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Issues and Challenges of Implementing Project Based Learning in Engineering Courses: Student and Faculty Perspective

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Abstract - Project Based Learning (PBL) is a concept adopted in higher education that is focused on the mode of learning by implementing projects using the concepts studied during a course. This model is now extended even to middle schools. This paper is a case study on the implementation of PBL in the engineering course. PBL implementation has several issues to be considered before offering it to the students. The issues are more related to the faculty and the institution. A survey was carried out among the students and faculty to know the effectiveness of PBL implementation. A set of questions were asked to the students to know the technical and non-technical advantages and limitations of the PBL. Descriptive questions are used to know the general opinion of the students and faculty about PBL. Various observations are made based on the outcome of the survey. As the overall outcome of the survey, the faculty and students are of the opinion that the PBL will enhance the learning outcome of the course, provided sufficient time and resources are available to implement the project and the faculty can guide the students with regular monitoring of the project's progress. Faculty competency in handling the concepts practically, and availability of time and resources are of concern. Both faculty and students felt that PBL must be practiced in the engineering curriculum to enhance the skills of the student.

Keywords: Engineering education; Internet of Things; Project based learning

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1. Introduction

NMAM Institute of Technology, Nitte is an autonomous institution affiliated with VTU, Belagavi, India. Being an autonomous institution, the institute has the flexibility to update the courses based on the needs of the stakeholders. The institute is affiliated with Nitte Deemed to be University from the academic year 2022-23.

Cooperative learning, creativity, communication, teamwork, self-learning, decision making, and the use of modern tools are the skills of the 21st century. Project Based Learning (PBL) is a teaching method in which students learn by actively engaging in real-world and meaningful projects. The PBL concept was introduced in the computer science and Information Science courses in 2018 under selected theory courses. The laboratory courses were having a project component even before. A few practices to be

followed while mentoring a project, for being called Project Based Learning include teamwork. The teams are to be mentored by a faculty with regular interactions and team meetings. Teams must present the work to faculty and faculty can suggest changes and monitor the progress of the work. Evaluation can also be done during this process.

As per the PBL concepts, students select a problem and work on the project over an extended period – from a week up to a semester – that engages them in solving a real-world problem or answering a complex question. They demonstrate their knowledge and skills by creating a public product or presentation for a real audience.

Implementing the PBL is a challenging task for educators and students. The mode of teaching with a shift from the classroom to the real world most certainly does not mean that teachers do not "teach" in a PBL classroom. Learning by doing will open various challenges of investing more time and studying beyond the prescribed syllabus. As a result, students develop deep content knowledge as well as critical thinking, collaboration, creativity, and communication skills. Project Based Learning unleashes a contagious, creative energy among students and teachers.

2. Literature Survey

The implementation of PBL has several challenges. In the paper titled, Project-based Learning (PBL): Issues faced by Faculty for its effective implementation [1], the authors have discussed the major challenges of Indian engineering education. In the Indian scenario, industries need engineers who can be immediately put to work after they are recruited. This needs more expertise in hands-on experiments along with theoretical knowledge. It is mentioned that the six core characteristics of PBL are

(i) Learning needs to be student-centered.

(ii) Learning has to occur in small student groups under the guidance of a teacher.

(iii) The teacher acts as a facilitator or guide.

(iv) The learning starts with a genuine problem.

(v) The problem is used as a base to achieve the required knowledge and problem-solving skills.

(vi) Self-directed learning is used for the acquisition of new information.

In the paper [1], a survey was carried out among the faculty of the Mechanical Engineering department of the Institution. The questionnaire had 14 questions. A Google form was prepared, and the questionnaire was emailed to 45 faculty members of the department. After a reminder email was sent to the faculty, 15 responses were received, which is 33.33 %. The questionnaire included the name of the faculty and the responses to 13 questions. The paper discusses the responses received from this survey. Faculty members had made an initial attempt to implement the PBL, but the number of faculty involved is very small. Most of the questions were descriptive and no quantitative results are given. Detailed explanations were given about the questions asked in the survey. 13 guidelines are given for the effective implementation of the PBL. In conclusion, PBL will increase the learning of the student but increases the workload and involvement of the faculty.

In the paper titled Project-Based Learning: Implementation & Challenges [2], the author has discussed an attempt to adopt PBL as a method of teaching in Bahraini Primary Schools. A study is made in this to discuss the challenges faced by the teachers. Some of these challenges are even applicable to technical education. Using PBL often takes more time than other methods of teaching which may delay the processes of presenting and covering the lessons scheduled. The faculty must decide whether the PBL is related to a specific chapter or the whole syllabus. In technical education, it shall be related to the whole syllabus. When the number of students is more, monitoring their progress during the process of the project was hard. Aligning the curriculum to the PBL and ensuring the involvement of all the team members in the work are essential components and apply to technical education as well.

In the paper titled, Project-based learning (PBL) in practice: active teachers' views of its' advantages and challenges [3], the authors have made an e-survey with some open questions in the context of teachers' reports of PBL in an international StarT program. Teachers from early childhood to secondary level participated voluntarily in this study. According to the paper, common barriers to implementing PBL effectively include teachers' resistance to student-driven learning because they often see this as giving up control of the class. Most of the teachers accepted

that an increase in learning level is the major advantage of PBL. Teachers valued collaboration and a sense of community generated by PBL. The paper also lists the comments given by the teachers in support of this. Time management is the major challenge as mentioned by the teachers. Technical and other issues of team management are other challenges.

The paper titled Project-based learning: A review of the literature [4] has an extensive survey about the implementation of PBL at various levels of education. Pre-school, Primary Schools, and Secondary schools are considered at the first level for the discussion. The implementation of PBL at higher education institutions is also discussed in the paper. It was mentioned that most of the PBLs are in engineering education. The level of support that teachers get from the school's senior management and other colleagues is of particular importance. Seven major guidelines that enable the effective implementation of PBL are discussed in this paper. The items listed in this paper are in line with other literature. Six different recommendations are made based on the observations from the literature.

In the paper titled Doing through Project Based Active Learning Technique [5] the authors have adopted the PBL active learning technique to deliver sensors and transducer unit of Electronics Measurement and Instrumentation course in second year B Tech class of Electronics and Telecommunication engineering. Group was formed with 4 students in a group. Marks were the criteria to make the groups. It was claimed that this practice will help slow learners improve their skills. The activity was for two months. The degree of learnability was analyzed after the course using a questionary. An increase in the attainment of Course Outcome (CO) was observed after implementing the PBL, in comparison with the previous year. It was concluded that PBL prompts students to collaborate while at the same time supporting self-directed learning leading to an increase in technical and soft skills. Students experienced self-directed learning and felt the teacher was a problem-solving colleague.

The PBL implementation was divided into 3 stages in the paper titled Implementation of project based learning in mechanical engineering education to enhance students' interest and enthusiasm [6]. The stages are Pre-project activity, Project activity, and Post Project evaluation and feedback analysis. As a conclusion of the feedback received from the students, they strongly agreed that the mini project helped them in learning the course content and was also of the opinion that the technique was better compared to classroom teaching. The statistical analysis for improvement in test marks was also performed and it was observed that the marks are improved. This was indicated with a graph in the paper.

The mapping of the project outcomes to the project work carried out by the students in the final year was discussed in the paper titled Project-Based Learning Technique for Holistic Development of Students [7]. Four course outcomes for the project work course are formulated based on these program outcomes. The project work was carried out in stages and the evaluations are carried out by the experts as per the rubrics defined. Each team will submit a report after the completion of the project as per the format given. The 3-point Likert scale can be used for the assessment of the program outcomes. The observations show that most of the program outcomes for these courses are satisfactorily achieved. From the results, it is observed that all the program outcomes are fairly mapped with the course outcomes. In the conclusion of the paper, it is stated that project-based learning positively supports the holistic development of the student.

In the paper titled Project Based Learning Approach in Digital Signal Processing Course for Increasing Learners' Cognitive and Behavioral Engagement to Promote Self-Learning [8] PBL was introduced in the signal processing courses to work on real-world signals such as speech, audio, music, ECG, EEG, and image and thereby associate with real-life signal processing applications. The project work was divided into three phases of one month each. A list of tasks to be achieved in each month is listed. A course instructor teaches the prerequisites and mentors student groups throughout the project execution phase. Frameworks for the assessment of the work are listed and aligned with the course outcomes. Rubrics are set for the evaluation of the work. The selected rubrics are listed in this paper. After the completion of PBL projects student feedback on their learning experiences is collected. The feedback questions are mapped to the Program Outcomes (POs). It was observed that due to the use of PBL, the level of PO achievement was high. It is concluded that this PBL activity stimulates critical thinking and higher-order cognitive level thinking and promotes self-learning.

It was mentioned in the paper titled Effective

Assessment Strategies for Project-Based Learning [9] that the KLE technological university offered an innovative course titled "Engineering Exploration," taught and co-designed by multidisciplinary faculty. The objective of this course was to achieve interdisciplinary engineering, teamwork, problem-solving, and engineering design process. Students are made to work on the project work in the steps of need statement, problem definition, generating concept, product architecture, selecting concept, virtual prototyping, and physical prototyping. Assessment strategies include Diagnostic assessments, formative assessments, and summative assessments. Diagnostic assessment occurs before the instruction, formative assessment occurs during the instruction, at the end of the activity, or a particular instance summative assessment helps to predict and judge the students' performance. The hybrid assessment approach is applied to all the modules of the engineering exploration course where PBL pedagogy has been used. Various aspects used in the hybrid assessment model are diagrammatically represented in the paper. The effectiveness of this assessment model is evaluated in the paper. It is concluded that the process of implementing PROBE activity before class can help faculty in understanding students' level of the content to be delivered.

3. Project-based Learning Implementation In Engineering Courses

At NMAM Institute of Technology, Nitte, the concept Project Based Learning was implemented through the assignment of mini projects in the curriculum. The concept of mini projects was included in some elective courses like Web programming, the Internet of Things, Big data, Cloud Computing, Machine learning, Database management systems, and Computer Graphics, in computer science and information science engineering courses. These courses are spread over the 5th, 6th, and 7th semesters.

For the evaluation, the project work was given 40% weightage in total marks. The faculty will deliver lectures related to the concepts. After the completion of almost 50% of the theory course, students were informed to start with the project work. Students were given the option to make teams as per their choice. Students are given the option to select the project of their choice. The project should be related to the theme of the course. Students were encouraged to select project topics from the real world or research articles. The projects aiming to address and solve the problem around the locality of the institution were given preference.

Issues and challenges

The engineering curriculum is understood better when implemented practically. PBL is a practice that will create a practical understanding of the concepts studied under various courses of the engineering curriculum. While implementing the PBL concepts, the following issues are to be considered and the challenges are to be addressed.

- It should be possible for the students to relate the course contents to real word problems without much effort. The topics should be compatible to implement the PBL.
- Students should not be overloaded with several PBL projects during the course.
- There should be sufficient time in the academic calendar for practicing the PBL, else the course contents should be adjusted to accommodate the PBL.
- ·Faculty should have a clear understanding of the PBL and the possibility of applying the PBL to the course.
- Institute should have the infrastructure support for implementing the PBL.
- The topics selected and a team formed by the students are to be reviewed by the faculty and it should support the smooth implementation of the project.

4. Case Studies

A. Introduction

As a case study for the implementation of PBL, the Internet of Things (IoT) course is taken as an example. The course was offered as an elective for the 6th-semester students of the Computer Science and Engineering (CSE) branch. 27 students opted for this course. The course was taught online mode during the lockdown due to the Covid-19 pandemic. The change in the mode of teaching did not impact the implementation of PBL, as the teams were able to collaborate and work on the coding and design of the

project. The course deals with the theory and practice of using IoT concepts to apply real-world problems. The course contents include an introduction to the hardware sensors, board structures of Arduino and Raspberry Pi, programming the Arduino board, and basics of Python libraries for Raspberry Pi. These programs are studied using simple experiments using sensors during classroom teaching. During the course, students are expected to implement a mini-project that covers the concepts that are discussed in the course.

PBL was applied in this course, by giving more emphasis to the project to be implemented. Theory concepts were studied based on the projects to be implemented. The steps involved in the IoT project implementation phase are listed below [10].

- Purpose & Requirements Specification
- Process Specification
- Domain Model Specification
- Information Model Specification
- Service Specifications
- IoT Level Specification
- Functional View Specification
- Operational View Specification
- Device & Component Integration
- Application Development

B. Methodology

1) Forming the groups

It was decided to have the student groups as per their choice and students were given the option to either select their problem statement or select the ones given by the faculty. Out of nine groups, two groups selected the problem statement given by the faculty. Others selected their problem by referring to various sources.

2) Selection of the topic

The teams were asked to prepare a one-page write-up that included the purpose & requirements specification, a list of components required, and a mention of the possible applications of the projects. This write-up was submitted to the faculty during the first team meeting. The team discussed with the faculty their plan based on the technical feasibility and applications of the project. The faculty would give his input, and the team decides on the modifications required in the idea.

3) Working with the concepts

Once the topic was decided, the student team will prepare the document with the model, service, level, and functional specifications. To prepare the document, the team had to apply the concepts studied to the problem selected. A detailed study was carried out by the team on the technical and implementation aspects of the selected problem. To specify the service model, the team is required to have a clear idea of the working of the final system and the services that are to be provided by the product. A few samples of existing projects of a similar type are to be studied and general knowledge was to be applied while preparing the document. One to two weeks were given for preparing the document. Teams had a meeting with the faculty to fine-tune the document. Faculty also needed to have a clear idea of the design and working of the product that is proposed in the project. A study may also be done by the faculty for this purpose. There may be more than one meeting with the student teams during the preparation of this document.

4) Design of the Project

In this stage, the student teams would design the circuit diagram, sequence diagram, and use case diagram based on the project. A draft of the user interface was also designed. The circuit diagram was drawn based on the knowledge of the sensors and the board that was studied during the IoT course. The designed documents were presented to the faculty during the team meeting and issues were discussed. Once the design was approved by the faculty, the student team proceeded with the implementation of the project. Faculty were expected to check for the correctness of the design and clarify the issue if any with the student members. Faculty needed to ensure that the steps mentioned above were covered till all the specifications were mentioned by now.

5) Implementation

This is the device component integration and

application development phase. The teams developed the project using the sensors and board based on the requirement specified. Suitable programming languages, either Arduino or Python, were used based on the project. A web-based user interface may also be developed based on the requirement that is specified and documented in the previous steps. Once the implementation was completed, the project was demonstrated to the faculty. A report was prepared by the team and submitted to the faculty. Faculty assisted the team during the implementation process if there were any issues that the teams were not able to resolve.

5. Results and Discussion

A survey was carried out to find out the effectiveness of the PBL implementation. The survey was conducted among 550 students in the 3rd and 4th years of the 4-year engineering course. Separate google forms were used for students (https://forms.gle/jLyJiS5n6oiBn4hk6) and faculty (https://forms.gle/iQeYNu6hLCumMMyY7). The students were from the computer science and information science departments. 407 students responded to the request and participated in the survey. 30 faculties from computer science and information science participated in the survey. These were the faculty who handled the courses that had a project component associated with it.

The questions were prepared to cover all aspects of PBL. The questions used in [1] are taken as references. Aspects of teaching, self-learning, time management, team formation, selection of problems, the facility given by the college, and technical challenges were considered as the basis for framing the questions. A separate set of questions was framed for the faculty. Aspects like teaching load, issues of handling multiple projects, faculty involvement in the work, and additional skills expected were considered as the basis for framing the questions for the faculty.

A. Students' perspective

Students of the Computer Science and Information Science engineering branches were invited to fill out the questionnaire. The questionnaire had 24 questions. In these, two questions were descriptive. The first one was to know the challenges faced by students during the implementation of the project and the other question was to write their opinion about the PBL concept. The results obtained from the survey and the inference drawn from the result are discussed in this section.

- Project-based learning is not a new teaching approach, mini project has been a part of the course for several years. But a methodical way of handling the project will lead to PBL. 361 students out of 407 were aware of the PBL concept. Only 46 students were not aware of this term as shown in Fig. 1.

- Working on a project is an interesting part of studying for many students. 395 students have indicated that they like to work on projects as a part of the course. Fig 2 shows the proportion of students showing interest in project-based learning.

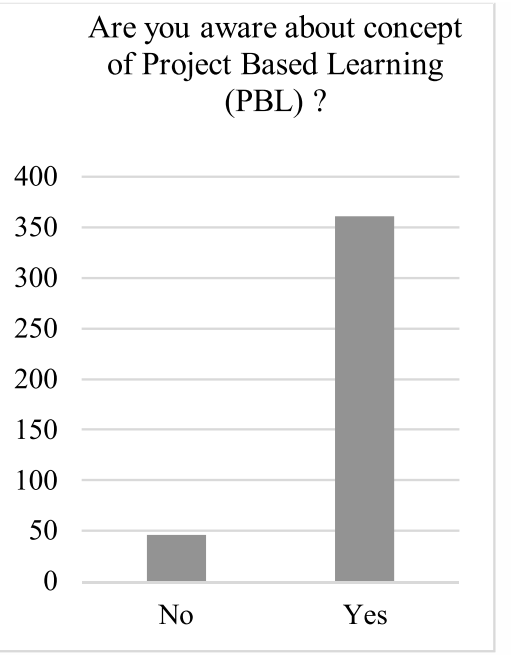

Fig. 1 : Awareness and linking for the PBL concepts.

- Students will select the problem from various sources. Faculty will suggest the domains on which the problems can be chosen from. A faculty may also suggest problem statements for the student teams. Most of the students selected the problems from internet sources. A considerable proportion of students had tried to address real-world problems. The problems were also chosen based on the peer discussion among the team members. It was observed that at times, the final problem selected was a combination of internet sources, the real world, and peer discussion. The problem related to the real world

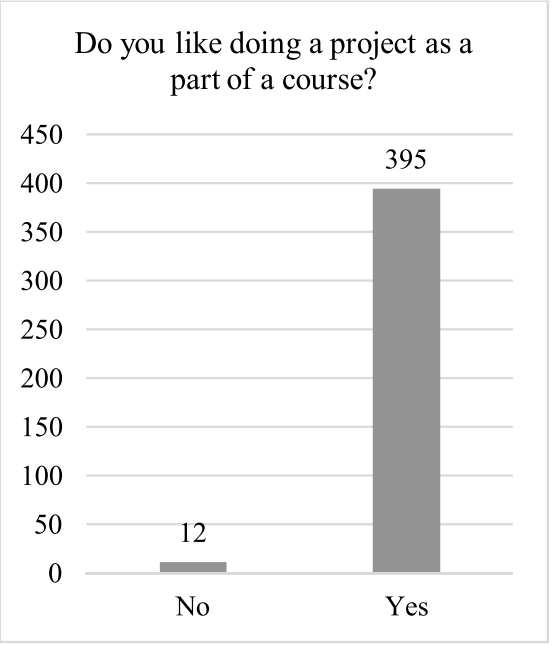

Fig. 2: Awareness and liking for the PBL concepts.

was searched on the internet and fine-tuned by peer discussion. The distribution of opinion is shown in Fig 3.

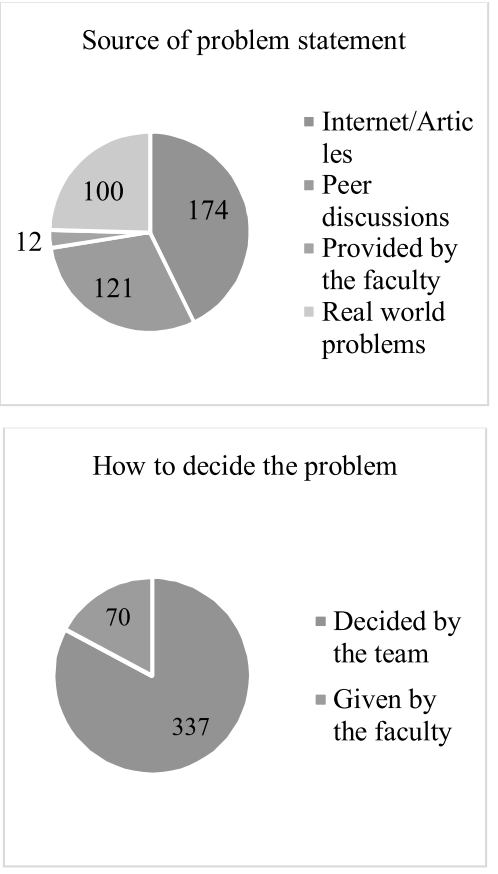

Fig 3 : Methods of selecting problem statement

- Around 400 students out of 407 agreed that doing a project will improve the understanding level of the student. In a group of students, the understanding level of each student is different. But each student agreed that his/her level will improve if he/she involves in the project work. All these 400 students accepted that there is a need to study beyond the preferred syllabus to complete the project. This will introduce the student to the habit of learning topics that are beyond the scope of teaching in the classroom. This habit will help the student in their workplace, as they must be involved in diverse types of projects, and this expects continuous learning.

- There is a mixed opinion about the number of members in a team as shown in Fig 4. 35.8% of students think that 3 is the ideal number. A considerable number of students (29.7% and 29.1%) have selected the number of members in the team as 2 or 4. Few have chosen 5 and 6. Ideally, it is recommended that 3-4 members in a team result in good teamwork. This also enables the students to share the workload and the implementation modules.

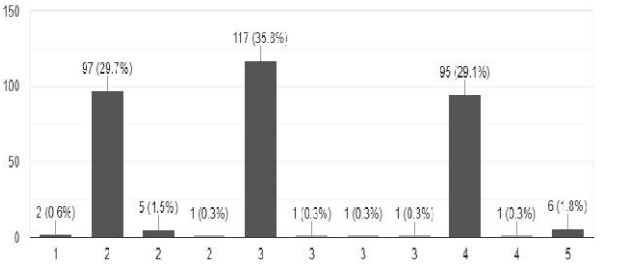

Fig 4. Expected number of students in a team

- The institution has the binding to provide the necessary infrastructure required for the students to execute the project. The students also have a responsibility to select a project where the requirements for resources are within acceptable limits. 306 students were happy with the resources provided by the institution for carrying out the project work.

- Majority of the students agreed that the project helped them to understand the concepts better. Fig. 5 shows the number of students who had given various ratings in the range of 0-4, 0 being poor and 4 being excellent. 60% of the students have marked level 3 and 30% have marked level 4.

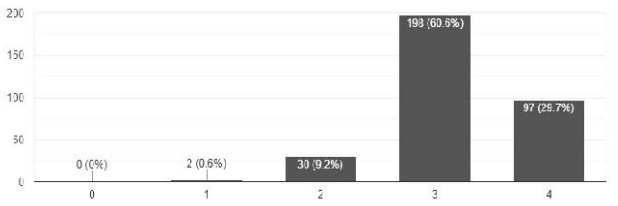

Fig. 5 : Level of understanding through PBL

- Based on the experience of understating the projects 362 students would like to have the projects for the courses even in the coming semesters. This indicates that the concept of PBL is successful in the engineering course of computer science and information science-related streams. Fig. 6 shows the proportion of students liking the adoption of PBL.

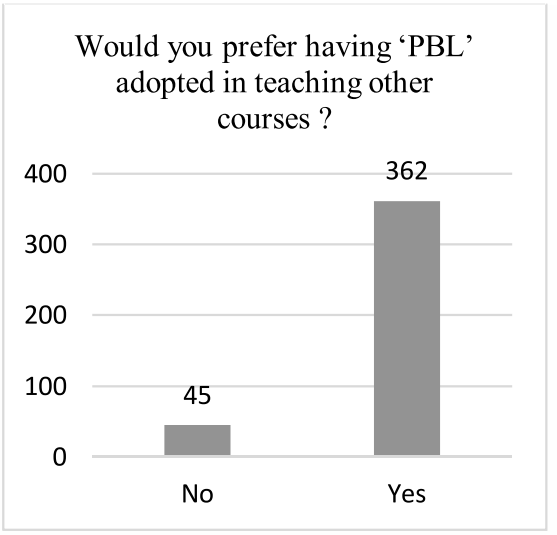

Fig 6 : Adopting PBL in other courses

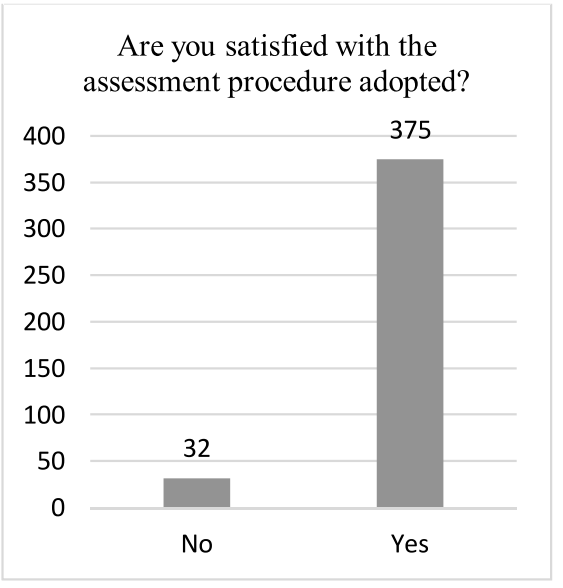

Fig 7: Acceptance of the evaluation procedure

- The students agreed that the procedure and rubrics followed by the faculty to evaluate the project are acceptable. 375 students were satisfied with the assessment procedure followed by the faculty. The proportion is shown in Fig. 7. This indicates that the same rubrics can be used even in the future for evaluation of the PBL.

- A student will spend 3-4 hours per week in the classroom, as discussed, the students need to study beyond the curriculum for the PBL. The number of hours spent by a student per week is within 5-20 hours. Fig. 8 shows the number of hours spent by a student per week. It can be observed that the points are accumulated in the range of 5-20 hours, indicating the majority of the students have worked in this range.

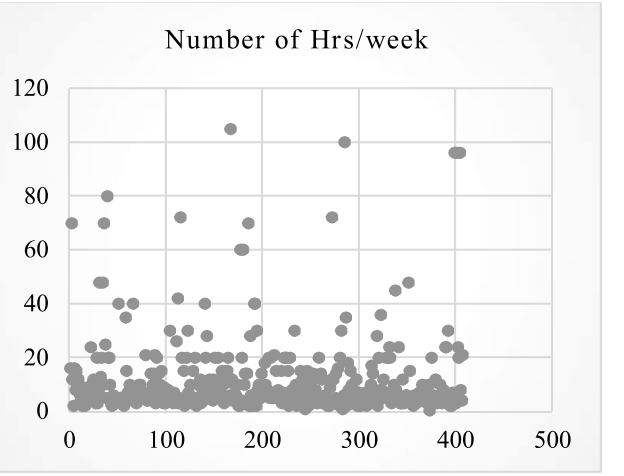

Fig. 8 : Amount of time spent by the students on the project.

- Amount of time spent by the faculty in a team meeting is mentioned by the faculty and by the students during the survey. 350 students accepted that the time spent by the faculty in the team meetings was adequate. Most of the faculty and students had informed that the 2- 4 team meetings were arranged by the faculty during the course of the project. 355 students indicated that this is an adequate number of meetings. 370 students indicated their happiness about the inputs given by the faculty during the meeting. All these aspects are visualized as graphs in Fig. 9, Fig. 10, and Fig. 11. In these graphs X-axis indicates the number of students.

- It is always a good practice to work in a team and it is supposed to give a better outcome than working alone. 375 students have agreed that they enjoy

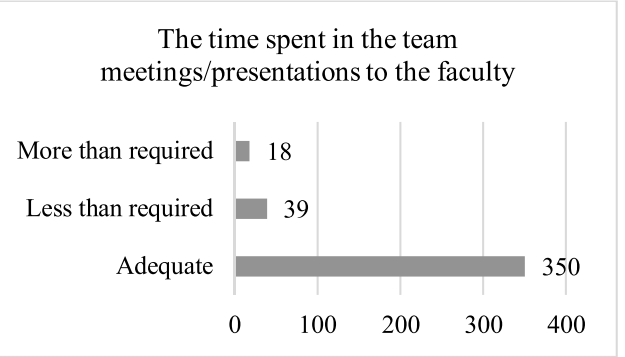

Fig 9: Duration of faculty interaction with students.

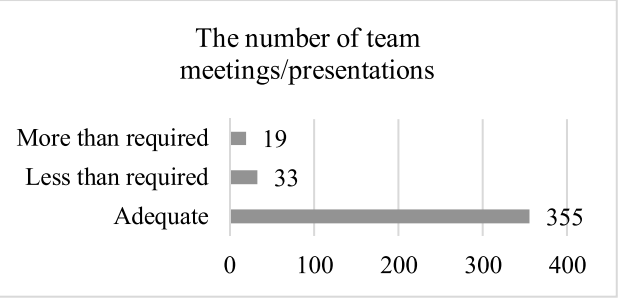

Fig 10: The number of team meetings.

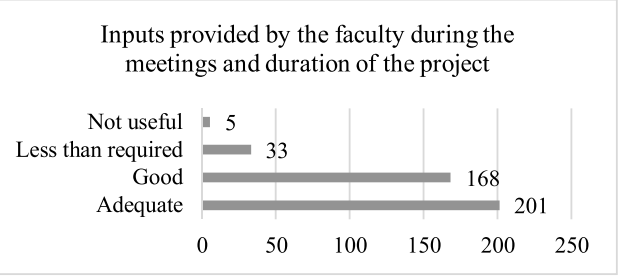

Fig 11: Opinion about team meetings.

working in a team more than working alone. Working on a team will improve team building and managerial skills in addition to technical and communication skills.

- As a conclusion to this, the students agreed that the PBL has improved their knowledge, and skills. They also had the opinion that PBL will help in their placements as it has improved their problem-solving skills.

From the survey carried out, it can be observed that the institution has implemented the PBL concept at a satisfactory level. Students have given a good response to this approach, and they appreciate having 2 or 3 courses in a semester that has the PBL concept in it.

B. Faculty perspective

Ten questions were used for feedback from the faculty. Most of the questions have the answers as - yes/no.

The following are the inferences drawn from the questionnaire given to the faculty.

- All the faculties were aware of the PBL concepts.

- All faculty agree that the PBL will help in enhancing the knowledge of students. During the student survey, students also accepted that they had to study beyond the syllabus for carrying out the project work. Faculty were happy to adopt the PBL concepts even in the future when they are handling a course that has provision to apply the PBL.

- Fig. 12 shows the opinion of the faculty on the method followed by the students to select the problem statement. Sixteen out of thirty faculty felt that the internet is the source for the students to select the problem statement. The faculty also gave the option to select the problem proposed by the faculty, but the students would not select these problem statements.

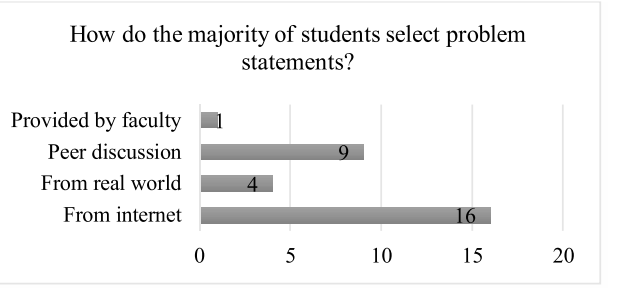

Fig 12: Selection of problem statement

- Majority of the faculty spent 2-4 hours per week with the team working on the project. The distribution is as shown in Fig. 13. Some outlier values may be ignored as exceptional cases. Spending more hours with the team is not feasible for the faculty as there are several teams. The course will have 40-60 students and the team will be usually 2 or 3 members per team. The number of teams in each course will vary from 10-30. The time spent by the faculty depends on the number of students and teams in the course.

- Spending some extra time is expected from the faculty to implement the PBL in the course. 22 out

of 30 faculty agreed that having a PBL would increase the workload of the faculty. Faculty needed to spend time in team discussions, study the problem domain and think about the suitability of the proposed solution. Evaluating the projects based on all these criteria is the responsibility of the faculty. These actions seek some investment of time. As per the mentions in the literature, faculty needed to be suitably rewarded for the effective implementation of the PBL concept. The institution should extend all support for the faculty during the implementation process and then the effort needs to be recognized suitably. As per Fig. 13, most of the faculty are spending less than 5 hours with the student teams per week.

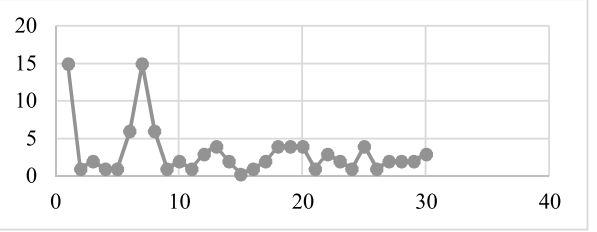

Fig. 13 : Duration of faculty interaction with the student teams

- PBL is a continuous learning process. Faculties are accepting the fact that introducing PBL would improve the knowledge of the faculty and inculcates critical thinking among the students.

- PBL gives more freedom for the students to think and apply the concepts to solve real problems. 23 out of 30 faculty believed that the students should select the problem of their choice. The problem thus selected should be related to the concepts discussed in the course syllabus. 7 faculty believed that the faculty should provide the problem statement. This will help in forming a problem statement of a similar complexity level. But brings an overhead of thinking for a problem from the faculty end.

Applicability of the project, Problem type, Objective, Problem statement, Mathematical model, Methodology, Correctness of the design, Technique used, Presentation with results, Outcome of the project, Novelty in the solution, and Complexity in the coding are the criteria used for evaluating the project. The faculty defined 5-6 evaluation parameters for every course, and the same was informed to the students. The evaluation was done in every team meeting and the average of the performance was considered the final mark.

In the students' feedback, students agreed that the evaluation method followed by the faculty was correct and acceptable. Even though the project is group work, students preferred to have the evaluation on an individual basis.

C. Implementation Challenges

Faculty and students have mentioned the challenges faced by them in executing the PBL concept. These challenges are discussed in this section.

a. Student's Perspective

- Initiating the project work was a challenge for the students. Where to begin with, was the issue for the students? Faculty had to list out the tasks to be carried out in the project, every week. These sequences will lead to the correct process of project implementation. Students are not well organized in the project planning and scheduling of the tasks.

- Managing the resources is a challenge for the teams. The resources include devices, storage, processing, internet, etc. Due to various limitations, students may not own the devices. Some devices required might not be available in the institution. Doing teamwork during lockdown due to the Covid-19 pandemic, was a challenge for the teams due to a lack of physical communication. Online communication was not effective.

- Collecting the required information is very important for building a project. Students found difficulties to get the right information on the internet based on their needs. Several attempts were required to come up with a successful code. The amount of study to be done beyond the syllabus varied based on the need of the problem. The additional learning requires an investment of time. Better planning and teamwork were expected for the timely completion of the work. Students believed that they had these issues as challenges. Faculty needed to intervene in this, and teams need to be guided to work better.

- Project planning was of major concern. This involved the time to be spent on study, estimation of the resources available with the institution or students, and division of work among the team members. Faculty might need to guide the teams here by indicating the exact topics to be studied as

per the requirement of the project, revision the design based on the available resources, and assisting in the division of work.

- Number of projects in a semester had to be decided by the department. Students expressed that, having 3 to 4 project works in a semester was creating a load on the students and they were not able to give equal importance to all projects. They were finding technical problems in some projects, that needed more time to fix. Due to this, other projects suffer.

- Challenges in team formation - In some cases, teams lack communication and understanding between team members. This even happens when the team consists of slow and fast learners. Some students raised the issue of non-cooperation by the team members. This could be resolved by the faculty by constantly monitoring the work of individual team members and during team meetings.

- Following are some of the statements by the students.

  - "Usually, we select a topic that is related to real-world or ongoing problems. We faced issues like less information on the internet, it was new and difficult in integrating it with our project because we were learning it for the first time. We must select the project when the course starts (within one month), the problem at that we don't know the concepts, before the course we have learned the concept and do it."

  - "While implementing the project, we get a lot of knowledge about the same in-depth, maybe more than what we study in theoretical courses. We refer to a lot of other websites and sources while working on the projects, which will enhance the knowledge and I always feel that project-based learning is way better than studying only theories."

  - "Our team had to work remotely due to the present pandemic situation, which is also a challenge for most of the students. But we were able to manage the work with the help of many platforms to interact with each another. As we were working remotely, we even had to face the challenges of weather, when there is heavy rain, our work used to slow down since the network would be weak. When it comes to the project resources, since our project concepts are out of the syllabus, we had to learn from outside the curriculum and implement them in the project, which is a good thing, since it improves our outside knowledge. Overall, it was a great experience."

  - "Sometimes to get the ideal or desired output, we need to study more and put in the extra effort. While doing so we spend most of the time on one project itself hence we lag in the rest of the projects and other academic-related things. Balancing all these things together might become a bit challenging.".

b. Faculty perspective

- As the number of students in a class was almost 60, there were 30-35 projects to be evaluated. This is a challenging task for the faculty and expects a lot of investment of time and effort from the faculty end.

- If the topics were to be suggested by the faculty, it is hard to think of many innovative projects. The students prefer to select the problem by themselves. This sometimes leads to substandard project topics. Such topics are to be further enhanced by the faculty.

- Conducting regular team meetings resulted in good outcomes in terms of project completion. If there are more teams, faculty need to invest a lot of time in these meetings.

- If the classes are in online mode, following up on the work with the students is challenging. Motivating the students to do innovative work instead of copying the project is tedious for the faculty. Properly designed rubrics will help in the correct evaluation of learning outcomes. The rubrics may include concept, innovation, creativity, usefulness, technical complexity, team coordination, presentation, etc.

- Institutions are also challenged to provide adequate resources for all the teams. Faculty are expected to have a clear knowledge of PBL to carry out the implementation effectively. It is challenging for institutions to retain and encourage such faculty.

6. Suggestions For Effective Implementation

- Students expressed their happiness about the PBL, and the concept was found to be beneficial to improve their knowledge. They are also of the opinion that there should be few projects every semester, but it should not burden the students.
- Individual contributions are to be considered during the evaluation process as the amount of contribution from each member is different. Faculty should play an active role in measuring the involvement of everyone.
- Appropriate resources and guidance are to be provided by the institution and faculty. This requirement varies based on the team and the knowledge level of the team members.
- Doing the project in remote mode or online mode was not effective and the load was more on a few members of the team. Teamwork could not be achieved due to a lack of communication and technical limitations.
- More weightage in marks may be allotted to the PBL than the theory as it requires more effort from the students in acquiring the required skillsets to do the project.
- A few feedback statements given by the students are quoted below.
    - "Giving more importance to projects than theory would be beneficial for a student. Only when we implement the things that we learn, makes us confident about that topic."
    - "It would have been better if there were a maximum of 2 projects to be carried out per semester. Managing 4 projects in a semester is very hectic. The focus should be given to the quality of projects, not the number of projects."
    - "Try to start PBL from 3rd sem itself. Will add much value to the studies as well as a carrier."
    - "It is more helpful if PBL is adopted for many courses that have even 10% of practical concepts. It saves a lot of effort for Visual Based Learners when preparing for exams."

7. Outcome of the study

Following are the inferences drawn and the outcomes achieved from the study.

- From the survey, it is observed that the students like to have the PBL in one or two courses in a semester.
- Students agree that their knowledge has increased due to the implementation of the project when compared to just studying the theory.
- Students were able to understand the local problems and propose solutions to them.
- Increase in the students' problem-solving skills was observed after undergoing the PBL courses.
- Faculty agreed that they need to invest more time and effort to handle the PBL.
- Faculty thought that PBL will result in better learning outcomes by reaching the higher Bloom's Taxonomy Levels (BTL).
- Implementation of the PBL will align with the internship concepts proposed by the new National Education Policy.
- Project works were included in the courses like Machine learning, Bigdata, Cloud computing, and Database systems which are focused on the problem-solving aspects.

Conclusion

Some of the faculties at NMAM Institute of Technology, Nitte attempted to introduce project-based learning while teaching engineering courses. Practicing the PBL is shown as one of the best practices followed by the institution for reporting to the accreditation bodies. The case study of this implementation was also presented in IUCEE Mini-Symposium in 2021 and the concept was well accepted by the audience.

A survey was conducted among the students and faculty of computer science and information science branches to know the effectiveness of implementation. From the survey results, it can be concluded that the PBL is beneficial to the students to

gain sound knowledge in the courses and to be good at problem-solving skills and teamwork. It was also observed that it needs more investment of time from the student and faculty side. The students expect mentoring from the faculty regularly, and giving additional input will be an added advantage. Individual evaluations are to be carried out for the work at regular intervals. It was observed that students expect regular team meetings whenever they complete a major stage. Students prefer to select their problem statements. From the results obtained, it was observed that the students were happy with the methods adopted by the faculty. It is also suggested to bring some changes in the process to make the process more effective.

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