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# Theme-based Mini Project Implementation for Basic Skill-set Development in Biotechnology

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**Abstract:** Biotechnology being an inter-disciplinary domain, demands an adequate theoretical knowledge of allied subjects along with good hands-on skill-sets for the graduates to be industry-ready. In this context, theme-based mini project for V semester was 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. The mini project was undertaken with the theme of "Isolation, Screening and Preliminary Characterization of Microorganisms Producing Selected Industrially Important Metabolites". A multi-level rubrics-based assessment was followed to measure the learning. The project addressed eight Program Outcomes (PO) whose attainment on a scale of 10 was calculated. It is concluded that the theme-based project was effective in experiential learning for the students which plays a key role in bridging the gap between industry and academia.

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## 1. Introduction

Biotechnology is considered as a sun-rise sector with an enormous potential in future from research and industrial perspective. Biotechnology includes a complex array of scientific and engineering disciplines, synergistically interwoven. Currently the main applications of biotechnology are in medicine, agriculture, industrial processes and environmental management. The sector is capital intensive, demands long incubation periods for product and process realization. It relies heavily on trained manpower in terms of domain knowledge and hands-on skill-sets. The methodically trained human resource in Biotechnology is crucial for any industry for its optimum performance. Hence, the academic institutions are expected to play a key role in enabling the students to make them industry-ready and bridge the gap between the two (Dahms, 2001). Various statutory bodies and professional societies like American Society for Microbiology recommend for skill-set development through academic initiatives (www.asm.org).

In the present scenario of Indian Biotechnology Sector, skilled workforce appears to be difficult to find due to various reasons. Hence it is essential and inevitable to transfer Biotechnology skills from academia to industry for effective implementation (Saberwal, 2009). In this regard, the present exercise

of strengthening the basic hands-on skill-sets for undergraduate students of Biotechnology was undertaken as part of Mini project. The mini project provides one of the best opportunities for active learning of the students which gives them an experiential learning. The broad objective of the activity was to enhance the fundamental skill-sets of the students from industry perspective and handle subsequent academic projects like Capstone with minimal hand-holding. As part of V semester, mini project was implemented with the aforementioned objectives i) To equip the students with basic skill-sets needed for executing the academic projects with minimal hand-holding, orient them to meet professional requirements and impart the culture of Good Laboratory Practices (GLP), and Standard Operating Procedures (SOP)of analytical instruments, together which account for practices with personal safety measures and ii) To impart basic microbiological and biochemical skill-sets which are indispensible quality needed for Biotechnology Career.

A wide gap has been observed between the skill sets required by the employers and those possessed by the fresh graduates. The gap is attributed to the difference in the prioritization between industry and academia. Nevertheless honing of fundamental skill sets for any Biotechnology is imperative for a successful professional career. This is underscored in the context of modern engineering profession which deals constantly with uncertainty, with incomplete data and competing demand from clients, government, environmental groups and the general public. Biotechnology discipline being close to these sectors, it is expected that a graduate is aware of these along with the technical know-how and do-how. The graduates are expected to be industry ready to take up the professional challenges with minimal training (Talgar and Goodey, 2003). The theoretical concepts learnt by the students are best complemented by the practices in the laboratory. This is best addressed by Projects directed to the acquiring of skill-sets needed for a typical Biotechnology graduate.

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, 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). Personal safety and environmental concern are an integral part of any Biotechnology related projects and research activities. The Laboratory sessions and respective projects should emphasize on various practices to be adopted for undertaking adequate safety measures.

The academic projects for Biotechnology at BVBCET, Hubballi comprise three levels of implementation – Mini, Minor and Capstone during V, VI and VIII semesters respectively. The present study discusses the Theme- Based implementation of Mini project for the entire class.

## 2. Methods

A. Design of the Mini Project:

The Mini project was designed taking into consideration the inputs from industry stake-holders, alumni and Departmental faculty. The project was of 3-credits and group-based. Each group comprised of four student members and 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. The recommendations of American Society of Microbiology were taken into account while designing the contents of the project.

B. Delivery of Mini Project:

Mini project was implemented for Biotechnology studentsof V semester with a perspective of strengthening the skill-sets predominantly pertaining to Microbiology and Biochemistry Accordingly the theme "Isolation, Screening and Preliminary Characterization of Microorganisms Producing Selected Industrially Important Metabolites". was framed with the objectives mentioned earlier. The project was implemented with two modules- 1). Training and 2). Project execution.

Following is the framework followed for the Mini project.

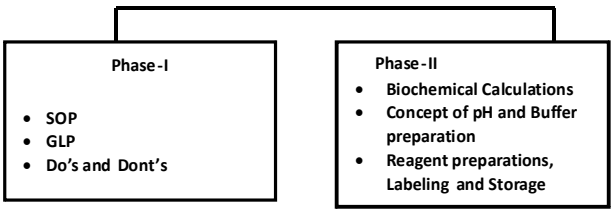


**Fig. 1 Training Modules of Mini Project**

Due emphasis was laid on Microbiology and Biochemistry as these were central to all the subsequent Biotechnology practices. The concept of Standard Operating Procedure (SOP) for laboratory equipments and Good Laborotary Practices (GLP) for processes in laboratories was introduced and practiced. The unit activities in phase III comprised exercises like aseptic techniques, pure culture isolation, media preparation, sample analysis, serial dilution, plating, enumeration and microscopic techniques.

The project execution module of Mini project began with the collection of soil samples from various locations for isolation of microorganisms. The samples were processed by serial dilution and the isolates were screened for production of selected industrially important enzymes (protease and amylase) using appropriate culture media (Casein-agar and starch-agar media). The potential isolates from the petriplates were reinoculated for reproducibility before proceeding for characterization. The isolates were characterized for morphological and biochemical parameters. The fungal isolates were identified upto genus level based on microscopic observation. The features of the isolates were tabulated and preserved by glycerol stocks for future use.

C. Assessment of Mini Project:

The overall assessment of the Mini project was performed in three distinct phases by the team comprising of faculty members of the Biotechnology Department.. The assessment of the training module was comprised of two phases. Phase- I was written which comprised objective/fill in the blanks questions and writing SOP's for instruments. Phase- II was activity and oral based wherein the students were made to demonstrate the operating of the instruments and explain their working principles .The third assessment of the project was for project execution. It was performed by review committee and examined for the written (report) and oral (presentation) communication skills. The practice of SOP and GLP during the project execution was also reviewed.

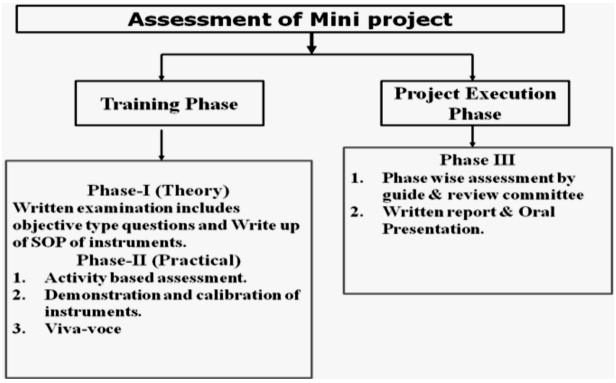


**Fig. 2 Assessment Phases of Mini Project**

Assessment was performed based on appropriate detailed rubrics as shown in Table 1.

**Table 1. Rubrics for Assessment**

| PI addressed | Inadequate (up to 25%) | Average (up to 50%) | Admirable /Good (up to 75%) | Outstanding (up to 100%) |
|---|---|---|---|---|
| Write up 10.1.2 | -Report has distracting mistakes, -Figures, tables and graph are hard to understand, | -Report is generally clear, but organization of report is weak. -Figures, tables and graph are hard to understand, | -Report is logical and easy to read, and organized strongly. -All figures, tables and graphs can be understood with information given | -Report is virtually error-free, with excellent transitions. -All figures, tables and graphs are easy to understand, |
| SOP 13.2.2 | Couldn't explain the steps of operating the instruments. unable to demonstrate the complete operation of the instrument. | -Able to narrate the steps but was unable to properly operate t he instrument | -Just able to explain all the steps regarding SOP. -Demonstrated the working of the instruments | Able to narrate all the steps in detail regarding the SOP of instruments. -Demonstrated the operating the instruments |
| Team work 9.3.1 | Team sh owed poor cohesion and poor interaction & poor respect. Tasks were NOT completed. | Team showed average cohesion, interaction respect. Team members did not utilize abilities of each team member. | Team showed good cohesion, interaction respect. Tasks were completed on time and with good results. | Team showed great cohesion, interaction respect. Team members shared the tasks equally and utilizing abilities of each team member. |
| Team work 9.1.1 | -No distribution of the work. -No coordination and hence hardly any learnings from each other in a team. | -Inappropriate distribution of the work. -Poor coordination and hence lower level of learnings from each other in a team. | Able to distribute the work moderately according to their preferences of learning. -Able to coo rdinate the learnings of each other | -Able to distribute the work perfectly according to their preferences of learning. -Able to perfectly coordinate the learnings of each other |
| GLP 13.1.2 | -No knowledge of shelf life and safe disposal of reagents/ chemicals/ cultures | Average knowledge of shelf life and safe disposal of reagents/ chemicals/ cultures | Preliminary knowledge of shelf life and safe disposal of reagents/chemicals/ cultures. | -Sound knowledge of shelf life and safe disposal of reagents/ chemicals/ cultures. |

| | | | | |
|---|---|---|---|---|
| **GLP 13.1.1** | -Unable to identify the hazards. -Knowledge of precautionary measures and personal protective equipments (PPE) totally lacking | -Able to identify the hazards. -No Knowledge of precautionary measures and personal protective equipments (PPE). | -Able to identify the different types of hazards. -Possess knowledge of precautionary measures and personal protective equipments (PPE) | Able to perfectly identify the different types of hazards. Possess sound knowledge of precautionary measures and personal protective equipments (PPE) |
| **Conduct 5.2.2** | -No knowledge of the principles, practices and applications of biochemical, microbial, molecular and analytical tools. | -Able to demonstrate only the principles but lacks application concepts of biochemical, microbial, and molecular tools. | Able to demonstrate the principles and practices but lacks application concepts of biochemical, microbial and molecular tools. | Able to demonstrate the principles, practices and applications of biochemical, microbial and, molecular tools. |
| **Oral presentation 10.2.2** | Student mumbles, incorrectly pronounces terms, and speaks too quietly for a majority of members to hear. | Student's voice is low. Student incorrectly pronounces terms. Audience members have difficulty in hearing. | Student's voice is clear. Student pronounces most words correctly. | Student uses a clear voice and correct, precise pronunciation of terms so that all audience members can hear |

Key elements like well organized reprts with tables and figure, practice of all steps in SOP and GLP, precautions to be taken, and traits like clear voice and fluency were taken as yardsticks for framing the rubrics. 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.

## 3. Results

The isolates of bacteria and fungi ranging from 3 to 5 were characterized and maintained as Department repository. The theme-based implementation of the mini project aimed at strengthening the basic skill-sets was instrumental in addressing eight program Outcomes (POs). Table No.1 illustrates the mapping of rubrics framed for assessment to the POs addressed

**Table 2. Mapping of Rubric Parameters with Program Outcomes and Performance Indicators for Mini project.**

| Mapping of Rubric Parameters with Performance Indicators | | | |
|---|---|---|---|
| **Sr. No.** | **PO's and Rubrics Parameters** | **PI Code** | **PI Addressed** |
| 1 | Conduct | 4.1.2 | Identify and apply relevant experimental procedure /bioinformatics tools /databases for a defined problem. |
| 2 | Team wor | 9.1.1 | Recognize a variety of working and learning preferences; appreciate the value of diversity on a team |
| 3 | Team work | 9.3.1 | Present results as a team, with smooth integration of contributions from all individual efforts |
| 4 | Written communication | 10.1.2 | Produce clear, well -constructed, and well -supported written engineering documents |
| 5 | Oral presentation | 10.2.2 | Deliver effective oral presentations |
| 6 | GLP | 13.1.1 | Identify hazards and take appropriate precautionary measures to en sure health and safety as per guidelines. |
| 7 | | 13.1.2 | Deconstruct and dispose -off unsafe materials following norms ensuring individual and environmental safety. |
| 8 | SOP | 13.2.2 | Follow standard operating procedures adhering to laboratory guidelines. |

During mini project, the SOP and GLP aspects which are most sought-after skills expected of a Biotechnology graduate were addressed and assessed. This assumes significance in the light of following safe practices leading to personal safety , personal protective equipments (PPE) and proper disposal of waste generated without causing environmental hazards.

A. Attainment of Program Outcomes:

The assessment was followed by calculating the attainment of each of the program Outcomes and corresponding Performance Indicators on a scale of 1 to 10.. The Program for conduct, teamwork and communication was good. There existed scope for improvement for SOP.

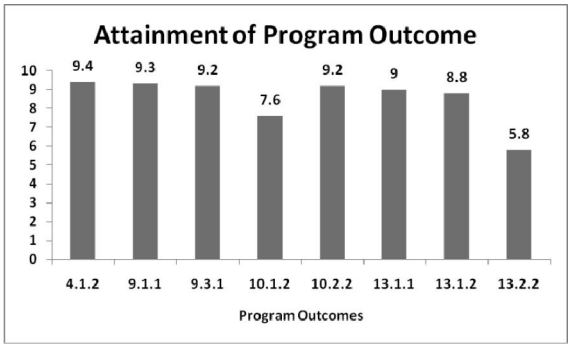


**Fig 3 Attainment of Program Outcomes and Performance Indicators.**

A formal anonymous feedback of the students was collected using Typeform online tool to identify the gaps and scope for further improvement in terms of resources, group dynamics, support from teaching and non-teaching staff, learning curve (experiments, written and oral). The students expressed satisfaction in terms of having acquired the basic skill-sets and communication traits.

**Table 3. Questionnaire for Feedback of Mini Project**

| | Questionnaire for Feedback of Mini Project |
|---|---|
| 1 | The mini project was instrumental in strengthening the basic skill-sets in terms of Microbiology and Biochemistry aspects. a). Strongly agree b). Agree c). Disagree d). Strongly disagree |
| 2 | A good acquaintance of SOP and GLP was obtained during the mini project a). Strongly agree b). Agree c). Disagree d). |
| 3 | The basic theory modules and hands-on-experience were effective in learning a). Strongly agree b). Agree c). Disagree d). Strongly |
| 4 | The training module was helpful in smooth execution of the mini project. a). Strongly agree b). Agree c). Disagree d). Strongly |
| 5 | The resources (chemicals, glasswares) provided were adequate. a). Strongly agree b). Agree c). Disagree d). Strongly |
| 6 | The support from teaching and non-teaching staff was good a). Strongly agree b). Agree c). Disagree d). Strongly disagree |
| 7 | Suggestions for improvement in terms of : a). Team forming b).Resources c). Time management d). Assessment e). Any other |

All the students either strongly agreed or agreed for the questions from 1 to 6. However for the question 7, few students expressed concern over the team formation . The present practice of team formation based on CGPA would be relooked into next cycle of project implementation.

## 4. Conclusions

Based on our experience of implementing the mini 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. It is envisaged to further improve the exercise by assessment from external reviewers from industry in the next cycle. In continuation of project, a minor project for VI semester is being implemented with the theme of Bioprocess development and statistical analysis to complement the skill-sets needed for a Biotechnology graduate.

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