Utilizing Design Thinking to integrate Project-Based Learning in addressing Real-Life Challenges

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***Abstract* — This paper discusses about the transformative teaching learning methodology inculcating Design Thinking and Project based learning (DT-PBL). The work initiates by outlining the fundamental tenets of DT-PBL, highlighting their individual merits and applicability within educational environment. Through the utilization of case studies, it delves into how these approaches enhance student involvement, foster the acquisition of future competencies, and nurture an environment conducive to innovative thinking. The approach transforms the role of educators as facilitators of inquiry, collaboration, and reflection in both methodologies, emphasizing the importance of students and empowerment in the learning process. A problem related to challenges encountered by Tourists in Locating Sustainable and Eco-Friendly Products is discussed in detail. Creating a travel kit, aimed at environmental protection represents a tangible application of design thinking and project-based learning (PBL) methodologies. Further the paper explains the practical implementation of DT-PBL in educational settings offering insights into curriculum development, pedagogical strategies, and assessment practices.**

***Keywords*— Design Thinking and Project-Based Learning (DT-PBL); Eco-Friendly Products; Innovative Thinking; Pedagogical Strategies; Travel Kit.**

I. INTRODUCTION

In the ever evolving dynamic landscape of education it has become vital to adopt innovative teaching and learning methodologies. According to World Economic Forum 2022, analytical thinking and innovation, active learning strategies, complex problem solving skills are among the top 10 skills of the future workspace skills to be highly in demand by 2025. Design thinking and project based learning (DT-PBL) is one such innovative educational approach that synthesize the problem solving approach of design thinking and project based learning methodologies (Lebid & Shevchenko, 2020). Project-Based Learning (PBL) fosters a student-centered approach, encouraging active learning through the development of individual objectives, fostering critical thinking, and enhancing skills applicable in both academic and real-life scenarios. (Ulseth et al., 2011; Sukackė et al., 2022)

The pedagogic significance of Design Thinking (DT) is recognized through collaborative efforts, research, idea generation, and quick prototyping exercises, laying the foundation for the development of metacognitive skills (Pratomo et al., 2021). Creativity and the cultivation of various thinking styles, coupled with affective skills like curiosity and interest, have the potential to catalyze innovative outcomes such as problem-solving and the identification of opportunities (Noh & Karim, 2021).

In recent times DT-PBL approach has attained importance as an effective teaching methodology to enhance empathy creativity and nurture diverse competencies among students (Farrar, 2020; Markula & Aksela, 2022; Pierce & Fox, 2012; Tu et al., 2018). DT-PBL can foster a culture of creativity and innovation in engineering education by encouraging students to think outside the box, explore multiple solutions, and take risks (Alptekin et al., 2005; Cuccio-Schirripa & Steiner, 2000; Dhabi, 2022). This approach focus on the development of essential professional skills in engineering students, which are crucial for success in engineering careers and lifelong learning. These methodologies inspire innovation and the development of novel engineering solutions.

1.1 Inculcating design thinking through project based learning methodology

Design Thinking (DT) has embraced various models, including Stanford's d.school model which is a six-phase model. While the specifics may vary, the stages in each model share similarities, progressing from investigation and discovery to defining the issue, followed by ideation and brainstorming, ultimately leading to the development of solutions that best fulfill the needs of the end-users. Stanford's d.school model of DT has been chosen for our course. It typically consists of five key stages.

Empathize: In this stage, designers seek to understand the needs, desires, and challenges of the end-users they are designing for. This involves empathizing with users through observation, interviews, and other forms of qualitative research to gain insights into their experiences.

Define: Once designers have gathered insights from the empathize stage, they define the core problem or challenge they are addressing. This involves synthesizing the research findings to identify the underlying issues and articulate a clear problem statement that guides the design process.

Ideate: In the ideation stage, designers generate a wide range of potential solutions to address the defined problem. This phase

encourages creative thinking and brainstorming, often through techniques such as brainstorming sessions, sketching, and prototyping.

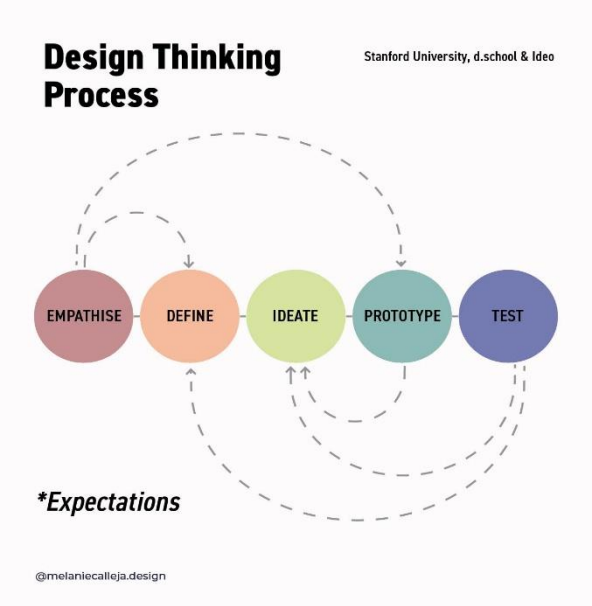


Fig.1. Stanford's d.school model

Prototype: After generating ideas, designers create prototypes or rough representations of their solutions. Prototyping allows designers to quickly and cheaply test their ideas, gather feedback, and iterate on their designs before committing to a final solution.

Testing: The final stage involves testing the prototypes with end-users to gather feedback and evaluate their effectiveness. Designers use this feedback to refine their solutions further, iterate on their designs, and ultimately develop a final solution that addresses the needs of the users

This model (shown in Fig.1) emphasizes a human-centered approach, focusing on understanding the needs of users, generating creative solutions, and iterating on designs based on feedback. It is a flexible and iterative process that encourages collaboration, experimentation, and innovation.

II. METHODOLOGY

In this Design Thinking course, the curriculum is designed for 12 weeks. The first 2 weeks students are introduced to design thinking and its approach to problem solving, resources available, some case studies related to DT. Students are divided into teams with 6-7 members each. Every team is mentored by the assigned faculty. Thereafter each team is encouraged to take up any real time problem statements to work upon. Some of the real life problems worked by the teams are listed in Table 1. The Approaches developed by teams to address these Challenges are quite helpful to solve the problems systematically, fostering innovation and delivering solutions that truly meet user needs.

TABLE I
TEAMS WITH THE PROBLEMS IDENTIFIED

S.No	Batch number	Problem statement
1	Batch 1	How to communicate with Deaf And Mute without Knowledge of Sign Language
2	Batch 2	Accidents caused by Drowsiness
3	Batch 3	Issues faced by daily wage laborers to find employment
4	Batch 4	Issues faced by tourists to find sustainable ecofriendly products
5	Batch 5	Issues caused by single use plastic
6	Batch 6	Food wastage at marriages and hotels
	Batch 7	How to increase the Voting percentage
8	Batch 8	Issues faced by rural people to access study material
9	Batch 9	Impacts of tobacco spitting at public places
10	Batch 10	How can we reduce the screen time
11	Batch 11	Issues faced by farmers in irrigation

2.1 Problem briefs

Some of the cases studied are as follows:

Case study-1: Bridging communication gap between normal people and deaf and mute people

The challenge for the team is to identify issues in communicating with deaf and mute people. Empathizing with deaf and mute individuals to understand their communication needs, challenges, and preferences through interviews, observations, and immersion experiences, the design team gained insights into the daily struggles faced by this community in interacting with others The goal was to come up with creative solutions that address the specific needs and preferences of the target users.

Case study-2: Drowsiness detection system to reduce accidents

Fatigue-related accidents pose a significant threat to road safety worldwide, with drowsy driving contributing to a substantial number of crashes each year. To address this issue, a Design Thinking (DT) approach was applied to develop a drowsiness detection system aimed at reducing accidents caused by driver fatigue. This case study explores the iterative process of designing and implementing such a system. The goal was to develop solutions that are user-friendly, unobtrusive, and effective in detecting signs of drowsiness.

Case study-3: Ecofriendly essentials travel kit for tourists

As the global tourism industry continues to grow, so does its environmental impact, with tourists often leaving behind a significant carbon footprint. To address this issue, a Design Thinking (DT) approach was employed to develop an eco-friendly essentials travel kit for tourists, aimed at promoting

sustainable travel practices and minimizing environmental harm. The solution included eco-friendly travel products such as reusable water bottles, biodegradable toiletries, sustainable packing materials, and eco-conscious travel guides.

Case study-4: Edible cups to replace disposable cups

The pervasive use of disposable cups contributes significantly to environmental pollution and waste generation, prompting a need for sustainable alternatives. To address this issue, a Design Thinking (DT) approach was employed to develop edible cups as a replacement for disposable cups, offering a novel solution that promotes sustainability and reduces single-use plastic consumption.

Case study-5: A Mobile application to reduce food wastage at hotels and events

Food wastage at hotels and events is a significant issue, contributing to environmental pollution and resource depletion. To tackle this problem, a Design Thinking (DT) approach was employed to develop a mobile application aimed at reducing food wastage by facilitating the donation and sharing of surplus food from hotels and events. These prototypes included features such as real-time food inventory management, geolocation-based matching of donors and recipients, and communication tools for coordinating food donations.

2.2. An example – case study

The PBL process of the above case study-3 (Ecofriendly essentials travel kit for tourists), using design thinking approach is presented in this context.

- *Problem identification*

The problem identified was "How can we reduce the carbon footprint of the tourists and the environmental impact while traveling?".

The team has interacted with regular travelers and identified a few challenges and the preliminary needs enlisted in Table 2. From the valuable insights emerged from the interview responses, prioritisation of requirements were listed in Table 3.

TABLE II
IDENTIFIED CHALLENGES AND INITIAL NEED

S.No.	Identified Challenges	Initial Needs
1	**Disposable product consumption**	1. Reusable alternatives for commonly used disposable items (water bottles, utensils, straws). 2. Biodegradable or compostable options for toiletries (shampoo, soap, toothpaste) 3. Packaging-free options for snacks and personal care products. 4. Easily accessible refill stations for water and toiletries.
2	**Limited access to alternatives**	1. Availability of eco-friendly products in tourist destinations. 2. Online resources or mobile apps for locating sustainable accommodations, restaurants, and attractions. 3. Education and information materials on sustainable travel practices.
3	**Consumer awareness**	1. Clear labelling and signage indicating eco-friendly options. 2. Interactive tools or guides to educate tourists about sustainable behaviours. 3. Incentives or rewards for choosing sustainable products and activities.
4	**Resource depletion and pollution**	1. Efficient and eco-friendly transportation options (public transit, bike rentals). 2. Waste reduction initiatives (recycling bins, waste management programs). 3. Energy-saving measures in accommodations (LED lighting, energy-efficient appliances). 4. Preservation of natural habitats and wildlife conservation efforts.
5	**Impact on local communities**	1. Support for local businesses and artisans 2. Cultural sensitivity training for tourists. 3. Community engagement activities (volunteer opportunities, cultural exchanges).

TABLE III
PRIORITISED LIST OF ESSENTIAL REQUIREMENTS

Priority	Requirements
High	1. Reusable alternatives for commonly used disposable items (water bottles, utensils, straws). 2. Biodegradable or compostable options for toiletries (shampoo, soap, toothpaste). 3. Easily accessible refill stations for water and toiletries 4. Availability of eco-friendly products in tourist destinations. 5. Education and information materials on sustainable travel practices.
Medium	1. Online resources or mobile apps for locating sustainable accommodations, restaurants, and attractions. 2. Clear labelling and signage indicating eco-friendly options. 3. Waste reduction initiatives (recycling bins, waste management programs). 4. Energy-saving measures in accommodations (LED lighting, energy-efficient appliances).
Low	1. Incentives or rewards for choosing sustainable products and activities. 2. Efficient and eco-friendly transportation options (public transit, bike rentals). 3. Preservation of natural habitats and wildlife conservation efforts. 4. Support for local businesses and artisans. 5. Cultural sensitivity training for tourists. 6. Community engagement activities (volunteer opportunities, cultural exchanges).

- *Solution Designed and Implemented*

The solution to this problem has been framed by following 5 phases explained below:

- *Phase-1 (Empathize):* The team empathized with the tourists in understanding their travel behaviors, preferences and environmental concerns through the following set of questions (refer Table 4) and Figs.2 and 3 depicts the interaction of the team with two travelers chosen through interviews.
  Through interviews, surveys, and observation of tourist activities, the design team gained insights into the environmental challenges associated with travel and the needs of eco-conscious travelers.

TABLE IV
QUESTIONNAIRE

S.No.	Set of Questions
1	As frequent travelers, what is the common problem faced by you guys when you're on a trip?
2	why do you think is the problem occurring during organizing your daily essentials?
3	what would you prefer to carry when you're travelling in case of your daily essentials?
4	Do you get all your essentials at one place or do you purchase them in different places?
5	What do you think will be the solution to this problem?
6	Do you prefer eco-friendly products in your daily life as well?

Fig.2. Interviewing with the Traveler-1

Fig.3. Interviewing with the Traveler-2

- *Phase-2 (Define):* Based on the insights gathered during the empathize stage, the design team defined the problem statement: "How might we create a comprehensive and eco-friendly essentials travel kit that enables tourists to minimize their environmental impact while traveling?"
- *Phase-3(Ideate):* The design team engaged in brainstorming sessions to generate innovative ideas for the eco-friendly essentials travel kit.

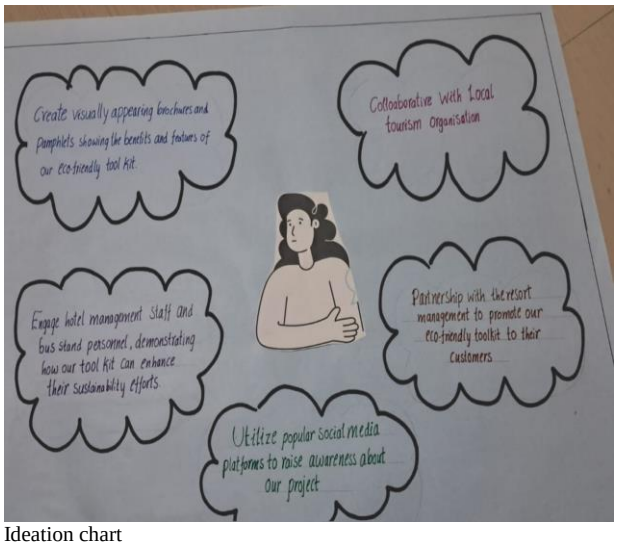


Fig.4. Ideation chart

- *Phase-4 (Prototyping):* Using the ideas generated (as listed in Fig.4) during the ideation stage, the design team created prototypes of the eco-friendly essentials of the travel kit. Figs. 5 and 6 represents the prototypes of the kit.

Fig.5. Prototype of the Travel kit

Fig.6. Eco-friendly essentials of the Travel kit

- *Phase-5 (Testing):* The prototype created by the team is tested by the eco-conscious tourists to access this travel kit through a website and Instagram handle, which can be still improved based on their feedback and collaborations can also be made with tourism organizations.

The ecofriendly Travel kits include:

1. *Bamboo toothbrushes*

Material: Bamboo is a sustainable and biodegradable alternative to plastic toothbrush handles.
Bristles: Choose toothbrushes with biodegradable or recyclable bristles made from materials like castor bean oil.

2. *Stainless steel straws*

Material: Stainless steel provides a durable and reusable alternative to single-use plastic straws.
Design: Offer different lengths and diameters to accommodate various drink types, and include cleaning brushes for maintenance.

3. *Biodegradable Toiletries*

- **Shampoo and Conditioner Bars:** Offer solid bars packaged in compostable materials to eliminate plastic waste.
- **Toothpaste Tablets:** Provide chewable tablets or powder packaged in recyclable or compostable containers.
- **Soap and Body Wash:** Offer bar soap made from natural ingredients and packaged without plastic or in biodegradable materials.

These eco-friendly essentials kit can be optimized to meet the needs of environmentally conscious consumers while promoting sustainability and reducing environmental footprint. This designed kit can be accessed by the consumer through an Instagram handle, using the link https://ecotravelessentials-9bjcgos.gamma.site/

Fig. 7 depicts the steps to make an order of the Travel kit by accessing the website designed.

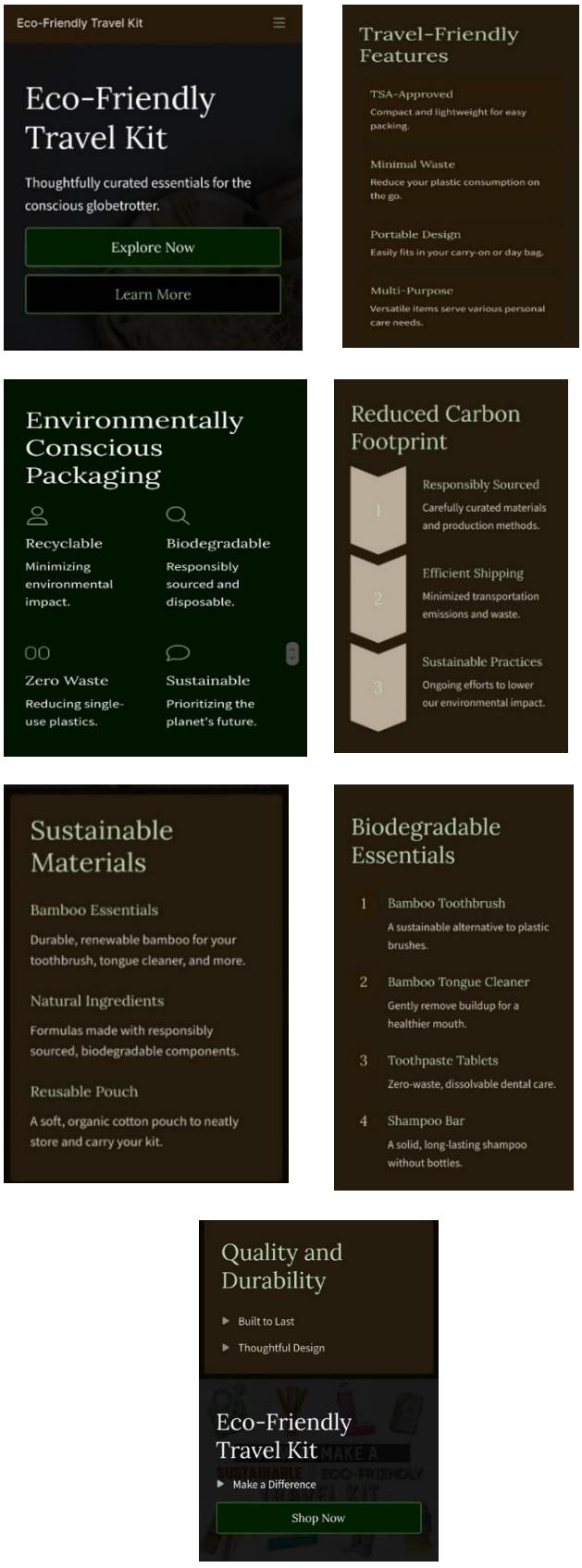


Fig.7. Steps to proceed for ordering the Travel kit

III. FINDINGS AND REFLECTIONS

DT-PBL approach of teaching learning methodology promotes a mindset shift from problem-focused to solution-focused thinking. It encourages reframing challenges as opportunities for innovation and growth.

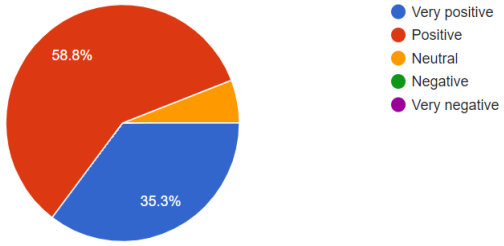
Interdisciplinary collaboration, brings individuals together with diverse backgrounds and imparts skills to tackle complex problems. DT-PBL offers opportunities for authentic assessment, where students demonstrate their understanding and skills through the completion of projects rather than traditional tests and quizzes. This assessment approach provides a more comprehensive view of student learning.

A. Findings

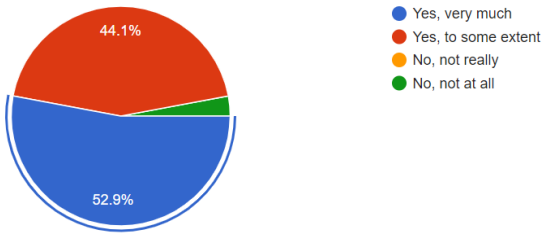
A survey was undertaken among the participants to evaluate their overall workshop experience and gather feedback on the methods employed (depicted in Table 5).

TABLE 5
PARTICIPANTS SURVEY

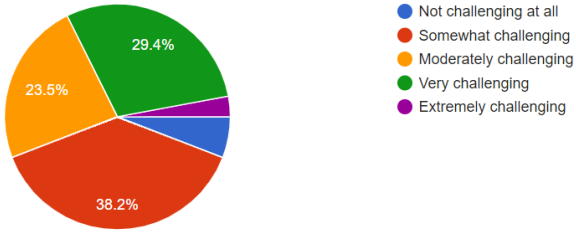
Q1. How would you rate your experience during the Empathize phase, where you focused on understanding the needs and experiences of users?



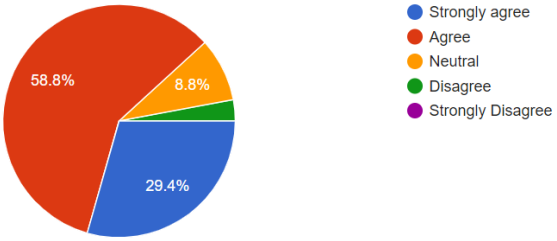
Q2. Did you find the Ideate phase conducive to generating a wide range of creative ideas?



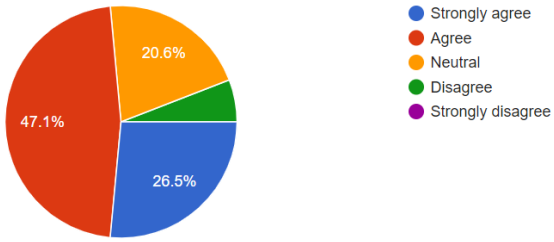
Q3. How challenging was it to create prototypes during the Prototype phase?



Q4. Do you suggest the implementation of DT-PBL to all other subjects?



Q5. Did you feel that you learned more through this DT - PBL project compared to traditional lectures or assignments



B. Reflections

- ***Complementary Approaches:*** Design thinking and PBL complement each other well, as both prioritize active, experiential learning and emphasize the importance of problem-solving skills.
- ***Lifelong Learning Skills:*** Both approaches aim to cultivate skills that are essential for lifelong learning, such as creativity, critical thinking, and collaboration, preparing students to thrive in an ever-changing world.
- ***Teacher Role:*** In both design thinking and PBL, the role of the teacher shifts from being a provider of knowledge to a facilitator of learning.
- ***Continuous Improvement:*** Both design thinking and PBL emphasize the importance of reflection and iteration.

Learners need to consistently evaluate their methods and explore strategies to enhance how these techniques are applied in the classroom.

IV. DISCUSSION AND CONCLUSION

In conclusion, the exploration of design thinking and project-based learning (PBL) has illuminated the transformative potential of these educational approaches. As we reflect on the findings and insights, it becomes evident that design thinking and PBL offer powerful frameworks for reimagining education in the 21st century. By prioritizing student agency, fostering a growth mindset, and promoting real-world application of knowledge, these approaches prepare learners to navigate the complexities of an increasingly dynamic and interconnected world.

Moreover, the integration of design thinking and PBL not only enhances the learning journey but also enables educators to instill a culture of innovation and lifelong learning in their classrooms. Embracing these methodologies empowers educators to nurture curiosity, resilience, and adaptability in their students, preparing them for success in an ever-evolving landscape.

A way forward for implementing likewise courses in the engineering education involves a multifaceted approach. A suggested pathway would be as follows

- Curriculum development that integrated DT-PBL principles.
- Faculty development programs and professional development to familiarize the educators with these methodologies to enhance their teaching.
- Allocate sufficient resources, including time, funding, and materials, to support the implementation of design thinking and project-based learning courses.
- Foster collaboration with external partners, such as industry professionals, community organizations, to provide authentic learning experiences and real-world projects for students.
- Create an inclusive and student-centered learning environment that encourages active participation, collaboration, and self-directed inquiry.
- Develop authentic and meaningful assessment strategies to measure student learning outcomes
- Establish mechanisms for ongoing reflection, feedback, and evaluation to continuously improve the quality and effectiveness of design thinking and project-based learning courses

Educational Institutions can create enriching learning experiences that empower students to develop essential skills and thrive in an ever-changing world.

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