for effective communication	8
16	Demonstrate an ability to perform experimentation with accuracy and reproducibility	9

17. Suggestions for improvement in the following area,
a. Lab Resources: When lab is alloted, it should be made sure all the equipments required are available in that lab, else leads to confusion and misunderstanding.
b. Module Design: Module was very helpful and useful in learning flask fermentation technology.
c. Activity chart and time slots: It helped us finish work on time and do easily with full of energy.
d. Supervision: Supervision was veryhelpfull. we did the work cautiously and perfectly due to supervision.
e. Module study material: Module material was helpfull in understanding in detail about the project.

18. Any other comments for improvement:

Sign:

Thanks for your valuable feed back

Fig.2 Feedback by students for minor project

3. Results

The theme-based implementation of the minor project aimed at strengthening the basic skill-sets was instrumental in addressing some of the program

Outcomes (POs). The following table illustrates the mapping of rubrics framed for assessment to the POs addressed.

Table 4. Mapping of Rubric Parameters with Performance Indicators

Mapping of Rubric Parameters with Performance Indicators			
Sr. No.	**Rubrics Parameters**	**PI Code**	**PI Addressed**
1	Analyze and interpret the results and correlate to objectives	2.4.2	Apply contemporary engineering tools and models to analyze and interpret the results
2		2.4.4	Develop clear understanding of the results and correlate to defined objectives
3	Use of analytical instruments/ tools and correlate the experimental results.	4.1.3	Use appropriate analytical instruments /software tools to carry-out the experiments
4		4.1.4	Correlate the experimental outcomes with underlying theoretical concepts and principles
5	Analyze data for trends and synthesize information about the problem	4.3.2	Critically analyze data for trends and correlations, stating possible errors and limitations
6		4.3.3	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions
7	Team work	9.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
8	Written skills	10.1.2	Produce clear, well-constructed, and well -supported written engineering documents
9	Oral skills	10.2.2	Deliver effective oral presentations
10	Use of media	10.3.2	Use a variety of media effectively to convey a message in a document or a presentation
11	Calibration, verification and reproducibility of data	13.2.1	Perform calibration and verification for obtaining accurate and reproducible data.

As part of Minor project, the students were exposed to hand-on skills pertaining to fermentation technology process. These include sub-culturing of microorganisms, inoculums preparation, inoculation, fermentation for metabolite production, analysis of effect of different parameters at varied levels, biochemical estimations and analysis of experimental results using statistical methods. The attainment of Program Outcomes (PO) was evaluated by conducting 4 phases of review as explained in methodology section. Review 1 was conducted for 50 marks, similarly review 2 for 20 marks, review 3 for 40 marks and review 4 for 40 marks. Students were finally evaluated for 150 marks based on the rubrics defined for each review by guides and review committee. Based on the mapping of rubric parameters with PO, attainment of various Program Outcomes on a scale of 10 was measured and represented in Fig.4.

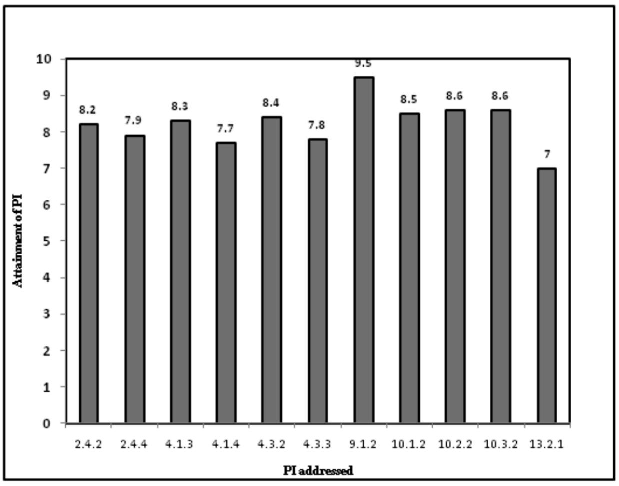

Fig.4 Attainment of Program Outcomes for minor project

The attainment was highest (9.5) for PI 9.1.2 which indicated a good team works while it was lowest (7.0) for PI 13.2.1 which shows there is scope for improvement for verification and calibration of equipment. The feedback of the students revealed that the project execution was smooth, satisfactory and gave them experiential learning. A limitation for scope for written skills was expressed since a formal template was provided for tabulation. This was addressed at the end of the project by giving training on report writing skills of the project.

4. Conclusion

Based on our experience of implementing the minor project, we conclude that the students were exposed to the SOP, GLP practices and honed their basic skill-sets which are expected of them in the industries as entry-level professionals. Attainment of PO clearly shows scope for improvement in the area calibration and verification of equipment (PO 13.2.1), proper use of analytical instruments (PO 4.1.3) and analysis of results by using statistics to reach appropriate conclusion (PO 4.3.3). It is envisaged to further improve the exercise by assessment from external reviewers from industry in the next cycle.

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