From Lecture-Based Learning to Problem-Based Learning: A Review on Navigating the Transformation in Engineering Education

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Abstract— The transition from Lecture-Based Learning (LBL) to Problem Based Learning (PBL) represents a significant shift in Educational systems. Traditional LBL doesn't have student centric approach but however, with the growing limitations in this approach educators are moving toward PBL to enable active learning, critical thinking and real world problem-solving skills. While the benefits of PBL are widely acknowledged, the challenges of implementing this pedagogical shift, particularly in terms of student acceptance and teacher adaptation, remain significant areas of concern. This paper presents the challenges and benefits of the transformation in education from LBL to PBL. The paper focuses on understanding the factors influencing student acceptance of PBL and the struggles faced by educators in implementing this innovative teaching approach. By exploring these dynamics, the study seeks to provide insights into effective strategies for facilitating the successful adoption of PBL in diverse educational contexts. The study employs a mixed-methods approach, combining quantitative surveys with qualitative interviews and observations. Initially, baseline data is collected to assess student attitudes and perceptions towards traditional lecture-based learning and their readiness for PBL. Subsequently, a carefully designed PBL curriculum is implemented, incorporating feedback from stakeholders and best practices in PBL pedagogy. Throughout the implementation process, data is collected on student engagement, learning outcomes, and teacher experiences. Successful implementation of PBL requires Student readiness, teacher training and Curriculum alignment. By addressing these factors proactively, educational institutions can maximize the benefits of PBL and create enriching learning experiences for students.

***Keywords*— Problem-Based Learning, Lecture-Based Learning, Education, Transformation, problem solving**

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I. INTRODUCTION

Lenschow (1998) For many years, teachers have predominantly used lecture-based teaching with a focus on theoretical instruction. It also made students to memorize the concepts related to formulae and procedures instead of understanding them. This approach treated engineering students as passive recipients of knowledge rather than active participants in their own knowledge. The outcome is Institutes are able to produce engineers with strong technical knowledge but lacking in real time problem-solving, teamwork and effective communication. As the world evolved, so did the demands placed on engineers, necessitating a shift in the way engineering education is conceived and delivered. This transition from traditional engineering education to innovative pedagogies represents a profound paradigm shift in the field, one that prioritizes research-driven pedagogies, interdisciplinary collaboration, and a holistic approach to engineering education. In this paper, we delve into the historical context and motivations behind this transition, exploring how it has reshaped the landscape of engineering education.

Problem Based Learning (PBL) is an outcome that emerged in response to the shortcomings of traditional engineering education. PBL advocates for a pedagogical transformation grounded in empirical research and evidence-based practices. It seeks to bridge the gap between theory and application by fostering active learning environments, integrating real-world challenges into the curriculum, and promoting critical thinking and problem-solving skills. This shift in the educational system is driven by the need to prepare engineering students not only with technical expertise but also with the adaptability and innovation required to tackle the complex, multifaceted challenges of the 21st century. In this paper, we embark on a journey through this transformative process, shedding light on its historical roots and the evolving methodologies that underpin it. By examining this transition, we aim to elucidate the motivations and aspirations that drive educators and institutions to embrace Engineering Education Research as the path forward in engineering pedagogy.

II. LITERATURE SURVEY

Devika S. V. (2018) explores the beliefs and roles of teachers in shaping student research capabilities, emphasizing that teachers can empower students by engaging them effectively in research activities during their undergraduate studies. This idea is further supported by Suresh et al. (2023), who illustrate how student involvement in community engagement not only fosters social responsibility but also enhances their learning experience. By integrating community service into the curriculum, students develop a sense of social consciousness that complements their academic growth.

Building on this theme of transformation in education, Lenschow (1998) discusses the shift from traditional teaching methods to student-centric approaches in undergraduate education. This shift is crucial for developing lifelong learning skills, as it encourages students to become more independent and self-directed in their learning.

Finally, Mills and Treagust (2003) examine the effectiveness of Problem-Based Learning (PBL) in engineering education, highlighting how it enhances student learning outcomes and classroom engagement. By focusing on real-world problems, PBL not only provides practical knowledge but also aligns with the broader educational goal of promoting critical thinking and problem-solving skills. Together, these studies underscore the importance of innovative teaching methods and community engagement in cultivating competent and socially responsible graduates.

III. IMPACT OF INNOVATIVE PEDAGOGIES ON THE CURRENT GENERATION STUDENTS

Engineering education research has a significant impact on the current generation of students, educators, and the engineering profession as a whole. This field of research focuses on improving the teaching and learning of engineering concepts, practices, and skills. Out of many advantages there are few points which shows significant difference for current generation teaching and Learning process.

a. Enhanced Learning Outcomes:

Teachers work on various pedagogies which connects to the students and make students participate/involve in the activities which improves the attention span of the students which in turn improves the learning outcome of the students, helping them acquire a deeper understanding of engineering principles.

b. Innovations in Pedagogies/Pedagogical approach:

Engineering education research drives teachers to explore more pedagogies like Problem Based Learning, Flipped classroom etc. which empower students to enhance their self-directed learning abilities and actively engage in hands-on academic experiences. Design is one of the fundamental processes and activities in engineering education (Mills, J. E., & Treagust, D. F. 2003).

c. Problem solving skills:

Suresh et al. (2023) Problem-Solving Skills: Engineering education research emphasizes problem-solving skills and critical thinking. Current students benefit from research-backed strategies that help them develop these essential skills, making them better-equipped for real-world engineering challenges.

d. Adaptation to Industry Needs:

Engineering education research helps engineering programs adapt to the evolving needs of industries. Graduates are better prepared to meet the demands of the job market with the skills and knowledge identified through research.

e. Assessment and Accreditation:

The pedagogies like Problem Based Learning, Presentations, Collaborative works implemented for all the courses in the classroom helps to map with the Program Outcomes in National Board of Accreditation) NBA and National Assessment and Accreditation Council (NAAC) which gives recognition to the Institution in giving clarity to the stakeholders about Outcome Based Education is being followed in the Institution.

Many of the criteria used by the NBA for program accreditation, such as curriculum relevance, student outcomes, and teaching-learning processes, are closely related to research-based teaching practices. Institutions that adopt these practices are better positioned to demonstrate compliance with NBA accreditation standards. The faculty expertise can positively influence accreditation processes as faculty members contribute to curriculum development, program assessment, and other key aspects evaluated by the Accreditation bodies.

IV. DRIVING FACTORS FOR TEACHERS

Now, in response to the changing landscape of education, colleges are increasingly shifting towards outcome-based education models. In this evolving paradigm, teachers are encouraged and sometimes even required to engage in engineering education research and employ a variety of pedagogical approaches to enhance the learning experiences of their students.

Motivating teachers is crucial for maintaining their enthusiasm, dedication, and effectiveness in the classroom. Here are some important aspects to consider when motivating teachers especially during the transition from Traditional teaching to Outcome Based Education:

a. Recognition and Appreciation

Acknowledge and appreciate the hard work, dedication, and contributions of teachers. Regularly recognize their

achievements, both big and small, through verbal praise, awards, and certificates.

b. Professional Development

Since the teachers are in the transition period and not confident on using the pedagogies in the classroom it is required to invest in teachers' professional growth by providing opportunities for training, workshops, and conferences. Teachers to be encouraged to expand their knowledge and skills, which can lead to improved job satisfaction.

c. Autonomy and Empowerment

Give teachers autonomy in their classrooms and allow them to make decisions about curriculum, teaching methods, and classroom management. Empowerment can lead to a greater sense of ownership and responsibility.

d. Recognition of Expertise

Recognize teachers as subject matter experts and encourage them to share their knowledge with colleagues. This can involve leading workshops, presenting at conferences, or mentoring junior teachers.

e. Student Success

Celebrate student successes and milestones, as teachers often find motivation in the progress and achievements of their students.

Different teachers may be motivated by different factors, so it's essential to tailor approaches to individual needs and preferences.

V. EXPLORING VARIOUS SUPPORT SYSTEMS

It is essential to give support to teachers to undergo various programs to get confidence and knowledge on the Engineering Education through various pedagogies.

Here are the list of opportunities to the teachers on various programs offered by Indo Universal Collaboration for Engineering Education (IUCEE).

a. OBE Certification program

This certification program focuses on defining clear learning outcomes or competencies for students and designing curriculum and assessment methods to ensure that students achieve these outcomes. Certification programs related to OBE are typically designed for educators, faculty members, and educational leaders who want to gain expertise in implementing OBE principles in engineering education.

Professors from various reputed Universities offer session on Curriculum Design, Teaching and Assessment Strategies, Technology Integration, Assessment of Student work, Peer Learning and other sessions related to enhancing Learning outcomes of the students.

b. IIEECP Certification Program

This certification program has 6 modules. Teacher completes this course will get confidence in using various pedagogies in the classroom. The Modules are: Teaching Learning Process, Fundamentals of course design, Creating a dynamic classroom, Technology Incorporated, Collaborative Learning and Effective Assessment.

These innovative pedagogies help the teachers in understanding and implementing PBL. These programs support teachers in preparing PBL framework including Assessment strategies.

VI. LEARNING THROUGH RESEARCH

Devika S. V. (2018) While faculty members who are new to engineering education research may face a learning curve, their commitment to exploration and the pursuit of knowledge can lead to meaningful contributions in the field. It's important for them to seek guidance from experienced researchers, collaborate with peers, and approach research with a growth mindset to maximize their learning and impact.

Engaging in research on engineering education, even without complete prior knowledge in the field, can be a transformative learning experience for faculty members. Through research, they actively explore the evolving landscape of education, diving into literature, current trends, and innovations. Faculty members can focus on specific areas of interest, gradually becoming subject matter experts in those domains. Collaboration with colleagues, attending conferences, and networking with researchers broaden their horizons and facilitate idea exchange. Conducting research also encourages hands-on application of knowledge in real-world educational settings, leading to insights into teaching and learning challenges. Additionally, faculty members can experiment with innovative pedagogies in their teaching, foster critical thinking and problem-solving skills, and contribute to the growing body of knowledge in engineering education. Through research, they gain awareness of the challenges and opportunities within the field and contribute to continuous improvement in their teaching practices. Overall, embracing research in engineering education is not only a learning journey but also a way to positively impact educational practices and advance their careers.

VII. CHALLENGES FACED BY THE TEACHERS DURING THIS TRANSITION

(Lenschow, R. J. 1998)Transitioning from traditional teaching to engineering education research can be a transformative journey for educators, but it also comes with its share of challenges. One significant obstacle is the potential lack of research skills among teachers who are more accustomed to traditional classroom instruction. As they embark on this

transition, faculty members may need to invest time in developing these essential research competencies.

Many educational institutions may have limited resources for research, including funding for research projects, access to specialized research facilities, and software tools. Without these resources, teachers may find it difficult to initiate and sustain research efforts effectively. Balancing teaching responsibilities, which often demand a significant portion of a teacher's schedule, with the demands of research can be a juggling act. Engaging in research requires dedicated time and effort, making it crucial to find a balance between teaching and research commitments.

"Acceptance" from Teachers as well as Students is the critical challenge during this transition. Transitioning from traditional lecture-based teaching to research-focused methods may encounter resistance from students who are more accustomed to traditional instructional formats (Devika, S. V. 2018). Convincing the important stakeholders of the value and benefits of research-based learning can be an ongoing process.

Institutional support, including funding, recognition, and time allocation for research, can vary widely among educational institutions. Faculty members may need to navigate administrative hurdles to gain the necessary support for their research endeavors.

Overcoming these challenges involves seeking professional development opportunities, collaborating with experienced researchers, accessing institutional support, and gradually integrating research-based teaching practices into courses. It's crucial for institutions and educational communities to recognize and address these challenges to facilitate a smoother transition for faculty members interested in research-focused teaching.

VIII. CREATING A SUPPORTIVE PBL ENVIRONMENT

- Creating a classroom that facilitates teamwork is essential for a successful Problem-Based Learning (PBL) environment.
- Providing students with access to various tools and the necessary data to support their exploration and experimentation.
- Encouraging students to present their ideas to facilitators, fostering open communication and collaboration.
- Motivating students to overcome challenges during the PBL process, and ensure a secure environment where they can experiment and learn from mistakes.
- Offering clear guidance on the PBL implementation process to help students navigate this innovative approach.

IX. MODIFICATIONS TO BE DONE IN CURRICULUM

Mills and Treagust (2003) To implement PBL effectively we need to do certain modifications in the curriculum. First, integrate real-world problems into the curriculum by designing content around complex, relevant issues that challenge students to apply their knowledge in practical contexts. This approach not only enhances engagement but also ensures that learning is directly applicable to real-life scenarios. It is necessary to adopt multidisciplinary approach by structuring the curriculum to involve various courses that helps students to explore broader domains to develop their problem solving skills.

Assessment is very critical component in the PBL. As this is one of the most important driving factor for the students to complete the tasks as per the timelines. Including assessment in the curriculum helps in providing clear guidance to the students throughout the entire process.

Timely feedbacks helps in understanding the students challenges in executing the tasks.

X. IMPACT ON STUDENTS LEARNING OUTCOME

Switching to PBL can greatly benefit students. They become more engaged in their learning, think critically, and apply what they learn to real situations. They get hands-on experience, learn how to solve problems effectively, and become better at understanding complex subjects. Students also pickup important research skills like analyzing data and sharing their findings. (Suresh & et. al 2023) This approach helps them prepare for future careers because it aligns with what industries need. It also teaches them to be adaptable and open to learning throughout their lives. Overall, students gain a better understanding of their subjects, more confidence, and the skills they need to succeed in their studies and beyond.

XI. CASE STUDY : FEEDBACK

A case study has been done in the Department of Electronics and Communication Engineering of Hyderabad Institute of Technology and Management, Hyderabad. Feedback is taken from various stakeholders using different methodologies. Initial feedback is taken from 200 students in the campus with structured questionnaires before and after implementation of PBL. The survey done with the students includes Likert-scale questions considering students attitude towards LBL and readiness to PBL. Also feedback is taken from 20 educators to explore their experiences and challenges during PBL implementation.

Through these quantitative surveys it has been observed that there was a mixed response from the students regarding transformation to PBL. Before implementing PBL, 65% of the students opinion about LBL was effective for understanding the fundamental and core concepts and around 30% felt LBL is boring and unengaging with 5% remaining neutral. In terms of readiness to PBL, it was observed that 50% students were excited trying PBL while 40% were in dilemma and clueless.

Post-implementation survey results indicated that 70% of students reported higher engagement in PBL sessions compared

to LBL. Furthermore, 60% felt that PBL helped develop their critical thinking skills, and 40% found the collaborative nature of PBL beneficial. However, 20% still preferred LBL due to its familiarity. Challenges with PBL were also noted, with 45% of students citing increased workload as a major issue, 30% mentioning difficulty adapting to the new learning style, and 25% feeling they needed more guidance from instructors.

Survey is conducted among teachers to understand the challenges and readiness for transformation. 50% teachers were somewhat confident and 40% were expecting for preparedness in terms of training in PBL. But 10% were confident and experienced in implementing PBL and confident to show improved academic performance. After implementing PBL, 60% of teachers felt PBL is engaging students effectively compared to LBL. 50% were happy, 40% faced challenges towards curriculum and assessment.

Qualitative interviews presented both positives and also challenges. There was appreciations from many students that their interpersonal skills, collaboration and communication had been improved. But students struggled with team work and unable to do some tasks independently.

CONCLUSION

The transformation in the educational system from Lecture-Based Learning (LBL) to Problem-Based Learning (PBL) helps students to enhance their problem solving skills and also improve academic performance. However this transition will have challenges both to students and teachers. By adopting appropriate strategies the challenges can be overcome. Successful implementation of PBL requires integration of real world problems in the curriculum, modifications in the assessment strategies to make student involve more and focussing more on the preparedness of teachers and students by addressing all the challenges. Though there may be some challenges along the way, the rewards are substantial. Teachers learn new skills and improve their teaching methods, making classes more engaging and effective. As a result, students get a better education. They become more interested in their studies, learn how to think critically, and can implement what they learn in real-life situations. The outcome of this transition in the education system helps student to become industry ready and enhance their employability skills. Teachers can become more confident in implementing innovative pedagogies and effective engagement in the classroom and will never think about “I am Teaching, are they Learning? ”.

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