Integrating Problem-Based Learning and Design Thinking for Sustainability: A Practical Approach to Teaching Real-World Problem Solving in Undergraduate Education

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Abstract

This practice paper presents the development, implementation and evaluation of a course, Design Thinking for Sustainability, a university core course for first-year students from undergraduate programs in Technology, Business administration, Computer applications and Design. As a greenfield private university in India, we integrated Design Thinking into the core curriculum to enhance problem-solving abilities. The course addressed real-world, ill-defined challenges through the United Nations' 17 Sustainable Development Goals (SDGs), equipping students with practical, creative problem-solving skills. Offered as a 21-day pre-semester credit course, it fostered interdisciplinary collaboration on sustainability-driven challenges.

Using Problem-Based Learning (PBL) approach, students worked in teams, applying the five stages of Design Thinking—Empathize, Define, Ideate, Prototype, and Test—to develop innovative, sustainable solutions. The design thinking process encouraged iteration, collective work, and optional participation. With this first version of the course, the focus of evaluation was to explore the challenges faced by faculty members and students, which allow for revision during the next iteration of the course.

The findings bring out various challenges perceived by our students and faculty members, and various strategies to overcome them. The challenges stated were psychological readiness for open ended problem-solving, struggle to identify and define real world problems, lacked access to stakeholders and sustainability related data. However, collaborative teamwork, prototyping and stakeholder feedback helped them to overcome the challenges and come up with feasible and workable solutions to the problems thereby developing problem solving skills. Faculty stated that they did not know design thinking whereas they learned it while during the course. Secondly, they had to put significant effort in designing, teaching and assessing in a way to promote active learning. They were agile during the course and did minor adjustments to the course during the course delivery. Overall, this paper provides practical insights for educators who will be seeking

to integrate PBL and Design Thinking into their curricula, particularly with inclusion of sustainability-driven innovation and active learning.

Keywords: Problem-Based Learning, Design Thinking, Higher Education, Problem Solving, Course Design.

1 Introduction

As technology trends evolve, students going to higher education, implicitly hope they have already acquired the skills to implement solutions for real-world problems. Traditional classrooms seldom advocate for a composite, abstract, or unknown solution approach. Thus, graduates fail to navigate uncertain situations. One site which does demand on such 'unpredictable –complex –unknown' character is the sustainability; it's a pressing global issue that calls for a level of focus of transdisciplinary and all-inclusivity which is very much beyond the normal expectation of teaching learning. Sadly, relative to the classroom, students rarely get opportunities to learn that sort of inclusionary skills and real, practical problem-solving operations based on collaboration systems. Thus to address the need, a multi-disciplinary faculty team at a private, greenfield university in India, designed a university core course titled, "Design Thinking for Sustainability" which is common to all first-year students from undergraduate programs namely Technology (B.Tech), Business Administration (BBA), Computer Applications (BCA) and Design (B.Des).

This is taught as a pre-semester credit course that runs for 21 days. While several universities in India offer design and sustainability courses are in tier-I cities, this course is offered in tier-2 city and seeks to understand the societal problems to ensure sustainable solutions for local problems which the students are grounded in.

Driven by three key motivations, the course aims to:

- Develop Problem-Solving Skills: Shift from passive learning to active, structured problem-solving using Design Thinking to create and test solutions.
- Embed Real-World Sustainability Challenges: Apply the 17 SDGs to local problems, ensuring authentic, hands-on learning.
- Foster Interdisciplinary Collaboration: Promote teamwork across technology, business, and design for holistic problem-solving.

This 21-day course equips students with practical problem-solving skills, an empathetic mindset, and a commitment to sustainability and community impact, setting a strong foundation for their academic and professional journey. While the course is aspirational, the first offering in this course was evaluated for the challenges that faculty members and students faced in order to redesign the course for the next offering during the academic year 2025-2026..

2 Literature Review

2.1 Design Thinking in Education

Design Thinking (DT) is a creative, structured, human-centered process used to solve problems (Brown, 2009). DT equips pupils with 21st-century skills that give them an advantage over others. In a higher education setting, DT is something that allows students to think critically and is transferrable skills needed to approach and solve problems in the real world (Razzouk & Shute, 2012). Almost all degrees in higher education have incorporated problem-solving into their curricular design and assessment for the success of graduates that needed to occur. The only drawback is that the DT classroom experience needs an adjustment by the participants of the standard classroom experience, which makes faculty confused who cannot easily defer from the guided exploration and start getting frustrated at the ambiguous experiences (Goldman et al.,

2009). A great tool to utilize in determining proper problem-solving strategies and a perfect precursor for PBL, DT is excellent.

2.2 Problem-Based Learning (PBL) and Interdisciplinary Approach

An approach similar to Design Thinking (DT) is Problem-Based Learning (PBL) in which students engage with real-world problems and an interdisciplinary approach to teamwork (Barrows, 1986). This increases student engagement and knowledge retention in the long term (Hmelo-Silver, 2004) and is often found in the fields of medicine and engineering (Schmidt et al., 2011). However, it also requires curricular reformation and trained facilitators (Dolmans et al., 2005). However, if this can be achieved, PBL develops essential teamwork and critical thinking skills across the disciplines and therefore would be highly effective for sustainability education.

2.3 Sustainability Education and the SDGs

Sustainability education is connected to the United Nations Sustainable Development Goals (SDGs) and seeks to prepare learners to combat anticipated challenges to future environmental, social, and economic well-being (UNESCO, 2017). In the realm of scholarship, much relative research exists at the collegiate level with sustainability projects through cross-disciplinary efforts and interprofessional research (Lozano et al., 2015). However, institutional barriers and faculty expertise gaps slow adoption (Sterling, 2011). When combined with DT and PBL, sustainability education fosters innovative, real-world solutions.

3 Methods

3.1 Course Design & Implementation

This course was offered a 3-credit, first-year course titled “Design Thinking for Sustainability” at a private engineering university in India. This course equips students with design thinking and sustainability skills through hands-on, collaborative learning. Offered as a Pre-semester, PBL, credit course for 21 days, the students define problems using design thinking tools, work in teams, and develop sustainable solutions that are environmentally, socially, and economically viable for the tier-2 city Solapur, Maharashtra. Following an in-semester to end-semester assessment ratio as 80:20, the course followed a typical three reviews during the milestones of problem definition, Ideation and Prototype, and testing. The students worked in teams of 6 with a gender-balanced team composition. A total of 24 projects focused on various SDG goals were completed by students that identified problems in Solapur region Project Titles.pdf. The key SDGs addressed were SDG 3 (Good Health and Well-being), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). Other SDGs covered included SDG 4 (Quality Education), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 15 (Life on Land).

3.2 Evaluation of the Course

For both faculty and students, this was the first time in designing and undergoing a design thinking course, respectively. Thus, this study employed a qualitative research approach using semi-structured interviews either in-person/online mode to gather insights from 05 faculty members and 11 students about the challenges they faced. The interviews were stopped after reaching the theoretical saturation. Ethical considerations, including informed consent and confidentiality, were ensured. Thus, the interviews focused on the same elements for both: Challenges faced in teaching and learning as listed in Appendix A. Thematic analysis was used to identify patterns and themes within the data (Braun & Clark, 2017).

4 Findings

This section separately presents the challenges that both faculty and students faced while designing and implementing, and undergoing the course, respectively. These challenges will be used as inputs during the redesign of the course for the next offering for the academic year 2025-2026.

4.1 Findings from Students

The findings from the analysis of student and instructor responses lead to a nuanced understanding of the challenges. The 11 codes that emerged from the thematic analysis of the student responses lead to seven broad but connected themes as shown in figure 1.

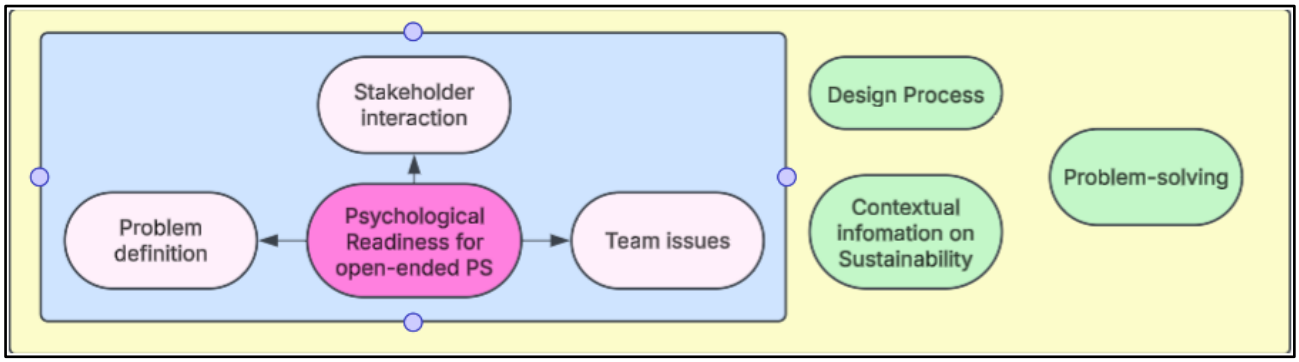

Figure 1 Challenges faced by students

The psychological readiness for open-ended problem-solving emerged as a critical challenge for students accustomed to structured, textbook-based exercises. The lack of predefined solutions led to initial uncertainty—“We felt lost initially, but breaking the problem into smaller parts helped.” To navigate this, students adopted a segmented approach, focusing on specific aspects such as “workload, problem parts, and budget” to manage complexity. Another challenge was identifying the difficulties, as students found it difficult to characterize actual sustainability issues. The interconnected nature of sustainability made narrowing their focus difficult—One of the biggest challenges was defining the problem itself, “Problems of sustainability are connected.” This is learned because much was spent on figuring out the technological viability and scope of a project before moving on to the next step. The second hardest part was assessing stakeholder engagement—students didn't always have access to their users—“We weren't able to do as many user interviews as we wanted.” Thus, their potential to validate or invalidate their assumptions and adequately pivot their problem statements was constrained. However, there was within the design process, they could prototype and get feedback through iteration. Students acknowledged the role of testing—“Prototyping and testing helped us refine our solutions”—but also noted constraints such as time pressure—“The 21-day duration forced rushed decisions, limiting research and iteration.” Team dynamics played a crucial role in problem-solving effectiveness. Some students faced disengagement from teammates, impacting collaboration—“Some teammates did not take it seriously.” However, structured communication and role delegation helped—“Once we defined each person’s role, collaboration became smoother.” Access to sustainability-related information in the local Solapur context was a barrier, as students struggled to find credible and relevant data to inform their solutions. Finally, the course was able to challenge students to think critically and develop structured problem-solving skills by engaging with real-world sustainability issues “"The DTS course pushed us beyond our comfort zones, encouraging us to think critically and creatively about sustainability. While there were challenges, they ultimately helped us grow and develop a structured approach to solving complex problems".

4.2 Findings from Faculty

The authors observe that the challenges faced by faculty lie at the intersection of multiple themes, making it difficult to delineate them precisely. The 11 codes emerging from thematic analysis led to three

interconnected themes as shown in figure 2. Faculty readiness, the effort-intensive nature of active learning, and the need for agile course development are deeply intertwined, influencing each other throughout the course implementation.

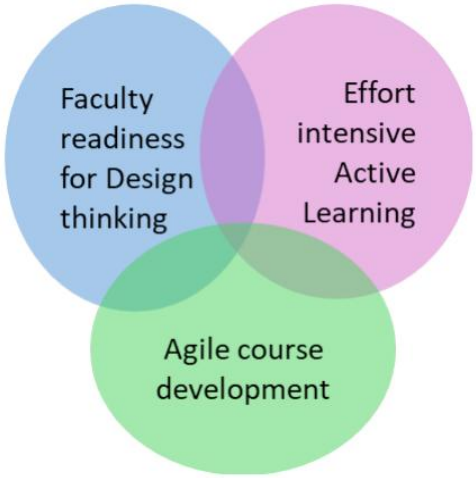

Figure 2 Challenges faced by faculty

Faculty faced multiple challenges in delivering this intensive course, primarily due to **limited prior exposure to design thinking**: "I learned about problem-solving using design thinking, which I had never encountered before." The lack of structured training led to inconsistencies: "Prior training was not conducted due to time constraints, causing inconsistencies." **Active learning** demanded significant effort, particularly in assessment: "Assessing individual performance was tough because they worked in groups." Faculty managed workload by sharing resources: "We ensured two faculty members per class by borrowing from other departments." **Agility** in course delivery was crucial, with real-time adjustments necessary: "Some activities in the empathy module were modified as they weren't feasible in class." The need for structured training and better planning was evident.

5 Conclusion and Recommendations

While the faculty team believes that the course enabled students to address wicked problems at a tier-2 city through a problem-based learning experience and focus on the SDGs, the findings sought to understand the challenges that faculty members and students faced which opens-up opportunities during the course redesign. To effectively address the challenges faced by faculty, the following recommendations are suggested: first, it is imperative to design a university specific induction program which also includes structured faculty training on design thinking courses and active learnings strategies (Goldman et al., 2009; Dolmans et al., 2005). Second, as courses like this need quick response even during delivery, the faculty must be trained on real-time course adaption techniques which leads to an agile course-redesign process (Sterling, 2011; Desai et al., 2025).

In addition, the students could benefit from structured orientation program that introduce to the ambiguity and ill-structuredness (Baligar, Joshi & Shettar, 2021) in sustainability related problems in our society. Second, to be able to implement a guided problem decomposition, it is also essential to include sessions on systems-thinking and stakeholder interaction. Lastly, problems transpired among group sizing for effective communication and capability, interdisciplinary teams, and time restrictions that prompted student feedback and adjustment in project development, which can be overcome by designing team interactions using cooperative (Baligar et al., 2022) or collaborative learning methods (Mercier et al, 2023; Desai et al., 2024).

Although design thinking gave a valuable, systematic method of guiding students through real world sustainability issues, we acknowledge that there are several drawbacks to the process. One criticism is a tendency to rush to solution generation and at times oversimplifying complex, systemic problems. To overcome this, we made a heavy focus in our course on staying with the problem in the Discovery and Define phases. The techniques including the 5 Whys, stakeholder mapping, systems diagrams, and reframing of the problem were also included to promote the higher exploration prior to ideation. This strategic orientation allowed the students to understand the relatedness of the sustainability challenges and generate solutions that were more appropriately addressed to the root causes.

Overall, to enhance future iterations, extending the course duration and reducing group sizes will allow for deeper exploration and stronger student participation. Providing clearer assessment rubrics, and a standardized operating procedure (SOP) will improve course consistency and evaluation. Increasing access to expert mentorship, case studies, and stakeholder collaboration will further strengthen problem-solving outcomes (Lozano et al., 2015). Strengthening interdisciplinary collaboration and structured peer feedback will enrich the learning experience, ensuring students are better prepared to tackle real-world sustainability issues effectively.

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Appendix A
Semi-Structured Interview Questions

Students:

1. What challenges did you face while undergoing this course on Design Thinking for Sustainability?
2. How did you overcome those challenges?
3. Any other things which you think is relevant to share here
4. Was the course beneficial? If yes, how?

Faculty:

5. What challenges did you face in designing, delivering, and assessing this course?
6. How did you overcome those challenges?
7. What improvements would you suggest for future iterations?