TRANSFORMING TECHNICAL EDUCATION THROUGH INDUSTRY-INSTITUTE COLLABORATION ECOSYSTEM

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ABSTRACT:

The manufacturing sector in India is a significant contributor to economic development; however, it encounters with challenges such as a persistent skills lacking and a delay in the adoption of technology. This study investigates the transformative potential of an Industry-Institute Collaboration Ecosystem (IICE) in bridging these gaps by utilising the CDIO (Conceive-Design-Implement-Operate) framework at the Ramco Institute of Technology (RIT). In order to comply with the current technological and workforce requirements, the Mechanical Engineering program incorporates industry feedback into curriculum development, with a particular emphasis on CDIO standards 3, 5, 7, 9, and 10. Key initiatives include the establishment of a New Product Development Centre with state-of-the-art facilities, curriculum revisions that emphasise hands-on projects, Additive Manufacturing (AM), and automation, and experiential learning opportunities through internships and industry-led training. The research emphasises the systematic improvement of faculty competencies through seminars, certifications, and industry interactions to guarantee that teaching methodologies and technical expertise remain industry relevant. A cutting-edge framework for teaching, learning, and assessment fosters the comprehensive development of students in the cognitive, affective, and psychomotor domains. Impact analysis illustrates quantifiable advantages, such as enhanced employability, the generation of intellectual property, and compliance with the Sustainable Development Goals (SDGs). The results emphasise the significance of collaborative innovation and continuous learning competencies in equipping graduates to meet the demands of a changing industrial landscape. This work offers a replicable model for the integration of industrial partnerships into technical education, thereby fostering the development of graduates who are socially accountable, technically proficient, and innovation driven.

KEYWORDS

Manufacturing, Industry-Institute Collaboration, Lifelong Learning, Employability, CDIO standards 3,5,7,9 and 10.

INTRODUCTION

India’s manufacturing sector has shown significant potential, becoming an essential element of the nation’s economic growth. However, despite its promise, the sector faces a variety of challenges. One of the major issues is the lag in adopting advanced technologies and the significant skills gap that still exists.

The National Education Policy 2020 (National Education Policy | Government of India, Ministry of Education, N.D.)(NEP 2020) aims to transform India into a vibrant knowledge hub, marking a significant milestone for the country's education system. By bridging the gap between academia and industry, the NEP 2020 seeks to create a dynamic workforce capable of navigating and leading in an increasingly complex technological landscape.

The All India Council for Technical Education (AICTE) (Government of India, 2023) is a national-level body that plays a key role in the development of technical education in India. AICTE proposed emerging areas not only reflect current technological advancements but also emphasize the need for educational institutions to adapt and evolve. By integrating these emerging fields into the curriculum through effective industry collaboration, institutions can better prepare students for the demands of the future workforce and ensure they possess the necessary skills to thrive in a rapidly changing environment (*Government of India, All India Council for Technical Education* , 2019).

Ramco Institute of Technology's Department of Mechanical Engineering has implemented the CDIO framework and standards in the B.E., Mechanical Engineering program since 2023. As a strategic initiative to encourage industry collaboration, the Mechanical Engineering program has implemented the CDIO framework, with a particular emphasis on standards 3, 5, 7, 9, and 10. CDIO standard 3 is the integrated curriculum, which is intended to guarantee that new graduates satisfy industry standards. In the delivery of design-implementation experiences through courses that enrich the student experience in capstone design projects at Levels 1, 2, and 3, intimate engagement with industry has consistently been a crucial component (CDIO standard 5). The integration of learning experiences (CDIO standard 7) and employability enhancement programs, which encompass apprenticeships, in-plant training, professional practices, industry lectures, industry-oriented courses, and skill development courses, further solidifies the connection to the industry. Ultimately, faculty members enhance their competencies (CDIO standards 9 and 10) through close collaboration with the industry. The objective of this paper is to illustrate a collaborative experience that is mutually beneficial for academics and industry. The collaborating industries contributions are i) sharing of resources i.e human and facilities; ii) Research & Development; iii) Competency and Skill development of both students and faculty/technical staff members; iv) Academic Curriculum/Co-curriculum in the domain of design and manufacturing.

The advantages of strong relationships between academics and industry are thoroughly articulated and detailed in the literature. Siddhartha Ghosh et al. (2020) emphasised the necessity of establishing an industry-institute interaction cell to enhance collaboration between industry and academia and its resultant outcomes. Ian Bridgwood et al. (2020) proposed a framework for enhancing knowledge distribution and value generation for both academia and industry, while also advancing the engineering competencies of students. The experiences of Yong Rashidah Mat Tuselim et al. (2020) in the development of an integrated curriculum for civil engineering graduates were presented. Carmen Jaca et al (2021) presented the experiences of collaboration between university and industry through the implementation of the Project-based Learning (PBL) model. Richa Awasthy et al., 2020 proposed a framework to improve the effectiveness of university– industry collaboration (UIC). The case study of collaborative training through the industry-institute alliance is examined by Mahesh P. Joshi et al (2022). In order to identify and implement industry-sourced CDIO initiatives in the curriculum, Soumya et al (2023) implemented a robust approach in consultation and collaboration with industry. Zeina Hojeij (2024) explored the establishment of successful UIC by conducting a review of existing literature to identify and synthesize key factors that enable collaborative innovation between industry and universities. Rosnelli et al (2024) qualitatively explored the contribution of maximizing work-integrated learning through industrial internships.

The literary review establishes industry-institute partnerships as vital to technical education reform through their ability to connect academic information with industry specifications. Studies demonstrate that joining industry with education results in better practical skill development for students who become more employable and innovative through practical education models. Researchers establish the need for curricula to align with industrial trends so graduates obtain the required competencies. Research confirms that when institutions create formal collaboration networks, they enable the exchange of knowledge which supports technology movement and advances research along with development work. Maximum effectiveness of such partnerships can be achieved only after resolving challenges that include lack of funding and inadequate industry participation and gaps in policy implementation. The study utilizes these findings to establish a framework which will explore strategies that maximize industry-institute collaboration for improving technical education results.

An investigative technique for data collection, analysis and interpretation of the role of industry collaboration in technical education was used which joined quantitative with qualitative approaches. In order to enhance the comprehensiveness of this study, the current research employs the better approaches that can be employed. Identifying the enablers was conducted through mapping the skills required in the industry as obtained in the skill gap analysis besides surveying authenticated sources like the World Economic Forum, Accreditation body guidelines and white papers of the industry. This benchmarking was conducted with respect to available global benchmarks, latest international practices in pedagogy, and acquiescence with national accreditation parameters pertaining to the course. The positive effect of these enablers was again confirmed by empirical evidence regarding their effects on learning outcomes. These models were chosen based on benchmarking other studies and case studies that have already been used in different industries. Moreover, the method adopted for assessing their need and impact offered an insight towards both the effectiveness of industrial improvements in the enhancement of technical education and the continuous improvement models as well.

BUILDING INDUSTRY – INSTITUTE COLLABORATION ECO SYSTEM

The Ramco Institute of Technology (RIT), a decade-old institution, fosters a tranquil industry-institute interaction ecosystem under the administration of the third-generation entrepreneur-owned Ramco Group of Companies. Systematic strategies were employed to establish an adaptable industrial collaboration environment that promotes the cultivation of lifelong learning competencies in students. In their first year of study, students at RIT begin their technical education with the "Student Induction Program," and in their final year, they ideally receive a high-quality placement offer in core industries or support and assistance for starting their own business as an entrepreneur. The following chapters present five strategies that RIT has adopted to build a strong industrial collaboration ecosystem, as illustrated in Figure 1. These strategies not only enhance the professional skills of students but also foster valuable connections between academia and industry. By cultivating partnerships with leading companies, RIT ensures that its curriculum remains relevant and that students are well-prepared to meet the demands of the evolving job market.

The Memorandum of Understanding for industry-institute partnership was signed to fulfil the desirable requirement of AICTE at the Ramco Institute of Technology (RIT) in Rajapalayam, Tamil Nadu, India. This connecting was a crucial milestone in cultivating an association ecosystem between academics and industry. Systematic approaches were used to establish this flexible partnership, highlighting the cultivation of lifelong learning skills in students. Critical variables evaluated were linking the curriculum with industry requirements, including practical projects, building advanced facilities like a New Product Development Centre, and developing avenues for faculty skill development. These projects, grounded on the CDIO framework principles, provide reciprocal benefits for students and professors, facilitating the acquisition of practical insights and skills while meeting industry demands. The department level coordinator of the Industry-Institute Interaction Cell (IIIC) will regularly monitor and review the progress of the ecosystem, and the same will be discussed in department advisory committee for continual improvement. For effectiveness, a dedicated faculty is nominated each MoU-signed industry based on their specialization.

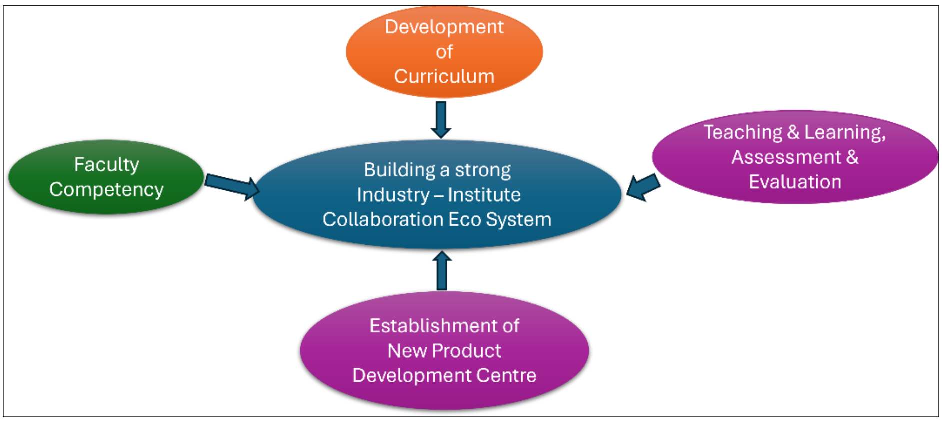
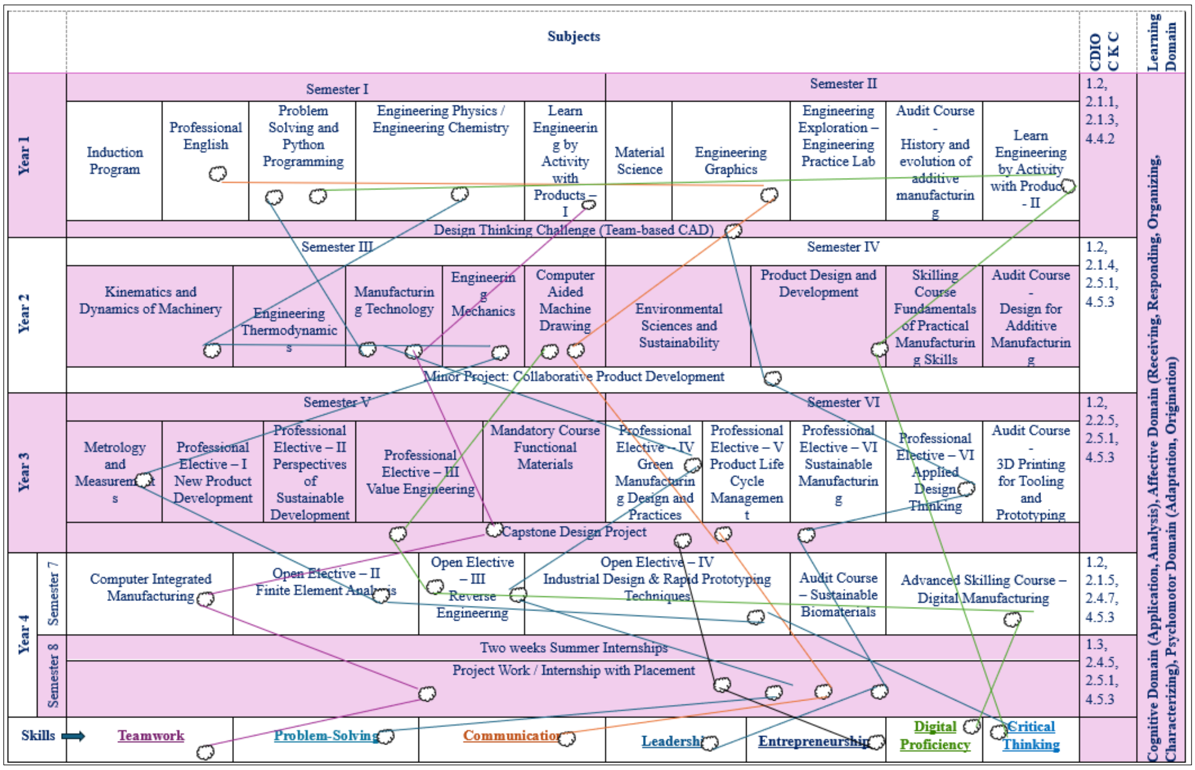


Figure 1. Strategies for building a strong Industry-Institute Collaboration ecosystem at RIT

Designing an Integrated Curriculum for Manufacturing Domain

Based on feedback from industry experts, the Department of Mechanical Engineering's program assessment and quality improvement committee conducted a curriculum gap analysis. The committee's findings indicated several opportunities for enhancement that align with current industry demands. By implementing these changes, the program aims to better prepare students for the evolving challenges in mechanical engineering. The identified curricular gaps include insufficient content in the syllabus/curriculum to address industry needs and expectations in the field of design and manufacturing, as well as a lack of exposure to the latest advancements and technological developments in courses related to design and manufacturing. To address these gaps, the program will integrate more hands-on projects and collaborations with industry partners, ensuring that students gain practical experience alongside theoretical knowledge. Additionally, updated coursework will incorporate emerging technologies such as additive manufacturing and automation, fostering a more comprehensive understanding of modern engineering practices.

The updated curriculum's primary objective is to develop a cohort of graduates who are proficient in the design and manufacturing sector, thereby ensuring that they are socially accountable, professionally skilled, and technically adept in the implementation of innovative manufacturing solutions, in accordance with the design process proposed by Malmqvist, Ostlund, and Edstrom (2006). This includes a benefit in obtaining skills in developing technologies and contemporary practices, including virtual manufacturing through additive manufacturing technologies, fast prototyping, digital production (both subtractive and additive), 3D scanning, 3D printing, and reverse engineering. The curriculum is formulated through a cyclical process that encompasses establishing learning outcomes, aligning them, designing learning activities, and implementing assessment systems in a cohesive manner to address the dynamic requirements of the industrial sector. Figure 2 below displays a sample of the revised curriculum design process. This process ensures that students not only acquire theoretical knowledge but also gain practical skills that are essential for success in the industry. By incorporating feedback from industry stakeholders, the curriculum is continuously refined to keep pace with technological advancements and workforce requirements.



*CKC – Curricular Key Components,

Figure 2. Integrated Skill Development Pathways in Manufacturing Domain

Integrated Skill Development Pathways in the Manufacturing Domain further developed in depth skills under the concept of experiential learning. In the second year, the Design Thinking Challenge (Team based CAD) and Collaborative Product Development through minor projects were conducted. Students also had an internship and project work/internship with placement in their final year (Figure 2). In the 7th and 8th semesters, students utilized theory of various subjects at the 3rd level to solve real world problems, like: Product Design and Development, Advanced Digital Manufacturing and Industrial Design & Rapid Prototyping. In addition to the industry training, students took core disciplinary courses in the 7th semester that include Metrology and Measurements; Value Engineering; and professionalism in Product Life Cycle Management and Sustainable Product Development. Students completed advanced coursework in Project Work, Additive Manufacturing, and Advanced Skilling in Digital Manufacturing in the 8th semester (Figure 2). The combination of these courses, supplemented by hands on learning, improved their teamwork, problem solving, communication, leadership, entrepreneurship, digital proficiency and critical thinking skills.

An analysis of the syllabus demonstrates significant knowledge deficiencies which reduce both industry-institute partnership success and graduate readiness for professional practice. Such learning gaps require attention because they could improve practical training along with interdisciplinary learning and education based on innovation.

- The training system requires better industry engagement through extended apprenticeships along with practical projects that deal with actual business scenarios.
- The educational setting fails to incorporate sufficient emerging technologies including AI and IoT with advanced manufacturing.
- Weak Interdisciplinary & Entrepreneurial Focus: Requires more cross-domain projects and startup incubation support.

Establishing New Product Development Centre

Building strong infrastructure and support for technical education enables students to more easily connect with professional skills. RIT facilitates technical education by establishing an infrastructure that aligns with CDIO standard 6: Engineering Learning Workspaces and other novel product-developing facilities (Figure 3), which are established through industry-institute collaboration. This facility supports an integrated learning environment that meets CDIO Standard 7 objectives. In addition to engineering and product development workspace, other activities like hackathons, incubation space, and partnerships with ecosystem enablers facilitate ecosystem penetration and set students up for lifelong learning. These initiatives not only enhance students' practical skills but also foster innovation and collaboration among peers and industry professionals. By engaging in real-world projects and competitions, students gain invaluable experience that prepares them for the dynamic challenges of the workforce.

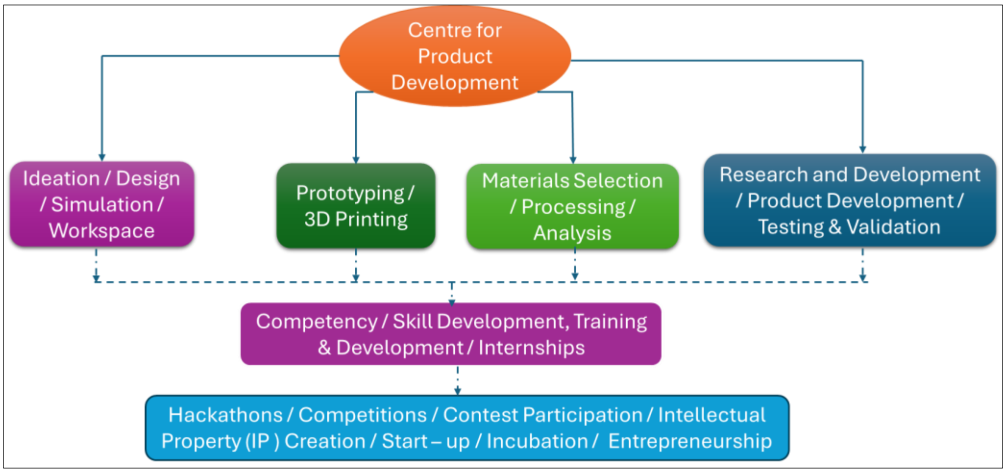


Figure 3. Integrated Workflow of the Centre for Product Development

RIT promotes the creation of cutting-edge infrastructure for the centre, encompassing 3D printing, 3D scanning, and comprehensive product development tools, with a designated area reserved just for the 3D Printing Centre. This centre collaborates with Medsby Healthcare and Engineering Solutions Pvt. Ltd. in Coimbatore, augmenting its capabilities and industry significance. Students receive intensive instruction in additive manufacturing, providing them with the competencies required for creativity and sustainable product development. RIT equips students for lifetime learning and real-world challenges through the integration of advanced technologies, industry partnerships, and experiential learning. The Student Internship and Training Ecosystem at RIT aims to connect academic education with actual industry applications, offering students experiential learning and applicable skills. This comprehensive approach not only cultivates creativity but also challenges students to critically evaluate the ramifications of their innovations across many sectors. Consequently, graduates become comprehensive professionals, prepared to assume leadership positions in the advancing domains of engineering and technology.

Faculty Competencies

The enhancement of faculty competency at RIT is a systematic approach aligned with CDIO standards and curriculum identifiers, facilitating a cohesive strategy for skill development, research engagement, and industry collaboration. Faculty members consistently enhance their topic knowledge and teaching abilities. To enhance their technical competency (CDIO Standard 9) in manufacturing and pedagogical abilities (CDIO Standard 10), faculty members are participating in online courses in developing disciplines and certification programs from accredited universities. They are engaging in workshops and receiving training in advanced tools and approaches. This talent fosters an employability and entrepreneurial mindset, advocating for lifelong learning. Figure 4 depicts the ways for enhancing competency. These programs furnish educators with up-to-date industry information while fostering a collaborative learning environment that encourages student invention. By incorporating practical applications into their syllabi, faculty members are more effectively equipped to motivate the next generation of experts in the manufacturing industry.

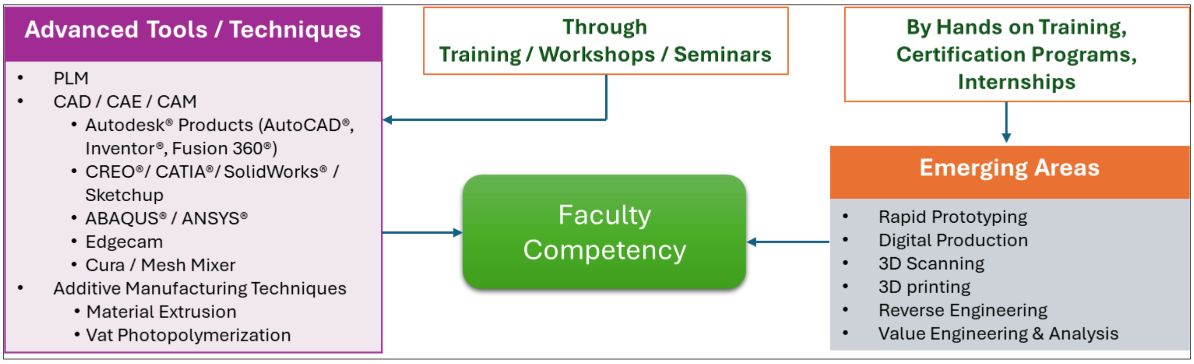


Figure 4. Building Faculty Competency for Advanced Tools and Emerging Technologies

Teaching & Learning / Assessment & Evaluation

This image illustrates (Figure 5) the interconnected framework of teaching, learning, and assessment through the Cognitive, Affective, and Psychomotor domains. It emphasizes knowledge, skills, and attitudes while categorizing engineering-specific knowledge into factual, conceptual, procedural, and metacognitive types. Formative assessments like quizzes and assignments complement summative evaluations such as exams and project reviews. Together, these elements ensure holistic development and effective evaluation of student outcomes.

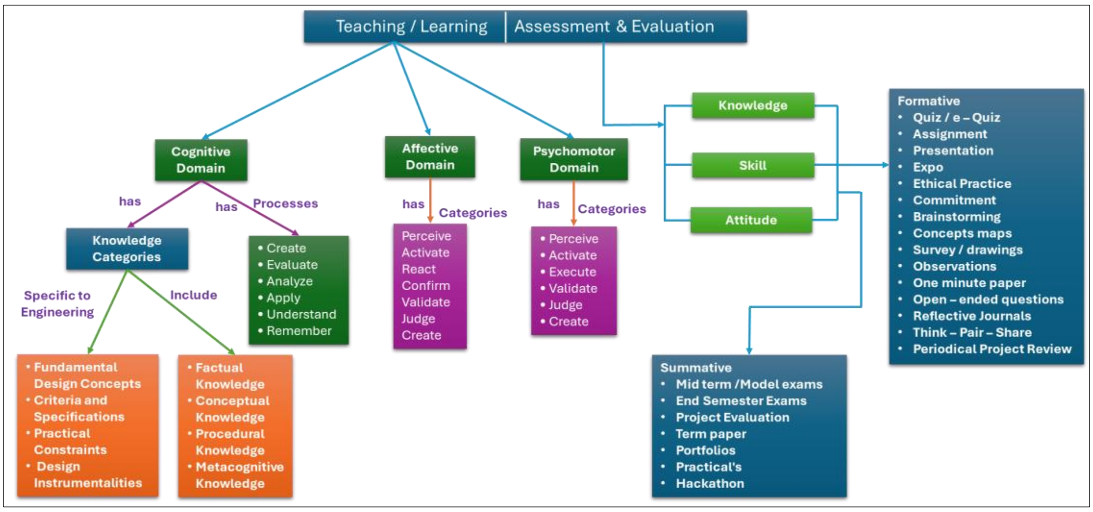


Figure 5. Teaching, Learning, and Assessment Framework in Engineering Education

The teaching-learning process for mechanical engineering integrates MATLAB® scripting and Simulink tools (Figure 6) to enhance students' understanding of key domains: design, thermal, and manufacturing. In the Design Domain, students engage in CAD Modelling, 3D printing simulations, and design optimization challenges to build their problem-solving skills. The Thermal Domain emphasizes understanding material-specific thermal behaviour, energy efficiency, and thermal gradients in AM processes, enabling students to apply these principles in practical scenarios, such as selective laser melting. In the manufacturing domain, students learn advanced techniques, post-processing methods, and sustainability practices, with a focus on quality control and hybrid part development. Case studies, such as analysing robotic arm dynamics and optimizing thermal gradients in turbine blades, provide hands-on learning opportunities. This approach fosters cognitive and psychomotor skills, enabling students to connect theoretical knowledge with real-world applications in AM.

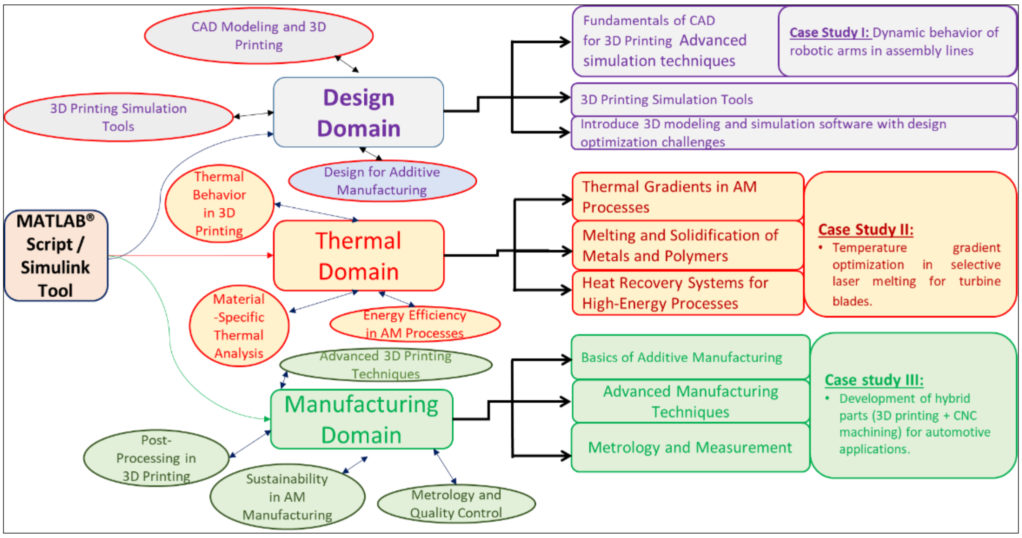


Figure 6. Integrating tool with Teaching & Learning: Mechanical Engineering Domains

The analysis of the shoulder link of a Kinova® Gen3 Ultra lightweight robotic arm connects theory and practice in additive manufacturing. Students learn how the robotic arm works and use MATLAB® FEM Tools to study how the shoulder link deforms under pressure. This helps them develop problem-solving skills by calculating deformations and analyzing how the arm responds to forces. They also practice using input parameters to optimize the arm's performance. This activity links directly to additive manufacturing by showing how material choice, design, and production methods affect the strength and performance of parts. Overall, it helps students understand the full process of designing and making better components for robotic systems.

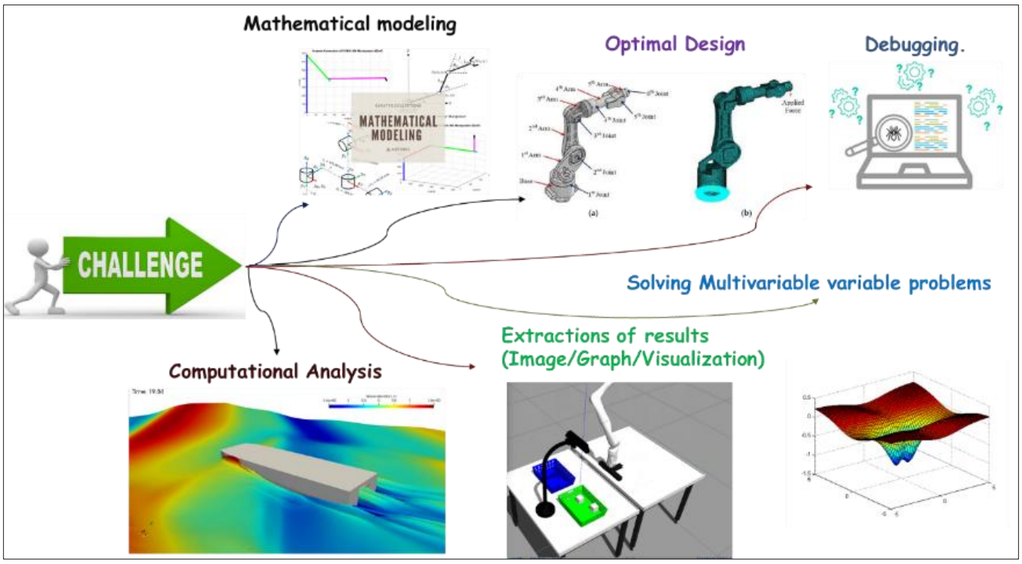


Figure 7. Engineering Challenge to Solution Workflow

The image illustrates (Figure 7) a systematic approach to solving engineering challenges, starting with mathematical modelling to understand system dynamics. It progresses to solving multivariable problems, optimising designs, and debugging for error resolution. Computational analysis is then performed to simulate real-world scenarios, and results are visualised through images, graphs, and 3D representations. This process emphasises critical thinking, problem-solving, and practical application, integrating theoretical and computational tools to address complex engineering problems effectively.

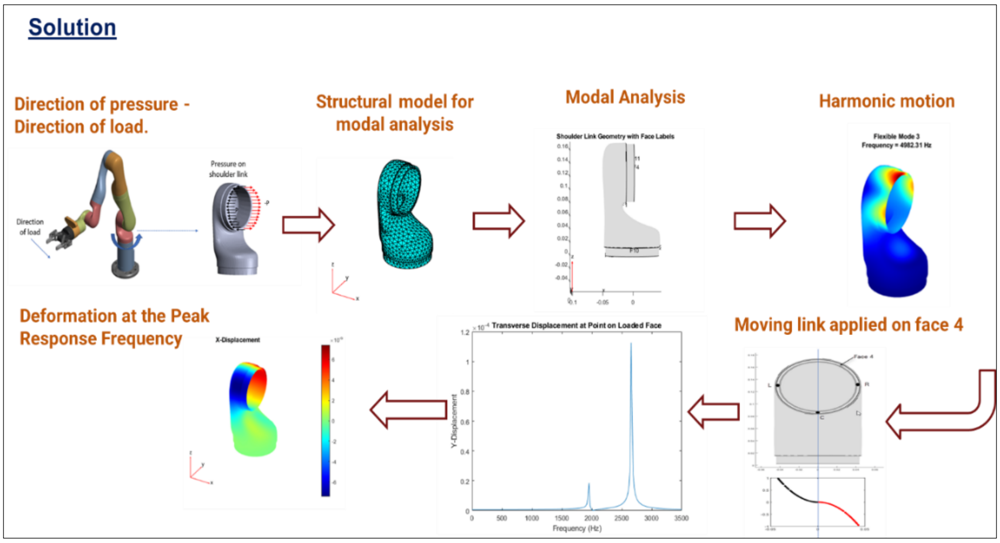


Figure 8. Engineering Problem Analysis and Solution sequence

The image outlines (Figure 8) a systematic approach to analyzing the deformation of a robotic arm's shoulder link under load. It starts with understanding the direction of pressure relative to the load and creating a structural model for modal analysis. The modal analysis finds the natural frequencies and modes of deformation. Then, the harmonic motion analysis checks how the structure reacts to dynamic loading. The results reveal deformation patterns and displacements at peak response frequencies, providing critical insights into the link's structural behaviour under operational conditions. This process helps optimize designs for better performance and durability.

Measurement of Learning Outcome

The actual situation of the Industrial collaboration ecosystem's penetration through integrated curriculum can be judged by measuring the learning outcomes. The learning outcomes in terms of knowledge, skill, and attitude are measured through organised formative and summative examinations. These evaluations are measured with appropriate assessment instruments, such as rubrics that are tailored to the specific assessment techniques. The projects are assessed through review mechanism by evaluating the parameters (Table 1) given below:

Table 1. Measurement of Project Learning Outcomes : Meta-Skills

Online Quizzes	**Meta-Skill:** Focusing, **Sub Meta-Skill:** Sorting: Ability to categorize and relate information. Attention: Focus on key factors in design and manufacturing. **Outcome:** Develop the ability to analyze 3D printing parameters and material selection. Identify critical components in 3D printing process chains.
	Meta-Skill: Adapting, **Sub Meta-Skill**: Openness: Growth mindset for adopting new methods. **Outcome**: Apply innovative solutions and adopt advanced printing techniques in projects.
Project Work Diary	**Meta-Skill**: Collaborating, **Sub Meta-Skill**: Teamwork: Work towards shared 3D printing project goals. **Outcome**: Foster group synergy in design, prototyping, and final product testing.
Project Presentation	**Meta-Skill**: Communicating, **Sub Meta-Skill**: Listening: Actively understand project details during discussions. Storytelling: Explain 3D printing concepts effectively with examples.. **Outcome**: Interpret industry requirements and translate them into feasible 3D printing solutions. Communicate design and functional details of prototypes to stakeholders.
	Meta-Skill: Creativity, **Sub Meta-Skill**: Visualizing: Translate ideas into 3D printable models. **Outcome**: Generate innovative designs and process workflows for 3D printing applications.
Project Review (I, II & III)	**Meta-Skill**: Curiosity, **Sub Meta-Skill**: Questioning: Ask key questions to enhance project understanding. **Outcome**: Assess feasibility and functionality of designs in various applications like medical, aerospace, etc.
	Meta-Skill: Critical Thinking, **Sub Meta-Skill**: Logical Thinking: Analyze and solve technical problems.**Outcome**: Resolve challenges in material selection and printing efficiency for prototypes.
Viva Voce	**Meta-Skill**: Initiative, **Sub Meta-Skill**: Self-Motivation: Act independently in resolving project challenges. Decision Making: Make informed choices in design and manufacturing. **Outcome**: Drive the progress of 3D printing projects by self-initiating testing and optimization processes. Select appropriate materials, methods, and post-processing techniques for 3D printing applications.

This structured assessment ensures students develop technical, managerial, and ethical competencies essential for real-world applications in additive manufacturing**.**

Experiential Learning and the Problem-Based Learning approach were used to support doing different phenomena in teaching. The program targeted the mutual development of curriculum content teaching tools and training for instructors. The level of integration depended on several elements like updating the curriculum with related Program Outcomes (PO) and Program-Specific Outcomes (PSO), aligning active learning methods to Teaching-Learning Methods (TLM) and setting up faculty training to support those changes. Examinations used student performance results industry comments and faculty development progress to test these interactions.

Effective results required the establishment of Key Performance Indicators to guide efforts towards best performance outcomes. The study examined the performance of these programs in both practical results and hidden weaknesses. Students gained better job prospects and sharpened their talents as well as deeper industry collaboration which proved that improved teaching techniques bring positive changes. The transformation process experienced opposition by teaching staff along with insufficient funding tools and problems expanding the update across the entire system. The successful use of experiential learning methods in higher education depends on overcoming the specified limitations.

IMPACT ANALYSIS OF INDUSTRIAL ECOSYSTEM

The impact of Industrial Collaboration ecosystem at RIT is measured in quantitative and qualitative aspects. Some notable impacts (Figure 9) include being recognized as one of the accredited programs by the National Board of Accreditation, New Delhi; consistently generating intellectual property rights in the form of patents, copyrights, and industrial designs; developing prototypes and products through student projects; regularly interacting with industrial experts to address curricular gaps through content beyond the syllabus; designing and developing courses; and offering them in the form of skill development, emerging areas, or audit courses. These initiatives not only enhance the learning experience for students but also contribute significantly to the institution's reputation as a leader in technical education. Furthermore, the collaboration with industry partners ensures that the curriculum remains relevant and aligned with current market needs, preparing graduates for successful careers.

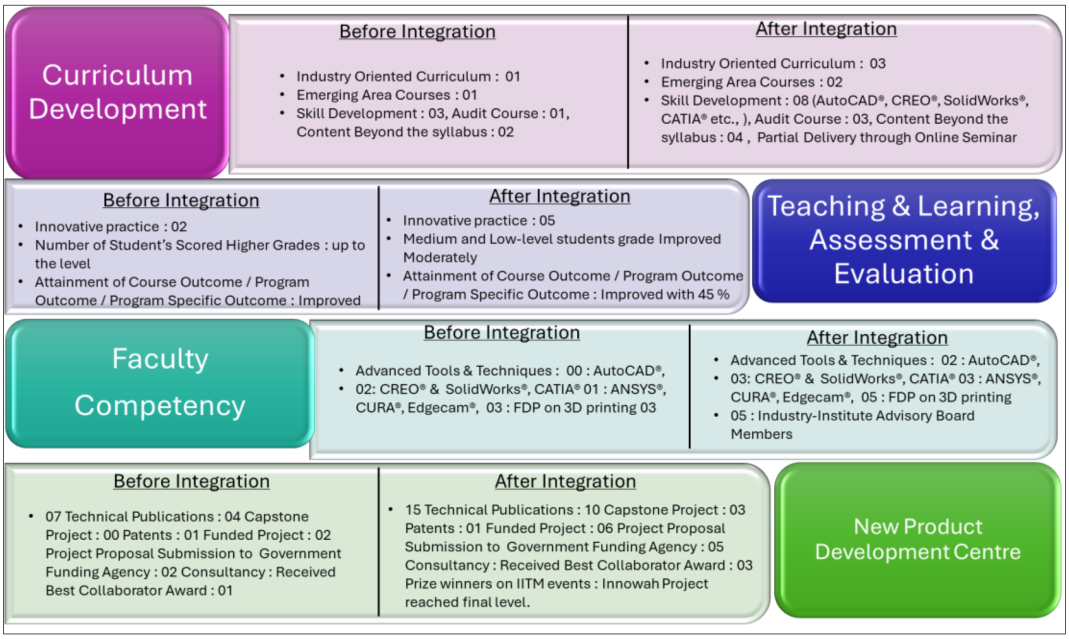


Figure 9. Impact Analysis of Industrial Ecosystem

This ecosystem in the department encourages the implementation of the Sustainable Development Goals (SDGs) and addresses societal real-time problems through industrial collaboration. Collaborated to produce joint research publications, submitted collaborative research proposals for funding, offered internships and practical training with placements, and enhanced faculty competence to fulfil the requirements and expectations of learners and other stakeholders. The department's facilities were consistently enhanced to align with industry standards. This ecosystem fortified connections with industrial partners, guaranteeing that graduates were adequately equipped to make significant contributions to society. The research presented here leads to technical education transformation because it builds strong industry-institute collaboration networks. The initiative successfully connects educational institutions to industrial stakeholders thus it improves student practical training together with academic curriculum alignment and develops technological learning experiences. Through collaborative partnerships students achieve better employment opportunities by getting practical training and relevant industry knowledge and this model speeds up research activities and tech developments. The initiative develops an entrepreneurial mindset alongside problem-solving abilities which strengthens both local and worldwide technological development of the workforce.

Some of the limitations are still experienced when it comes to the Institution-Industry Collaboration (IIC) for curriculum accreditation; this is due to the fact that the courses need to be proved relevant to the industries. There is a research gap since there is insignificant research done to establish the correlation between curriculum development, faculty training, the use of practical and valid experiences and employment placement. The prior research mainly examines theoretical collaboration models with the little emphasis placed on lived experiences. This research seeks to fill this gap by developing, trialling, and evaluating a functional IIC system where the usability of this construct in improving employability outcomes will be investigated. The findings will help to advance the best practices in matching up the curriculum to industry practices and in technology integration, benchmarking, and promoting collaborative models.

In order to evaluate the educational framework, both the quantitative and qualitative analytical tools were carried out. This was done in a quantitative manner through an assessment of changes in students learning outcomes, skills developed as well as their overall performance. At the same time, the qualitative aspect aimed at gathering the perception of students and the experience of faculty members and industry professionals to get a better view of change implementation. Data collecting was done using pre- and post-implementation information, questionnaires to key personnel, feedback mechanisms, and performance reports. To evaluate learning effectiveness of the program, quantitative and qualitative research designs were adopted, which involved the analysis of test scores and results as well as Participant Observation research design involving the assessment of actual sessions of collaboration between the industry and students. The considerations also focused on sustaining the improvement approach to implement innovative teaching processes appropriate to the future educational system.

CONCLUSION

Technical education must experience transformation through established industry-institute cooperation systems to connect theoretical knowledge with industrial job needs. Such collaborations play an important role to develop skills while improving employment prospects together with advancing innovation efforts. A collaborative approach provides students with practical experience of actual industry problems which turns them into capable professional workers for corporate roles.

The proposed model contains structured frameworks that work together with active industry involvement and updated curricula to improve the collaboration between academia and industry. Scientifically advanced teaching environments with research methods coupled to practical learning will help technical educational organizations stay relevant to workplace changes.

The success of this ecosystem requires students to stay connected and administrators to perform regular evaluations so they can develop flexible strategies which support new technologies and industry developments. Future academic studies need to devote their efforts to establishing better collaboration models together with investigations of extended time effects and development for various engineering fields. This eco-system of industry-institute partnership creates a sustainable education system based on innovation which delivers advantage to students alongside educators and industrial representatives.

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REFERENCES

Government of India. (2023, September 1). About National Education Policy | Government of India, Ministry of Education. Www.education.gov.in. https://www.education.gov.in/nep/about-nep.

Ankrah, S. N., & Al-Tabbaa, O. (2015). Universities-Industry Collaboration: A Systematic Review. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2596018

Awasthy, R., Flint, S., Sankarnarayana, R., & Jones, R. L. (2020). A framework to improve university–industry collaboration. Journal of Industry-University Collaboration, 2(1), 49–62. https://doi.org/10.1108/jiuc-09-2019-0016

Ian Bridgwood, John Aasted Sørensen (2020). Strengthening CDIO In B.Eng. Final Projects with An Industry Roadmap, Volume 2, pp.111-117, Proceedings of the 16th International CDIO Conference, hosted on-line by Chalmers University of Technology, Gothenburg, Sweden, 8-10 June 2020

Ghosh, S., Padmaja, A., & Praveen Kumar, Y. (2020). Strengthening Industry Institute Collaboration and Its Outcome. *Journal of Engineering Education Transformations*, *33*(0), 595. https://doi.org/10.16920/jeet/2020/v33i0/150126

Malmqvist, J., Östlund, S., Edström, K. (2006). Using integrated program descriptions to support a CDIO, programme design process. World Transactions on Engineering and Technology Education, 5(2), 259-262.

Zeina Hojeij. (2024). An overview of university-industry collaboration in the Arab world. *Journal of Innovation and Entrepreneurship*, *13*(1). https://doi.org/10.1186/s13731-024-00400-9

Government of India, All India Council for Technical Education |. (2019). Aicte-India.org. https://www.aicte-india.org/

Carmen Jaca, Marta Ormazabal, Mikel Arizmendi, Carmen Blanco (2021), Project-Based Learning Implementation. Collaboration Between University and Industry, Proceedings of the 17th International CDIO Conference, hosted on-line, Chulalongkorn University & Rajamangala University of Technology Thanyaburi, Bangkok, Thailand, June 21-23 2021

Khanna, A., Agarwal, A., & Maheshwari, P. (2018). University-industry collaboration: A new way of educating future generations of engineers in India. *2018 Advances in Science and Engineering Technology International Conferences (ASET)*. https://doi.org/10.1109/icaset.2018.8376929

Soumya K Manna, Nicola Joyce, Anne Nortcliffe. (2023). Integration Of Graduate Employability Skills Through Industry Outsourced CDIO Project, ISBN 9788230361863

ISSN 2002-1593, The 19th CDIO International Conference: Proceedings, pp. 425-435.

Model Syllabus | Government of India, All India Council for Technical Education. (n.d.). Retrieved January 11, 2025, from https://www.aicte-india.org/education/model-syllabus

Rashidah Mat Tuselim, Y., Muhammad, S., & Chau Mai Politeknik Ungku Omar, R. (2020). Integrated Curriculum Approach in Developing 21st Century Industry-Ready Graduates, Volume 2, pp.239-249, Proceedings of the 16th International CDIO Conference, hosted on-line by Chalmers University of Technology, Gothenburg, Sweden, 8-10 June 2020 239

Rosnelli, Ariyanto, M., & Purba, S. (2024). The Role of Industrial Internship Activities to Improve Digital Competency of Engineering Students: Perception of Engineering Managers in Industry. *International Journal of Learning, Teaching and Educational Research*, *23*(9), 498–517. https://doi.org/10.26803/ijlter.23.9.25

Säisä, M., Tiura, K., & Roslöf, J. (2018). Waterfall Vs. Agile Project Management Methods In University-Industry Collaboration Projects, Proceedings of the 14th International CDIO Conference, Kanazawa Institute of Technology, Kanazawa, Japan, June 28 - July 2, 2018.

Tiewtoy, S., Krusong, W., & Kuptasthien, N. (2019). The Collaboration Between Academia and Industry for Enhancing Employability and Faculty Development, Proceedings of the 15th International CDIO Conference, Aarhus University, Aarhus, Denmark, June 25-27, 2019.

BIOGRAPHICAL INFORMATION

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