Impact of AICTE IDEA Lab Training on Skill Development of Diploma College Students in Advanced Manufacturing

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***Abstract*— This paper evaluates the impact of a series of three-day All India Council for Technical Education (AICTE) IDEA (Idea Development, Evaluation, and Application) Lab workshops designed to enhance the skill development of polytechnic students of various colleges in advanced manufacturing. The workshop delivered a comprehensive educational experience by integrating hands-on training in advanced manufacturing processes, including 3D printing, laser cutting & etching, 3D scanning, and CNC wood routing. In addition, it introduced participants to design thinking and engaged them in project-based learning (PBL) focused on product development. Feedback data indicated a significant improvement in participants' self-assessed understanding, with average ratings rising from 2.9 before the workshop to 4.1 afterward, reflecting a notable enhancement in their theoretical knowledge. Furthermore, the workshop successfully boosted students' confidence in applying the techniques learned, with 52 out of 60 students expressing a strong interest in participating in future advanced workshops. Evaluations also revealed high levels of satisfaction with the workshop's content, structure, and the effectiveness of the instructors. The positive feedback highlights the workshop's success in bridging knowledge gaps, fostering practical skills, and generating enthusiasm for continued learning in advanced manufacturing. Overall, these findings demonstrate that the workshops have a significant impact on preparing students for future challenges in the field, greatly enhancing their capabilities and confidence in advanced manufacturing while also strengthening their STEM competencies.**

***Keywords*— Advanced manufacturing; Design thinking; Hands-on training; IDEA Lab; Project-Based Learning; Skill development**

***ICTIEE* Track*:* Technology Enhanced Learning**
ICTIEE Sub-Track: Transforming Education Through Technology: Best Practices and Case Studies

I. INTRODUCTION

THE rapid evolution of advanced manufacturing technologies, including 3D printing, laser cutting & etching, and CNC wood routing, underscores the need for continuous skill development among students to prepare them for the future job market. As these technologies advance, they become increasingly crucial across various industries due to their ability to produce complex and precise components (Pimal & Sudeep, 2020). This ongoing development emphasizes the critical need to equip students with up-to-date skills and knowledge, enabling them to effectively utilize emerging technologies and meet the demands of a rapidly evolving industry. Rapid progress in manufacturing technology has redirected educational focus towards fostering a balance of theoretical knowledge and practical skills, particularly in the area of advanced manufacturing (Marcela, et al., 2020). This emphasis ensures that students are well-prepared to navigate the complexities of modern manufacturing environments and contribute meaningfully to the industry. Experiential learning is crucial for understanding technical concepts and effectively applying them to transform ideas into prototypes (Heather & Adam, 2022). Additionally, acquiring multidisciplinary skills is essential for addressing societal and industrial challenges. In the technology sector, the advent of Industry 4.0 (Eliseo, et al., 2022; Isaías & Antonio, 2018; Moraes, et al., 2023; Bashir, et al., 2020) has revolutionized how companies manufacture and distribute their products, with key technologies like digital manufacturing and the Internet of Things (IoT) emerging as central components of this revolution. Research highlights the need to blend hands-on learning with traditional engineering education to effectively prepare students for modern industrial challenges (Rodrigo, et al., 2022). Continuous skill development workshops are shown to bridge the gap between theory and practice, significantly boosting student confidence and engagement (Timothy, et al., 2017). Integrating project-based learning (PBL) and design thinking into these trainings enhance creativity and problem-solving skills. Workshops have emerged as a particularly effective method for bridging the gap between theoretical knowledge and real-world application (Karin, 2020). Short-term, skill-focused workshops

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significantly boost student confidence and engagement, leading to better learning outcomes. Incorporating PBL and design thinking fosters creativity, problem-solving, and innovation (Ravikantha, et al., 2024; Kuen-Yi, et al., 2021).

The AICTE-IDEA Lab Scheme, led by the All India Council for Technical Education (AICTE) in New Delhi, is a progressive initiative designed to nurture entrepreneurship by applying Science, Technology, Engineering, and Mathematics (STEM) concepts through practical, hands-on projects (Basavaraj, et al., 2024). This scheme aims to equip individuals with the skills needed to become successful entrepreneurs by providing access to state-of-the-art, multidisciplinary facilities. These facilities enable students to address real-world societal and industrial challenges using critical thinking and problem-solving skills. In line with the National Educational Policy (NEP) 2020, the IDEA Lab promotes multidisciplinary and interdisciplinary projects and internships, encouraging collaborations with industry professionals to spark innovative project ideas. This collaborative environment facilitates a rapid transition from the lab to the market by offering comprehensive, affordable support for product development and startup ventures. Additionally, the IDEA Lab supports faculty development through specialized programs and provides high-tech equipment for research and development, enhancing both teaching and research capabilities. This holistic approach ensures that both students and faculty benefit from an enriched educational experience, fostering a dynamic ecosystem that drives academic and entrepreneurial success.

The effectiveness of these workshops is often evaluated through participant feedback and self-assessment, with improvements in self-assessed knowledge post-workshop indicating successful knowledge transfer (Carma, et al., 2008). Feedback provides insights into the clarity, relevance, and usefulness of the content, helping educators identify strengths and areas for improvement (Kathryn, Shawnee, & Laura, 2020). Self-assessment involves participants reflecting on their knowledge or skills before and after the intervention, with improvements indicating successful knowledge transfer (Huy, Vicky, & Carol, 2021). This approach, grounded in self-perception theory, is supported by research showing that self-assessment often correlates with actual learning gains, making it a valuable tool for evaluating the success of educational programs.

In the context of advanced manufacturing, IDEA Lab specifically focuses on enhancing student competencies through hands-on training, PBL, and design thinking (Basavaraj, et al., 2024). IDEA Lab workshops led to significant improvements in practical skills and increased confidence in applying advanced manufacturing techniques. Research has shown that high levels of satisfaction with both the content and instructional methods are strong indicators of the workshop's potential for long-term impact on skill development (Ann, et al., 2007). Positive feedback helps ensure that the workshop effectively meets its educational goals and supports sustained learning and growth. The IDEA Lab has been conducting three-day's skill development programs to the students of six polytechnic colleges in Dakshina Kannada districts aiming at enhancing the technical and creative skills. This study assesses the workshop's effectiveness in achieving these objectives and provides recommendations for future improvements.

II. METHODOLOGY

The methodology of this study involved organizing and evaluating a three-day IDEA Lab workshop aimed at enhancing the skills of diploma college students in advanced manufacturing. This process included carefully designing the workshop to integrate both theoretical and practical components, such as hands-on training in 3D printing, laser cutting, and wood routing. To assess the impact, participants' understanding and confidence were measured before and after the workshop using detailed questionnaires. Feedback was gathered to evaluate various aspects of the workshop, including content relevance, instructional effectiveness, and overall satisfaction. The approach provided a thorough evaluation of the workshop's effectiveness in improving students' skills and readiness for future industry challenges.

A. Workshop Design and Content

The workshop was designed to offer a balanced combination of theoretical and practical learning experiences. It featured hands-on training in advanced manufacturing processes, an introduction to design thinking, and project-based learning activities centered on product development. The schedule was carefully crafted to align with industry standards and educational objectives, ensuring that the content was both relevant and applicable to real-world scenarios. By integrating these elements, the workshop aimed to provide participants with a comprehensive understanding of advanced manufacturing while also preparing them for practical challenges in the field. Outline of the 3 Day Workshop is as follows:

1) Day 1: Hands-on Training in Advanced Manufacturing Processes

3D Printing: The workshop provided a thorough introduction to the principles of 3D printing, including an overview of various types of 3D printers, the materials used, and their diverse applications. Students participated in practical sessions where they designed and printed simple objects, gaining hands-on experience with layer-by-layer manufacturing techniques. They were also introduced to common troubleshooting methods to address issues that may arise during the printing process, which contributed to a comprehensive understanding of 3D printing technology and its practical applications. Additionally, students used Tinkercad, a free web app for 3D design, and learned to operate Creality Ender slicer software, setting parameters such as layer thickness, infill density, and other critical parameter settings for successful 3D printing.

Laser Cutting: The workshop provided a detailed explanation of laser cutting technology, covering its advantages, the various types of lasers used, and the range of materials that can be cut with this technology. Participants were introduced to the principles of laser cutting, including how lasers achieve precise

and clean cuts in different materials. Beyond the theoretical overview, students engaged in hands-on activities where they designed and cut intricate patterns and shapes from various materials. These practical sessions enabled students to apply their knowledge directly, using laser cutting equipment to bring their designs to life. This hands-on experience not only reinforced their understanding of the technology but also helped them develop practical skills in operating laser cutters for complex tasks. Additionally, students performed laser cutting and engraving operations and learned to use LaserCAD software. They gained experience in setting the intensity and speed of the laser depending on the type of operation being performed.

Fig. 1. a) SJEC AICTE IDEA Lab b) 3D printer c) Laser cutter d) CNC Wood router

CNC Wood Routing: The workshop offered a comprehensive overview of wood routing techniques and equipment, emphasizing their applications in creating precise and detailed woodwork. Practical sessions allowed students to design and execute routing operations, which enhanced their understanding of tool handling and safety measures. They utilized ArtCAM software to create simple designs commonly used with wood routing machines. Additionally, students were given demonstrations on various power tools, including drilling machines, grinding machines, power saws, wood lathes, and PCB milling machines.

The facilities available at the IDEA Lab, including 3D printing, laser cutting, and CNC wood routing, are presented in Fig. 1. This hands-on experience not only deepened their technical skills but also familiarized them with the various capabilities of the equipment available at the SJEC AICTE IDEA Lab.

2) Day 2: Introduction to Design Thinking and Team Formation

Design Thinking: The workshop included a comprehensive introduction to design thinking, covering its five essential stages: Empathize, Define, Ideate, Prototype, and Test (Rouxelle, 2022; Martha, 2020). Each stage was explored in depth to help students understand the process of creative problem-solving. The focus was on fostering creativity and enhancing problem-solving skills through hands-on activities and real-world examples. Participants engaged in exercises that encouraged them to empathize with users, define problems clearly, generate innovative ideas, build prototypes, and test heir solutions. This approach aimed to develop their ability to tackle complex challenges and think critically in a structured manner.

Team Formation for Project-Based Learning: Students were divided into teams to promote collaboration and collective problem-solving. Each team was tasked with conceptualizing a project that would apply the advanced manufacturing techniques they had learned during the first two days of the workshop. This team-based approach was designed to encourage creative thinking and teamwork, allowing students to integrate and apply their knowledge of 3D printing, laser cutting, and wood routing. By working together on a project, students could explore practical applications of the techniques and develop solutions that incorporate multiple aspects of the advanced manufacturing processes covered.

Project Planning: Teams began planning their projects with guidance from instructors on feasible designs, materials, and manufacturing processes. The instructors provided valuable insights and feedback to ensure that the projects were practical and aligned with the capabilities of the available equipment. The IDEA Lab supplied all necessary materials and resources to support the projects, including access to 3D printers, laser cutters, and wood routing tools. This support allowed the teams to effectively implement their designs and experiment with various manufacturing techniques, fostering a hands-on learning environment and enhancing their overall workshop experience.

3) Day 3: Product Development

Developing the Product: The teams worked on turning their project ideas into tangible products. Students took a total of 3 to 4 hours to plan, design, and fabricate the project. Throughout this process, instructors offered continuous support and feedback, helping teams use advanced manufacturing techniques correctly and follow design principles. This guidance ensured that the projects were executed effectively and aligned with the workshop's objectives. The hands-on approach allowed students to refine their designs and overcome challenges, applying their skills to create functional and innovative products (Norman, 2021).

Final Presentations: Teams presented their completed projects, detailing their design process, the challenges they encountered, and the solutions they implemented. This presentation session offered an opportunity for peer review, allowing other participants to provide constructive feedback. The feedback session was valuable for identifying strengths and areas for improvement and fostering a collaborative learning environment where students could learn from each other's experiences and refine their skills (Jesmine & Wenli, 2022).

The demo session on advanced manufacturing processes and the sample projects developed by the student teams are presented in Fig. 2. This figure showcases the outcomes of the students' hands-on work, including the various techniques they

employed and the results of their projects. It highlights both the process and final products, providing a visual representation of how the advanced manufacturing techniques were applied in their projects.

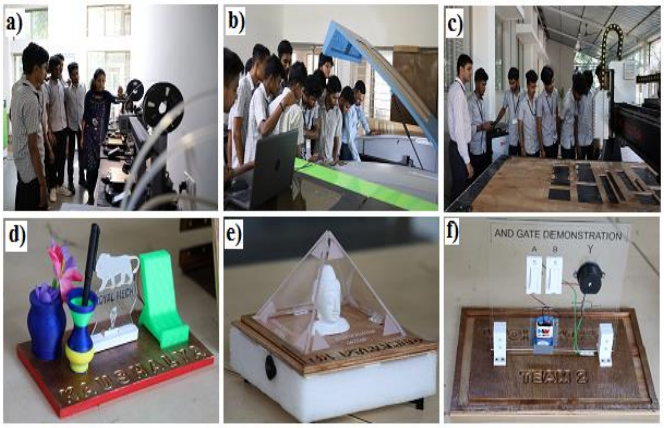

Fig. 2. Demonstration of machine a) 3D printer b) Laser cutter c) Wood router d-f) Sample projects done by students.

B. *Feedback and Satisfaction Analysis*

A structured questionnaire was designed to collect comprehensive feedback from participants across various dimensions, including learning outcomes, workshop content, logistical arrangements, and suggestions for future programs. The questionnaire was divided into five sections (A-E), each targeting specific aspects of the workshop experience.

Participants were asked to rate their understanding of advanced manufacturing processes both before and after the workshop using a Likert scale, which ranged from "poor" to " excellent " to measure the impact of the training. Importantly, feedback was collected anonymously, ensuring that participants' identities were not revealed, which encouraged honest and unbiased responses. The detailed feedback questions are provided in Table I.

C. *Data Analysis*

To evaluate the workshop's impact, we employed a comprehensive approach. We first assessed participants' understanding of advanced manufacturing processes by comparing their self-reported knowledge levels before and after the workshop, aiming to gauge their educational effectiveness. Descriptive statistics were then used to summarize quantitative data on students' confidence in applying the techniques learned and their interest in future workshops. This provided insight into how well the workshop translated into practical skills and student engagement. Additionally, we analyzed qualitative feedback by categorizing it into common themes to identify strengths and areas for improvement. This qualitative analysis helped us understand participants' perceptions of the workshop's content, relevance, and instructional quality in more detail. Combined, these methods offered a thorough assessment of the workshop's effectiveness, revealing significant improvements in participants' understanding and positive feedback on the workshop's instructional quality and relevance.

This methodology allowed for a comprehensive evaluation of the workshop's impact on students' skill development, providing valuable insights into the effectiveness of hands-on, PBL in advanced manufacturing education.

TABLE I
FEEDBACK QUESTIONNAIRE

A. Learning and Skill Development	
1. How would you rate your understanding of advanced manufacturing processes before and after the workshop?	Rating 1-5, 1 for poor and 5 for excellent.
6. How satisfied were you with the organization and arrangement of the workshop?	Not satisfied Slightly satisfied Satisfied Very satisfied
7. How would you rate the facilities and equipment provided during the workshop?	Poor Fair Good Excellent
8. How effective were the instructors in delivering the content and assisting with projects?	Not effective Slightly effective Effective Very effective
D. Suggestions for Future Programs	
9. What topics or techniques would you like to see included in future workshops?	
10. How can we improve the structure and delivery of the workshop?	
11. Would you be interested in attending more workshops on advanced manufacturing or related topics in the future?	Yes No
E. Overall Rating	
12. Overall, how would you rate the IDEA Lab workshop?	Poor Fair Good Excellent
13. Any additional comments or suggestions	

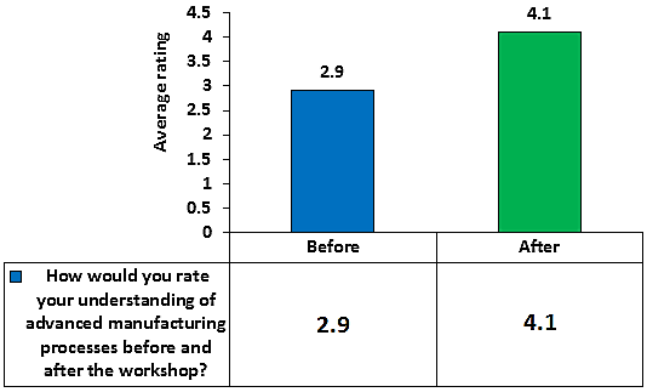

Fig. 3. participants' understanding of advanced manufacturing processes: before vs. after workshop.

III. RESULT AND DISCUSSION

The IDEA Lab training had a significant impact on the skill development of diploma college students in advanced manufacturing, as demonstrated by the notable improvement in their self-assessed understanding of advanced manufacturing processes. This enhancement in their knowledge is reflected in the data presented in Fig. 3, which compares participants' understanding of advanced manufacturing processes before and after the workshop. The Fig. 3 illustrates the extent of improvement in their self-reported comprehension, highlighting the effectiveness of the training in advancing their skills and knowledge in the field.

Before the workshop, the average rating of participants' understanding was 2.9, indicating that most students perceived their knowledge of advanced manufacturing processes as below average or merely adequate. However, after completing the training, this average rating increased to 4.1, demonstrating a substantial improvement in their confidence and competence regarding the subject. This significant shift suggests that the workshop was highly effective in enhancing both practical skills and theoretical knowledge. By providing students with a stronger foundation in advanced manufacturing processes, the training has better equipped them for their future careers in the industry (Shuting, et al., 2023). The notable rise in ratings highlights the workshop's success in addressing existing knowledge gaps and significantly boosting students' overall proficiency in this specialized field. This improvement not only reflects the effectiveness of the training but also indicates that students are now more prepared to tackle the challenges of advanced manufacturing in their future roles.

The IDEA Lab Training had a positive impact on the skill development of diploma college students in advanced manufacturing, particularly in building their confidence to apply the techniques learned. The distribution of confidence levels among the students reveals that a substantial majority felt empowered by the workshop (Fig. 4). While a small group (8 students) felt only slightly confident, the majority (32 students) were confident, and an additional 20 students were very confident in applying the advanced manufacturing techniques they learned. This suggests that the training was effective not only in imparting technical knowledge but also in fostering a strong sense of self-assurance among the students. By enhancing their confidence, the workshop demonstrated its ability to do more than just teach skills—it also prepared students to apply those skills effectively in real-world scenarios. The absence of any students who felt completely unconfident highlights the workshop's success in providing practical training and developing the students' competence. This outcome is crucial because it ensures that the students are well-

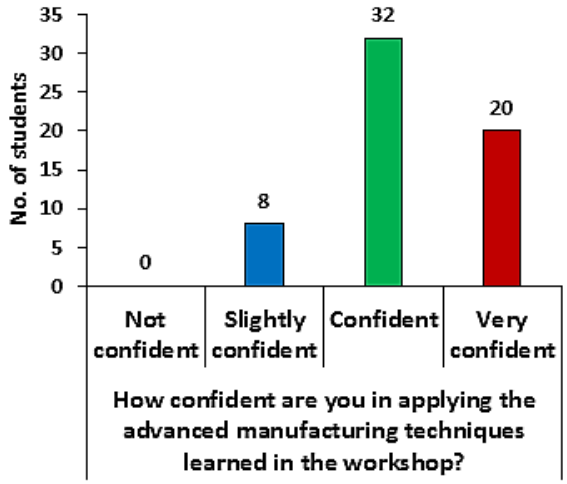

Fig. 4. Participants' confidence in applying advanced manufacturing techniques learned during the workshop.

prepared to tackle the challenges, they will face in their future roles within the manufacturing industry. The workshop's success in building both technical proficiency and self-confidence is essential for equipping students with the tools they need to excel in their careers and adapt to the evolving demands of the field.

The feedback from students regarding the IDEA Lab Training reflects a positive impact on their experience and skill development in advanced manufacturing. The participants' feedback on workshop content is presented in Fig. 5. The overall content of the workshop was well-received, with the majority of students rating it as "Good" (32 students) or "Excellent" (20 students), indicating that the curriculum was effective and met their expectations. Additionally, the relevance of the workshop to their academic and career goals was also affirmed, with 32 students finding it "Relevant" and 24 students finding it "Very relevant." This suggests that the training was closely aligned with the students' educational needs and future aspirations. Moreover, the hands-on training sessions were particularly effective, as most students found them "Engaging" (34 students) or "Very engaging" (19 students). Only one student found the sessions "Not engaging," which highlights the overall success of the practical components of the workshop in maintaining student interest and participation. The combination of well-structured content, relevance to career goals, and engaging hands-on activities underscores the workshop's

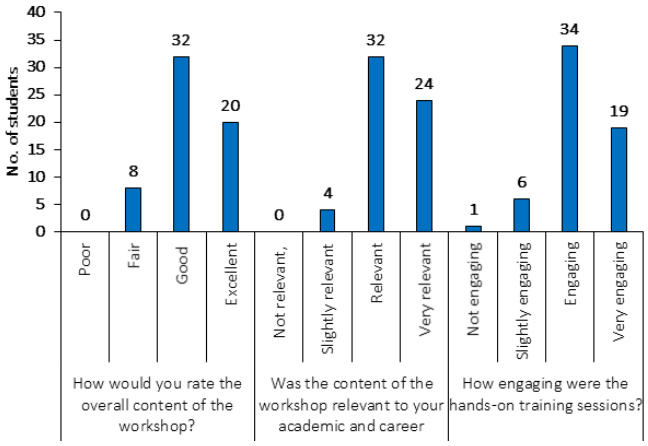

Fig. 5. Participants' feedback on workshop content.

effectiveness in enhancing students' skills and confidence in

advanced manufacturing.

The feedback on the IDEA Lab Training workshop indicates a generally high level of satisfaction among the students (Fig. 6). Regarding the organization and arrangement of the workshop, the majority of students were either "Satisfied" (28

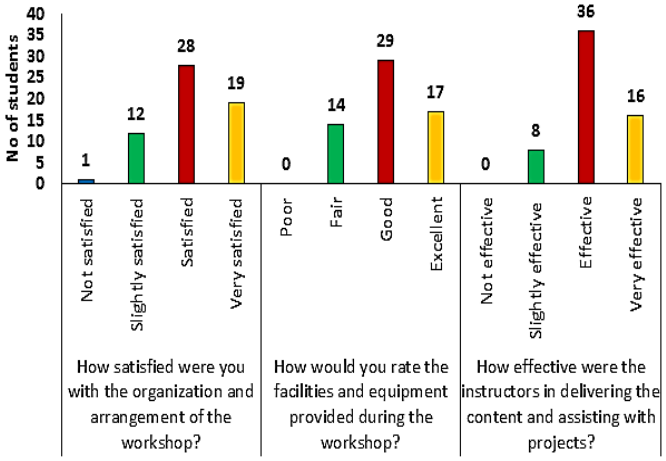

Fig. 6. Participants' feedback on workshop organization.

students) or "Very satisfied" (19 students), demonstrating that the workshop was well-structured and managed. Only one student was "Not satisfied," which suggests that any logistical or organizational issues were minimal and did not significantly impact the overall experience. The facilities and equipment provided during the workshop were also well-regarded, with 29 students rating them as "Good" and 17 as "Excellent." While 14 students rated them as "Fair," the absence of any "Poor" ratings indicates that the resources available were generally adequate and met the needs of most participants. This feedback suggests that the workshop was supported by sufficient infrastructure to facilitate effective learning. Furthermore, the effectiveness of the instructors in delivering the content and assisting with projects was highly rated, with 36 students finding them "Effective" and 16 students considering them "Very effective." Only 8 students rated the instructors as "Slightly effective," which highlights the overall success of the instructional team in engaging students and enhancing their understanding of advanced manufacturing techniques. This positive feedback reflects the instructors' ability to effectively communicate complex concepts and provide valuable support throughout the workshop.

The IDEA Lab Training on advanced manufacturing appears to have had a positive impact on the skill development of diploma college students, as evidenced by their strong interest in attending future workshops. When surveyed about their willingness to participate in additional workshops on advanced manufacturing or related topics, a substantial majority of 52 students responded positively, while only 8 students indicated they were not interested. This high level of enthusiasm suggests that the training was not only beneficial but also ignited a genuine desire for continued learning and engagement in the field. The students' eagerness to explore further opportunities indicates that they found significant value in the current training and are motivated to expand their knowledge and skills. The strong interest in ongoing education underscores the effectiveness of the IDEA Lab Training in creating a learning environment that encourages students to pursue further professional development. Additionally, students were invited to provide feedback on topics or techniques they would like to see in future workshops and to suggest improvements for the structure and delivery of the training. Although specific suggestions were not detailed in the provided image, the inclusion of these questions reflects the workshop organizers' commitment to continuous improvement and responsiveness to student needs. This approach is likely to contribute to the development of even more effective and relevant training sessions in the future. However, there is always room for improvement. Future workshops could benefit from incorporating additional advanced topics and emerging technologies in manufacturing to keep the curriculum current. Expanding the duration or frequency of the workshops might provide more in-depth coverage of each topic and allow for extended hands-on practice. Additionally, gathering more detailed feedback on specific areas of the workshop, such as individual session effectiveness or the adequacy of practical exercises, could provide insights for refining the content and delivery. Addressing these areas could enhance the overall impact of the training and better prepare students for the evolving demands of the manufacturing industry.

Conclusion

The AICTE IDEA Lab training workshop has demonstrated a significant positive impact on the skill development of diploma college students in advanced manufacturing. Over the three-day program, participants exhibited a marked improvement in understanding, with average ratings rising from 2.9 to 4.1, indicating the workshop's success in addressing knowledge gaps and enhancing both theoretical insights and practical competencies. Students expressed heightened confidence in applying newly acquired techniques and showed strong enthusiasm for participating in similar future initiatives. The overwhelmingly positive feedback regarding the workshop’s content, structure, and the instructors’ expertise underscores its relevance and effectiveness. This training has not only equipped students with critical industry-aligned skills but also empowered them to tackle the evolving challenges of advanced manufacturing, making it a highly impactful and transformative learning experience.

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