Enhancing Engineering Education through Drone Technology Skilling Program: Analyzing the Impact on Program Outcomes

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***Abstract*—The interdisciplinary skilling program at the AICTE IDEA Lab focused on drone technology aimed to enhance the achievement of Program Outcomes (POs) for engineering students. Over six days, students engaged in activities like rapid prototyping, simulation-based learning, and AI-driven automation. These methods targeted critical POs, including engineering knowledge, problem-solving and modern tool usage. The program utilized direct assessments (tests conducted after each module) and indirect assessments (student feedback) to measure PO attainment, both rated at level 3. Collaborative hands-on projects, peer teaching, and real-world applications enabled students to bridge the gap between theoretical learning and practical skills. Positive feedback highlights the program's success in fostering interdisciplinary competencies and preparing students for technological challenges.**

***Keywords*— AICTE IDEALAB, Skilling Programs, Project based learning, Program Outcomes**

***JEET Category*—Case Report**

I. INTRODUCTION

The rapid advancements in engineering and technology have transformed industry demands, requiring graduates to possess not only robust theoretical knowledge but also the ability to apply this knowledge in real-world contexts. This paradigm shift has led to significant reforms in engineering education, emphasizing hands-on learning, problem-solving, and interdisciplinary approaches. Bridging the gap between academic concepts and industry needs is a persistent challenge in this evolving landscape(Dong et al., 2022). To address this, the All India Council for Technical Education (AICTE) introduced the IDEA Lab initiative, aimed at fostering innovation, creativity, and practical skills among engineering students. By integrating advanced technologies such as 3D printing, robotics, artificial intelligence, drone technology, and smart manufacturing, the IDEA Lab serves as a platform for experiential learning(Alonzo et al., 2023). Its interdisciplinary skilling programs immerse students in real-world applications through short, intensive training sessions that prioritize technical proficiency, design thinking, and problem-solving. A key educational approach within these programs is the integration of simulation-based learning (SBL) and project-based learning (PBL)(a. Davidovitch, 2006). Both methodologies have gained traction in engineering education due to their demonstrated effectiveness in enhancing student engagement and skill development(Campos et al., 2020). Simulation-based learning leverages interactive environments to bridge theoretical concepts and practical applications, as highlighted by Davidovitch et al. (2023). Similarly, PBL emphasizes real-world problem-solving through collaborative and hands-on projects, fostering critical thinking and teamwork skills, as explored by Kaushik (Kaushik, 2020) and Munje (*Munje, R. K. (2022).*)These strategies not only enhance technical competencies but also nurture soft skills essential for professional success. Outcome-Based Education (OBE) provides a structured framework for implementing such methodologies, ensuring alignment with predefined learning outcomes. Studies like those by Rao (Rao, 2020)and Hu et al. (2023) highlight how OBE principles can be effectively integrated into curriculum design, assessment, and teaching practices to improve educational quality(Hu et al., 2023). These principles resonate with AICTE IDEA Lab's goals, offering a structured pathway to measure and enhance student learning outcomes.

However, despite the growing adoption of SBL, PBL, and OBE frmeworks, there is limited research on their combined application in interdisciplinary skilling programs, particularly in cutting-edge areas like drone technology. This gap in the literature underscores the need for further investigation into how these approaches can be synthesized to address evolving educational and industry challenges effectively. This study aims to bridge this gap by evaluating the outcomes of a 6-day interdisciplinary skilling program at the AICTE IDEA Lab, focusing on drone technology to prepare engineering students for the demands of the modern workforce. Waghmare et al. (2024) underscore the significance of technology-enhanced learning (TEL) as a catalyst for improving engineering education. Their work demonstrates that TEL not only augments students' technical knowledge but also encourages active learning, critical thinking, and engagement with real-world engineering problems, which are essential components for skilling programs focused on drones. By providing interactive and technology-driven learning environments, students can gain hands-on experience with drones while simultaneously reinforcing theoretical concepts(Waghmare et al., 2024).

Project-based learning (PjBL) has emerged as a complementary pedagogical approach for bridging classroom instruction with practical application. Nagamalla et al. (2024) provide empirical evidence that PjBL enhances creativity, communication, and adaptability among engineering students by immersing them in problem-solving scenarios that extend from the classroom to the community. Applied to drone technology programs, this approach facilitates experiential learning, where students design, build, and operate drones, thereby improving both technical competencies and soft skills that are aligned with POs(Nagamalla et al., 2024).

Patange et al. (2019) reinforce the effectiveness of PjBL in improving program outcome attainments, particularly in mechatronics courses. Their findings suggest that structured project activities, coupled with iterative evaluation, enable students to acquire practical skills, integrate multidisciplinary knowledge, and achieve measurable program outcomes. In the context of drone technology, PjBL can ensure that students not only understand drone mechanics but also develop problem-solving capabilities and innovation-oriented mind-sets (*Patange et al. 2019*.).

Rubric-based assessments have been highlighted by Agrawal and Das (2018) as an effective tool for evaluating and enhancing program outcomes. Their comparative study shows that clearly defined evaluation criteria provide students with explicit expectations and guidance, fostering higher accountability and motivation. Implementing rubric-driven assessment in drone skilling programs can help instructors systematically measure competencies such as flight operation skills, programming, and adherence to safety protocols, thereby ensuring alignment with POs(*Agrawal, S. S., & Das, C. 2018*).

Finally, outcome-based education (OBE) strategies have been recognized as essential for aligning curricular activities with industry-relevant competencies. Arun Kumar (2020) presents a methodology for designing and implementing outcome-based learning in value-added courses, highlighting that careful course design directly contributes to enhanced skill acquisition and PO achievement. For drone technology programs, integrating OBE principles ensures that each module—from drone assembly to autonomous flight programming—is intentionally structured to meet specific learning outcomes, ultimately enhancing employability and readiness for advanced engineering challenges(R, 2020).

A. Importance of Skilling Programs

In today's competitive job market, possessing practical skills alongside theoretical knowledge is essential for engineering graduates. Skilling programs provide students with opportunities to apply their academic knowledge in real-world scenarios, fostering critical skills such as problem-solving, collaboration, and innovation. These programs also address the growing demand for interdisciplinary expertise by offering practical training in areas like robotics, drone technology, and smart manufacturing(*All India Council For Technical Education (AICTE). (2019)*)

Unlike traditional Faculty Development Programs (FDPs), which are designed for upskilling educators, skilling programs focus directly on students. They immerse participants in hands-on learning experiences that enhance both technical and soft skills, equipping them to meet industry expectations. The emphasis on project-based learning ensures that students develop solutions to complex engineering problems while engaging with advanced tools and techniques.

B. Problem Statement

Many engineering institutions prioritize theoretical instruction over practical, interdisciplinary learning, leaving graduates underprepared for modern industry challenges. Skilling programs that integrate theory with real-world, cross-disciplinary applications are essential to bridge this gap and align education with industry demands.

C. Objectives

This paper aims to evaluate the impact of interdisciplinary skilling programs offered by the AICTE IDEA Lab in enhancing Program Outcomes (POs) defined by the National Board of Accreditation (NBA). The specific objectives are:

1. Mapping Program Outcomes: Assess how programs in drone technology, robotic system design, and smart manufacturing contribute to achieving POs.
2. Enhancing Technical Skills: Evaluate the effectiveness of methodologies like rapid prototyping, simulation-based learning, and AI-driven automation in improving students' practical knowledge.
3. Promoting Experiential Learning: Investigate the role of hands-on projects, peer teaching, and collaborative activities in preparing students for industry challenges.
4. Analyzing Student Feedback: Collect and analyze data on students' perceptions of how these programs

bridge the gap between theoretical knowledge and practical application.

II. Methods

A. AICTE IDEA Lab Skilling Programs

The AICTE IDEA Lab (Innovation, Design, and Entrepreneurship Academy Lab) is a flagship initiative by the All India Council for Technical Education (AICTE) aimed at fostering innovation and creativity in engineering education. IDEA Labs provide state-of-the-art facilities, including 3D printers, CNC machines, laser cutters, drones, robotic kits, and tools for AI and IoT applications. These resources enable students to engage in design, prototyping, and real-world problem-solving. (AICTE)(2019).

The skilling programs under the AICTE IDEA Lab are short-term, intensive training modules typically lasting 5 to 7 days. They focus on emerging technologies like drone technology, robotic system design, and smart manufacturing, emphasizing interdisciplinary learning. These programs allow students to apply theoretical concepts in practical settings, develop solutions to engineering challenges, and gain a competitive edge in their careers.

B. Drone Technology

As detailed in Table I, the schedule for the Drone Technology Skilling Program was carefully designed to incorporate key learning activities and assessments.

TABLE I
SCHEDULE OF DRONE TECHNOLOGY SKILLING PROGRAM

Day	Time	Activity	Details	Teaching Technology	Mapped Program Outcomes (POs)
Day 1	09:00 - 10:00	Introduction to Drone Technology	Overview, applications, types of drones, components	Flipped Classroom	PO 1, PO 2
	10:00 - 12:00	Drone Components and Assembly	Assembly of drone kits, explanation of key parts	Hands-On Learning	PO 3, PO 5
	12:00 - 01:00	Basic Flight Mechanics	Flight principles, dynamics, and control	Simulation-Based Learning	PO 1, PO 4
	01:00 - 02:00	Safety and Regulations	Safety protocols, regulatory requirements, no-fly zones	Interactive Lecture	PO 6, PO 7
	02:00 - 03:00	Reflection and Q&A	Recap of the day's learning, open discussion, Q&A	Reflective Practice	PO 10
Day 2	09:00 - 10:30	Advanced Components and Sensors	Sensors integration: LiDAR, cameras, thermal imaging	Hands-On Learning	PO 3, PO 5
	10:30 - 01:30	Drone Assembly: Advanced Techniques	Advanced assembly including sensors, component calibration	Project-Based Learning (PBL)	PO 3, PO 5
	01:30 - 03:00	Flight Controller Configuration	Introduction to Mission Planner, configuration and tuning of flight parameters	Simulation-Based Learning	PO 5, PO 11
	03:00 - 04:00	Reflection and Q&A	Recap of the day's learning, open discussion, Q&A	Reflective Practice	PO 10
Day 3	09:00 - 10:30	Indoor Flight Training	Basic maneuvers in a controlled environment, hands-on practice	Simulation-Based Learning	PO 1, PO 4, PO 9
	10:30 - 12:00	Flight Simulation	Use of simulation software to practice maneuvers, analysis of flight data	Simulation-Based Learning	PO 5, PO 4
	12:00 - 01:00	Troubleshooting Common Issues	Identifying and solving common flight problems, hands-on troubleshooting	Problem-Based Learning (PBL)	PO 4, PO 5
	01:00 - 03:00	Reflection and Q&A	Recap of the day's learning, open discussion, feedback, Q&A	Reflective Practice	PO 10
Day 4	09:00 - 11:00	Outdoor Flight Training	Advanced maneuvers and exercises in an outdoor environment	Hands-On Learning	PO 1, PO 4, PO 9
	11:00 - 12:30	Real-World Applications	Case studies, planning and executing a real-world mission	Project-Based Learning (PBL)	PO 3, PO 7
	12:30 - 02:00	Data Collection and Analysis	Using drones for data collection, analyzing data with Mission Planner	Simulation-Based Learning	PO 4, PO 5
	02:00 - 03:00	Reflection and Q&A	Recap of the day's learning, open discussion, Q&A	Reflective Practice	PO 10
Day 5	09:00 - 11:00	Drone Customization	Modifying drones for specific tasks, hands-on customization activities	Hands-On Learning	PO 3, PO 5
	11:00 - 01:00	Project Planning and Execution	Teams plan and execute a small drone-related project	Project-Based Learning (PBL)	PO 3, PO 9, PO 11
	01:00 - 02:30	Project Implementation	Implementing projects, focusing on flight missions	Project-Based Learning (PBL)	PO 4, PO 11

			and data collection		
	02:30 - 03:00	Reflection and Q&A	Recap of the day's learning, open discussion, Q&A	Reflective Practice	PO 10
Day 6	09:00 - 11:00	Final Project Presentations	Teams present their projects, including objectives, implementation, and outcomes	Project-Based Learning (PBL)	PO 10, PO 11
	11:00 - 12:30	Evaluation and Feedback	Evaluation of performance and learning outcomes, feedback from students and instructors	Reflective Practice	PO 4, PO 12
	12:30 - 01:30	Certificate Distribution and Closing Remarks	Distribution of certificates, closing remarks, discussion of future learning paths	Reflective Practice	PO 12
	01:30 - 03:00	Free Time / Additional Practice	Optional time for additional practice or assistance with any remaining queries	Hands-On Learning	PO 9,PO8, PO 12

1) Day 1: Introduction and Basics

Students are introduced to drone technology, components, and assembly through flipped classrooms and hands-on sessions, addressing PO 1 (Engineering Knowledge), PO 2 (Problem Analysis), PO 3 (Design), and PO 5 (Modern Tools). Safety norms, ethical considerations, and regulatory compliance align with PO 6 (Society), PO 7 (Sustainability), and PO 8 (Ethics). Simulation-based learning reinforces PO 4 (Investigations) and PO 10 (Communication).

2) Day 2: Advanced Techniques

Day 2 Focuses on advanced components like LiDAR, sensors, and flight controllers. Project-based learning enhances PO 3, PO 5, and PO 11 (Project Management). Ethical and environmental discussions integrate PO 7 and PO 8. Reflective sessions emphasize PO 10.

3) Day 3: Practical Training

Day 3 had Indoor flight training and troubleshooting foster PO 1, PO 4, PO 5, and PO 9 (Teamwork). Safety, sustainability, and ethical considerations remain core themes under PO 7 and PO 8.

4) Day 4: Outdoor Applications

Advanced flight training and real-world missions target PO 3, PO 4, PO 5, and PO 7. Data collection and analysis emphasize environmental impacts and data privacy (PO 8).

5) Day 5: Customization and Projects

Students modify drones for specific applications, addressing PO 3, PO 5, PO 9, and PO 11. Safety and ethical compliance remain central, underlining PO 8.

6) Day 6: Presentations and Evaluation

Projects are presented and evaluated, fostering PO 10 and PO 12 (Life-long Learning). Feedback highlights safety and ethics, reinforcing PO 8 and future learning.

The program integrates interdisciplinary learning, hands-on training, and ethical awareness, effectively mapping to POs and preparing students for industry challenges.

C. Problem-Based Learning (PBL):

PBL is incorporated on Days 3, 4, and 5 to challenge students with real-world scenarios and troubleshooting tasks. On Day 3, students identify and solve issues during practical flight training, developing critical problem-analysis and troubleshooting skills. On Day 4, they address mission planning challenges, such as accounting for environmental and regulatory factors. On Day 5, PBL focuses on solving customization-related challenges, such as integrating specific sensors or adapting drones for specialized tasks. These tasks require applying knowledge, fostering creativity, and encouraging innovative problem-solving, ensuring alignment with Program Outcomes like PO 4 (Conduct Investigations) and PO 8 (Ethics).

D. Project-Based Learning (PjBL):

PjBL is a core element on Days 2, 4, and 5, structured around extensive projects that involve planning, execution, and evaluation. On Day 2, students assemble advanced drone components and configure systems, laying the foundation for real-world application. On Day 4, they apply skills in executing real-world missions, integrating data collection, analysis, and ethical considerations. On Day 5, students complete comprehensive team projects to customize drones for specific use cases, such as mapping, surveillance, or delivery, allowing them to manage resources and adhere to project timelines. These activities enhance capabilities in teamwork, project management, and system design, aligning with PO 3 (Design/Development of Solutions), PO 9 (Teamwork), and PO 11 (Project Management).

E. Integration into the Program

Both PBL and PjBL are strategically distributed to complement the program's objectives. PBL introduces students to specific problems, fostering critical analysis and real-time decision-making. PjBL allows students to consolidate these skills in broader, practical applications. Together, they create a comprehensive learning environment that emphasizes technical proficiency, collaborative problem-solving, and an understanding of ethical, societal, and environmental considerations.

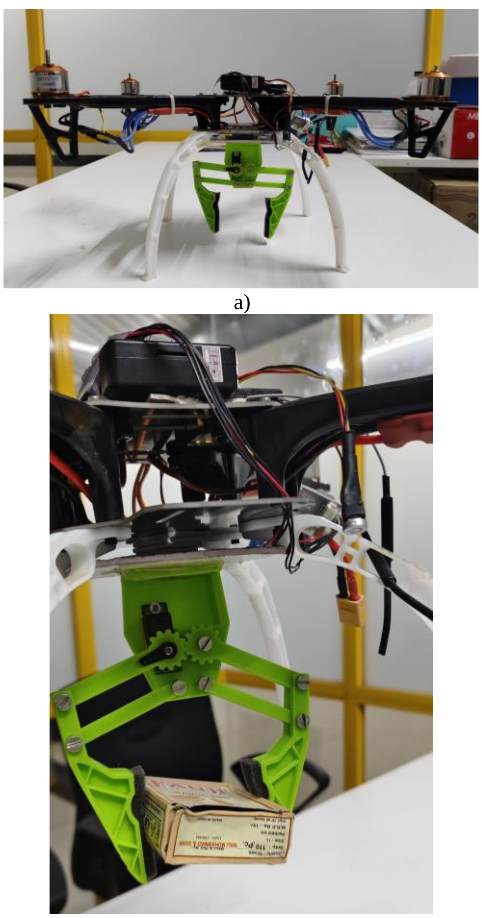
In this program, Hands-On Learning involves students actively engaging with drone technology by assembling kits, integrating advanced sensors, practicing flight maneuvers, and customizing drones for specific tasks.

III. Results and Discussion

A. Case Study: Drone for Auto Pick and Place with Self-Adjusting Gripper

In a Drone Technology Skilling Program involving undergraduate students from various engineering branches, one of the standout projects was the development of a drone for auto pick-and-place applications**,** designed with a self-adjusting 3D-printed gripper**.** This project was conceptualized, developed, and executed in the Idea Lab, a creative engineering space where students had access to advanced technologies such as 3D printing, CAD software, and drone components.

The project aimed to develop a drone capable of autonomously picking up objects of various sizes and shapes, transporting them, and placing them at designated locations. The key innovation was **a** self-adjusting gripper designed to dynamically adapt to the object's size, making it versatile for industrial and logistical applications. The gripper was 3D printed using materials optimized for strength and flexibility. Figure 01 illustrates (a) the auto pick and place drone and (b) the 3D printed gripper used in the skilling program.



a)

b)

Fig. 01-a) Auto pick and place drone, b) 3D printed gripper

TABLE II
MAPPING OF POs WITH SKILLING PROGRAM ACTIVITIES

Methodology	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Flipped Classroom	2	2				2	2	2	2	2		2
Hands-On Learning	3	2	3	2	3	2	2	2	3	2	3	3
Simulation-Based Learning	2	3	2	3	3	2	2	2	3	2	3	3
Interactive Lecture	2	2				3	2	2		3		2
Problem-Based Learning	2	3	3	3	2	3	3	3	3	3	3	3
Project-Based Learning	3	2	3	2	3	3	3	3	3	3	3	3
Reflective Practice	2	2	2	2	2	3	2	2	2	3	2	3

Table II shows the Mapping of POs with Skilling Program Activities used in skilling program.

1) Flipped Classroom

A WhatsApp group was created for all 50 participants to facilitate communication and resource sharing. Basic drone mechanics and 3D printing technology videos were shared a day before the workshop. Students were asked to watch these videos prior to attending the session, ensuring they arrived with a foundational understanding of the key concepts. During the workshop, a few basic questions were posed to reinforce their understanding and gauge their preparedness. In implementing the flipped classroom methodology for developing a drone with a self-adjusting 3D-printed gripper, students first engaged with theoretical content on drone design and 3D printing outside of class(Cho et al., 2021), ensuring a solid foundation in engineering principles (PO1). In-class sessions were then dedicated to applying this knowledge to real-world problems, such as analyzing and addressing design challenges for the drone and gripper (PO2). This approach enabled students to actively participate in the design and development process, including creating and refining prototypes during class time (PO3). The hands-on nature of the in-class work allowed students to conduct investigations and experiments, such as testing the gripper's functionality

(PO4). Modern tools like 3D printers were utilized during class, integrating practical tool usage with theoretical learning (PO5). The flipped classroom also emphasized understanding the societal impacts of their designs, such as improving automation efficiency, and encouraged consideration of environmental and ethical implications (PO6, PO7, PO8). Students collaborated and communicated effectively on their projects, enhancing their teamwork and communication skills (PO9, PO10). Although not directly mapped, the project involved managing tasks and resources, providing experience in project management (PO11). Finally, the methodology fostered continuous learning and adaptation to new technologies, reflecting a commitment to life-long learning (PO12).

2) Hands-On Learning

Students spent significant time in the Idea Lab, where they built the drone, designed and printed the gripper using CAD software, and integrated it with the drone's control systems. They also fine-tuned the drone's flight mechanics and payload capacity.

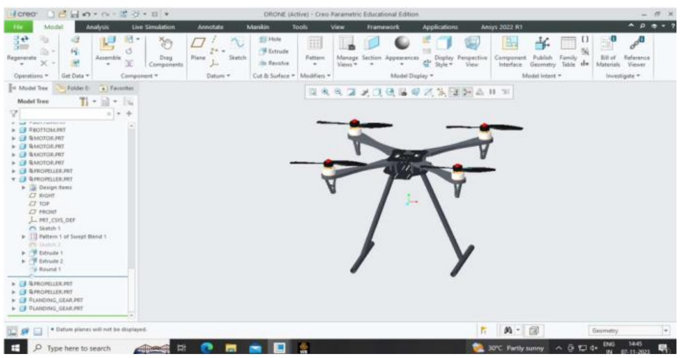
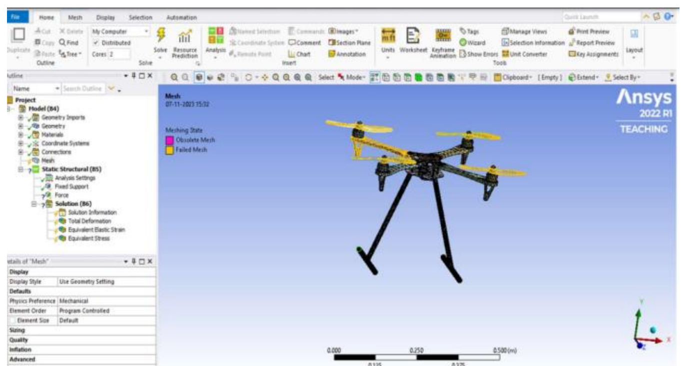


Fig. 02 CAD Modeling of Drones

Figure 02 displays the CAD modeling of drones used in the skilling program, while Figure 04 illustrates the mapping of Program Outcomes (POs) related to hands-on learning within the program. In designing a drone for auto pick-and-place applications with a self-adjusting 3D-printed gripper, various methodologies were employed, mapping to key Program Outcomes (POs). Initially, students acquired foundational knowledge in drone mechanics and 3D printing technology, which was crucial for understanding the design principles and functionality of the self-adjusting gripper (PO1). As they progressed, they engaged in problem analysis to address specific challenges related to the drone's performance and the gripper's adaptability, refining their problem-solving skills (PO2). The hands-on design process allowed students to develop and iterate on the drone and gripper, incorporating practical feedback and optimizing their solutions (PO3). They conducted investigations by testing prototypes, gathering data, and making necessary adjustments to enhance the design (PO4). Modern tools such as 3D printers and simulation software were integral to the project, enabling efficient prototyping and performance optimization (PO5). The project also connected with societal benefits by demonstrating how automation can improve operational efficiency, and students considered the environmental impact by utilizing sustainable 3D printing practices (PO6, PO7). Ethical considerations were taken into account to ensure the design was safe and effective, reflecting on the implications of their work (PO8). Students collaborated on various aspects of the project, enhancing their teamwork and communication skills, while also managing resources and timelines to ensure successful project completion (PO9, PO10, PO11). Finally, the methodology promoted continuous learning by integrating new technologies and design techniques, fostering a commitment to ongoing education (PO12).

3) Simulation-Based Learning

Before physical testing, students simulated the drone's pick-and-place operation in software to predict its flight stability and gripper performance under different conditions. Simulations helped optimize the gripper's design to ensure proper force distribution during object grasping(Salazar-Peña et al., 2023).



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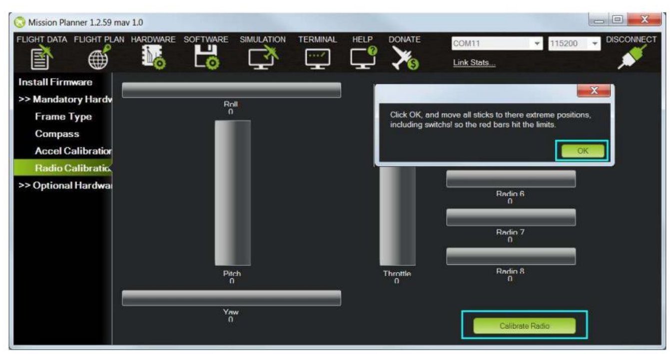


b)

c)

Fig. 03 a) Analysis of Drone using Ansys, b) Simulation of Drone Transmitter using mission planner and c) Simulation of auto navigation with mission planner

Figure 03 provides (a) an analysis of the drone using Ansys, (b) a simulation of the drone transmitter using Mission Planner, and (c) a simulation of auto navigation with Mission Planner. Simulation-based learning played a crucial role in the development of the drone for auto pick-and-place applications with a self-adjusting 3D-printed gripper, aligning with several Program Outcomes (POs). By utilizing simulation tools, students gained a deeper understanding of drone mechanics and the behavior of the 3D-printed gripper under various conditions (PO1). This approach enhanced their problem analysis skills, allowing them to identify and address potential issues in the design before physical prototypes were built (PO2). The simulations facilitated the design and development of solutions, enabling students to test and refine their concepts in a virtual environment, thus improving their design and development capabilities (PO3). Through virtual experiments and performance testing, students conducted investigations and gathered valuable data to optimize the drone's functionality (PO4). The use of simulation software equipped students with modern tool usage skills, essential for analyzing complex systems and predicting outcomes (PO5). Although the societal and environmental impacts were considered less directly through simulations, students still reflected on the broader implications of their designs (PO6, PO7). Ethical considerations were incorporated into the simulation scenarios, ensuring that the virtual models adhered to safety and operational standards (PO8). The project promoted effective communication and collaboration as students shared simulation results and insights, which were crucial for team coordination (PO9, PO10). Project management aspects were addressed by using simulation to plan and test design iterations efficiently, although this was less emphasized (PO11). Finally, simulation-based learning encouraged continuous adaptation and exploration of new technologies, fostering a commitment to life-long learning (PO12).

4) Interactive Lecture

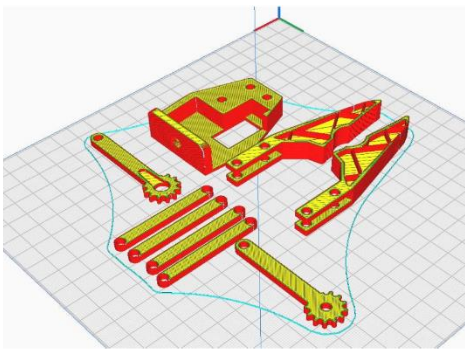
Faculty-led interactive sessions were conducted to clarify complex drone dynamics, object-grasping algorithms, and ethical considerations related to autonomous systems. In the development of the drone for auto pick-and-place applications with a self-adjusting 3D-printed gripper, interactive lectures served as a crucial methodology, aligning with several Program Outcomes (POs). These lectures provided a solid foundation in engineering principles and design concepts, enhancing students' understanding of drone mechanics and 3D printing technology (PO1). The interactive nature of the lectures facilitated in-depth discussions and problem-solving sessions, allowing students to analyze and address design challenges effectively (PO2). The lectures also integrated discussions on the broader societal and environmental impacts of engineering solutions, helping students consider the implications of their designs in real-world contexts (PO6, PO7). Although ethical considerations were touched upon, the primary focus was on understanding and applying theoretical knowledge rather than on direct ethical practice (PO8). The interactive format promoted effective communication skills as students shared their ideas and engaged in collaborative discussions (PO10). Finally, the methodology supported the concept of life-long learning by encouraging students to continuously seek new knowledge and adapt to evolving technologies (PO12).

5) Problem-Based Learning (PBL)

The project was approached as a real-world problem, where students had to overcome challenges like designing a lightweight yet strong gripper and ensuring that the drone could accurately detect and grasp objects(Ahmed & Indurkhya, 2020). This methodology engaged students in tackling real-world problems, allowing them to apply their engineering knowledge to the design and development of the drone and gripper (PO1). Through PBL, students conducted in-depth problem analysis to identify and resolve challenges related to the drone's performance and the gripper's functionality (PO2). They actively participated in the design and development process, using PBL to create and refine solutions iteratively, which enhanced their problem-solving and design skills (PO3). The approach also involved conducting investigations and experiments, where students tested their prototypes and adjusted their designs based on experimental findings (PO4). PBL encouraged the use of modern tools and technologies, including 3D printing and simulation software, to develop and optimize their solutions (PO5). It also facilitated discussions on the societal and environmental impacts of their designs, promoting a holistic understanding of the broader implications of engineering solutions (PO6, PO7). Ethical considerations were integrated into the problem-solving process, ensuring that designs adhered to safety and operational standards (PO8). Students collaborated extensively, enhancing their teamwork and communication skills as they worked together to address complex problems (PO9, PO10). PBL provided a framework for managing project tasks and resources, giving students experience in planning and executing engineering projects (PO11). Lastly, the methodology supported life-long learning by fostering a mindset of continuous inquiry and adaptation to new challenges and technologies (PO12).

6) Project-Based Learning (PjBL)

The entire project was structured as a long-term endeavor, with students managing time, resources, and tasks collaboratively. The project's goal was to develop a drone capable of picking and placing objects in an automated warehouse setting(Ahmad & Yahya, 2023).



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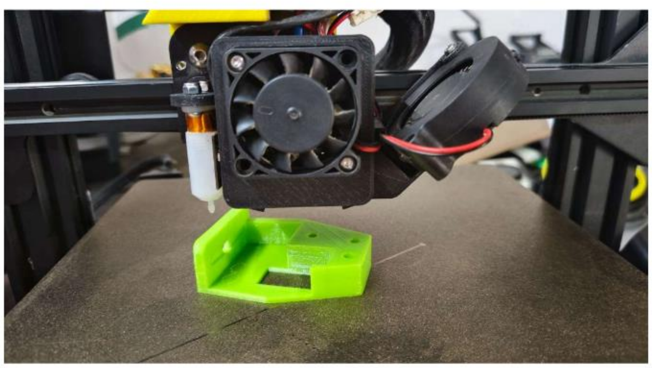


b)

Fig. 04 a) Part manufacturing with 3D printing on CURA software, b) Part manufacturing on 3D printing machine and

Figure 04 shows (a) the part manufacturing process using CURA software for 3D printing, (b) the actual part manufacturing on the 3D printing machine, and (c) the mapping of Program Outcomes (POs) related to project-based learning within the skilling program. In the development of the drone for auto pick-and-place applications with a self-adjusting 3D-printed gripper, project-based learning (PBL) was an essential methodology that mapped effectively to several Program Outcomes (POs). PBL provided students with a comprehensive, hands-on experience, allowing them to apply engineering knowledge to a real-world project, thereby enhancing their understanding of drone mechanics and 3D printing technology (PO1). Through this approach, students engaged deeply in problem analysis, identifying and addressing challenges related to the design and functionality of the drone and gripper (PO2). The iterative design and development process inherent in PBL enabled students to create and refine their solutions, which fostered their problem-solving and design skills (PO3). Students conducted investigations by testing prototypes and gathering data, which informed their design decisions and improved their experimental techniques (PO4). PBL encouraged the use of modern tools and technologies, such as 3D printers and simulation software, to develop and optimize their designs (PO5). Additionally, students considered the societal and environmental impacts of their project, integrating these aspects into their design process (PO6, PO7). Ethical considerations were addressed throughout the project, ensuring that the designs adhered to safety and operational standards (PO8). The project-based approach also facilitated effective teamwork and communication, as students collaborated on various aspects of the project and shared their findings (PO9, PO10). Although project management was not the primary focus, students gained practical experience in managing resources and coordinating tasks (PO11). Finally, PBL promoted life-long learning by encouraging continuous exploration and adaptation to new technologies and challenges (PO12).

7) Reflective Practice

Implementation: After the project, students wrote reflective reports, assessing their own learning, team dynamics, and the challenges they faced in integrating 3D printing with drone technology(Daniëls et al., 2023). Reflective practice encouraged students to regularly review and assess their design processes and outcomes, fostering a deeper understanding of engineering principles and improving their problem analysis skills (PO1, PO2). By reflecting on their design and development efforts, students were able to evaluate the effectiveness of their solutions and identify areas for improvement (PO3). The methodology also supported the development of modern tool usage by helping students understand how their design decisions affected the performance and functionality of the drone and gripper (PO5). Although the focus on societal, environmental, and ethical considerations was less pronounced, reflective practice allowed students to consider these aspects in the context of their project (PO6, PO7, PO8). Effective communication and teamwork were enhanced as students shared their reflections and insights with peers, contributing to a collaborative learning environment (PO9, PO10). Reflective practice also supported life-long learning by encouraging students to continuously evaluate and adapt their approaches based on their experiences and new insights (PO12). While project management and planning aspects were less emphasized, students gained some insights into managing their projects more effectively through reflection on past experiences (PO11). Overall, reflective practice provided a valuable framework for integrating theoretical knowledge with practical application, contributing to the achievement of several Program Outcomes. This project exemplifies the integration of cutting-edge technology, such as 3D printing and drone automation, with active learning methodologies. Students gained practical skills in design thinking, rapid prototyping, and team collaboration, while achieving the desired Program Outcomes (POs). PO3 (Design/Development of Solutions): The final design featured a self-adjusting gripper made from lightweight, durable materials that could effectively pick up objects of varying sizes. PO5 (Modern Tool Usage): Students mastered advanced tools like 3D printers and simulation software, which are critical in today's engineering landscape. PO9 (Individual and Team Work): Teams demonstrated effective collaboration, drawing on the strengths of students from different disciplines to complete the project successfully(Adeani et al., 2020).

This auto pick-and-place drone with a 3D-printed self-adjusting gripper is a prime example of how diverse teaching methodologies can be leveraged to achieve holistic learning. It showcases how active learning and project-based experiences can enable students to address complex, real-world engineering challenges while attaining essential Program Outcomes (POs).

8) Skilling Program Outcomes (SPO)

Table III provides the detailed Skilling Program Outcomes (SPO). Table IV shows the mapping of skilling program outcomes with Program Outcomes, while Table VA and VB presents the calculation for indirect PO attainment.

TABLE III
SKILLING PROGRAM OUTCOMES (SPO)

Sr. No.	Outcome	Revised Bloom's Level	Action Verb
SPO1	Understand and apply safety protocols, regulatory requirements, and ethical considerations related to drone operations, ensuring responsible and compliant use of drone technology.	Understanding	Understand, Apply
SPO2	Demonstrate the ability to assemble, configure, and operate drones effectively, integrating various sensors and using simulation software.	Applying	Demonstrate
SPO3	Analyze and troubleshoot common operational issues and data anomalies encountered during drone flights.	Analyzing	Analyze, Troubleshoot
SPO4	Plan, execute, and manage drone-related projects, including mission planning and data collection, while working collaboratively in teams.	Creating	Plan, Execute, Manage

TABLE IV
MAPPING OF SKILLING PROGRAM OUTCOMES WITH PROGRAM OUTCOME

Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
SPO 1	3					2	3	2		3	1	2
SPO 2	3		2		3				3	3		2
SPO 3	3	2	2	2	3				3	3		2
SPO 4	3	2	2	2	3		3	2	3	3	1	2
Average	3	2	2	2	3	2	3	2	3	3	1	2

To assess the attainment of learning outcomes from the skilling programs in drone technology, need to analyze feedback collected from 4 distinct programs, each involving 50 students per program, across multiple semesters. The feedback focuses on the following questions:

1. **Understanding and Applying Safety Protocols**: Are you able to understand and apply safety protocols, regulatory requirements, and ethical considerations related to drone operations, ensuring responsible and compliant use of drone technology?
2. **Assembling and Operating Drones**: Are you able to assemble, configure, and operate drones effectively, integrating various sensors and using simulation software?
3. **Analyzing and Troubleshooting Operational Issues**: Are you able to analyze and troubleshoot common operational issues and data anomalies encountered during drone flights?
4. **Planning and Managing Drone-Related Projects**: Are you able to plan, execute, and manage drone-related projects, including mission planning and data collection, while working collaboratively in teams?

9) Steps for Analysis

1. **Data Collection and Organization**
   - Gather feedback from all four skilling programs.
   - Structure the data for each question, with responses categorized into "Excellent," "Very Good," "Good," "Average," and "Below Average."
2. **Data Aggregation**
   - Combine the feedback data from the four programs into a comprehensive dataset.
   - Calculate the total number of responses for each feedback category across all programs.
3. **Attainment Calculation**
   - **Define Attainment Goals**: Establish what percentage of students should achieve the "Excellent" or "Very Good" ratings to meet the program goals.

- **Calculate Attainment**: For each feedback question, calculate the percentage of students who rated the program as "Excellent" or "Very Good."
- **Compare with Goals**: Determine if the attainment meets the predefined goals.

4. **Visualization**
   - Create visualizations such as bar charts or pie charts to depict the distribution of feedback ratings for each question across all programs.
   - Compare the percentage of high ratings ("Excellent" and "Very Good") to the total responses.

10) Calculation for Indirect PO Attainment

TABLE V(A)
FEEDBACK FOR INDIRECT PO ATTAINMENT

Outcome	Excellent	Very Good	Good	Average	Below Average
Are you able to Understand and apply safety protocols, regulatory requirements, and ethical considerations related to drone operations, ensuring responsible and compliant use of drone technology?	102	58	18	12	10
Are you able to assemble, configure, and operate drones effectively, integrating various sensors and using simulation software?	105	55	20	10	10
Are you able to Analyze and troubleshoot common operational issues and data anomalies encountered during drone flights?	107	55	18	10	10
Are you able to Plan, execute, and manage drone-related projects, including mission planning and data collection, while working collaboratively in teams?	100	60	20	10	10

TABLE V(B)
CALCULATION FOR INDIRECT PO ATTAINMENT

Program	Question	Excellent	Very Good	Good	Average	Below Average	Average Attainment
Program 1	Understanding and Applying Safety Protocols	31	9	5	3	2	81.50
Program 2		28	12	7	2	1	
Program 3		35	8	4	2	1	
Program 4		31	8	6	4	1	

Program	Question	Excellent	Very Good	Good	Average	Below Average	Average Attainment
Program 1	Planning and Managing Drone-Related Projects	32	10	4	2	2	84.50
Program 2		30	11	6	2	1	
Program 3		34	9	5	2	0	
Program 4		33	10	4	2	1	

Program	Question	Excellent	Very Good	Good	Average	Below Average	Average Attainment
Program 1	Assembling and Operating Drones	25	13	9	2	1	80.50
Program 2		26	14	8	1	1	
Program 3		27	15	6	1	1	
Program 4		29	12	6	2	1	

Program	Question	Excellent	Very Good	Good	Average	Below Average	Average Attainment
Program 1	Analyzing and Troubleshooting Operational Issues	28	12	6	3	1	81.00
Program 2		28	11	8	2	1	
Program 3		32	10	6	2	0	
Program 4		31	10	6	2	1	
Average Indirect PO Attainment				**81.75%**			
Indirect PO Attainment Level				**3**			

Average attainment of 81.75 with attainment level 3 is obtained. Sample calculation of attainment is as follows-

1. Total Responses**:** Sum the feedback responses for each question across all programs.
2. **Percentage Calculation:**

For each question: Percentage of Excellent and Very Good=

$$\frac{\text{Total Excellent} + \text{Total Very Good}}{\text{Total Responses}} \times 100$$

Example for "Understanding and Applying Safety Protocols":

Total Excellent = 31 + 28 + 35 + 31 = 125

Total Very Good = 09 + 12 + 8 + 8 = 37

Total Responses = 50 × 4 = 200

$$\text{Percentage} = \frac{125+37}{200} \times 100 = 81.5\%$$

The attainment level is assigned based on the average feedback percentage obtained:

If the average feedback is greater than 80%, it is categorized as 'High' (Level 3).

If the average feedback falls between 60% and 80%, it is categorized as 'Moderate' (Level 2).

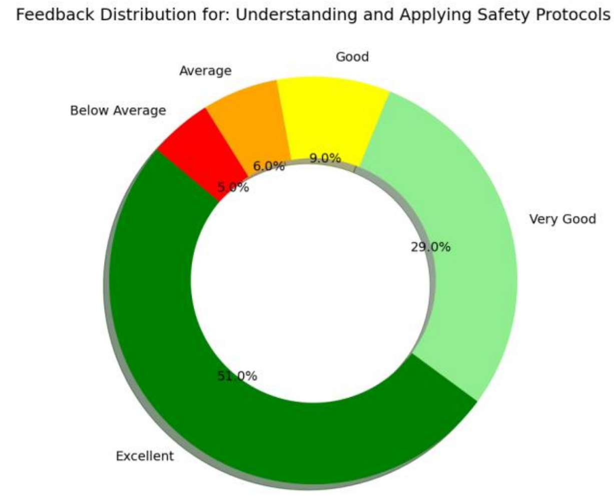
If the average feedback is below 60%, it is categorized as 'Low' (Level1).

Table VI presents the data on indirect PO attainment.

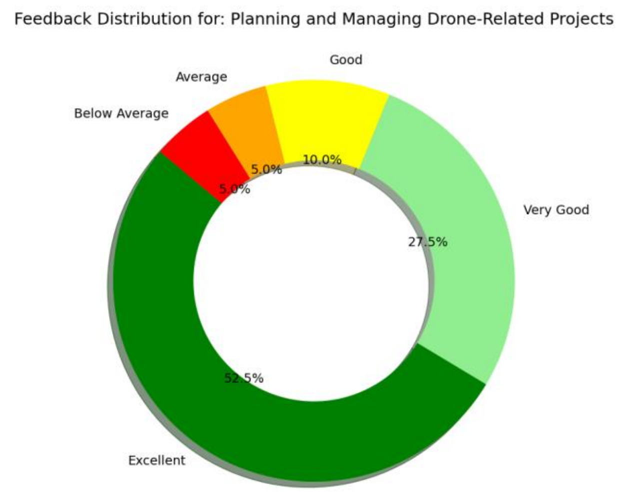
TABLE VI
INDIRECT PO ATTAINMENT

Drone Technology Skilling Program	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
Indirect Attainment Level	3	2	2	2	3	2	3	2	3	3	1	2

The feedback analysis reveals that most students feel confident in their drone technology skills. Understanding and Applying Safety Protocols received strong positive ratings, with 102 students marking it as Excellent, indicating robust safety knowledge. Planning and Managing Drone-Related Projects and Assembling and Operating Drones also saw high ratings of Excellent (105 and 107 respectively), showing effective training in these areas. Analyzing and Troubleshooting Operational Issues received 100 Excellent ratings, reflecting strong problem-solving skills. Although the majority rated their skills positively, there are small areas for improvement, particularly for those who rated their skills as Good or lower(Hu et al., 2023).



a)



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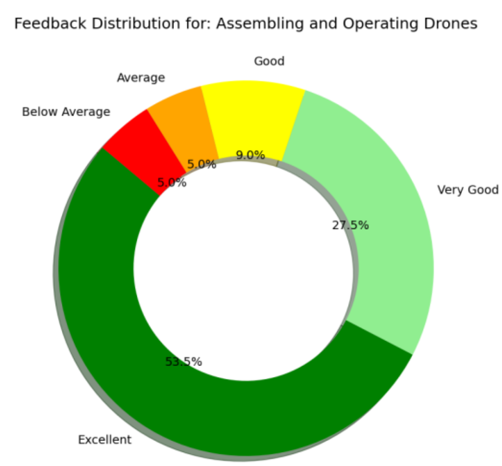

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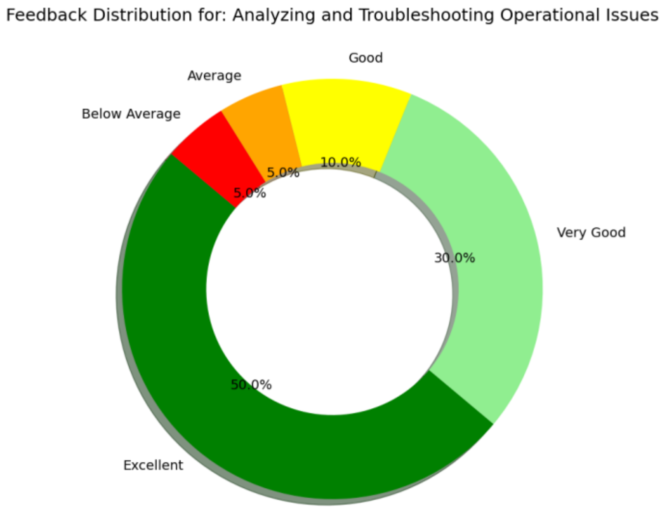

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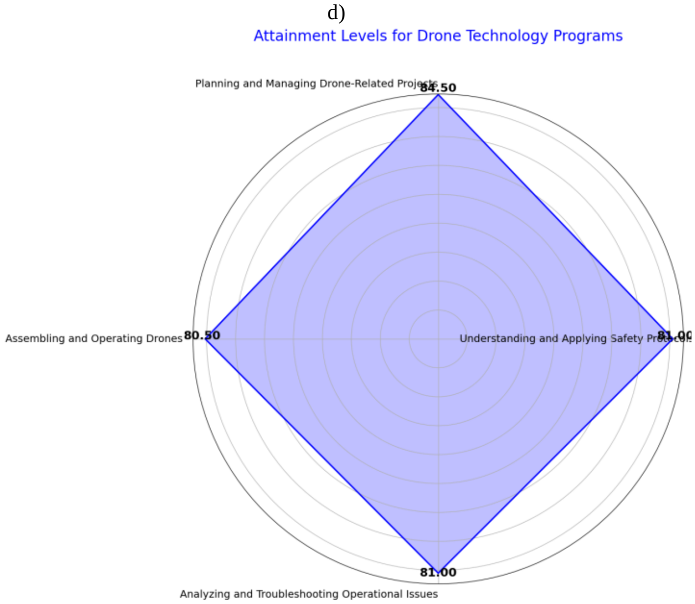

e)

Fig. 05a) Feedback Analysis of question 1, b) Feedback Analysis of question 2, c) Feedback Analysis of question 3 , d) Feedback Analysis of question 4 and e) Question wise percentage attainment

Figure 05 includes (a) the feedback analysis for Question 1, (b) the feedback analysis for Question 2, (c) the feedback analysis for Question 3, (d) the feedback analysis for Question 4, and (e) the percentage attainment for each question.The percentage attainment for various aspects of the drone development project demonstrates strong student engagement and proficiency. Understanding and applying safety protocols achieved an 81.00% attainment rate, reflecting students' solid grasp of essential safety measures necessary for operating drones. Planning and managing drone-related projects saw a slightly higher attainment of 84.50%, indicating effective skills in organizing and executing drone projects, which is critical for successful implementation and completion. Assembling and operating drones garnered an 80.50% attainment, showcasing students' practical abilities in building and handling drones, although there is room for further refinement. Analyzing and troubleshooting operational issues also reached an 81.00% attainment rate, illustrating students' competency in diagnosing and resolving problems encountered during drone operations. Overall, these results highlight the students' comprehensive understanding and application of key concepts and skills, with slight variations indicating areas where additional focus could further enhance their capabilities.

B. Direct Attainment

In this study, a comprehensive assessment was conducted following each skilling program, where students were evaluated through a test of 30 marks. The test was structured to align with the course outcome weightage as follows:

- SPO1: 7 marks
- SPO2: 7 marks
- SPO3: 8 marks
- SPO4: 8 marks

The performance of students across the four skilling programs was analysed based on their scores. Specifically, the number of students scoring above 21 marks in each program was recorded, and the percentage attainment was calculated. The results are summarized as follows:

TABLE VII
DIRECT PO ATTAINMENT

Parameter	Program 1	Program 2	Program 3	Program 4
Number of students having marks > 21	38	39	39	41
Percentage Attainment	76.00%	78.00%	78.00%	82.00%
Average Direct PO Attainment	78.50%			
Direct PO Attainment Level	3			

Table VII provides the details on direct PO attainment, while Table VIII summarizes the total PO attainment. These results indicate that all four programs successfully met and exceeded the target assessment threshold of 70%. The percentage attainment across the programs not only surpassed the set target but also demonstrated a consistent performance improvement, particularly in Program 4. This suggests that the skilling programs effectively contributed to achieving the desired course outcomes and highlights the positive impact of the structured assessment approach used. Figure 06 illustrates the histogram of test marks across the four programs, while Figure 07 shows the total attainment levels for the Drone Technology Skilling Program.

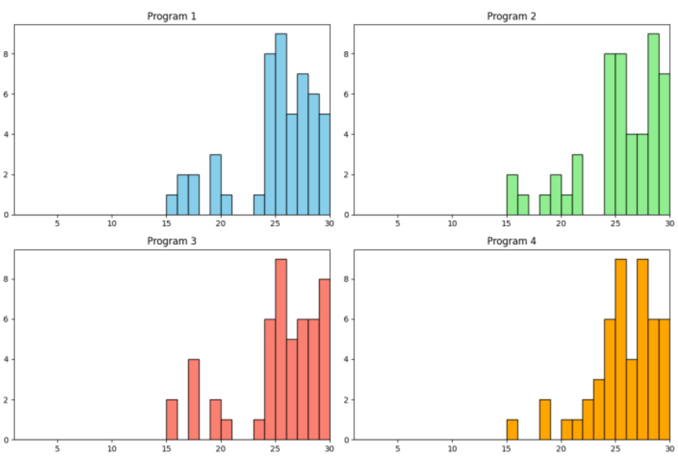

Fig. 06 Histogram of Test Marks throughout 4 programs

According to the Institute NBA Coordinator Guidelines, 80% of the weightage is given to Direct Attainment**,** which includes assessments like exams, projects, and labs that directly measure student performance. The remaining 20% is allocated to Indirect Attainment, which involves feedback and perceptions from surveys, alumni, and employers, providing insights into the program's broader impact but not directly assessing student outcomes. This balance ensures both direct evaluation of student skills and an understanding of the program's overall effectiveness.

TABLE VIII
TOTAL PO ATTAINMENT

Drone Technology Skilling Program	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Direct Attainment Level (80%)	3	2	2	2	3	2	3	2	3	3	1	2
Indirect Attainment Level (20%)	3	2	2	2	3	2	3	2	3	3	1	2
Total Attainment Level (100%)	3	2	2	2	3	2	3	2	3	3	1	2

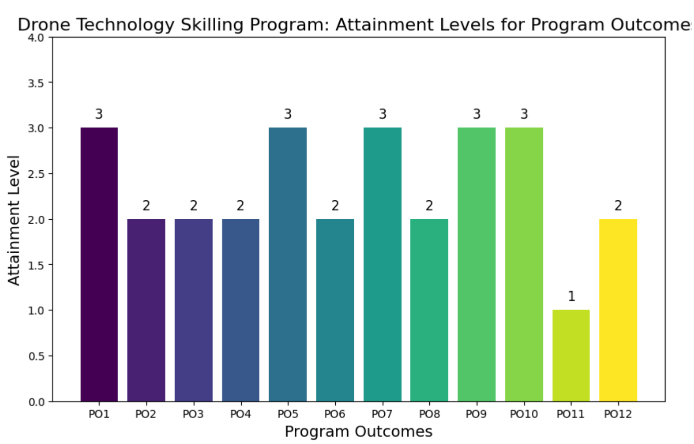

Fig. 07 Total Attainment of Drone Technology Skilling Program

The Drone Technology Skilling Program demonstrates comprehensive attainment across various Program Outcomes (POs). The Direct, Indirect, and Total Attainment Levels for each PO are consistently rated at either 2 or 3, indicating a strong performance. Specifically, POs 1, 5, 7, and 9 achieve a Direct, Indirect, and Total Attainment Level of 3, reflecting high effectiveness in these areas. Conversely, POs 4, 6, 8, 10, 12 show a slightly lower attainment level of 2. This balanced attainment across POs suggests that the program effectively addresses the majority of learning outcomes, with particular strengths in certain areas, ensuring a well-rounded skill development experience for participants.

This study is crucial for addressing NBA Criterion 2 (Program Curriculum and Teaching-Learning Process) and Criterion 3 (Program Outcomes and Program Specific Outcomes). By identifying curriculum gaps, it ensures that engineering programs meet NBA standards and equip graduates with industry-relevant skills. The study emphasizes integrating interdisciplinary projects and innovative teaching methods like Problem-Based Learning (PBL) and Project-Based Learning (PjBL) to strengthen students' ability to solve real-world problems. It also highlights the importance of indirect attainment, such as workshops and feedback, to continuously improve the curriculum. This approach aligns the program with industry needs and fosters holistic skill development, ensuring students are well-prepared for diverse careers and future challenges in the engineering field.

CONCLUSION

The 6-day skilling programs facilitated by the AICTE IDEA Lab have proven highly effective in enhancing engineering education by promoting hands-on learning, technical competency, and problem-solving abilities. Positive student feedback highlights the value of these programs, with many noting significant gains in both practical skills and confidence in applying theoretical knowledge. The limited batch size ensured that students received personalized attention, maximizing the impact of hands-on training. Additionally, industry-led training played a crucial role in aligning the programs with current technological trends and industry needs, further amplifying their effectiveness.

The Drone Technology Skilling Program, in particular, demonstrated strong indirect attainment in key Program Outcomes, including PO1 (Engineering Knowledge), PO5 (Modern Tool Usage), PO7 (Environment and Sustainability), and PO9 (Individual and Team Work). While there is room for improvement in areas such as PO10 (Communication) and PO11 (Project Management and Finance), the overall positive impact of these skilling programs aligns well with the goals of modern engineering education.

C. Future Scope

- Long-term Impact: Research could assess the long-term career success of graduates who participated in skilling programs.
- Expansion: Investigating the application of skilling programs across other engineering disciplines like AI or robotics.
- Industry Collaboration: Exploring the potential for expanding industry partnerships to enhance real-world relevance and training quality.

- Skill Enhancement: Focusing on improving communication and management skills within these programs.
- Comparative Studies: Comparing traditional learning models with short-term skilling programs for broader insights.

These future directions can help further strengthen the AICTE IDEA Lab model, ensuring it continues to deliver impactful, industry-aligned training that prepares students for the demands of the modern engineering workforce.

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