

A Problem-Based Learning (PBL) Approach in Effective Implementation of Innovation and Entrepreneurship Education for Engineering Undergraduates

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Abstract—In the 21st century, innovation and entrepreneurship are major forces behind social advancement, economic expansion, and environmental sustainability. Problem Based Learning (PBL), is a type of student-centered learning where learning occurs in a context-specific manner, students actively participate in the process and they accomplish their objectives through social interactions. The purpose of this study is to investigate how entrepreneurship and innovation education in a course developed under the PBL model might foster the entrepreneurial spirit in engineering students. The students were required to work in groups and finish tasks that took the shape of challenges in order to represent actual issues that an entrepreneur would face. Multiple assessment patterns such as class activity participation, case study analysis, Ideathon or Hackathon participation, business model canvas and value proposition canvas presentation, pitch deck participation, company formation, patent filing, funding proposal submission were part of the course evaluation. Evaluation rubrics were framed for each assessment pattern planned in this study to grade the students. The entire student groups completed case study analysis, participated in ideathon and hackathon, designed their business model canvas and formulated a business plan based on their product which was presented in the pitch deck. The quantitative survey feedback and qualitative testimonies received from students, point to PBL's prospective strengths and its ability to help people become better entrepreneurs. The results make it abundantly evident that the exercises created for this study can be repeated in any interdisciplinary classroom setting.

Keywords—Innovation, Entrepreneurship, PBL, Engineering.
JEET Category—Research

I. INTRODUCTION

A Country's capacity for innovation, as well as its long-term economic viability and competitiveness, are largely shaped by education through the development of human capital (Hanushek & Woessmann, 2023).

It is evident that academic institutions all over the world are focusing greater significance towards entrepreneurship education (Syed et al., 2023). NEP 2020's core tenet for directing the educational system is to foster students' critical thinking and creativity so they can become innovators (Bhardwaj et al., 2024).

The creations of an idea or invention and its subsequent commercialization, or “exploitation” are the two separate processes that lead to innovation (Wang et al., 2021). Innovation is a tool used by entrepreneurs to find and seize new opportunities (Carayannis et al., 2015). Innovation and entrepreneurship refer to the endeavors of utilizing both fresh and preexisting concepts to launch new companies (Malele, 2020). Lifelong learning, or entrepreneurship education, focuses on equipping people and organizations with the skills necessary to handle, create, and relish increasingly complex and uncertain situations in all facets of life (Duval-Couetil, 2013). The dynamic processes of creativity, transformation, and vision comprise entrepreneurship (Schiuma et al., 2022). It calls for putting in a lot of effort and passion in the development and deployment of original concepts and inventive solutions. The ability to create an efficient venture team, the creative ability to gather necessary resources, the basic ability of creating a strong business plan, a readiness to undertake calculated risks in regards to time, equity, or career, and, lastly, the vision to see opportunity where others see chaos, contradiction, and confusion are all necessary components (Chang & Chen, 2020).

The teaching approach known as Problem-Based Learning (PBL) uses challenging real-world issues rather than straightforward factual and conceptual instruction to help students understand concepts and ideas (Mann et al., 2021). Many academics have been using PBL for a very long time, and there is ample evidence in the literature to support the idea that PBL pedagogy improves students' knowledge and abilities (Mahajan et al., 2021). PBL offers chances for group work, the discovery and analysis of research resources, and lifelong learning in addition to aiding in the acquisition of course information (Hursen, 2021). It can also foster the growth of

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problem-solving, analytical thinking, and interpersonal abilities. PBL emphasizes learning by doing and calls for metacognitive awareness from its students (Almulla, 2020). In other words, students need to develop an awareness of the knowledge they already know about a problem, the information they require to solve it, and the approaches they can take to solve it (Hmelo-Silver, 2004).

II. NEED FOR PBL IN INNOVATION AND ENTREPRENEURSHIP EDUCATION

It has been discovered that the majority of entrepreneurship education follows the "about" method, which employs a more conventional instructional design and fails to involve students in projects or activities (Ratten & Usmanij, 2021). Experience-based entrepreneurship education has a greater impact than any other methodical teaching strategy (Pinto & KJ, 2021). PBL has a lot of scope for courses that aim to integrate several domains; that's especially true for programs in the fields of management and engineering. Students studying entrepreneurship might be characterized as self-reliant individuals who hate routines, constraints, and limitation (Michaelis et al., 2022). They are able to think creatively, particularly in vague and ambiguous situations. PBL is frequently regarded as an excellent and trustworthy technique for training qualified professionals and encouraging long-term retention of the information and skills gained during the learning process (Sousa & Costa, 2022). Thus, the PBL approach of instruction will allow the students to learn more effectively by repurposing class time for an investigation. This study aims to determine the effects of problem-based learning and pinpoint all the variables that affect the students' success.

III. METHODOLOGY

A. Course Design

The "Foundation on Innovation and Entrepreneurship" course was offered to the third year undergraduate engineering students as a compulsory course that carries 2 credits. This course has a generic curriculum which is common for students from any discipline. PBL has been used in this course so that learning is not restricted to in-person interactions or classroom lectures. The problem given to the students is to "Create a new business idea with the potential to generate a million dollars in revenue annually by year five". The course objectives included problem identification, an actionable plan, a formal investor presentation, and an elevator pitch. The students gained knowledge of and experience with addressing a variety of entrepreneurial problems, such as opportunity identification, intellectual property protection, fundraising, and bootstrapping. As a result, they participated in an integrated learning process centered on an actual entrepreneurial endeavor. The lecturer functioned as facilitator than as instructor. The course consists of 5 modules with 1 hours of lecture and 3 hours of in class activity for each week to complete this course. The course modules and its respective activities are listed out in table 1.

TABLE I
COURSE MODULES WITH THEIR RESPECTIVE ACTIVITIES

Module no.	Module topics	Activities
1	Entrepreneurial Mindset	Presentation on Success and Failure stories of Entrepreneur's
2	Design Thinking for Entrepreneurs	Design Thinking Workshop, Ideathon
3	Problem Solution Fit	Case Studies on Achieving Problem-Solution Fit, Failure Analysis in the existing one, Field Visit for Problem Identification
4	Product Market Fit	Value Proposition Canvas, Business Model Canvas, Business Plan, Hackathon
5	Industry Compliances, IPR and Funding Strategies	Pitch Deck, IPR Filing, Proposal Submission for funding, Company Registration

This course delves into the dynamic world of innovation and entrepreneurship. Students will gain insights into the principles of innovation, creativity, and idea generation, while also developing practical skills in launching and managing entrepreneurial ventures. The course had a total of 5 course outcomes with one outcome for each module.

B. Course Implementation

1) Target audience

The course highlighted in this study was pursued by undergraduate computer science engineering students with no prior knowledge on concepts of innovation and entrepreneurship. The students in a class were segregated into teams comprising of not more than 5 members per team. The teams were formed based on their common interest with no interference from the facilitator side. The teams were asked to frame a team name and create a common drive folder in which all the team works will be submitted periodically.

2) Pedagogy & Activities

The course was designed to have various activities to effectively incorporate the learning outcomes of the course and to have a defined learning progress for the students. Each course module had unique activities to make the learners understand the core concepts and skills to become an entrepreneur.

For module 1, the storytelling was used as pedagogy to make the students to attain an entrepreneurial mindset and understand the characteristics of successful innovators and entrepreneurs. The students as a team presented the success and failure entrepreneur's stories with a chart. Figure 1 depicts a presentation by a student team. This activity acted as case study analysis of various successful and failure ventures as both are required to understand the characteristics of an entrepreneur.



Fig. 1. Representation of a Storytelling student activity on successful and failure entrepreneurs.

As part of module 2, Workshop and ideathon events were organized to make the students understand the design thinking process and to apply the acquired design thinking to entrepreneurship. During the workshop for this module an interesting activity titled “D.I.S.R.U.P.T” – an idea trigger activity was carried out. D.I.S.R.U.P.T is a new way of thinking and generating ideas which stands for Derive, Include, Separate, Repurpose, Unite, Personalize and Transplant. Figure 2 represents the D.I.S.R.U.P.T poster displayed in the classroom to explain and conduct the activity. Derive represents the ideas that can be generated by extending an original idea or modifying it to create a new business idea. Include is the process of adding a value to an existing business to make it different. Separate removes the connection between two or more things in an existing business and create a new idea. Repurpose is when we change something in a product or service and use it for a different purpose. Unit is when we combine two products to create a new product. Personalize is to design or produce a product / service to meet specific people’s requirements. Transplant is to take an idea that works in one place and introduce it in another place, which can be a country or a different customer segment. This activity helped the students to think and do ideation to acquire business ideas. Post this workshop, an ideathon event was organized on the theme “Technology Driven University Campus”, where students presented their ideas on the mentioned theme.



Fig. 2. Representation of D.I.S.R.U.P.T interactive activity poster displayed for students.

For module 3, Field visits were encouraged for the students to identify and analyze the problem well. Also case study analysis was mandated to ensure the students team to achieve problem – solution fit. Brain storming activity was performed as part of this module. The students were asked to brainstorm using mind maps via Padlet platform (<https://padlet.com/>). Plotting ones business objectives, strategies, and key performance indicators (KPIs) inside a mind map will help the team to create a clear and well-organized summary of the team’s business vision. The team can quickly see the connections between various tasks and goals by putting them into a graphical depiction. Figure 3 represents the pictorial representation of a mind map developed by a student team during this activity for this course.

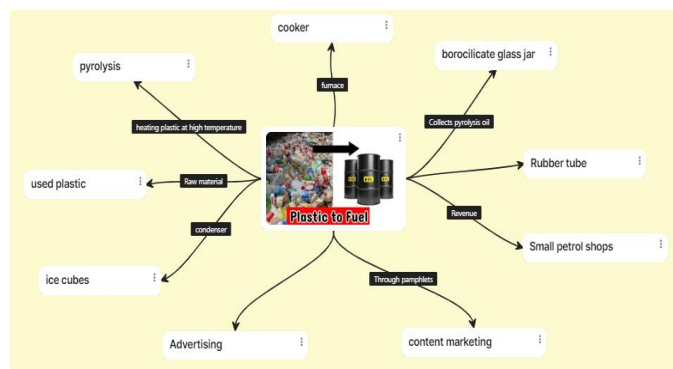


Fig. 3. A sample brainstorming mind map prepared by the students for their business plan in Padlet platform.

For module 4, game based simulations like Unicorn (<https://toggl.com/startup-simulator/>) and Virtonomics (<https://virtonomics.com/>) were introduced to the learners to create interest and curiosity among them. These simulation games gave student players the opportunity to run fictitious start-ups across a number of industries in a simulated environment. Figure 4 depicts the home page of Virtonomics simulation game. During this module, the students were encouraged to participate in hackathon’s to make students present their ideas and get valid suggestions from external sources.



Fig. 4. A snapshot from the homepage of Virtonomics simulation game used in this study.

Finally during module 5, to conclude the course and to review the business idea of a team, pitch deck presentation was conducted. To provide initial idea about pitch presentation the students were shown example pitch presentations using clips from “Shark Tank India” (<https://www.sonyliv.com/shows/shark-tank-india-1700000741>) and “Mission Start AB”

(<https://www.primevideo.com/detail/Mission-Start-Ab/0IW1NH39CLWYI1OD57H3RXOLS0>) reality shows. During these clip projections, a discussion session was arranged at the end to help the students understand the things to do and not to do during a pitch presentation. The students were then asked to prepare and present their pitches as a team. Figure 5 depicts a pitch deck presented by a student team for this course.



Fig. 5. Representation of a pitch deck presentation by a student team on their business idea.

C. Assessments

In this course, instead of the traditional written assessments the student participants were provided with activity based multiple assessment patterns such as class activity participation, case study analysis, ideathon or workshop participation, business model canvas or value proposition canvas presentation, hackathon participation, pitch deck presentation, company formation, patent filing and funding proposal submission. The mark distribution for each evaluation criteria along with its relevant course outcome is described in Table 2. The students were encouraged to attain a maximum mark of 100 from any of these given assessment pattern based on their progress throughout this course. Evaluation rubrics were framed for each assessment pattern planned in this study to grade the students.

TABLE II

ASSESSMENT PATTERNS USED IN THE “FOUNDATION ON INNOVATION AND ENTREPRENEURSHIP” COURSE WITH ITS RELEVANT MARK DISTRIBUTION AND MAPPED COURSE OUTCOME

Assessment	Maximum Mark	Course outcome
Class Activity Participation	10	Develop an entrepreneurial mindset, including creativity, risk-taking, and adaptability
Case Study Analysis	10	
Ideathon or Workshop Participation	10	Master design thinking for innovative problem-solving
Hackathon Participation	20	Identify market problems, validate with customers, and create effective solutions
Business Model Canvas or Value Proposition canvas Presentation	20	Define target markets, segment customers, and craft compelling value propositions
Pitch Deck Presentation	15	
Company Formation	25	Understand industry-specific regulations, compliance,
Patent Filing	20	Intellectual Property Rights (IPR)
Funding Proposal submission	20	filing, funding strategies, and financial management for startups

1. Class Activity Participation

The active participation of student in various class activities and tasks are assessed as mere attendance to a class cannot be considered as a student's overall participation. Here the assessment rubrics includes whether the student arrives at class prepared; quickly participates in conversation without taking over; thoughtfully advances the topic through remarks based on the reading; demonstrates interest in and respect for the opinions of others; actively engages in all group activities.

2. Case Study Analysis

Investigating a business problem, evaluating potential solutions, and presenting the best option with supporting data are all necessary for a case study analysis. Here the students are assessed based on the quality of their case study analysis of successful and failure entrepreneurs.

3. Ideathon or Workshop Participation

The ideathon's objective is to encourage students to get a stage on which to present their creative ideas in a startup-like environment and get feedback, coaching, and possibly even funding opportunities. The ideathon gave the students and forum for exploring their design thinking skill.

4. Business Model Canvas or Value Proposition canvas Presentation

The objective here is to create the business model's architecture using Osterwalder and Pigneur's (Osterwalder, 2010) business canvas model template. Value proposition, customer segmentation, customer relationships, channels, key partners, key activities, key resources, cost structure, and income streams are the nine components that make up the Business Model Canvas. The student teams are requested to develop the

business model canvas for their business idea and present the same.

5. Hackathon Participation

The purpose of the motivating students to participate in hackathon is to ignite the students' creative thinking so they may tackle enduring problems, solve issues in real time with technology, and pursue entrepreneurial goals. The students attended hackathon organized by various institutes.

6. Pitch Deck Presentation

A pitch deck presentation, sometimes referred to as a slide deck or startup pitch deck, is a visual document that gives investors vital details about your product or services, target market, valuation, and financial objectives, as well as your company strategy and fundraising requirements (Shimasaki, 2020). This is the final presentation a student team does during this course.

7. Company Formation

As part of this course, the student team with potential business ideas are guided and encouraged to register their company in the MSME (Udayam) portal (<https://udyamregistration.gov.in/Government-India/Ministry-MSME-registration.htm>). Most of the students registered their company as micro enterprise in this portal. The registration process is fully online, paperless and based on self-declaration with no fee.

8. Patent Filing

For a predetermined amount of time, patent grants the sole right of the creator to produce, utilize, and market their invention. The main goal is to motivate the student teams to protect their ideas through the patent laws which could be commercialized in a later stage.

9. Funding Proposal submission

The students were provided with knowledge on various funding bodies and also guided to submit their business idea as proposal for incubation.

During the scoring of team tasks, the scores for members within a team were differentiated from the other members of the team. For instance, when a member of a specific team puts forth an extraordinary amount of effort and is acknowledged for it then that individual received a higher score than the rest of the team from their fellow team members. A team member who performs poorly was also negatively impacted by this scoring process. The team members were asked to distribute 100 points to the other team members, where together with the numerical score, there should be a qualitative statement explaining the scores awarded. Underperforming team members found motivation from this form of peer assessment and evaluation, which provided the student-team a sense of control over individual team member conduct.

D. Student Feedbacks

Feedbacks were collected at the end of course. The feedback was collected via a questionnaire with set of questions relevant to their knowledge, interest, skill levels on

innovation and entrepreneurship to be scored on a five-point Likert scale (Ivanov et al., 2018). A total of 52 students responded to the feedback and the result of the post-course survey are depicted in table 6.

TABLE III
STUDENT'S RESPONSE^a TO POST-COURSE SURVEY

Survey Items	Average of Response	Standard Deviation
Rate your level of knowledge towards developing entrepreneurial mindset, including creativity, risk-taking, and adaptability	4.4	0.24
Rate your level to Master design thinking for innovative problem-solving	4.33	0.23
Rate your level to Identify market problems, validate with customers, and create effective solutions	4.38	0.25
Rate your level to define target markets, segment customers, and craft compelling value propositions	4.4	0.25
Rate your level to understand industry-specific regulations, compliance, Intellectual Property Rights (IPR) filing, funding strategies, and financial management for startups	4.25	0.21
How in overall you rate this course "Foundation on Innovation and Entrepreneurship" in developing the entrepreneurial mindset and essential skills in you.	4.52	0.26
Open feedbacks given by students on this course		
This course on transformed my approach to problem-solving, emphasizing the importance of user-centered design.		
The entrepreneurship course was an amazing experience that covered everything from identifying business opportunities to developing a business plan.		
Taking the Innovation and Entrepreneurship course was an enlightening journey. The curriculum was thoughtfully structured, providing a comprehensive understanding of the entrepreneurial landscape.		

The analysis of feedback survey implies that a high majority of the student respondents give the impression that the course "Foundation on Innovation and Entrepreneurship" was extremely effective in terms of knowledge and skill transfer. On a 5-point scale, the course received an overall rating of 4.52. The pedagogy and activities incorporated in this course is highly valued by the students. Students found the curriculum to be interesting and challenging. Remarkably, the students express that this course has inculcated them with a strong understanding of innovation and entrepreneurship concepts and how to practice it in real life.

IV. DISCUSSION

Third-year undergraduate computer science engineering students had the opportunity to enroll in a new elective course called "Foundation on Innovation and Entrepreneurship" as an initiative to enhance the entrepreneurial mindset of engineering students. The goal of the course's design, utilizing PBL principles, is to involve and stimulate the students through challenging activities to understand the journey of an entrepreneur. The course evaluation's results were really promising.

As part of the evaluation for this course, the students independently and as a group accomplished well. The students

enthusiastically contributed in various activities related to the course like workshop, case-study analysis, participation in ideathon and hackathon, business model canvas preparation, pitch deck presentation and company formation. The case study analysis and business model canvas was prepared and submitted by all the student teams with appreciable quality. Out of the 18 teams formed by students during this course 16 teams have successfully registered their business idea as a company in MSME portal. Around 3 teams have prepared and submitted their business idea as a proposal for funding agencies. Two teams have filed their innovative ideas as patent.

The presence of innovative pedagogy and activities in this PBL method of teaching for this course is effective. Thus it requires a comparatively longer amount of participation time for the students. Additionally, it has been established that the assessment techniques incorporated in this course provided experiential learning and aligned with the PBL style of teaching. The advantage of utilizing a PBL approach, especially for the faculties to monitor the students' passionate commitment towards participative learning is particularly inspiring.

It is immediately evident that problem based learning and the conventional teaching approach differ significantly. Exams that measure the knowledge gained from in-class lectures and self-study resources are used in traditional teaching methods for formative and summative evaluation. In contrast, there are several processes involved in problem-based learning, such as the professor providing instructions on the topic to be covered in the planned activities, workshops, competitions, and presentations, along with suitably defined evaluation rubrics. In addition, PBL evaluates students' social skills in addition to their cognitive and emotional competences, whereas traditional teaching methods solely evaluate students' cognitive abilities (Ssemugenyi, 2023). Additionally, under the mentorship of their facilitator during the course implementation, students could cooperate, contribute, communicate, and use their critical thinking skills using the PBL teaching technique. It was discovered that this particular teaching approach yielded the highest level of student involvement in the learning process. Students gained the ability to learn on their own.

Through problem-based learning, engineering students who wished to pursue careers in management and entrepreneurship or who wanted to launch their own business were exposed to sufficient fundamental information. Pupils arrived with fresh concepts for businesses. They gained a general understanding of the significance of innovation in entrepreneurship as a result.

V. CONCLUSION

One of the life's skills is entrepreneurship. Leaders and innovators who think outside the box and act accordingly to achieve their objectives will be the ones in the future. Students' views on entrepreneurship are evolving as a result of

its potential to develop their unique personalities and abilities. Accordingly, our educational system must likewise adjust to the changes. By offering experiential learning, academic institutions may help students develop their entrepreneurial skills. The pedagogical approaches discussed in this study under PBL mode of teaching were discovered to be the most successful in terms of student involvement in learning and when compared to traditional classroom instruction. An essential component of a successful PBL implementation is self-belief. Since aspirational outcomes foster lifelong learning and inquiry outside of the classroom, evaluating them might be viewed as one of the alternate forms of evaluation in this methodology. To sum up, it is good to see that PBL approaches are being accepted well by students as it encourages them to learn on their own. The students are highly appreciative of the innovative pedagogies utilized in PBL approach. But it's important to take into account the limitations pertaining to the timeline and workload of both student and faculties.

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