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Implementing Project-based Learning in Civil Engineering- A Case Study

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Abstract: Project-based learning (PBL) promotes experiential learning and critical thinking through group activities. This paper presents the experience with the PBL implementation in a III semester undergraduate course in Civil Engineering. An open ended problem, to demonstrate the application of the concepts of Fluid Mechanics in real world scenarios through working models, was given to the students. Conceptualization of the idea, technical aspects of the model, communication skill and ability to work in teams were the major outcomes of the project. These outcomes were evaluated using analytical rubrics. Overall results show that the entire class was actively involved in the PBL activity and deep learning, linking to the real world application happened outside the class room through the PBL.

Keywords: Project based learning, Civil Engineering, Analytical rubric, Peer evaluation

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1. Introduction

Project based learning (PBL) is an approach, where the students are actively involved in the learning process through investigations (Bulmenfeld et al., 1991). The essential components of a PBL are the problem around which the students orient their investigations, and the series of activities associated with the investigations. Students, in groups, identify the learning issues and work together to find meaningful solutions (Hmelo-Silver, 2004). The activities involved in the PBL drives learning by doing, rather than just listening (Savege et al., 2007). However, the problem solving is not the only objective of the PBL (Ribeiro and Mizukami, 2005). In addition to the knowledge acquisition, PBL also helps to impart the essential skills relevant to the course and also a positive attitude towards self-motivated learning. Effectiveness of PBL in promoting active learning in engineering education has been largely reported in literature (Smith et al., 2005; Woods, 1994).

In this experiment, PBL was introduced as a part of the internal evaluation in III semester Undergraduate Civil Engineering. The problem designed, method of implementation, evaluation criterion and the overall experience of this PBL exercise are presented in this paper.

2. PBL Experience with III Semester Students

PBL was implemented in the course Mechanics of

Fluids in the III semester Civil Engineering Undergraduate Program. In this class, there were 69students with varying learning backgrounds and learning abilities.There were highly competent students joined through competitive exams, a small percentage of students joined directly without any competitive exams, and a small percentage of students joined after completing Diploma in Civil Engineering. Some students had undergone the pre-requisite courses at the Higher Secondary level in the native language medium. The current system where the English language is the medium for communication in the class room, poses an initial challenge for such students.

Mechanics of Fluids is a core subject, which is designed to impart basic knowledge about the properties of fluids at rest and in motion, how the fluid interacts with the other systems, and the applications of the above concepts to real world problems. The basic concepts learnt through this course are the pre-requisite for various higher level courses involving the analysis and design of Civil Engineering Structures carrying fluids. Since the concepts of the course are related to many practical applications in daily life, it has enormous scope for experiential learning. More over such projectshelps the students to understand the concepts better by relating them to any real world applications.

The PBL was implemented as a group activity. Heterogeneous groups of 8-9 students were formed in the class with the criteria that each group must contain at least one female student and at least one student who had completed Diploma in Civil Engineering. The students were asked to develop a working model to demonstrate any of the concepts learnt in the class room. Development of team work, improved self-motivation, ability to extend the concepts to the real world problem, developmentof oral and written communication skills andimproved critical thinking were the outcomes expected from the PBL. Like many other PBL, the project involved problem analysis, problem solving and reporting (Kolmos, 1996).

A. Assessment Criteria for the III Semester Course

The PBL was used as an Alternate Assessment Tool (AAT), thereby replacing the conventional quiz used for the Continuous Internal Evaluation (CIE). Since the expected outcome were (i) experiential learning and critical thinking and (ii) team work and communication, the project was evaluated in two stages. Experiential learning and critical thinking of the teams were evaluated through model demonstration, viva-voce and reports. On the other hand, soft skills like team work and communication were evaluated through peer evaluation. In addition, students' feedback was collected at the end of the course.

Table 1. Analytical rubric used for the group performance evaluation

Criteria	Excellent (2 Marks)	Average (1 Mark)	Very poor (0 Mark)
Objective and relevance	Project objectives are clear and the model is relevant	Project objectives are vague	Objectives are not well defined or the model is not relevant to the subject domain
Working principle	Working principle is well understood and explained. Could well relate the working principle to the course content	Working principle is understood, but not able to explain. Could not relate the working principle to the course content	Working principle is not understood and not able to explain
Model	A good working model	Model is ready, but not working due to some minor issues	Model is not ready
Report	A neat report with all the concepts mentioned clearly. Photograph of the model is included	Report is submitted, but incomplete. Working principle, tools used, procedure or the photographs are not included	Report incomplete. Content are not directly related to the model constructed. Unable to explain the content presented in the report
Viva	Able to answer most of the questions during the demonstration	Able to answer only a few questions, indicating lack of understanding of the model or its working principle	Unable to answer the questions satisfactorily

Rubrics are the effective means of communication between the teacher and the students in a PBL. Martínez et al. (2011) mentioned that an analytic rubrics used in a PBLhelps the students to know the expectations from the beginning. By making the expectation transparent, it becomes easy for the students to work towards achieving the same. In this study, analytical rubrics were used for the group evaluation as well as for the peer assessment. Table 1 shows the analytical rubric used for the evaluation of the working model and Table 2 shows the analytical rubric used for the peer assessment.

contribution, overall team work and contribution in implementing the concept into the model. Each student was asked to complete the peer evaluation of all the other group members and the evaluation was submitted confidentially.

The PBLinvoked critical thinking and discussions among the team members. It was assumed that the individual learning from the PBL was directly related to the involvement of the student in the group activity, as well as the student's technical and overall contribution. Therefore, the average score of a student from peer assessment, expressed as a percentage of

Table 2. Analytical rubric used for the peer evaluation

Criteria	Good (2 Marks)	Average (1 Mark)	Very poor (0 Mark)
Ability to work in group	Positive response to feedback, good conflict management, listen to all team members suggestion and good cohesion with all the team members	Can work in team, but sometimes difficult to manage the conflict between individual and team interests	Does not collaborate with the team members or more focused on individual interest
Accountability and work sharing	Always participate in decision making and execution	At times not involved in the team activity	Not cooperating in any stage of the project
Communication skill	Good and clear communication with the team members	Poor communication	No or very poor communication
Technical contribution	Significant contribution to the technical discussions and input for the model	Often participate in the technical discussion	No technical contribution
Overall contribution	Good contribution for the concept development, model building and report	Poor contribution for the concept development, model building and report	No contribution for the concept development / model building / report

The PBL was designed as a Team Assisted Individualization (TAI) activity. Accordingly, the slight variation observed in the individual learnings of the team members were averaged and was used to evaluate the performance of the team as a whole. Using the analytical rubric, the groups were rated excellent, average or very poor, and accordingly marks were assigned for the technical competency.

Since the group size was large, it was difficult to identify the individual student's involvement in the project. Therefore, the peer assessment was introduced within each team, whereby each student evaluated their team members for their technical

total mark for peer assessment, was used as the weightage for the learning of individual students. The group score was then multiplied by the weightage to arrive at an individual score to reflect the overall technical learning as well as the ability to work in a team. The peer evaluation integrated with the overall group evaluation was therefore used as the tool for the assessment of individual learning.

3. Outcome of the PBL

The students came up with exciting working models to demonstrate various principles of Fluid Mechanics. Heron's fountain demonstrating the

hydrostatic law and suction pressure, working model of a centrifugal pump demonstrating the energy transformation, Hydraulic lift, Hydraulic brake, Hydraulic bridge etc. demonstrating thePascal's law were a few of them. Fig. 1 shows a few pictures of the teams demonstrating the working model as a part of the PBL.

A. Evaluation of the PBL activity

An open ended problem was assigned for the PBL. Multiple solutions were possible for the problems. Each concept learnt as a part of the course can be demonstrated through different types of application. The typical example was the Pascal's law. Many groups had selected Pascal's Law for the demonstration, however using different applications such as hydraulic bridge, hydraulic brake, hydraulic arm, and hydraulic lift. The PBL thus opened the scope of analysing the real world application with the background knowledge learnt in the class room. In addition, by developing the working model, the students got the opportunity for experiential learning. Each team was evaluated for the conceptual knowledge, technical information about the model, and their oral and written communication skills using the rubric shown in Table.1.

Since all the groups came up with a working model and submitted a report about their model satisfactorily, the overall group performance was rated satisfactory. Fig. 2 shows the variation in the group performance in a scale 1-10.

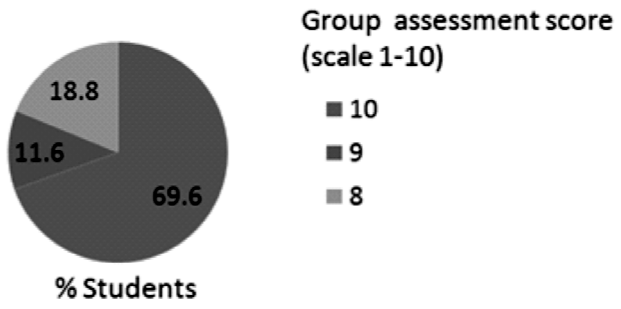

Fig. 2 Group performance evaluated on a scale 1-10

Self motivation, capability to work in a team and leadership qualities were the soft skills needed to be assessed individually. A peer review by the team members was used to assess these skills. The analytical rubric used for the peer assessment is shown in Table.2. Average score for the students

Teams displaying the working models created as a part of the PBL

during the peer evaluation was obtained as 9.8. Fig. 3 shows the percentage of the students and their score during peer evaluation.

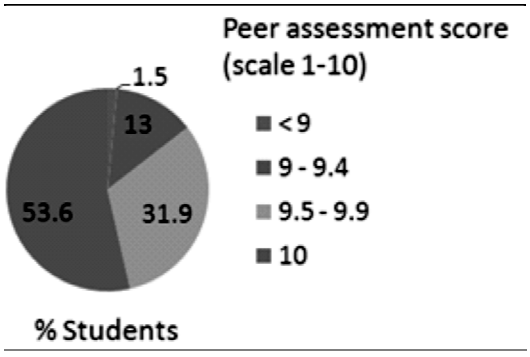

Fig. 3 Group performance evaluated on a scale 1-10

All the students were actively involved in the group activity as indicated by the high scores during the peer evaluation.

B. Overall attainment of the PBL outcome

Performance of the students during the model demonstration indicated a thorough understanding of the concept learnt through experiential learning. Also, the peer evaluation results indicated the involvement of the students in the group activity, their capability to work in group and also technical contribution towards the project. Oral feedback from the students indicated that the students enjoyed the PBL activity. The activity was challenging to the students in ways where they needed to conceptualize their ideas and to identify the appropriate materials for the model construction.

Though the model making invoked critical thinking and experiential learning, the huge amount of time required for the model making was reported as the major drawback of the PBL activity by the students. Another major drawback of the PBL was the group size. In this case the group size ranged from 7-9. However the problem designed for the PBL did not have the scope to assure appropriate workload to all the group members. And hence the involvement of all the students were evaluated merely based on the peer assessment.

4. Conclusions

A project-based learning activity was implemented as a part of the III semester undergraduate course Mechanics of Fluids. The over objective of the PBL was to enhance experiential learning and to impart essential skill and attitude towards self motivated learning. An open ended problem to demonstrate the application of fluid mechanics concept in the real world was assigned to the students.

The students put appreciable effort to transfer the concepts into working models of significance in the real world scenario. The model demonstration exhibited the knowledge gained by the students and also the level of critical thinking that went into the conceptualization of the idea. Also, the peer assessment and the students' feedback indicated that all the students were actively involved in the activity and enjoyed the exercise, which otherwise would have been difficult to achieve in the conventional class room based learning.

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References

[1] Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., guzdial, M., and Palincsar, A. (1991) Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning, Educational Psychologist, 26 (3&4), 369-398.

[2] Hmelo-Silver, C. E. (2004) Problem-based Learning: What and How Do Students Learn? Educational Psychology Review, 16 (3), 235-266.

[3] Kolmos, A. (1996). Reflections on Project Work and Problem –based Learning. European Journal of Engineering Education, 21 (2), 141-148.

[4] Martínez, F, Herrero L. C and Pablo, S. (2011) Project-Based Learning and Rubrics in the Teaching of Power Supplies and Photovoltaic Electicity. IEEE Transactions on Education, 54(1), 87-96.

[5] Ribeiro, L. R. C, and Mizukami, M. D. N. (2005) Problem-based learning: a student evaluation of an implementation in postgraduate engineering

education, European Journal of Engineering Education, 30(1), 137-149.

6. Savege, R. N., Katherine, C. C., and Vanasupa, L. (2007) Integrating Project-based Learning throughout the Undergraduate Engineering Curriculum, Journal of STEM Education, 8(3-4), 15-27.

7. Smith, K.A., Sheppard, S. D., Johnson, D. W., and Johnson, R. T. (2005) Pedagogies of Engagement: Classroom-Based Practices. Journal of Engineering Education, 94(1), 87-101.

8. Woods, D.R. (1994)Problem-Based Learning: How to Gain the Most from PBL, Woods Publishing, Waterdown, Ontario.