Library Progress International *Print version ISSN 0970 1052*
Vol.44 No. 3, Jul-Dec 2024: P.14453-14464 *Online version ISSN 2320 317X*

Original Article *Available online at www.bpasjournals.com*

Integrating Project-Based Learning and Industry Partnerships in Engineering Education: A Multi-Institution Study

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How to cite this article: Geetha V, YVR Naga Pawan, Ajay Kumar Dogra, Deepak Kohli, Megha Batola, Ajay Sudhir Bale, Mamta B Savadatti (2024) Integrating Project-Based Learning and Industry Partnerships in Engineering Education: A Multi-Institution Study. *Library Progress International,* 44(3), 14453-14464.

ABSTRACT

This work focuses on the need of Project-Based Learning (PBL) and industry partnerships in engineering education across multiple institutions. With the use of various case studies, the integration between them is discussed. With the use of these case studies the PBL approaches are explored and how this enhances student engagement, practical skill developments and in the preparation of engineering careers is studied. This study highlights new programs such MIT's NEET, Stanford's ME310, Purdue's EPICS, and others that have shown successful integration of two domains. It is observed that this integration will lead in the development of both technical and soft skills of the students. This will further help the students to have an authentic learning experience which can align with engineering education with real world industry demands.

Keywords: PBL, education, innovation, industry, integration

1. Introduction:

In the 21st century, in an environment that is interconnected and interdependent, it is essential for the learning of potential engineers to equip students with abilities that are aligned with the present circumstances, as well as instil in them the appropriate principles and mindsets. Active pedagogies, wherein one can take on a leadership role in their own education while the instructor acts as a learning guide, are being recognised as an effective approach to achieving this comprehensive instruction. PBL is extensively used in the field of engineering since the latter half of the 20th century to enhance students' academic progress and develop their useful abilities. The development of this teaching-learning system originated as PBL in medical education, in order to address the issues caused by mere memorising in students studying health sciences. PBL not only enhances academic achievement and sustains student focus and involvement, but also fosters the acquisition of both technical and non-technical competencies that are crucial for achieving success in one's professional career. Considering this setting, it is important to acknowledge the significance of Bloom's classification in the classroom of engineering. The hierarchy offers a well-organized structure for cultivating advanced cognitive abilities, allowing scholars to not only comprehend and utilise mathematical principles but also critically assess, appraise, and generate inventive resolutions for intricate engineering challenges. Etzkowitz argues that whereas schools and the manufacturing industry were formerly strictly separate, their link has now grown more direct and widespread [2]. The convergence between manufacturing and training is a prevalent area of study in worldwide vocational schooling and a shared objective in the advancement of professional schooling in many nations. In China, the fusion between manufacturing and education is needed in vocational schools due to the demands of industrial advancement and local economic growth amidst the ongoing profound industrial revolution. Furthermore, the fusion of production and education may provide robust backing for the enhancement of the essence of vocational education (VE) and the advancement of company and engineering. This approach to someone growth is both academic and feasible, keeping up with the current times. It not only includes essential material but also offers a clear path for execution in a way to establish a contemporary VE structure. In the context of integration, "production" can be recognised as the function of creating or "learning how to do" something, which is a crucial component of useful education. "Education" relates to the process of instructing and usually encompasses practical instructing tasks and content. The integration of theory and practice is a basic prerequisite. The merger of production and education entails the collaboration and amalgamation of the manufacturing industry and educational institutions, with the objective of enhancing the practicability of schooling and technological innovation. Given this context, project-based teaching serves as a significant organisational structure used to execute collaboration tasks which combine production and education. Compared to industrialised Western nations, vocational schooling in China has been somewhat slow to grow, and the implementation of project-based teaching approaches has also been delayed. Currently, the majority of newly converted vocational colleges in China are at the early stages of integrating production and education. Their skill growth strategies remain at a low level, and as a result, that they have not yet achieved the desired level of deep integration between manufacturing and education. Engineering is a career that utilises expertise in mathematics and natural sciences, acquired via research, hands-on experience, and practice, to find practical applications for both forces and materials found in its very nature, ultimately benefiting humanity [1]. The engineer uses their expertise to conceive and create functional gadgets, processes, and structures. The process involves making decisions, typically in a repetitive manner, by using the principles of fundamental sciences, mathematics, and engineering to efficiently use resources in order to fulfil specified requirements [3]. Successfully completing a CD programme in environmental and civil engineering is a crucial endeavour. Replicating projects seen in design workplaces may be a difficult task, since there is a possibility that graduation design courses may end up focusing more on analysis rather than practical implementation [4]. Civil and environmental engineering design is often dictated by site circumstances and municipal legislation. Teachers with no practical expertise will not have the same educational influence as professionals actively engaged in the subject. As a result, multiple organisations collaborate with industry customers to financially support capstone projects. The participation of industries is an essential element in student learning as it provides valuable experience and knowledge via connected activities. In the field of technological education, there is widespread consensus on the significance of professional skills such as relationships, collaboration, interaction, and ability to solve problems. However, companies have noted a significant disparity between their expectations and the actual proficiency of graduates in these areas. One of the key motivations for doing this research was to fulfil our objective as teachers to equip students in engineering with the necessary skills for thriving in their professional careers in the industry. Regarding engineering practice, existing research has shown notable disparities in the level of thoroughness in design and expertise between academic settings and professional work environments. Hence, the inclusion of a group of engaged engineers and experts from the industry will enhance the professional aspects of schooling in engineering. Company participation in capstone courses is often achieved by company sponsoring of design initiatives. This sponsorship generally includes providing mentoring, financing, and support to the assignments and team members. Based on a 2005 survey on CS courses in the United States, it was found that 71% of these courses included projects funded by industries. Capstone teachers see the course as a platform for students to use their knowledge gained all through their undergraduate education by engaging in an unrestricted design project inside a simulated real-world setting. The literature has extensively highlighted the advantages of involving practicing engineering experts. Research found that feasible initiatives could be implemented when there was a robust collaboration between the institution and the municipality. The writers contended that a completed project had exceptional public relations prospects both for the institution and town, while also cultivating a group of fresh experts that comprehended the intricacy and red tape associated. Additionally, several of these engineers later became workers for the companies that sponsored the programme. They determined that the ideal number of pupils in a group was four, with one of them being skilled in sketching. Teams consisting of less than four members often found themselves confused by all of the elements they were required to examine throughout the design process. Teams consisting of more than four people sometimes had a lack of significant contribution from individual members, which in turn led to the team overwhelming the consultant [3]. The industry gains advantages by obtaining technical support from experienced students who do initial analysis and designs to evaluate various potential solutions and offer innovative ideas for addressing current issues. The students gain advantages from engaging in practical challenges, collaborating with expert engineers, and encountering practical limitations related to economics, law, and regulations that are not typically covered in traditional undergraduate courses. Additionally, there is the potential for the students to secure employment with their mentors upon completing their studies. As a result, students obtain essential knowledge about the fundamental aspects of design in their specific subject and develop the necessary abilities to join the profession.

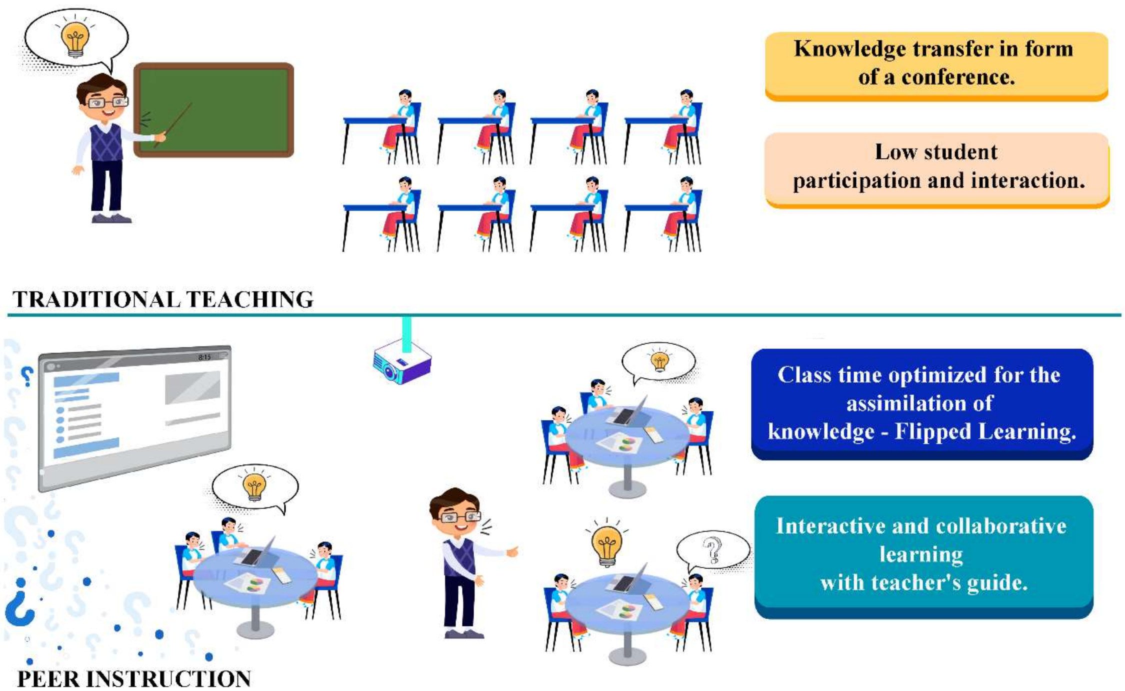

Figure 1: Peer education is an innovative approach to conventional teaching [5]

This work brings out the uses and benefits of integrating PBL and Industry Partnerships in Engineering Education. With the use of many cases, we will discuss these topics

2. Flipped Classroom as a Learning Environment

The work in [4] was conducted at a university where the FC method, an innovative teaching style, is used across all levels and courses. Through the reversal of the conventional classroom dynamics, we have successfully attained improved learning outcomes, enhanced student comprehension, and heightened efficacy process. Many use the structural components of pre-home preparation, active classroom activities (such as collaboration, problems-solving assignments, and discussion formats). The instructor, in the position of a mentor, facilitates personalised learning by accommodating individual learning speed and style, and promotes active student engagement. Additionally, it facilitates group collaboration and fosters peer-to-peer learning, often known as collaborative learning. We combine technology from the internet with the Teams and Moodle platforms to provide pre-learning resources in a digital format, including videos, online measurements, and engaging tasks. Within this educational setting, the process incorporates feedback and evaluations, enabling students to promptly rectify and enhance their performance. Within this dynamic and interactive learning setting, the work already achieved superior outcomes in learners as compared to the prior, more traditional instructional environment. When assessing the level of enthusiasm to study, they have taken into account student feedback obtained via electronic means and written submissions, both throughout the courses and at the conclusion of each semester.

3. Enhancing student engagement and enthusiasm in the educational process

The TLP is still defined by the enduring use of conventional approaches, where the educator serves as the conveyer of knowledge and pupils passively receive it. Research shows that the format of a master-class or lecture-style setting is not conducive to students actively engaging in their learning. This is because their level of participation and dedication to class activity decreases as their drive declines during the process. At first, inverted learning sparked debate amongst students and their parents. The increased learning by yourself by educators throughout the epidemic has been very significant for enhancing their knowledge, skills, and talents, notwithstanding the accompanying stress. Yet, students were able to recognise that their gaming skills surpassed those of professors in aesthetic matters. Nevertheless, they were not very adept at self-learning. The significant aspect of this situation is that due to the lockdown, several educators had the chance to establish a rapport with information and communication technology (ICT). This, in turn, facilitated the streamlining of the assessment process and enhanced desire to complete tasks. Databases like the Web of Science and Scopus have had a substantial impact on the current level of knowledge and have sparked research interest because of the significance and organisation of their materials. However, it is important not to overlook other sources that are freely accessible. Therefore, it is essential to modify the teaching methods and dynamics of the classroom environment in order to empower students and engage them actively in their own learning process. Research has shown that this approach enhances students' comprehension, academic achievement, and classroom progress. It also has a greater impact on students' attitudes, expertise, drive, dedication, and happiness with their schooling compared with conventional methods of instruction. Diverse pedagogical approaches foster student engagement and provide a novel alternative to the conventional patterns that have persisted throughout time. These interactive strategies enhance educational outcomes and cultivate individuals with the ability to think deeply, evaluate critically, analyse effectively, and regulate their own learning. PI is an instructional approach that successfully encourages active, engaged, and interactive learning. It creates an environment for student involvement and provides formative feedback. This has been supported by several studies. Due to its distinctive features and instructional versatility, this tool may be customised to suit various settings, academic levels, and classroom conditions in alignment with their educational goals. Problem-based instruction (PI) is an interactive educational approach that assesses the learner's comprehension of a particular subject via the implementation of questions and answers. It also encourages student engagement through conversation and debate. Prior to this, students should possess a preliminary understanding and familiarity with the subject matter that will be covered in the class. Consequently, the relationship is enhanced with individual expertise. By implementing inverted learning, the TLP can optimise class time by shifting the focus from information transmission to tasks which promote knowledge integration, directed engagement, problem-solving, and consolidation of learning. Conversely, lessons on knowledge transfer are conducted at home, allowing students to engage with the subject matter eagerly and allocate sufficient time for private study. This serves as a foundation for their eventual engagement in class. However, it is important to note that technology is playing a growing function in facilitating the adoption of innovative interactive teaching techniques that cater to the interests and demands of students and modern society. Information and communication technologies (ICT) have become increasingly prevalent in the educational sector, resulting in more engagement and improved outcomes when using these innovative teaching approaches. PI is not an exception in this regard, since the optional use of ICT enhances the experience for the participants. Yet, the achievement of technology depends on the pedagogical expertise that underlies digital knowledge and abilities. These, in turn, facilitate the achievement of the educational goals set by the teacher's field of study. Gaining knowledge in engineering is crucial for driving innovation in the TLP. The use of technology in education is grounded in principles of engineering and aligned with the learning sciences in order to effectively adapt to the ever-evolving nature of education. Therefore, by integrating the educational, technical, and subject-specific expertise that a teacher needs, it is feasible to effectively address present difficulties and optimise the utilisation of these approaches. The purpose of this paper is to demonstrate how a collaborative instructional method based on PI may be used, using a learning design approach, to bring innovation to the TLP. This is a reaction to the issue addressed in the current study about the durability of conventional teaching techniques, which need more student engagement and motivation in relation to their TLP. Therefore, it is crucial to encourage instructors to think creatively and establish innovative instructional approaches [5]. This will enable them to enhance their classroom environment, as seen in Figure 1.

4. Methodologies

The Figure 2 shows the various universities and their PBL models. The cases of these models are discussed in detail in the following sections

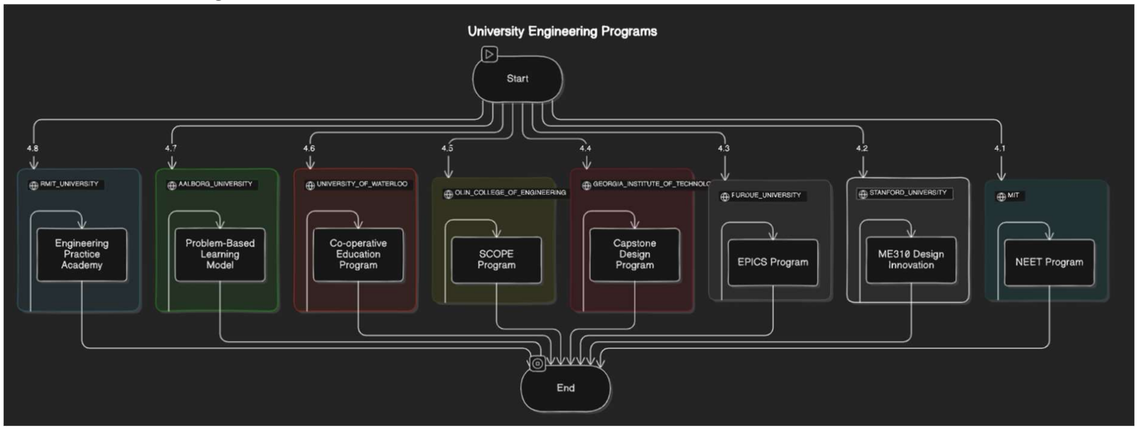

Figure 2: Diagram showing all the cases studied

4.1. Massachusetts Institute of Technology (MIT) - NEET Program

The demands of industry and society for engineering education have evolved over the last several decades, but the conventional bachelor engineer curriculum has remained mostly unaltered. In the autumn of 2016, the Dean of the School of Engineering at MIT established the New Engineering Education Transformation (NEET) programme. The program's objective is to educate engineers in the development and construction of innovative devices and systems that can effectively tackle the significant community demands and obstacles of the 21st century. NEET graduates will be equipped to function as entrepreneurs, inventors, creators, and explorers by acquiring and using the NEET Styles of Thoughts: cognitive strategies that enhance students' ability to think, strategize, and acquire knowledge autonomously and collaboratively. The programme saw a consistent growth in student enrolment, starting with 28 students in Fall 2017, increasing to 52 students in Fall 2018, and reaching 83 students in Fall 2019. This growth has made the programme considerably bigger than the majority of recently established academic programmes, as well as larger than many other majors. In Fall 2018, NEET initiated a pilot programme at MIT to implement the Ways of Thinking (WoT) concept. This involved collaboration between faculty and colleagues from the School of Humanities, Arts and Social Sciences, the School of Architecture + Planning, and the engineering faculty. The main objective was to create concise modules to facilitate the development of WoT skills. A total of 25 courses were implemented over the Fall 2018, Spring 2019, and Fall 2019 semesters. These modules focused on the subjects of Ethics, Creative Thinking, Critical Thinking, and Self-learning. We provide a detailed account of the development and piloting of those modules, the assessment of their effectiveness, the insights gained from their deployment, and the implications for future endeavours. An important discovery is that the Ways of Thinking should be more closely included into how students do project work in NEET [16-18].

4.2. Stanford University - ME310 Design Innovation

Innovation has evolved throughout time, and organisations are always striving to improve their operations in order to gain an edge over their competitors. Creativity has become recognised as an inclusive and cooperative process, including the participation of many stakeholders within the overall system [19-22]. Universities are highly suitable candidates for transforming the climate of innovation and making significant contributions to the development of a knowledge-based economy. This research investigates a partnership between a university and industry, specifically focusing on an innovation initiative under the ME310 programme. Porto Design Factory (P.Porto) and IKEA Industry collaborated to address a challenge using the Human-Centred Design (HCD) methodology. The case study technique facilitates comprehension of the results that demonstrated the capacity of HCD to address a technical issue while improving the customer experience. Moreover, it is feasible to acknowledge the advantages that each institution gained via collaboration. The business's invention endeavour was supported by research, prototypes, and detailed documenting that captured all the information created throughout the process. PDF also provided unique learning environments and job prospects for its pupils. The results indicate that firms gain advantages by establishing interfaces with other organisations, as well as that institutions play a significant role in the community of innovators, fulfilling their third goal. Additional inquiry might examine the extent to which the ideas derived from these collaborations are put into practice, as well as their long-term effects on the organization's values and work processes [19, 23-26].

4.3. Purdue University - EPICS Program

The Engineering Projects in Community Service (EPICS) programme at Purdue University is an innovative endeavour that integrates project-based learning with community service and collaborations with industry. Below is a concise summary of the programme: EPICS was established at Purdue University in 1995 with the objective of involving engineering students in the process of designing, constructing [27-31], and implementing actual solutions to address engineering-related issues among regional community service and educational organisations. The programme has since grown to include several campuses around the United States and beyond. EPICS is fundamentally organised around interdisciplinary groups of students that collaborate on enduring projects that have a positive impact on the community [32]. These projects usually extend across many semesters, which enables the maintenance of consistency and the creation of intricate solutions. Students from diverse engineering specialties, as well as other sectors such as business and the liberal arts, work together in these teams. The programme collaborates with local non-profit organisations, schools, and community organisations to identify issues that may be resolved via technical solutions [33-35]. Initiatives include the development of assistive technology for those with impairments, the creation of teaching tools for K-12 STEM education, and the design of environmentally friendly remedies for environmental concerns. EPICS also engages industrial partners in diverse roles. Corporations have the option to financially support initiatives, guide and support groups of students, or provide their specialised knowledge and assets. Students benefit from industry interaction since it provides them with opportunities to familiarise themselves with professional standards and procedures while engaging in socially conscious initiatives. The EPICS approach places equal emphasis on the acquisition of technical abilities and the cultivation of business abilities, including project management, collaboration, communication, and ethical issues. Students acquire skills in customer interaction, budget management, and navigating the intricacies of bringing about solutions in real-world scenarios [20].

4.4. Georgia Institute of Technology - Capstone Design Program

Capstone Design is an advanced course provided to undergraduate students in many fields at the Georgia Institute of Technology, serving as the last and most important subject in their curriculum. Students collaborate in groups to create, construct, and evaluate prototypes that have practical uses in the real world [36-38]. Students display their work at the "Capstone Design Expo" at the conclusion of each semester. This offers students the chance to collaborate on real-world, complex, multidisciplinary problems presented by sponsors from industry and academic projects. They acquire and use the technical design method, which involves establishing functional demands, conceptualising ideas, doing analysis, identifying potential hazards and corresponding preventive measures, making selections, and creating physical prototypes. Student teams create and construct functional, tangible prototypes to verify the effectiveness of their proposals. Through collaborative work, individuals enhance their abilities in management, teamwork, managing problems with scheduling, fulfilling weekly goals and deadlines, and effective communication with teammates, supervisors, and course teachers. Teams participate in lectures delivered by industry and academia specialists on various subjects such as industrial design, production, research on markets, advertising, patents, starting a business, code and requirements, and ethics. At the conclusion of the semester, student teams present and promote their ideas and commercial potential to a committee of judges, invited guests, media, and other students, all while vying for monetary rewards. This is a wonderful chance for sponsors to see the conceptualization of their project by the teams at the expo [21].

4.5. Olin College of Engineering - SCOPE Program

The engineering programme at Olin College places a strong emphasis on experiential learning and design. Starting from the first semester, all students actively participate in the creative endeavour of conceptualising, developing, constructing, and evaluating a device, system, or process with the aim of accomplishing a certain objective. The design process is conducted in a collaborative team setting inside an open-source studio environment [39-41]. This environment allows for the public presentation of the design process, which serves as the primary means of social discussion on campus. The design emphasis is maintained throughout all eight semesters, gradually increasing in complexity and breadth, fostering significant proficiency in collaboration and practical science. This culminates in the senior year, where all students are obligated to undertake a two-semester capstone experience known as the Senior Consulting Project in Engineering (SCOPE). This particular project consolidates the preparation from several fields and applies it to a significant technological challenge that a corporate customer is ready to spend a big amount to solve. This project is the final culmination of a four-year educational programme designed to provide students with the necessary skills and knowledge to become engineers. The programme focuses on providing students with hands-on experience rather than only teaching them theoretical concepts via applied science courses. At Olin, they hold the belief that engineering is better characterised as a dynamic and creative art form rather than a passive and analytical scientific discipline. Thus, it is inherent that a genuine achievement should hold the primary position for every student in fulfilling an Olin education. Olin's SCOPE project goes above the norm by pushing the edge in various areas, even though many engineering schools now include a mandatory senior design project. Furthermore, it strives to fulfil the primary learning goals of each of these three B.S. degree programmes, but there are other components of the educational programme that also target one or more of these purposes [22].

4.6. University of Waterloo - Co-operative Education Program

This program works as an alternate way for the students who wish to complete the four-month academic term in the campus, a four-month work in industry follows that. This pattern continues throughout the degree course helping students to complete four to six work terms by graduation. A unique feature of Waterloo’s cooperative program is well integrated curriculum. This feature is one of the core components in Many engineering programs. The strong bond between industry and academia will help students to secure their cp-op positions. There are various support firms which help students to develop skill, develop job search and build career. Students often move from entry-level tasks in their first work term to more complex, project-based work later. This helps for the practical application of academic knowledge and the development of professional skills. This program helps both students and employers. Students gain valuable work experience and can have different career paths, and get secure full-time employment upon graduation were as employers can access to a pipeline of talent and can evaluate likely future hires over extended periods [23].

4.7. Aalborg University (AAU) (Denmark) - Problem-Based Learning Model

Engaging in Problem Based Learning with a focus on the Sustainable Development Goals can be a profoundly inspiring catalyst, particularly when the solutions generated can be implemented and have tangible effects on individuals and communities. There is the collaboration between three engineering students from Aalborg University, Denmark, and the South African Organisation Green Shoots. The objective of this collaboration was to provide IT-supported Maths instruction to underprivileged learners from townships and rural regions in the Western Cape. The initiative afforded the Danish students an unparalleled educational opportunity and had a lasting influence on the participating communities. The project's main objective was to introduce IT-supported Maths education to learners in disadvantaged areas of the Western Cape. Additionally, the project offered valuable insights into the implementation of student projects that aim to benefit communities facing socio-economic challenges such as poverty. Furthermore, the work examined three crucial factors to establish the feasibility of such projects: aligning learning objectives with project outcomes, ensuring that the project generates value for the partner organisation and communities, and managing the workload of university supervisors to prevent overload. They are of the opinion that student projects centred on Sustainable Development Goals (SDGs) has significant potential in terms of offering extremely inspiring student projects while also making a positive impact on the world via solutions that continue to be used even after completion. Nevertheless, our research was limited to a solitary instance involving a single cohort of three students. The work anticipate that the study will provide motivation for doing more extensive research, which would include collecting more quantitative data to determine the most effective approach for implementing successful projects. Additionally, the research aims to showcase the benefits that these projects may provide to both students and society [24].

AAU is very well known for its unique PBL model, which has been a main talking point of the university from the time it started in 1974 [42-43]. All disciplines in the university follow this model but mainly it is acquired from engineering disciplines. This model mainly focuses on project work in collaboration. The student spends half the time during this course to complete the course work and remaining half time on real world problem solving. This makes sure that the students acquire both theoretical as well as practical skills. The projects are usually semester long and are sponsored and worked with industry collaboration. The projects are faced on the problems that are faced by industries or even by the society. As the problem statements are worked in consultation with the industry experts, the students will be able to work on projects which are relevant to the industry and current demands. The students are clubbed in the group consisting of 4-6 individuals. They plan the problem statement, research methodology, and develop the solution for the problems. As this is self-directed approach students are exposed to real time problems and due to this, they acquire critical thinking and team work skills. The role of instructors is just like facilitators. They help the students in the learning process, give their valuable feedback if required, and makes sure the project will be in line with the study outcome. This model is available to students from first to eight semesters of their study time [44-46]. The beauty of this project is that, as the students' progress through this project, the difficulty level increase and the students acquire more skills. The students are assessed for their individual and group work components. They are assessed on their collaboration skills, the process they have acquired and their individual contributions to the project. The outcome of this course is found to have produced students who are ready for industry level challenges and can work for any real-world problems which can help the society. And, any companies actively seek out these students from AUU for these qualities [47-48].

4.8. RMIT University (Australia) - Engineering Practice Academy

RMIT has an engineering practice academy which focuses on PBL in a professional environment. The program is designed to be a workplace like system for the students are referred as associates and educators as coaches of engineering practice. The curriculum focuses on real industry projects apart from traditional teaching methods. Students work on the projects as a team to arrive at the solutions to complex problem with the help of industry experts. This allows for the integration of technical knowledge, professional skills, industry standards with a practical approach [49-51]. The infrastructure is designed to mimic a workplace rather than a academic structure which helps associates to get accustomed to workplace scenario and professional settings right from early stages of career building. They learn skills like team work, project management, engineering ethics, communication skills etc. They are motivated to take responsibility of their own learning and professional development [52-54].

5. Conclusion and Future Scope

When PBL integrates with industry partnerships, it becomes a big step in the development of engineering education, which helps the education become more practical and enhances industry-based learning experience. The case studies in this work have shown that when they are properly implemented, they will help in the developing the student engagement, and develop important professional skills. For this to be success, careful planning, allocating the resources and good collaboration between industry and academia is required. The future research should focus on the collaboration of industry and academia which can provide long term solutions. It should also help in creating more jobs and also higher education opportunities. As these models gets better, the advanced level will help more institutions to acquire the techniques and get benefit from it. More projects need to be planned and more industry academia collaboration is required as there are lot of problems which needs to be tackled by the society and for this, these types of plans are very essential. The models as discussed in this work looks very promising in the development of future PBL techniques and the industry collaboration.

The future scope for PBL and industry collaboration integration should consist of several aspects. There should be a long-term study which will identify the major problems; this will help in building a very standard best practices for dealing the issues in real-time. The model should also use adaptive learning method by which the quality of solutions provided will be enhanced. There is a lot of demand and need for these models to be explored and get new models which will faster in getting the solutions and provide a standard solution to the problems. The objective of these research and development endeavours is to enhance and broaden the efficacy of problem-based learning (PBL) and collaborations with industries in equipping upcoming engineers to tackle the changing demands of their field.

References:

1. Lavado-Anguera, Silvia, Paloma-Julia Velasco-Quintana, and María-José Terrón-López. "Project-Based Learning (PBL) as an Experiential Pedagogical Methodology in Engineering Education: A Review of the Literature." Education Sciences 14.6 (2024): 617.
2. Wang, X.; Lee, C.-F.; Li, Y.; Zhu, X. Digital Transformation of Education: Design of a "Project-Based Teaching" Service Platform to Promote the Integration of Production and Education. Sustainability 2023, 15, 12658. https://doi.org/10.3390/su151612658
3. Badir, A.; O'Neill, R.; Kinzli, K.-D.; Komisar, S.; Kim, J.-Y. Fostering Project-Based Learning through Industry Engagement in Capstone Design Projects. Educ. Sci. 2023, 13, 361. https://doi.org/10.3390/educsci13040361
4. Köpeczi-Bócz, T. The Impact of a Combination of Flipped Classroom and Project-Based Learning on the Learning Motivation of University Students. Educ. Sci. 2024, 14, 240. https://doi.org/10.3390/educsci14030240
5. Rivadeneira, J.; Inga, E. Interactive Peer Instruction Method Applied to Classroom Environments Considering a Learning Engineering Approach to Innovate the Teaching–Learning Process. Educ. Sci. 2023, 13, 301. https://doi.org/10.3390/educsci13030301
6. R. L. P. Teixeira, P. C. D. Silva, R. Shitsuka, M. L. de Araújo Brito, B. M. Kaizer and P. da Costa e Silva, "Project Based Learning in Engineering Education in Close Collaboration with Industry," 2020 IEEE Global Engineering Education Conference (EDUCON), Porto, Portugal, 2020, pp. 1945-1953, doi: 10.1109/EDUCON45650.2020.9125341.
7. Faizi, Jamilurahman, and Mohammad Sarosh Umar. "A conceptual framework for software engineering education: project based learning approach integrated with industrial collaboration." International Journal of Education and Management Engineering 11.5 (2021): 46.
8. Pan, Gary, et al. "Essence of partnership management in project-based learning: Insights from a university's global project programme." Journal of international education in business 14.2 (2021): 297-319.
9. González-Domínguez, Jaime, et al. "Application of circular economy techniques for design and development of products through collaborative project-based learning for industrial engineer teaching." Sustainability 12.11 (2020): 4368.
10. Ricaurte, Marvin, and Alfredo Viloria. "Project-based learning as a strategy for multi-level training applied to undergraduate engineering students." Education for Chemical Engineers 33 (2020): 102-111.
11. Hussein, Bassam. "Addressing collaboration challenges in project-based learning: The student's perspective." Education Sciences 11.8 (2021): 434.
12. Ståhl, Daniel, Kristian Sandahl, and Lena Buffoni. "An eco-system approach to project-based learning in software engineering education." IEEE Transactions on Education 65.4 (2022): 514-523.
13. Qin, Zhuoli. Understanding Intermediary Organizations Facilitated University-Industry Collaborative Project-Based Learning In Higher Education. MS thesis. 2023.
14. Attard, Catherine, Nathan Berger, and Erin Mackenzie. "The positive influence of inquiry-based learning teacher professional learning and industry partnerships on student engagement with STEM." Frontiers in Education. Vol. 6. Frontiers Media SA, 2021.
15. Belwal, Rakesh, et al. "Project-based learning (PBL): outcomes of students' engagement in an external consultancy project in Oman." Education+ Training 63.3 (2020): 336-359.
16. Crawley, Edward F., et al. "Implementing the NEET ways of thinking at MIT and assessing their efficacy." (2020).
17. Lavi, Rea, et al. "The NEET Ways of Thinking: Implementing Them at MIT and Assessing Their Efficacy." Advances in Engineering Education (2021).
18. Lavi, Rea, and Aikaterini Bagiati. "The New Engineering Education Transformation Program at Massachusetts Institute of Technology: The Evolving Design and Implementation of a Programmatic Evaluation Study." Transdisciplinarity and the Future of Engineering. IOS Press, 2022. 658-667.

19. Silva, Tiago Filipe Pereira da. Innovation, creativity and new product development: A human central design case study. Diss. 2020.
20. Lyon, Graham Pierce. Measuring Authentic Learning within Purdue University's Epics Program. Diss. Purdue University, 2023.
21. Capstone design. Retrieved July 16, 2024, from Gatech.edu website: https://www.capstone.gatech.edu/
22. Miller, R. K.. Learning to be an engineer: Retrieved July 16, 2024, from Richard-k-miller.com
23. Co-operative education home. (2012, January 30). Retrieved July 16, 2024, from Co-operative Education website: https://uwaterloo.ca/co-operative-education/
24. Pedersen, Jens Myrup, et al. "PBL Student Projects and Sustainable Development Goals: A Case Study." International Symposium on Project Approaches in Engineering Education (PAEE). Vol. 10. 2020.
25. Drummond, Calum John. "Royal Melbourne Institute of Technology and a Road Less Traveled." Technology and Innovation 22.2 (2022): 251-256.
26. Van Schaik, Leon, and Anna Johnson, eds. By Practice, by Invitation: Design Practice Research in Architecture and Design at RMIT, 1986-2011. Actar D, Inc., 2022.
27. D. Gowda G and T. U, "Thermoelectric Simulation of a Microresistor Beam," 2019 Global Conference for Advancement in Technology (GCAT), Bangalore, India, 2019, pp. 1-3, doi: 10.1109/GCAT47503.2019.8978310
28. A. S. Bale, N. Ghorpade, R. S, S. Kamalesh, R. R and R. B. S, "Web Scraping Approaches and their Performance on Modern Websites," 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC), Coimbatore, India, 2022, pp. 956-959, doi: 10.1109/ICESC54411.2022.9885689.
29. S. Saravana Kumar, S. Varun Yogi, Swetha Vura, R. Baby Chithra, N. Vinay, P. Pravesh, Chapter 8 - Network and security leveraging IoT and image processing: A quantum leap forward, Editor(s): Prashant Johri, Adarsh Anand, Jüri Vain, Jagvinder Singh, Mohammad Quasim, In Emerging Methodologies and Applications in Modelling, System Assurances, Academic Press, 2022, Pages 123-141,ISBN 9780323902403, https://doi.org/10.1016/B978-0-323-90240-3.00008-4.
30. T. P. Purohit, M. F. Hashim, and S. Navale, "Blockchain and its applications in industry 4.0," A Roadmap for Enabling Industry 4.0 by Artificial Intelligence. Wiley, pp. 295–313, 16-Dec-2022.
31. A. S. Bale et al., "Nanosciences fostering cross domain engineering applications," Mater. Today, vol. 43, pp. 3428–3431, 2021.
32. Arushi Gupta et al., "Mobile Cloud Computing - Enabling Technologies and Applications," 2021 6th International Conference on Signal Processing, Computing and Control (ISPCC), Solan, India, 2021, pp. 491-496, doi: 10.1109/ISPCC53510.2021.9609344.
33. Chandu L y et al., "Advancements of Lab on Chip in Reducing Human Intervention: A Study," 2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), Greater Noida, India, 2021, pp. 38-42, doi: 10.1109/ICAC3N53548.2021.9725466.
34. Vada, Y. R. ., Oshiojum, B. E. ., Lakkineni, U. K. ., Rao, C. ., Venkatesh6, K. ., & Rani, I. . (2023). ChatGPT in Software Development: Methods and Cross-Domain Applications. International Journal of Intelligent Systems and Applications in Engineering, 11(9s), 636–643. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/3212
35. A. Biswas, S. Malik, E. Uchoi, S. U. Soni and A. Soni, "IoT Applications in Blockchain Technology," 2023 International Conference on Computer Science and Emerging Technologies (CSET), Bangalore, India, 2023, pp. 1-6, doi: 10.1109/CSET58993.2023.10346695.
36. M. Rajani, N. Taj, S. A. S, G. Amala and K. Lal, "Connecting Autonomous Engineering Domains with the Shared Language of Deep Neural Networks," 2024 2nd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA), Namakkal, India, 2024, pp. 1-6, doi: 10.1109/AIMLA59606.2024.10531318.
37. Soni, S. U. ., Rajput, D. S. ., R., H. ., Saranya, S. ., Joy, S. ., Chithra R., B. ., & Savadatti, M. B. . (2023). 5G Wireless Communication and Its Adverse Effects on the Human Body: Distinguishing Falsehoods from Reality. International Journal of Intelligent Systems and Applications in Engineering, 12(5s), 101–112. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/3870

38. S. Saravana Kumar, P. Rao and A. K. J., "A Recent Trend in DC Microgrid," 2021 International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), Greater Noida, India, 2021, pp. 543-546, doi: 10.1109/ICACITE51222.2021.9404668
39. S. C. Reddy, H. Chandramouli, S. Ponnuru, S. Saranya and K. Lal, "Review on Intelligent Social Networking Algorithms and Their Effects on Predicting the Adequacy of Renewable Energy Sources via Social Media," 2024 Second International Conference on Smart Technologies for Power and Renewable Energy (SPECon), Ernakulam, India, 2024, pp. 1-6, doi: 10.1109/SPECon61254.2024.10537390.
40. H. R, B. Prakash, P. S. Babu, R. Gupta and S. Malik, "Recent Scientific Achievements and Developments in Software Defined Networking: A Survey," 2023 1st International Conference on Circuits, Power and Intelligent Systems (CCPIS), Bhubaneswar, India, 2023, pp. 1-6, doi: 10.1109/CCPIS59145.2023.10291262.
41. S. C. Reddy, H. Chandramouli, S. Ponnuru, S. Saranya and K. Lal, "Review on Intelligent Social Networking Algorithms and Their Effects on Predicting the Adequacy of Renewable Energy Sources via Social Media," 2024 Second International Conference on Smart Technologies for Power and Renewable Energy (SPECon), Ernakulam, India, 2024, pp. 1-6, doi: 10.1109/SPECon61254.2024.10537390.
42. K. A. Patil, D. S. N. Reddy and B. R. Reddy, "Comparative Evaluation of 6T, 8T and 10T Ternary SRAM Cells Schemes for Future VLSI and Power Electronics," 2024 Second International Conference on Smart Technologies for Power and Renewable Energy (SPECon), Ernakulam, India, 2024, pp. 1-7, doi: 10.1109/SPECon61254.2024.10537347
43. N. Ghorpade, "Acute Lymphoblastic Leukemia Detection Employing Deep Learning and Transfer Learning Techniques," 2024 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2024, pp. 1-6, doi: 10.1109/ACCAI61061.2024.10602062.
44. Sharada, K.A., Vijaykumar, S., Ghorpade, N., Savadatti, M.B., Hamsalekha, R. (2024). IoT Based Hydroponic System for Sustainable Organic Farming. In: E. Balas, V., Prakash, K.B., Varma, G.P.S. (eds) Proceedings of the International Conference on Internet of Everything and Quantum Information Processing. IEQIP 2023. Lecture Notes in Networks and Systems, vol 1029. Springer, Cham. https://doi.org/10.1007/978-3-031-61929-8_19
45. M. Patil, M. G. Prathima, S. V. Telgane, N. Ghorpade and B. Anish, "Augmenting Knowledge Management with Immersive Technologies: Exploring Transformative Use Cases for AR and VR," 2024 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2024, pp. 1-6, doi: 10.1109/ACCAI61061.2024.10602348.
46. Joy, S., Bale, A.S., Anju, M.I., Baby Chithra, R., Patil, K.A., Neethu, P.S. (2024). IoT Based Enhanced Safety Monitoring System for Underground Coal Mines Using LoRa Technology. In: E. Balas, V., Prakash, K.B., Varma, G.P.S. (eds) Proceedings of the International Conference on Internet of Everything and Quantum Information Processing. IEQIP 2023. Lecture Notes in Networks and Systems, vol 1029. Springer, Cham. https://doi.org/10.1007/978-3-031-61929-8_18
47. R. Mahajan et al., "Breaking news at machine speed: The rise of AI in real-time journalism," Libr. Prog. (Int.), vol. 44, no. 3, pp. 1060–1069, 2024.
48. A. S. Bale et al., "Harnessing AI and IoT for optimized renewable energy integration and resource conservation," Libr. Prog. (Int.), vol. 44, no. 3, pp. 1412–1426, 2024.
49. P. Shrivastava, M. T. Pawar, S. Kumar, J. K. Gupta, P. Kumar, and A. S. Bale, "Shaping the future of higher education with AI: Challenges and strategies directions," Libr. Prog. (Int.), vol. 44, no. 3, pp. 9787–9797, 2024.
50. A. Tomer et al., "AI governance in the business world: Legal standards and management practices," Libr. Prog. (Int.), vol. 44, no. 3, pp. 10640–10649, 2024.
51. R. S. Solanki, K. D. Gautam, A. S. Khan, R. Kaur, and A. S. Bale, "AI -driven innovations in higher education: Key challenges and future prospects," Libr. Prog. (Int.), vol. 44, no. 3, pp. 9521–9529, 2024.
52. Sudhir Bale, A. ., Dhumale, R. B. ., Beri, N. ., Lourens, M. ., Varma, R. A. ., Kumar, V. . ., Sanamdikar, S. ., & Savadatti, M. B. . (2023). The Impact of Generative Content on Individuals Privacy and Ethical Concerns. *International Journal of Intelligent Systems and Applications in Engineering*, *12*(1s), 697–703. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/3503
53. J. Aditya Khatokar et al., "Carbon nanodots: Chemiluminescence, fluorescence and photoluminescence properties," Mater. Today, vol. 43, pp. 3928–3931, 2021.

54. Ajay Sudhir Bale et al 2020 IOP Conf. Ser.: Mater. Sci. Eng. 872 012008; https://doi.org/10.1088/1757-899X/872/1/012008