Project-Based Learning Technique for Holistic Development of Students

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Abstract - **International accreditation norms like Washington Accord or the national norms like NBA have defined program outcomes for undergraduate professional engineering courses. These norms aim at the holistic development of students. This paper presents project-based learning as a strong pedagogy tool for the overall development of students. The undergraduate project course is considered a case study for this pedagogy technique and the attainment of Program outcomes is illustrated in the results. The major desired outcomes for project work like communication, collaboration, knowledge application, documentation, work ethics, teamwork and independent learning are the parameters included in the Program Outcomes. The three point Likert scale is used for the assessment of the program outcomes. The results show that most of the program outcomes for these courses are satisfactorily achieved. Thus, it can be established that project based learning techniques help inculcate specific knowledge, skills and attributes into the students thereby assisting their holistic development and growth.**

Keywords - program outcome, holistic development Likert scale

JEET Category - **Practice**

I. INTRODUCTION

This paper is focused on the analysis of the mapping of the project outcomes to the project work carried out by the students in their final year and the relativity of their holistic development in this process. The Program Outcomes specified by NBA need to be incorporated into the various courses offered with the aim to inculcate specific knowledge, skills and attributes into the passing out graduates. Program outcomes help explore the course contents with an aim to check its contribution towards the accomplishment of the department or Institution's goals. The parameters like quality, quantity, supporting facilities, mapping with industry requirements and fiscal sustainability are also effectively addressed. Documentation, a vital parameter for the comprehensive growth of the student is also included in the program outcomes. Documentation helps ensure consistency, efficiency and standardization. It is observed that the majority of these are attained by the project work which is executed by the final year students. The Ministry of Education states that the project work avails the learning experience where the students get an opportunity to combine their knowledge from various fields and apply it precisely to real-life problems. Project-based learning inculcates skills like effective problem solving, self-learning, critical thinking, time management and report generation skills. Working in a team nurtures the qualities like sharing, leadership, boosted productivity, enhanced personal growth, improved tackling of the objective and better handling of challenges. The key focus and desired outcomes for project work are - communication, collaboration, documentation, knowledge application and independent learning. All these parameters are included in the Program Outcomes specified by NBA.

II. REVIEW

Thuy Diem Thi Thu (Thuy 2018), in his conference paper titled 'using PBL technique to enhance student's writing skills' has indicated project based learning technique as one of the most effective ways to engage students and develop language skills. An action research was executed in four steps - preparation, implementation, presentation and evaluation. It was observed that with this learning technique, learning for students became a self improvement activity for themselves.

In the article 'Relative effects of problem and project based learning techniques on student's academic achievement in building technology' (Yi Salihu 2019) the result of student that compared the mean achievement scores of students exposed to problem and project based learning against those exposed to conventional teaching methods was presented. The results indicated a significant difference in the mean ratings of students. The Quasi experimental research design was adopted to carry out the study. The mean achievement gain score with problem based learning was 18.07, with project based learning was 20.23 while with conventional method was 6.31. This showed that the problem and project based learning techniques surpassed the traditional or conventional techniques and effectively assist the holistic development of the students.

The article 'Holistic development of education' (P.S. Kaladevi 2020) narrates the changes incorporated in the National Education Policy since 1968 till now. The aim was 'educate all'. The National Education Policy formulated by former Indian Prime Minister, Indira Gandhi, in 1968 focussed on compulsory education to children between 6-14 age group and formulated the three language formula. The 1986 National Education Policy formulated by former Indian prime minister, Rajiv Gandhi implemented it as the New Education Policy and called it as child centered approach in Primary education. The focus was on opening special schools for disabled children, availability of library books and introduction of extra curricular and co-curricular activities. The Nation Education Policy 2020 formulated by current Indian Prime Minister, Narendra Modi is the New Education System that includes creative classroom arrangement with focus on the holistic development approach for students as well as faculty. During the pandemic period, remote learning through online classes was promoted. With no constraint on medium of communication and the adaption of various innovative teaching tools and best practices, the e-learning process could be made interactive and interesting for

students. Technology is being widely incorporated in the teaching learning process.

The research on Project based learning by Ol Osadchuk (2020) pens down the findings of the study of experimental test of effectiveness of pedagogical conditions for development of information skills in students in Project based learning. The leading research methods were pedagogical experiment and expert assessment. The methodologies for assessing the projects completed by students as well as the methodology for assessing the development of the information skills among students were used. It was concluded that the information competence of a specialist helps understand their ability to implement information activities related to the process of searching, receiving, transforming, accumulating and transmitting information in any form to solve personal, social or global problems. The study can be used to design the training sessions in social, humanitarian, natural science and engineering disciplines.

In the work reported on development of Student Accountability in a Project-based Learning Environment by Ah Jamal (2017) has explained an approach to development of student accountability for study of a subject in the project-based learning environment through its specific organization by a teacher is proposed. The accountability is developed by a seven step process - preparing the sample-project, setting initial knowledge assessments, ensuring subject study through sample-project performance, promoting self-formed collaborative student groups for performing projects of different levels of complexity, adapting PBL by setting the adaptive assessments of knowledge, sustaining collaborative performance of the project tasks and measuring student accountability. The accountability measure of a student is a combination of the personal accountability measure and the additional accountability measure of the collaborative group members which helps to form the reinforced accountability measure of a student for performance of the project tasks.

The research by B. Sai (2019) and Patenge et al. (2019) speaks about the paradigm shift in the teaching styles and methods. It states that teachers are the fulcrum of a society who plays the role of being the informer, exemplary and influential.

III.   METHODOLOGY

The 12 program outcomes as specified by NBA are based on the aspects of engineering knowledge, problem solving, design/development of solutions, conduct investigation of complex problems, modern tool usage, engineer and society, environment and sustainability, ethics, individual and team work, communication, project management and finance and lifelong learning.

A.   *Project Course Outcomes*

Four course outcomes for the project work course are formulated based on these program outcomes. They are,

1. identify and define technical problems related to various fields.

2. implement and test the designed stages involved in solving the defined problem statements.

3. work in a team and abide by the norms of professional ethics.

4. gain effective communication and documentation skills along with self learning ability.

B.   *Assessment Process*

The project work offered to the final year students is divided into 2 courses - project phase I and project phase II spread over 2 semesters. A group of 3 to 4 students is allotted one mentor/project guide. The student groups are encouraged to go for industry based and research based project statements along with the in-house project statements. The project statements cover various domains like healthcare, environment, automation, process control, societal aspects. The execution of these projects is promoted keeping in mind the latest trends and need. Each project group is asked to submit an Abstract and the PERT chart for their respective project statement. With the support of these documents, the project statements are finalized based on the a series of discussions with the students, faculty and the external experts if involved. On finalization of the project statement, a final copy of the Abstract and the PERT chart is submitted by the respective project group in consultation with their project guide. Project phase I includes the formulation of the objective, preparation of the timeline, literature survey, paper designing, component selection and component testing. Project phase II involves the implementation of actual design, testing, data analysis and result review. For both the courses, two internal evaluations are carried out which are addressed as first assessment, second assessment, third assessment and fourth assessment respectively. During semester I, the first assessment is done based on the criteria - understanding of the project statement, literature survey and design and percentage completion of the project as per the PERT chart submitted. The second assessment is based on the criteria - design and experimentation results, individual contribution, coordination in a team, documentation maintained and percentage completion of the project as per the PERT chart submitted. The criteria for third assessment in the second semester are - extra features, innovation, individual contribution and percentage completion of the project as per the PERT chart submitted. For the fourth assessment the criteria considered are - objective achieved, team work, effective communication, self learning ability, multidisciplinary approach, documentation. At the end of each course, the assessment is carried out through presentation and oral accompanied by report submission.

C.   *Project Reports*

Each project group submits a comprehensive project report based on the documentation maintained by them and the work done during the two semesters. A specific format is shared with all the project groups for the drafting of the project report. The format includes the following - title page, certificate, sponsorship letter (wherever applicable), acknowledgment, abstract, list of abbreviations, list of figures, list of tables, chapters, references and plagiarism report. The flow of the chapters in the report generally follow the sequence as - introduction, literature survey, system overview, system details, experimentation results, conclusion and future scope. For the literature survey, each group includes overview on a few technical papers published in renowned journals and conferences based on their respective project statement. The reference lists the titles of the various textbooks, manuals, websites and so on refereed for the project work. Each group

includes the similarity percentile report for checking the plagiarism. The similarity percentage allowed is maximum 15%. The faculty supports and encourages the project groups to write technical paper based on their project work.

D.   Attainment Assessment

With the aim to assess the attainment of the Program Outcomes for these 2 courses, the program outcomes are mapped with the course outcomes of these courses. The mapping shows that out of the 12 specified program outcomes, all the program outcomes are attained for these courses. The 3-point Likert scale can be used for the assessment of the program outcomes. A Likert scale is a psychometric scale that employs questionnaires. It is the most widely used approach to scaling responses in research surveys. It is a specific type of rating scale that focuses on a spectrum of range of answers. It can consist of number of rating choices - such as stars or numeric responses. The 3 Point Likert scale is a scale that offers 3 level of options - satisfactory/agree, not satisfactory/disagree and neutral. The survey is done based on the feedback responses received from the students and the assessment done by the faculty, sponsors and the examiners.

Another vital parameter that is taken care of is the competitiveness. It promotes the student to showcase their talent in terms of their project work, test their ideas in comparison to the outside world project statements, get a chance to interact with the industry experts, hone their communication skills and boost their confidence. All the project groups are encouraged to participate in various competitions organized by other higher education institutes and in national and international level competitions like Smart India Hackthon, Robocon, BAJA. As a part of the collaboration with core companies and certain research and medical foundations, project competition is conducted which assists in building a strong industry institute bond. A college level competition of all the projects across all departments is conducted to validate the innovative component in the projects with a view of patent publishing. Such selected projects are supported by the college with the process of patent filing and execution.

E.   Benefits of Project Work

The observations show that most of the program outcomes for these courses are satisfactorily achieved. With the execution of such kind of project work, the multiple facets like problem tackling, time management, understanding importance of professional and moral ethics. communication, documentation and overall coming up with a optimum solution are developed and inculcated in the student. The survey results help in improvising the selection process of the project statements for the further batch of students.

IV.   RESULTS

The mapping of the course outcomes for the project work courses (project phase-I and project phase-II) with the program outcomes is done for each academic year. The level of mapping is specified by numeric values as 1,2 or 3 with 3 being the strongest level of mapping. The tables below (Table I to Table III) show the mapping of the course outcomes with the program outcomes for the AY 2020-21, 2019-20 and 2018-19 respectively.

Table I
CO-PO MAPPING[AY 2020-21]

		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	identify and define technical problems related to various fields	3	3										
CO 2	implement and test the designed stages involved in solving the defined problem statements			3	2	3	2	2					
CO 3	work in a team and abide by the norms of professional ethics								3	3			
CO 4	gain effective communication and documentation skills along with self learning ability										3	3	3

Table II
CO-PO MAPPING[AY 2019-20]

		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	identify and define technical problems related to various fields	3	3										
CO 2	implement and test the designed stages involved in solving the defined problem statements			3		3	2	2					
CO 3	work in a team and abide by the norms of professional ethics								2	2			
CO 4	gain effective communication and documentat										1	1	1

		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	ion skills along with self learning ability												

Table III
CO-PO MAPPING[AY 2018-19]

		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	Identify and define technical problem related to various fields.	3	3										
CO 2	Implement and test the designed stages involved in solving the defined problem statements.			3		2	1			3	2	2	3
CO 3	Work in a team and abide by the norms of professional ethics.		2		3			3					2
CO 4	Prepare and present technical documentati on of the developed system.										3	3	3

Fig. 1 shows the graphical representation of the CO-PO mapping for the AY 2020-21, 2019-20 and 2018-19 resp.

(a)

(b)

(c)

Fig.1. CO-PO Mapping

Table IV shows the distribution of the projects for the AY 2020-21, 2019-20 and 2018-19 based on the three categories - in-house, industry sponsored and research based. Fig. 2 shows the corresponding distribution in graphical form.

Table IV
PROJECT CATEGORY DISTRIBUTION

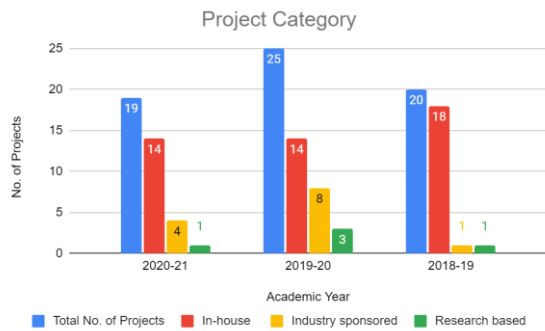| Academi c Year	Total No. of Project s	In-house	In-hous e	Industry sponsore d	Industry sponsore d	Researc h based	Researc h based
		No. of project s	%	No. of projects	%	No. of projects	%
2020-21	19	14	73.6 4	4	21.04	1	5.26
2019-20	25	14	56	8	32	3	12
2018-19	20	18	90	1	5	1	5

59

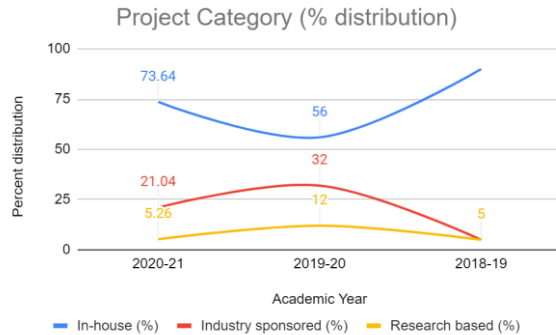Fig. 2. Distribution of Projects

Fig. 3. Percentile Distribution of Projects

The percentile distribution of the projects into the 3 categories is indicated in Fig. 3.

On completion of the project work, a survey is conducted for the project course. A project review questionnaire is formed and responses are taken from students. The assessment executed by the faculty, sponsors and examiners helps in understanding the performance of the projects. The survey questions are as listed below in Table V.
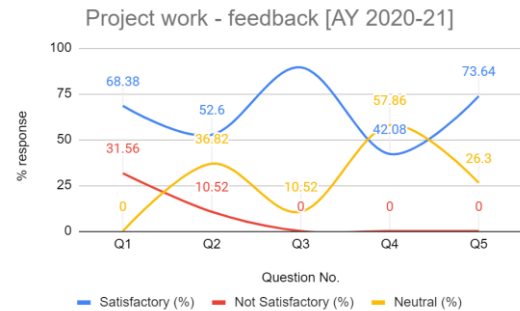
Table V
SURVEY QUESTIONNAIRE

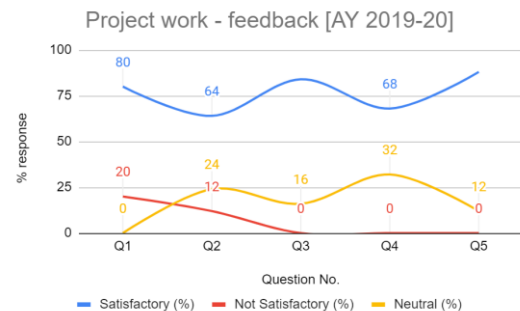| Question No.	Question
Q1	How was the process of identification and management of risk factors?
Q2	Level of accuracy with respect to the time estimations for the predefined deliverables?
Q3	Level of achieving the project's outputs/deliverables?
Q4	How was the level of usage of best possible technical tools or processes?
Q5	Experience regarding team work and harmony amongst team members

The responses are taken based on the 3-point Likert scale as Satisfactory or Not satisfactory or Neutral. Table VI shows the survey results for the three academic years of AY 2020-21, 2019-20 and 2018-19. Fig. 4 indicates the percentile response of the survey results.
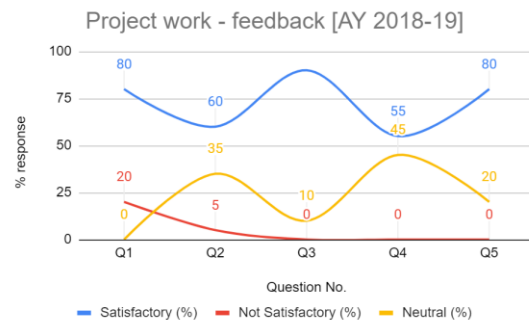
Table VI
STUDENT SURVEY DATA

Question No.	AY 2020-21 [Total Projects - 19]			AY 2019-20 [Total Projects - 25]			AY 2018-19 [Total Projects - 20]		
	Satisfactory	Not Satisfactory	Neutral	Satisfactory	Not Satisfactory	Neutral	Satisfactory	Not Satisfactory	Neutral
Q1	13	6	0	20	5	0	16	4	0
Q2	10	2	7	16	3	6	12	1	7
Q3	17	0	2	21	0	4	18	0	2
Q4	8	0	11	17	0	8	11	0	9
Q5	14	0	5	22	0	3	16	0	4

(a)

(b)

(c)

Fig. 4. Project work survey - students

V.   DISCUSSION

From the tabular data (Table I) and its graphical representation (Fig. 1) it can be seen that all the program outcomes are fairly mapped with the course outcomes. The level of mapping for certain program outcomes has improved over the academic years. Due to the pandemic situation, a slight slack is observed in the level of mapping for the academic year 2019-20.

The project statements are categorized as - in-house, industry sponsored or research based. The distribution of the projects based on these three categories is shown in Fig. 2 and Fig. 3. The in-house project statements are provided by the college faculty of various departments. These are based on certain parameters - for instance the laboratory set-up requirement of certain departments. The industry sponsored and research oriented project statements provide additional assistance in the mapping of the program outcomes from PO6 and upwards. These two project categories help the students to get a first hand understanding and experience of the work culture in industry and the research domain. The projects in the research domain are procured from various research institutes and government organizations which also deal with certain societal cause and need. A significant rise can be seen in the number of industry sponsored projects from academic year 2018-19 to 2019-20. Due to the pandemic situation the number of industry sponsored projects has slightly dropped for the academic year 2020-21.

The feedback taken from the students based on a questionnaire helps understand the confidence level of the students as well as the performance index of the project groups. The internal and external assessment carried out in the form of internal assessments, presentations and oral examination acts as a source of analysis on the multi facet growth of the students. The selection of the various criteria for the four internal assessments is done considering the program outcomes and the course outcomes. The various types of survey and their analysis indicate that nearly all the NBA specified program outcomes are mapped. Majority of the projects receive accolades by participating in various competitions at national and international level. A handful of the project statements are taken ahead by the students as a start-up. The initial support for setting up their start-up is provided by the college.

Few case studies will be discussed here for realization of the holistic development of the student through the Project based learning approach.

In the four year degree course, the students in the first three years complete various core courses associated with lab sessions, learn few programming languages and deal with Audit courses that handle concepts of self expression and stress relief sessions based on recreative non-technical topics like dance, music, drawing, yoga and so on. The students are offered programme elective courses and open elective courses based on specific verticals related to key domains like Automation, Healthcare, Industry 4.0, Nanotechnology and Smart sensing. All these multidimensional courses benefit the students in proper selection and better execution of the project statement.

A.   Case Study

Case Study 1: The project titled 'Design and Development of Smart Shoe' was executed by a group of four students. The idea was suggested and supported by a Research Scientist from a renowned Research Institute. The group started with a literature survey where they had a comparative study of the available smart shoe brands in the market. Various technical papers were referred to understand and realize the work being carried out related to smart shoe technology. Based on this survey, the sensing parameters were finalized and further work was initiated. This group completed the breadboard design as per the decided timeline and participated in the Smart India Hackathon competition at National level. Smart shoe project was done under the health and care discipline. There were three stages in the whole process. The first stage involved submission of ideas, the second stage included presentation of a prototype. The prototype submitted by this project group got selected among 6000 other prototypes. The third and final round was conducted at various locations in India. This group was allotted the Chennai location. The third round was executed for a week, where mentors were allotted for each group and all the groups worked on the final model. In the final round this team was listed in the top 10 teams. It was an extremely knowledgeable experience for the group and they got a chance to interact with stalwarts in the field of innovation and research. This group participated in the Kedar Tumne Innovative Project competition held by the college in which they bagged the first prize among the 22 participating teams. This group received the first award in the project competition organized by the Pathirakha Foundation in collaboration with the Instrumentation and Control department of the college. All these facets greatly helped the students of this project group in learning process with knowledge updation and refinement of concepts, resulting in a gradual expertise in the area of smart sensing and control. The students also realize the importance of the skills they possess and evaluate their viability based on their actual work assignment.

Case Study 2: The project titled 'Water Pollution treatment using Machine learning' was executed by a group of four students. The idea was suggested and supported by a Research Scientist from a renowned Research Institute. The group started with a literature survey where they had a comparative study of the available water treatment solutions in the market. Various technical papers were referred to understand and realize the work being carried out related to water pollution analysis. Based on this survey, the platform and the technology were finalized and further work was initiated. This project group participated in the Natarajan Education Society's Innovative Project Competition in which they bagged the first prize with a cash prize of fifty thousand and certificate. Two of the group members took this project idea into a start-up 'Aivara Solution'. As a start-up they received grants from Nidhi Prayas EIR scheme and Bhau Foundation. The performance of this project group clearly indicates the holistic development of the students with the help of the Project based learning technique.

VI.   CONCLUSION

The study of the mapping of the course outcomes with the program outcomes shows that with all the program outcomes covered by the specified course outcomes, the comprehensive growth of the student can be nurtured. The category of the project statement relates to certain program outcome/s which helps with the overall development of the student. The analysis

of the survey taken from the students strongly indicates the impact of project based learning on the overall growth of the student. The feedback received from the faculty, sponsors and examiners through the various internal assessments and oral examinations, provides guidelines for the project statement selection process which is associated with the mapping of the program outcomes and to the universal evolution of the student. Involving the students into patent filing and technical paper writing develops the innovative outlook and documentation skills in the students. Project based learning helps sharpens the life skills like creativity, in-depth understanding, self confidence, problem tackling, critical thinking, perseverance, project management, empowerment and curiosity of the student. Overall project based learning positively supports the holistic development of the student.

REFERENCES

1. Ah Jamal , O Tilchin (2017) Development Of Student Accountability In A Project-Based Learning Environment, Academia.Edu.
2. B. Sai Soujanya Kumari (2019) Developing student teacher relationships for holistic development of the student.
3. A. D. Patange, A. K. Bewoor, S. P. Deshmukh, S. S. Mulik, S. S. Pardeshi, R. Jegadeeshwaran (2019), Improving Outcome Attainments Using Project Based Learning approach for: UG Course – Mechatronics, Journal of Engineering Education Program Transformations, 33(1), 1-8
4. Ol Osadchuk, Ev Lopanova (2020) Development Of Students' Information Skills During Project-Based Learning, Journal Of Physics
5. P.S. Kaladevi (2020) Holistic Development Of Education, International Journal Of Advanced Research And Emerging Trends
6. Thuy Diem Thi Thu (2018) Using Project-Based Learning Technique To Enhance Students' writing Skills, KATE International conference: locally appropriate language pedagogy in the Post-method Era
7. Yi Salihu (2019) Relative Effects Of Problem And Project-Based Learning Techniques On Student's Academic Achievement In Building Technology, Asia Proceedings Of Social Sciences

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