Implementation Challenges and Effectiveness of Problem-Based Learning: Insights from Engineering Faculty

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Abstract

Engineering and polytechnic education in India is increasingly adopting Outcome-Based Education (OBE), which emphasizes the development of learners' knowledge, skills, and attitudes (KSA) through student-centered instructional approaches. In this context, Problem-Based Learning (PBL) has emerged as a learner-centered alternative that promotes real-world problem solving, collaboration, and self-directed learning, addressing limitations associated with traditional lecture-based teaching. The present study examines the implementation of PBL in engineering education, with a focus on faculty-perceived effectiveness and the challenges encountered during classroom practice.

As part of a faculty development and research initiative, engineering faculty members underwent structured training programmes on PBL methodologies prior to implementation. Following the training, PBL was implemented across various engineering disciplines. Data were collected from 231 engineering faculty members using a structured questionnaire to capture their perceptions of PBL effectiveness and implementation challenges.

The analysis revealed a high level of faculty agreement regarding improved student engagement and learning outcomes through PBL implementation. More than 90% of the respondents indicated that PBL enabled students to apply theoretical knowledge to real-world problems and enhanced transferable skills such as teamwork and self-directed learning. However, challenges related to implementation were also evident. A substantial proportion of faculty members (90.9%) reported difficulties in balancing PBL activities with traditional course requirements, while concerns related to assessment fairness were expressed by 95.7% of respondents. In addition, institutional factors played a significant role, with 81.4% of faculty acknowledging the availability of institutional resources and policies, and a notable proportion expressing the need for greater support in terms of industry and community engagement opportunities.

Keyword

Problem based learning, Faculty Perceptions, Learning effectiveness, Implementation challenges

Introduction

Due to implementation of Outcome based education, effort has been made to change the method of teaching from teacher centered to student centered. As problem-based learning is one of the student centered approaches, it is decided to take for the research work. This PBL approach encourages students to learn concepts by thinking and provide confidence on domain knowledge [1] [5]. The role of teacher is essential in this PBL approach. Faculty members have to ensure the learning outcomes are met, in addition to facilitate the learning process [3] [7]. The PBL approach was introduced in medical field. Now it is in STEM education. Engineering is one of the main creator of the world, critical thinking is essential for the future generation. Several studies shows that the PBL approach as one of the most effective methods to prepare students for better future which enhances students capability in team work, to handle real time problems, develop communication skill, and patient interaction skills [4]. This PBL approach has many advantages over the teacher centered method where students are passive recipients of information [8]. In addition, PBL also helps students to acquire the skills of integrated knowledge delivery and information processing, and promote their active participation [9].

Literature Review

Problem-Based Learning (PBL) has emerged as a prominent learner-centered instructional approach in engineering education, emphasizing active learning, real-world problem solving, and the development of higher-order cognitive skills. Originating from constructivist learning theory, PBL shifts the instructional focus from content transmission to knowledge construction through inquiry, collaboration, and reflection [11] [13]. In engineering education, PBL has been widely adopted to bridge the gap between theoretical knowledge and professional practice [15].

Various studies report that PBL improves students' problem-solving ability, critical thinking, and capacity to apply theoretical concepts to real-world engineering problems [14] [20] [21]. Compared to traditional lecture-based instruction, PBL is often associated with higher levels of student engagement, motivation, and active participation in the learning process[22].

In addition to cognitive outcomes, PBL has been shown to support the development of transferable and professional skills that are essential for engineering graduates [18]. These include teamwork, communication, self-directed learning, and adaptability. Several studies emphasize that PBL environments simulate professional engineering practice, thereby preparing students for industry expectations and interdisciplinary collaboration.

The successful implementation of PBL largely depends on the role of faculty members, who transition from traditional instructors to facilitators of learning [4] [16]. Faculty preparedness and professional development are identified as critical factors influencing PBL effectiveness. Training programs and institutional support play an important role in enhancing faculty confidence and competence in designing PBL activities, facilitating teamwork, and implementing appropriate assessment strategies [17].

The many research work discussed about student-related challenges, such as limited prior experience with teamwork, low motivation for self directed learning, and varying levels of preparedness which complicated the implementation [6] [18].

Although extensive research has examined the impact of PBL on student learning outcomes, relatively fewer studies have focused on faculty perceptions, particularly in the context of post-implementation experiences. Understanding faculty insights into both the effectiveness and challenges of PBL is essential for informing institutional policy, curriculum design, and faculty development initiatives. This study addresses this gap by systematically examining engineering faculty members perceptions of PBL effectiveness and implementation challenges following classroom application.

The National Institute of Technical Teachers Training and Research Chennai (NITTTR) have started using PBL for their training programme especially to train the teachers. NITTTR is used to give more training for faculty members in Technology Enabled learning, Instructional Design and Delivery System (IDDS), Advanced Pedagogy, Outcome Based Education (OBE) and many more. In these courses PBL approach was introduced and educated the faculty members of various discipline to adopt themselves in preparatory steps, planning and organization.

The National Institute of Technical Teachers Training and Research (NITTTR), Chennai, has been actively implementing PBL in its faculty training programmes, particularly for professional development of engineering educators. NITTTR conducts a wide range of training programmes in areas such as Technology-Enabled Learning, Instructional Design and Delivery Systems (IDDS), Advanced Pedagogy, and Outcome-Based Education (OBE). As part of these programmes, the PBL approach was systematically introduced to train faculty members, from various engineering disciplines, enabling them to adopt PBL through structured preparatory steps, planning, and organized implementation. Consequently, faculty members trained at NITTTR, Chennai, formed an appropriate and relevant population for the present study.

Methodology

This section describes the research design, development and validation of the instrument, data collection procedures, and statistical techniques used to evaluate the effectiveness of Problem-Based Learning (PBL) and the challenges faced in its implementation in engineering education from the perspective of faculty members. The study adopted a quantitative, descriptive survey questionnaire. This questionnaire was designed to focus to capture the perceptions, experiences, and evaluations of faculty members regarding learner centered instructional strategies such as PBL. The study focused on systematically measuring multiple constructs related to PBL effectiveness and implementation challenges using a structured questionnaire.

After undergone the training at NITTTR Chennai, the faculty members implemented the PBL approach. The target population for the study comprised faculty members from engineering institutions who had implemented Problem-Based Learning in one or more of their courses at the undergraduate or postgraduate level. The same group of faculty members are encouraged to participate in the survey. The questionnaire was circulated to 270 faculty members. A total of 231 faculty members responded for this questionnaire. Figure 1 shows the flow of the methodology.

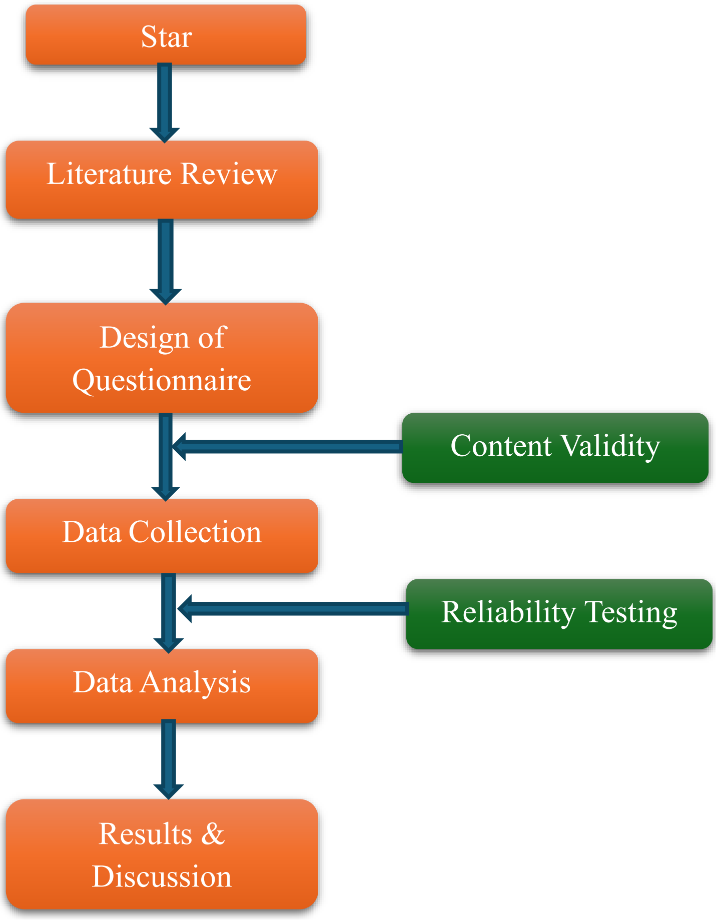

Figure 1. Methodology flow chart

Elements of PBL

Problem-Based Learning (PBL) is a learner-centered instructional approach that emphasizes active engagement, critical thinking, and collaborative problem solving [2] [11]. The effectiveness of PBL depends on the interaction of several core elements that collectively shape the learning experience. These elements serve as essential inputs that guide the design, implementation, and outcomes of PBL in engineering education.

One of the fundamental elements of PBL is the use of authentic and ill-structured problems, which reflect real-world situations and encourage learners to explore multiple solution pathways. Such problems stimulate inquiry, promote deeper understanding, and enable students to integrate theoretical knowledge with practical application. Closely associated with this is the student-centered nature of PBL, wherein learners assume responsibility for identifying learning needs, seeking information, and constructing knowledge, while instructors function primarily as facilitators [6] [11].

Collaborative learning is another critical element of PBL, as students typically work in small groups to analyze problems, share perspectives, and develop solutions. This collaborative environment enhances communication skills, teamwork, and peer learning [10]. The role of the facilitator is to guide discussions, provide scaffolding, and ensure alignment with learning objectives without directly transmitting content.

Self-directed learning and reflection are integral to the PBL process. Learners are encouraged to independently acquire knowledge, evaluate information sources, and reflect on both the problem-solving process and learning outcomes [12]. Continuous assessment and feedback further support learning by providing opportunities for self-assessment, peer evaluation, and facilitator feedback, focusing on both learning processes and outcomes.

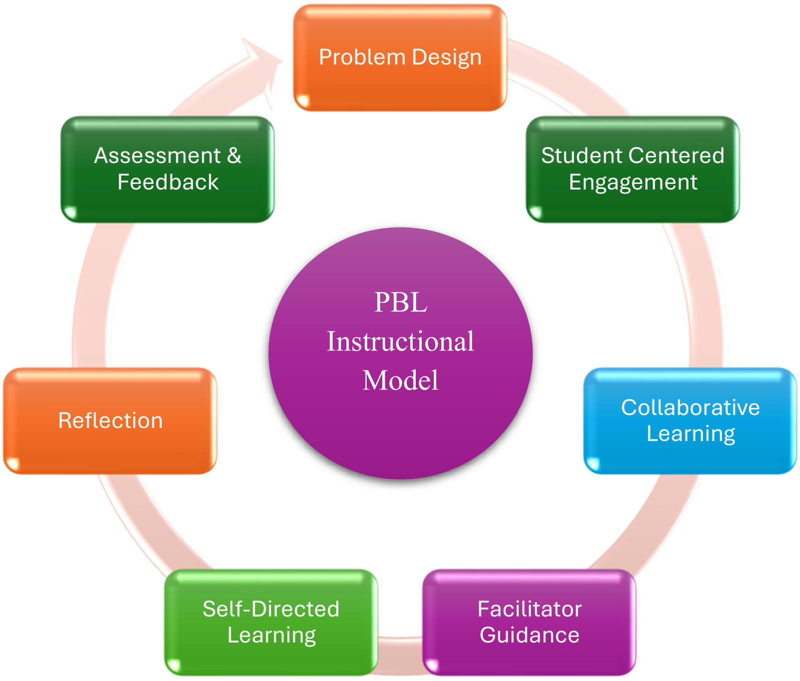

Figure 2. Elements of Problem Based Learning Instructional Model

Figure 2 illustrates the important features of PBL as interconnected inputs that influence the learning process and contribute to desired educational outcomes such as enhanced problem-solving ability, critical thinking, and collaborative skills. Together, these elements form a comprehensive framework for effective implementation of PBL in engineering education

Content Validity Assessment

Content validity of the questionnaire was assessed by ten experts in engineering education and instructional pedagogy. The relevance of each item was evaluated using the Item-level Content Validity Index (I-CVI). The I-CVI calculated as the proportion of experts rating an item as either quite relevant or highly relevant, as expressed by:

$$\text{I-CVI} = n_e/N$$

Where, n_e represents the number of experts indicating agreement on item relevance and N denotes the total number of experts.

For a panel of ten experts, items with an I-CVI value below threshold value (0.78) were removed.

The overall content validity of the questionnaire was determined using the Scale-level Content Validity Index based on the average method (S-CVI/Ave). It is computed by using following equation

$$S\text{-}CVI/Ave = \sum I\text{-}CVI / k$$

Where, k denotes the total number of items in the instrument.

An S-CVI/Ave value of 0.80 or higher was considered indicative of good content validity. In the present study, the S-CVI/Ave value was 0.88, which is confirming good content validity of the questionnaire.

Based on expert validation and content refinement, a structured questionnaire consisting of 20 items was finalized for data collection. The instrument was designed to capture faculty perceptions on the effectiveness of Problem-Based Learning (PBL) and the challenges encountered during its implementation in engineering education. The finalized items were conceptually grouped into seven domains: (i) PBL Planning and Design (3 items), (ii) Effectiveness on Student Learning (4 items), (iii) Development of Professional and Soft Skills (3 items), (iv) Faculty Experience and Facilitation (3 items), (v) Assessment and Evaluation in PBL (3 items), (vi) Challenges in PBL Implementation (3 items), and (vii) Institutional Support (1 item).

The questionnaire was designed to capture a comprehensive view of the implementation of Problem-Based Learning (PBL) in engineering education. Rather than focusing solely on student learning outcomes, the instrument addressed multiple interrelated dimensions that influence the effectiveness of PBL. Accordingly, the questionnaire examined seven key areas: PBL planning and design, effectiveness on student learning, development of professional and soft skills, faculty experience and facilitation, assessment and evaluation practices, challenges encountered during implementation, and institutional support. This multidimensional approach enabled a holistic assessment of PBL by considering not only learning outcomes but also the pedagogical, organizational, and contextual factors that contribute to successful implementation.

Since the study required insights specifically from faculty members who had prior experience in implementing Problem-Based Learning, purposive sampling was employed. Only those faculty members who had undergone PBL training at NITTTR, Chennai, and subsequently implemented PBL in their undergraduate or postgraduate courses were considered eligible for participation. Accordingly, the questionnaire was circulated to 270 faculty members who met the inclusion criteria.

The population for the present study comprised faculty members from engineering institutions who had implemented Problem-Based Learning (PBL) in one or more undergraduate or postgraduate courses. Considering that the study focused on faculty members with first-hand experience in classroom implementation of PBL, purposive sampling techniques was adopted.

Purposive sampling was considered appropriate as it allows for the deliberate selection of participants possessing specific characteristics relevant to the research objectives.

Accordingly, the questionnaire was circulated to 270 faculty members across various engineering disciplines. However, 231 faculty members provided complete responses, which were included in the final analysis. After data collection, the internal consistency reliability of the questionnaire was examined using Cronbach's alpha. Reliability analysis was performed for each construct to assess the consistency of the items measuring the same underlying dimension.

Reliability Analysis

Reliability refers to the degree to which an instrument consistently measures the constructs it is intended to assess. Establishing reliability is essential to ensure that the responses obtained from the questionnaire are stable, dependable, and free from random measurement error. In survey-based educational research, reliable instruments enhance the credibility of the findings and ensure that observed variations in responses reflect true differences in perceptions rather than inconsistencies in the measurement tool.

The primary purpose of reliability analysis in the present study was to examine the internal consistency of the questionnaire, that is, the extent to which items within each construct measure the same underlying dimension related to Problem-Based Learning (PBL) effectiveness and implementation challenges.

After the collection of survey responses, internal consistency reliability was assessed using Cronbach's alpha (α). Reliability analysis was performed separately for each construct as well as for the overall scale. The Cronbach's alpha values for the individual constructs ranged from 0.72 to 0.88, indicating acceptable to good internal consistency A Cronbach's alpha value more than 0.7 was considered as acceptable reliability. The overall scale demonstrated a Cronbach's alpha value of 0.8, which is confirming the reliability of the instrument. The internal consistency reliability of the questionnaire was assessed using Cronbach's alpha. Reliability analysis was conducted separately for each construct as well as for the overall scale.

Results and Discussion

The demographic characteristics of the respondents were analyzed to obtain a general understanding of the background of the faculty members who participated in the study. The analysis was carried out to ensure that the respondents represented a diverse range of engineering disciplines, teaching experience, and levels of academic engagement, thereby strengthening the credibility and generalizability of the findings.

It is assumed that the respondents possessed adequate academic experience and exposure to teaching–learning processes, as all participants had undergone structured training in Problem-Based Learning (PBL) at the National Institute of Technical Teachers Training and Research (NITTTR), Chennai, and subsequently implemented PBL in their respective courses.

Consequently, the demographic composition of the sample is considered appropriate for examining faculty perceptions regarding the effectiveness of PBL and the challenges encountered during its implementation.

The demographic variables considered in the study included academic discipline, years of teaching experience, and level of courses taught (undergraduate and/or postgraduate). The distribution of respondents across these variables indicates a reasonably balanced representation, thereby providing a reliable basis for further statistical analysis and interpretation of results.

Demographic Profile

The demographic profile of the respondents was analysed based on their academic department, teaching experience, and level of teaching, including undergraduate and postgraduate programmes.

Figure 3 illustrates the distribution of respondents based on their teaching experience. The distribution indicates that the majority of respondents fall within the early to mid-career stages. It is observed that a substantial proportion of the faculty members have less than five years of teaching experience (42%), followed by those with five to ten years of experience (37%).

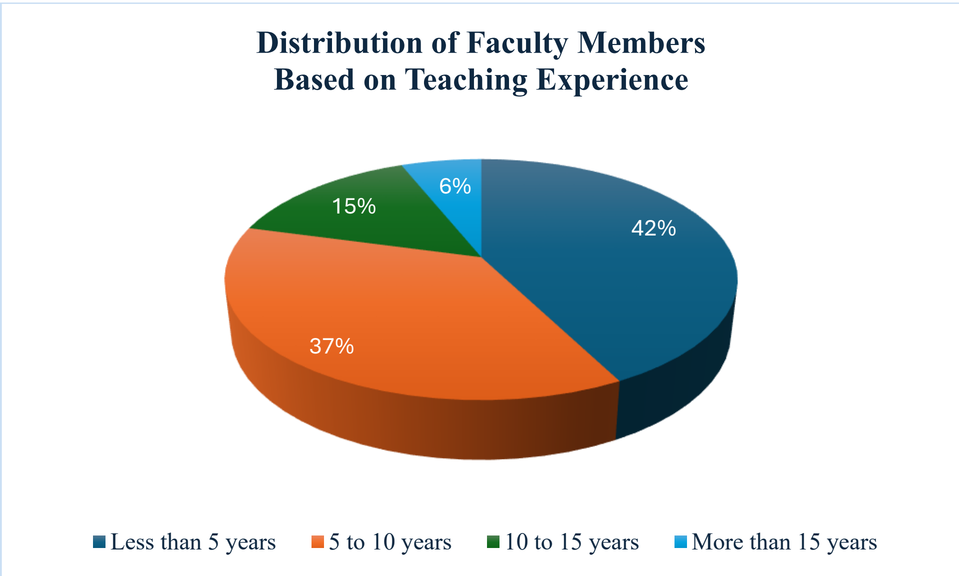

Figure. 3 Distribution of faculty based on teaching experience

Faculty members with ten to fifteen years of experience constitute 15% of the respondents, while those with more than fifteen years of teaching experience represent a smaller proportion (6%).

Table 1. Department-wise Distribution of Faculty Members

S.No.	Discipline	Number of Faculty	Percentage (%)
1	Civil Engineering	21	09%
2	Mechanical Engineering	29	13%
3	Electrical & Electronics Engineering	33	14%
4	Electronics & Communication Engineering	38	16%
5	Computer Science / IT	94	41%
6	Architecture	11	05%
7	Printing Technology	05	02%
	Total	**231**	**100%**

Table 1 presents the discipline-wise distribution of faculty respondents in percentage. It is observed that faculty members from Computer Science and Information Technology constitute the largest proportion of respondents (41%). This is followed by Electronics and Communication Engineering (16%), Electrical and Electronics Engineering (14%), and Mechanical Engineering (13%). Civil Engineering faculty members account for 9% of the respondents, while Architecture (5%) and Printing Technology (2%) represent smaller proportions.

The distribution reflects a multidisciplinary participation of faculty members across core engineering and allied disciplines. The higher representation from Computer Science and Information Technology may be attributed to the larger number of departments and programmes in these disciplines across engineering institutions, resulting in a greater population of faculty members. Majority of faculty members implemented this PBL in the Undergraduate programme only minimum number of faculty implemented in Postgraduate.

A structured questionnaire was developed to examine the effectiveness of Problem-Based Learning (PBL) and the challenges encountered during its implementation from the perspective of engineering faculty members. The instrument was designed to be administered after faculty members had implemented PBL in their respective courses, thereby ensuring that responses were based on direct classroom experience rather than theoretical understanding.

The questionnaire comprised 20 items, measured using a five-point Likert scale ranging from Strongly Agree to Strongly Disagree. The items were formulated based on an extensive review of literature on PBL, faculty development, and instructional innovation, and were refined to ensure clarity, relevance, and alignment with the objectives of the study.

The questionnaire addressed four broad areas relevant to the research focus: (i) effectiveness of PBL in enhancing student learning and skill development, (ii) challenges faced during the design and implementation of PBL, (iii) faculty perspectives on facilitation roles and pedagogical preparedness, and (iv) institutional support for PBL implementation. Table 2 shows the questionnaire used for the data collection.

Table 2. Questionnaire used for analysis

S.No.	Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	I possess adequate pedagogical knowledge to design structured PBL activities with sustainable learning objectives.	84.4%	15.6%			
2	Balancing PBL projects with traditional professional courses during curriculum design is challenging.	78.8%	12.1%	9.1%		
3	The PBL course design aligns well with the overall curriculum and supports students long-term academic and professional development.	40.3%	46.7%	13.0%		
4	Students are able to identify real-world problems and apply theoretical knowledge to develop practical solutions through PBL.	80.1%	12.1%	7.8%		
5	The duration of PBL implementation has a significant impact on student learning effectiveness.	76.6%	23.4%			
6	Students who experience PBL across multiple stages of learning demonstrate better familiarity with the PBL approach.	88.7%	11.3%			
7	PBL effectively develops transferable skills such as communication, teamwork, and self-directed learning.	82.2%	16.5%	1.3%		
8	The PBL environment enhances students' practical competencies and design-based skills.	77.9%	12.1%	10.0%		
9	In project-oriented or interdisciplinary PBL settings, students show improvement in global perspectives and cultural sensitivity.	75.8%	24.2%			
10	I am comfortable transitioning from a traditional lecturer role to a facilitator role in PBL.	82.7%	17.3%			
11	Balancing professional guidance with allowing students autonomy in their learning process is challenging.	76.6%	9.1%	14.3%		
12	I have received sufficient pedagogical training to facilitate PBL activities and	83.5%	8.7%	7.8%		

	manage student team dynamics effectively.					
13	Alternative assessment methods (e.g., self- and peer-assessment) are more effective than traditional examinations in evaluating student learning in PBL.	75.7%	9.1%	15.2%		
14	Ensuring fairness and honesty in self- and peer-assessment processes is challenging.	78.4%	17.3%	4.3%		
15	Formative assessment tools (e.g., progress reports or project reviews) are effectively used to monitor teamwork and learning progress.	15.2%	77.0%	7.8%		
16	Students lack of prior teamwork experience or low motivation for self-directed learning affects PBL implementation.	59.7%	23.8%	16.5%		
17	Language barriers or limited technical vocabulary hinder effective communication within student teams.	9.1%	22.5%	68.4%		
18	A high student-to-faculty ratio limits the effectiveness of facilitation in PBL.	74.9%	25.1%			
19	The institution provides sufficient learning resources, funding, and clear policies to support PBL implementation.	22.9%	58.5%	18.6%		
20	The institution facilitates industry or community engagement to provide students with real-world learning experiences through PBL.	25.1%	14.7%	52.4%	7.8%	

The analysis of responses from 231 engineering faculty members reveals a strong endorsement of Problem-Based Learning (PBL) as an effective pedagogical approach, alongside the identification of several implementation challenges. A substantial majority of faculty members reported confidence in their pedagogical preparedness to design structured PBL activities, with 84.4% strongly agreeing and 15.6% agreeing that they possess adequate pedagogical knowledge. Similarly, 82.7% of respondents indicated comfort in transitioning from a traditional lecturer role to that of a facilitator, reflecting readiness to adopt learner-centered instructional practices.

With respect to the effectiveness of PBL, faculty perceptions were overwhelmingly positive. More than 92% of respondents (80.1% strongly agree, 12.1% agree) affirmed that PBL enables students to identify real-world problems and apply theoretical knowledge to practical solutions. Additionally, 98.7% of faculty members agreed that PBL effectively develops transferable skills such as communication, teamwork, and self-directed learning. Sustained exposure to

PBL was also viewed as critical, with 100% agreement that students who experience PBL across multiple learning stages demonstrate better familiarity with the approach.

Curriculum alignment and assessment practices further reinforced the perceived effectiveness of PBL. Approximately 87% of faculty members agreed that PBL course design aligns well with the overall curriculum and supports students' long-term academic and professional development. Formative assessment practices were widely adopted, with 92.2% of respondents indicating that tools such as progress reports and project reviews are effectively used to monitor teamwork and learning progress. Alternative assessment methods, including self- and peer-assessment, were considered more effective than traditional examinations by 84.8% of respondents; however, concerns regarding assessment integrity were also prominent, with 95.7% acknowledging challenges in ensuring fairness and honesty in peer- and self-assessment.

Despite these positive outcomes, faculty members reported notable challenges in implementing PBL. A large proportion (90.9%) found it challenging to balance PBL projects with traditional course requirements, while 85.7% reported difficulty in maintaining an appropriate balance between providing guidance and allowing student autonomy. Student-related challenges were also evident, with 83.5% of respondents indicating that students' lack of prior teamwork experience or low motivation for self-directed learning affected PBL implementation. Furthermore, a high student-to-faculty ratio was identified as a significant constraint by 100% of the respondents.

In contrast, issues related to language barriers and technical vocabulary elicited more neutral responses, with 68.4% of faculty members neither agreeing nor disagreeing that such factors hindered effective communication within teams. This suggests that communication challenges may be context-dependent rather than universally experienced. Perceptions of institutional support were mixed; while 81.4% of respondents acknowledged the availability of learning resources and supportive policies, more than half (52.4%) expressed neutral views regarding institutional facilitation of industry or community engagement opportunities.

Overall, the findings demonstrate that engineering faculty strongly recognize the effectiveness of PBL in enhancing student learning, skills, and engagement. However, the sustainability and scalability of PBL implementation depend on addressing key challenges related to curriculum integration, assessment integrity, class size, and institutional support. Strengthening these areas can further enhance the impact of PBL in engineering education.

Conclusion

The present study examined the effectiveness and implementation challenges of Problem-Based Learning (PBL) from the perspective of engineering faculty members who had implemented the approach in their classrooms. The findings indicate strong faculty endorsement of PBL as an effective pedagogical strategy for enhancing student learning, problem-solving ability, and the development of transferable skills. Faculty members reported high levels of confidence in designing and facilitating PBL activities and recognized the value of sustained exposure to PBL across multiple courses for improving student familiarity and learning outcomes.

Despite the positive perceptions of effectiveness, the study identified several challenges that influence the successful implementation of PBL. These include difficulties in integrating PBL within traditional curricula, managing assessment fairness in self- and peer-evaluation, addressing students' limited prior experience with teamwork and self-directed learning, and coping with high student-to-faculty ratios. The findings further suggest that while institutional resources and policies provide moderate support for PBL, opportunities for industry and community engagement remain limited and require greater emphasis.

Overall, the study concludes that PBL holds significant potential to improve the quality of engineering education; however, its long-term sustainability depends on targeted institutional support, continuous faculty development, appropriate assessment strategies, and manageable class sizes. Addressing these factors can facilitate more effective and scalable implementation of PBL across engineering programs.

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Reference

[1] Adeoye, F. (2010). Effects of Problem-Solving and Cooperative Learning Strategies on Senior Secondary School Students' Achievement in Physics. Journal of Theory and Practice in Education, 6(2), 235-266.

[2] Barrows H. S. (1986). A taxonomy of problem-based learning methods. Medical Education, 20, 481–486.

[3] Benoit Galand, Mariane Frenay and Benoit Raucent, "Effectiveness of Problem-Based Learning In Engineering Education: A Comparative Study on Three Levels of Knowledge Structure", International Journal of Engineering Education Vol. 28, No. 4, pp. 939–947, 2012

[4] Bijsmans, P., Versluis, E. Problem-based learning and the relevance of teaching and learning European Studies in times of crises. Eur Polit Sci 19, 668–686 (2020). https://doi.org/10.1057/s41304-020-00263-0

[5] Canavan, B. 2008. A summary of the findings from an evaluation of problem-based learning carried out at three UK universities. International Journal of Electrical Engineering Education 45(2): 175–180.

[6] Dolmans, D.H.J.M., Loyens, S.M.M., Marcq, H. et al. Deep and surface learning in problem-based learning: a review of the literature. Adv in Health Sci Educ 21, 1087–1112 (2016). https://doi.org/10.1007/s10459-015-9645-6

[7] Ertmer P. A., Schlosser S., Clase K., Adedokun O. (2017). The grand challenge: Using a PBL approach to teach cutting-edge science. In Brush T., Saye J. (Eds.), Successfully implementing problem-based learning in classrooms: Research in K-12 and teacher education (pp. 163–195). Purdue University Press.

[8] Ghani, A.S.A., Rahim, A.F.A., Yusoff, M.S.B. et al. Effective Learning Behavior in Problem-Based Learning: a Scoping Review. Med.Sci.Educ. 31, 1199–1211 (2021).

[9] Gijbels D., Dochy F., Van Den Bossche P., Segers M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. Review of Educational Research, 75(1), 27–61.

[10] Han, I., Application of Problem-Based Learning in English Language Teaching: A Systematic Review in the Korean Context. Sage Open, 15(2). 2025

[11] Hmelo-Silver C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review, 16(3), 235–266.

[12] Halizah Awang, and Ishak Ramly, "Creative Thinking Skill Approach Through Problem-Based Learning: Pedagogy and Practice in the Engineering Classroom", World Academy of Science, Engineering and Technology International Journal of Educational and Pedagogical Sciences Vol:2, No:4, 2008

[13] Husin, M., Usmeldi, U., Masdi, H., Simatupang, W., Fadhilah, F., & Hendriyani, Y. (2025). Project-Based Problem Learning: Improving Problem-Solving Skills in Higher Education Engineering Students. International Journal of Sociology of Education, 14(1), 62–84. https://doi.org/10.17583/rise.15125

[14] Maudsley, G., E.M.I. Williams, and D.C.M. Taylor. 2008. Problem-based learning at the receiving end: A mixed methods study of junior medical students perspectives. Advances in Health Sciences Education 13: 435–451.

[15] Nel, P.W., S. Keville, D. Ford, R. McCarney, S. Jeffrey, S. Adams, and S. Uprichard. 2008. Close encounters of the uncertain kind: Reflections on doing problem-based learning (PBL) for the first time. Reflective Practice 9(2): 197–206.

[16] Nicholus G, Muwonge CM, Joseph N. The Role of Problem-Based Learning Approach in Teaching and Learning Physics: A Systematic Literature Review. 2023 Nov

[17] P. Chen and Y. C. Chang, "Enhancing creative problem-solving in postgraduate courses of education management using project-based learning," International Journal of Higher Education, vol. 10, no. 6, pp. 11-21, 2021

[18] Serife, A. K. (2011). The effects of computer supported problem based learning on students' approaches to learning. Current Issues in Education, 14, 1.

[19] Sopwan, I. D., Soetisna, U., and Redjeki, S. (2018). Implementation of PBL model to enhance critical thinking skills and argumentation skills of students. Edubiol. J. Penel. Ilmu Dan Pendidikan Biol. 6, 94–98. doi: 10.25134/edubiologica.v6i2.2369

[20] Sproncken-Smith, R., and T. Harland. 2009. Learning to teach with problem-based learning. Active Learning in Higher Education 10(2): 138–153.

[21] Wijnia, L., Loyens, S. M. M., Derous, E., & Schmidt, H. G. (2015). How important are student-selected versus instructor-selected literature resources for students' learning and motivation in problem-based learning? Instructional Science. doi:10.1007/s11251-014-9325-6.

[22] Xiong, X., Xu, J., Luo, M. et al. Efficacy of problem-based learning combined with case-based learning versus lecture-based learning in orthopedic education: a systematic review and meta-analysis. BMC Med Educ 25, 1357 (2025). https://doi.org/10.1186/s12909-025-07741-3