Beyond Books: Transforming Academic Libraries into Innovation Hubs through Equipment Lending

[1]Avinash More, [2]Koteswararao Anne
[1,2]Mukesh Patel School of Technology Management and Engineering, NMIMS Deemed-to-be-University, Mumbai, 400056, India,
[1]Avinash.More@nmims.edu, [2]Koteswararao.Anne@nmims.edu

***Abstract*— Academic libraries are evolving from traditional repositories of information to dynamic spaces that promote innovation, cooperative work, and hands-on learning. This paper presents a case study of transforming an institute library into an Innovation Hub by creating a Common Component Studio (CCS) — an equipment-lending facility or hardware components library integrated with the institute's library Online Public Access Catalogue (OPAC). The CCS offers over 1200+ prototyping components and tools for home lending, enabling students to engage in Project-Based Learning (PjBL) and Problem-Based Learning (PBL) without the delays and costs associated with sourcing hardware. The study outlines the proposed CCS framework for PjBL and PBL, which impacts Iteration Frequency (IF), Project Completion Rate (PCR), Innovation Quality Score (IQS), and Interdisciplinary Participation (IP) for hands-on learning and rapid prototyping in project-based learning. The results demonstrate that library-led equipment lending can significantly enhance the learning experience and position the CCS as a central hub for lending hardware components in institutional innovation ecosystems.**

***Keywords*—Academic Library Innovation Hub; Common Component Studio (CCS); Equipment Lending; Interdisciplinary Collaboration; Project-Based Learning (PjBL); Problem Based Learning (PBL); Prototype Development.**

***ICTIEE Track*—Innovative pedagogies and Active Learning**

***ICTIEE Sub-Track*—Project-Based and Problem-Based Learning**

I. INTRODUCTION

The role of academic libraries is now extending beyond the traditional practice of book lending to facilitating access to technology, collaborative space, and support for active learning approaches. In the case of engineering education, the increased emphasis on experiential learning, rapid prototyping, and problem-solving across disciplines has created new opportunities for libraries to be an integral part of the innovation and skill-acquisition process. This paper describes how a university library was transformed into an Innovation Hub through the creation of a Common Component Studio (CCS), a library of components and devices at institute. By integrating the CCS with the library's Web OPAC and through the provision of home lending of equipment, the studio provides students unprecedented access to the hardware components or devices required for PjBL and PBL in engineering education.

PjBL and PBL presented by (Evelina et. al., 2025) and (Aryan et. Al., 2024) respectively, along with the review on challenges and evidence-based active learning presented by (Doulougeri, et. al., 2024) and (Sukackė, et. al., 2022) focus on development of real, practical products through student-initiated projects that integrate theoretical concepts with hands-on applications. With the fast growth in IoT, AI, robotics and cloud computing having gained momentum, PjBL allows students to develop industry-specific and industry-ready prototypes.

The inclusion of a CCS in an academic library provides students with direct access to essential hardware components, such as sensors, prototyping boards (e.g., Arduino, Raspberry Pi), motors, power banks, and a set of electronic tools, thereby eliminating equipment availability and cost constraints. For example, students can borrow environmental sensors, microcontrollers, and wireless modules from CCS to design artificial intelligence-based environmental monitoring systems that gather and process sensor data in real-time, or industrial actuators and controllers to design autonomous drones for disaster management. Inclusion of CCS with PjBL and PBL pedagogies leads to radical improvement of end-to-end learning—covering the process of identifying a problem, requirement analysis, system design, implementation, testing, and presentation—thus facilitating technical skills as well as critical recent trends in industry requirement, such as collaboration, project management, and innovation, also highlighted by (Rommel et. al., 2025). Additionally, (Sean et al., 2025) have presented PjBL and PBL in hybrid (online and offline) settings.

The following research questions and objectives have been built to facilitate the building of core skill sets among the students through the implementation of PjBL and PBL approaches, leveraging the hardware facilities made available in CCS.

A. Research Objectives

1. *Determine the potential of academic libraries to function as innovation hubs through equipment lending.*

This objective focuses on understanding how academic libraries can extend their traditional role of providing access to books and journals to innovative hardware solutions, rapid prototyping, and develop critical problem-solving skills in an actual testbed. The CCS support for component lending, which includes low-power microcontroller boards (such as Arduino, ESP32, and Raspberry Pi), sensors, and motors, enables students to apply theoretical knowledge in practice by using hardware components for a prototype testbed tailored to project requirements.

2. *Compute the impact of equipment lending on the following performance parameters such as Iteration Frequency (IF), Project Completion Rates (PCR), Innovation Quality Score (IQS), and Interdisciplinary Participation (IP).*

The CCS links curriculum objectives with practical PjBL and PBL. This study computes the equipment accessibility or lending from CCS leads to students' multidisciplinary, active engagement in PjBL and PBL. The study will analyse data about component checkout rates, resources, and the variety of projects completed (i.e. PCR) within the time limit. The evaluation will investigate how CCS establishes an environment for independent learning with innovative quality of projects (IQS) that motivates students to implement projects (with sufficient IF) without delay.

B. Research Questions

1. *How can academic libraries support hands-on engineering education through equipment or component lending?*

This question examines the strategies required for libraries to transition from primarily information repositories to active enablers of practical, skill-based learning. It will investigate how integrating a CCS with the library's OPAC and lending policies can provide students with on-demand access to prototyping using various electronic components, thereby embedding hands-on experimentation into the academic learning process.

2. *What is the impact of library-integrated CCS resources on project outcomes in student-led projects and problem-based learning?*

This question suggests that CCS enhances the likelihood of projects reaching completion, increases the technical sophistication of solutions, and improves innovation outcomes (e.g., novelty, usability, problem relevance). The goal is to link CCS access directly to observable improvements in project deliverables.

The CCS is used for PjBL and PBL by the component lending system, which allows more than 1,200+ electronic components for prototyping. Before the implementation of CCS, PjBL and PBL activities faced restrictions due to component unavailability, which limited opportunities for iterative prototyping and resulted in reduced prototype development and extended project completion times. After Post lending, students accessed the components through the WEB OPAC, which enabled rapid prototyping alongside immediate experimentation and enhanced cross-disciplinary teamwork.

The paper organize is as follows: Section II discusses the existing strategies used in PjBL and PBL in modern engineering education. Section III outlines the proposed CCS-based equipment lending framework. Section IV presents result analysis from the pre- and post-lending study of components, followed by Section V, which discusses the conclusions and future work.

II. Literature Review

We have presented the literature review by examining key studies on PjBL and PBL emphasizing their roles in enhancing prototyping, project and problem handling, collaboration, and practical skills set development. We have also identified pedagogical frameworks and its implementation strategies in this study.

The North Carolina State University (NCSU) Libraries proposed that the Maker space partner with SparkFun Electronics, Inc., to integrate Maker technologies (Rogers et. al., 2015). This initiative supports student learning through workshops and develops best practices with the help of lending components (Arduino, Raspberry Pi, 3D printing, and laser cutting) provided by academic departments, students (undergraduate and postgraduate), faculty, and staff. However, our CCS comprises more than 1,200 hardware components and is integrated with the library's OPAC, providing easy access to students, faculty, and staff. The authors (Tait et al., 2016) have presented the transformation of academic library services using IT utilities which helps reduce physical book stock and increase collaborative learning in the academic library sector.

The authors (Sheafter et al., 2023) proposed loan program at Clemson University Libraries to borrow the technology equipment, such as AR/VR headsets, projectors, cameras, video camcorders, and audio equipment, which patrons use both before and after borrowing for digital literacy purposes. In CCS, this high-end equipment will be procured according to the requirements and made available upon request for faculty, students and staff. The authors (Akers et. al., 2024) used an internal grant to create a new collection of specialised equipment, including C-Pen readers and sensory items, in the academic library to bridge the gaps between component accessibility and curriculum requirements. This article also discussed the steps taken for best practices for cataloguing, storage, and promotion of the new equipment collection. However, CCS has larger number of sensors, memory cards, and other similar equipment for PjBL and PBL.

The PBL was proposed by (Jayashree et. al., 2025), and a study was conducted for the undergraduate Fuzzy Logic course to enhance student-centered skills. This PBL activity helps to improve cognitive and analytical skills by analyzing and understanding core concepts. This structured PBL activity enhances active learning and provide relevance to real-world applications.

The PjBL, as presented by (Muhammad et al., 2025), significantly enhances problem-solving skills, improves critical thinking, teamwork, and industry readiness, as demonstrated by pre- and post-tests in a physics course (first year) of engineering students. The study presented by (Liutauras et al., 2024) compare PBL and Traditional Learning (TL), with results showing that PBL improves critical thinking, teamwork, and presentation. However, in the case of TL, it supports individual learning and in-depth theoretical understanding, especially for closed-ended assessments.

The work proposed by (Yunjeong et. al., 2024), based on a real-world context, shows significant improvement in students' behavioural, cognitive, and emotional engagement. Further, students could enhance their understanding of technology engagement and service learning outcomes. The study compares (Sean et. al., 2025) engineering students' perceptions of a PBL module using mixed methods (face-to-face and online mode). Here, teamwork satisfaction and collaboration remained consistent in mixed mode in each setting, emphasising the importance of delivery modality in PBL design.

The authors (Al et al., 2024) proposed the Project-Oriented PBL technique to enhance productivity at high proficiency and found that skill improvement is aligned with an integrated STEM program. Findings also highlighted that Project-Oriented PBL is more effective in problem-solving, collaboration, and communication with real-world projects within and outside the group. The study presented by (Rahmita et. al., 2024) based on PjBL, PBL, and self-confidence outcomes for sport education. The result showed PjBL and PBL individually improved engagement and understanding, while their combination with self-confidence had no significant added impact. The findings support adopting innovative models to enhance learning in sports education.

Kolmos et al. (2024) introduce an interdisciplinary PjBL and PBL framework where the students engage in configurations ranging from individual teams to networks of teams, and from disciplinary to broadly interdisciplinary groupings. The authors outline six types of projects that form a conceptual framework for interdisciplinary learning within engineering education, from small single-team projects to large multi-team projects for dealing with the most complex challenges.

The meta-analysis presented by (Lisette et. al., 2024) found that problem-driven learning methods like PBL, PjBL and Challenge-Based Learning (CBL) (Kerstin et.al., 2024) have a positive effect on beliefs, values, and attitudes of student motivation. However, the effects were more potent in single courses, healthcare and STEM fields, with no significant differences between the three methods. The following section explains the CCS framework along with its implementation for PjBL and PBL which enhances hardware prototyping skills together with critical thinking, innovativeness as well as communication abilities and other cognitive competencies required during higher engineering education.

III. CCS FRAMEWORK - INTEGRATION WITH ACADEMIC LIBRARY

The Common Component Studio (CCS) – Device library has been deployed in order to facilitate hands-on prototype creation. CCS enables the prototyping of mini projects, senior design projects, capstone projects, Vertical Integrated Program (VIP) projects, and Engineering Projects in Community Services (EPICS) projects within the institute. CCS facilitates learning across disciplines by providing access to over 1,200 hardware components. CCS is connected to the institutional library through a digital web OPAC. The CCS framework facilitates easy component availability search, booking, and tracking. Hence, it simplifies the process from idea generation to prototype creation.

The CCS initiative is organised with three fundamental pillars: component accessibility, learning integration, and innovation facilitation. The component accessibility enables students to effectively identify the necessary hardware components required for mini projects, capstone/senior design projects, and other extracurricular activities in CCS. The learning integration enables CCS resources to be integrated within the academic curriculum, allowing faculty and students to design project and problem-based activities to improve their rapid prototyping. The final Innovation facilitation involves students from different programs working together on a project and performing collaborative work. This facility also supports datasheets and recommended configurations of components if not available in CCS, which allows students to expedite their experimental processes.

A robust lending and monitoring mechanism complements CCS to ensure accountability for resources while promoting responsible use. Fig. 1 shows the user and admin interface implemented and integrated with the institute library software via web OPAC for component lending. The lending policies (guidelines) enable the students, faculty members and research scholars to retain hardware components for their project work and then return them for reuse. The backend admin login system monitors the lending history, which can be used to analyze the component usages and determine the relationship between component availability and the requirement of specific component (s) in high demand. For example, Arduino Boards, Raspberry Pi (IV/V) are always in demand from students for their project work or project-based learning assignments. In user interface mode, students use the web OPAC login to identify or select the required components. If the component(s) is/are available, the user can hold the component(s) and complete the hold request. Once the hold request is received, the admin interface verifies the hold request and scans the barcode of the selected component to issue it to the user. It automatically records all components' details during scanning at the backend interface.

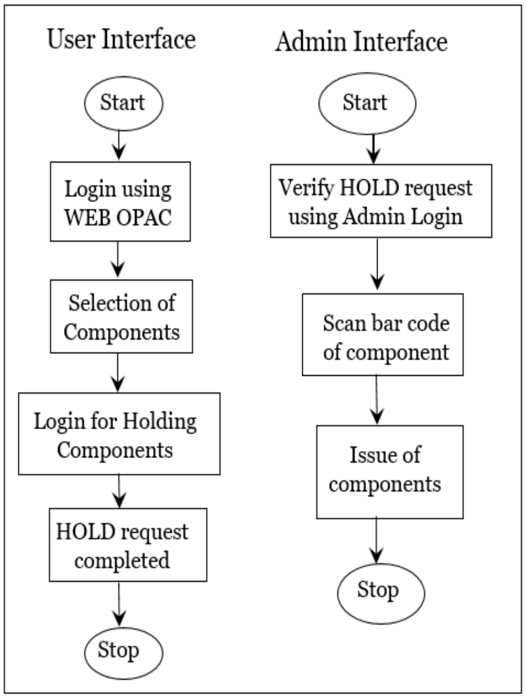

Fig. 1. CCS – User and Admin Interface through WEB-OPAC

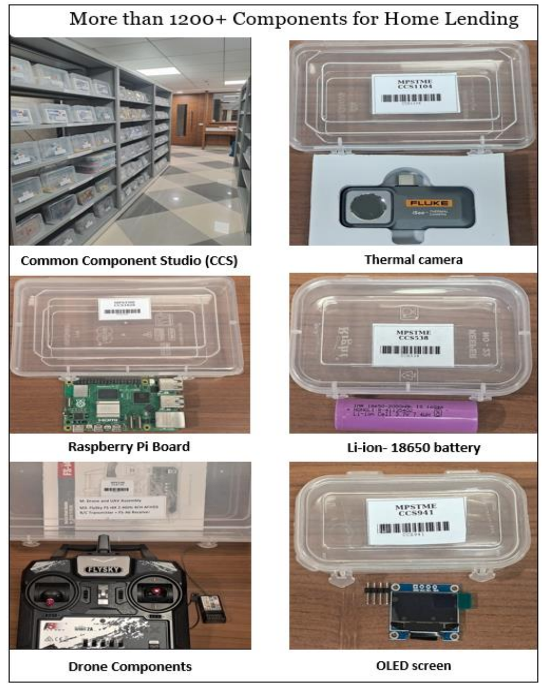

Fig. 2. Sample hardware components in CCS - Barcode-Integrated Lending System

Based on the accessibility of hardware components with integrated web OPAC for data-driven management, the CCS transforms traditional academic support facilities, such as engineering labs, into active innovation hubs. Due to this, students will enhance their practical skill sets and learning collaboration in a multidisciplinary manner by sharing resources, information, and technical skills. It also raises the technical quality of student projects, improves the quality of innovation, and prepares students more effectively for entrepreneurship or industry work.

Fig. 2 shows the sample hardware components with barcodes kept in CCS for lending. CCS offers a range of boards, including Arduino, Raspberry Pi, video and audio scaler ICs, sensors, motors, power supply units, and drone assembly components. The collection also includes advanced modules such as FPGA boards, TinyML kits, and IoT-enabled devices, catering to foundational experiments and high-end research applications. This comprehensive inventory ensures that students, faculty members and research scholars have easy access to these components for rapid hardware prototyping, innovation, and interdisciplinary collaboration. The components are issued with barcode tagging for tracking. This barcode tagging consists of lending records, which include the issue date and due date (based on the approved Duration: Short (SD) $\leq$ 15 days, medium (MD) $\leq$ 30 days, and long (LD) $\leq$ 45 days). Furthermore, additional extension is permitted for long-term projects, such as VIP and EPICS.

IV. RESULT ANALYSIS- PRE/POST LENDING

The CCS Device Library is widely suitable for PjBL and PBL, supporting hands-on innovation practices. Thus, CCS is used for lending electronic, mechanical, and hardware components, which helps students implement project- and problem-based learning beyond scheduled laboratory sessions, based on the Capstone project. In addition, faculty members identified suitable courses for project-based learning across multiple disciplines or interdisciplinary areas where CCS resources could enhance the project outcomes for student learning. Students were assigned open-ended projects for project-based learning where iterative prototyping was essential. For prototyping, students can borrow sensors, boards (e.g., ESP32, Arduino), power supply tools (e.g., batteries, rechargeable), and other hardware components as needed for the project. The lending log and project tracking sheets were maintained to test multiple design versions and repeated trials for the project, which included different components issued by CCS. This helps to capture component usage and the number of design iterations done by each group. The data collected based on key evaluation parameters 'before and after CCS integration' was used to measure the impact assessment. These performance indicators or evaluation metrics are –

1. *Iteration Frequency (IF)* **–** *(Number of iteration cycles Per Project)*
2. *Project Completion Rates (PCR) - (% of projects meeting defined outcomes)*
3. *Innovation Quality Scores (IQS) - (Rubric-based faculty scoring – Faculty Assessment Report (FAR))*
4. *Interdisciplinary* Participation (IP) **-** *(Number of inter-departmental teams)*

These evaluation parameters provide a detailed evaluation of how CCS, a device library, enhanced the effectiveness of PjBL and PBL methodologies. We used a quasi-experimental pre/post lending study because the random assignment of students to CCS and non-CCS groups was not feasible within the academic setting. Instead, outcomes were measured for the same type of courses and project cohorts before and after CCS integration (previous and current semesters of academic year 2024-25 and 2025-26 respectively), enabling a direct comparison of performance metrics such as IF, PCR, IQS and IP.

We have incorporated 40 projects from various programs (B Tech and MBA Tech). For the sample size '*n*' = 40, involving approximately 120 students, using pre- and post-lending assessments conducted during the even (previous) and odd (current) semesters of the academic year 2024–25 and 2025-26 respectively. This evaluation forms part of the Internal Continuous Assessment (ICA) for the one-credit course "Essential Electronics Practices", which includes a weekly two-hour laboratory session. Fig. 3 shows the projects submitted on the MS Teams platform by the MBA Tech Computer Engineering program, uploaded by the student groups for odd (current) semester of academic year 2025-26. Also, the projects submitted in the even (previous) semester of academic year 2024-25 is shown in fig. 4. The other students of odd (current) semester in B Tech programs (EXTC, CE, and AI) also submitted their mini projects on the MS Teams platform in their respective class teams. We have conducted this activity for three classes in the B Tech program and one class in the MBA Tech program, with 30 students in each batch. At our institute, around 480 (60*8) students are registered for this course across 8 divisions, with an average of 30 students per batch (lab size). While all divisions undergo evaluation by respective faculty members, we present here only a sample set of 40 projects from four divisions representing multiple programs. A sample size of 40 projects is considered sufficiently robust for presenting trends and outcomes because it captures diversity across programs and project categories, while enabling meaningful comparative analysis.

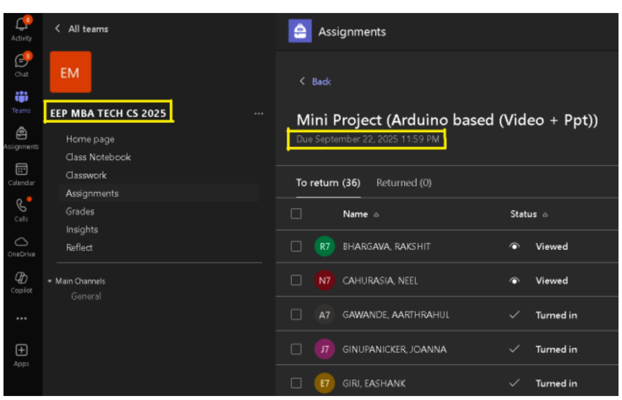

Fig. 3. Sample Mini Projects submitted on MS Teams platform by MBA Tech Computer Engineering students of odd semester of academic year 2025-26.

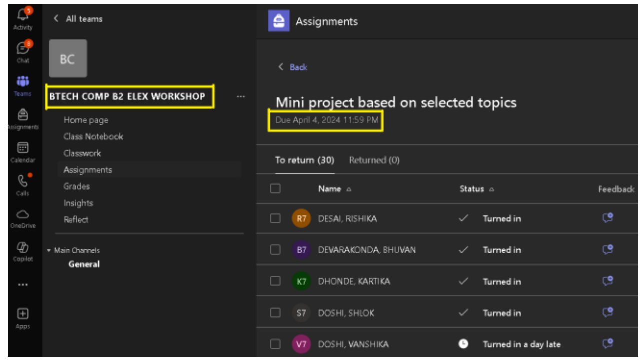

Fig. 4. Sample Mini Projects submitted on MS Teams platform by B Tech Computer Engineering students of even semester of academic year 2024-25.

We have successfully integrated the CCS front-end and back-end with the existing Web OPAC. CCS can track the issued component, renewal records, and availability of hardware components in the library. Fig. 5 illustrates the component lending (check out) by students in September 2025 for project work in the even (current) semester of the 2025-26 academic year. Furthermore, a sample list of completed projects from various programs for the odd (current) and even (previous) semesters of Academic Year 2025-26 and 2024-25 is given below. A sample mini-project submission on the MS Teams platform is presented in fig. 6, and a sample list of completed mini-projects is shown in fig. 7.

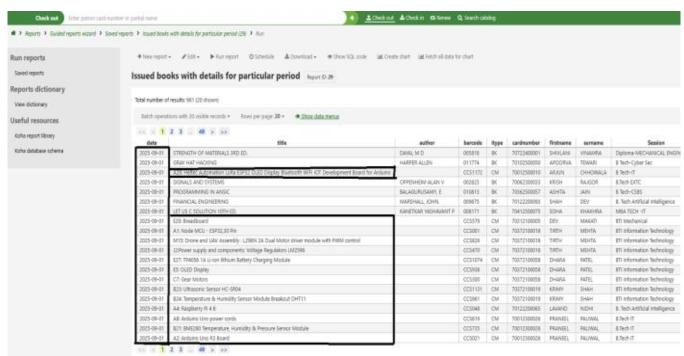

Fig. 5. shows the issue of hardware components issued by students in the month of September 2025.

Below is a sample list of projects completed in the previous semester of AY 2024-25 from the Department of Electronics and Telecommunication Engineering, along with the student group's roll calls.
1. Trash level Indicator (D071, D074, D075)
2. Smoke and fire alarm (D038, D039, D043)
3. GPS Tracker (TrailTAG) (D046, D047, D048)
4. Mini Music Reactive LED system (D064, D065, D067)
5. Smart rain detection system (D071. D073, D076)

Similarly, the list below shows projects completed in the odd (current) semester of AY 2025-26 from the Computer Engineering Department.
1. LED matrix using Arduino (B001, B002, B003)
2. LED Domino Clock (007, B008, B010)

3. Obstacle avoidance robot (B019, B020, B021)
4. Automatic Dustbin (B046, B047, B048)
5. Line Following Robot (B037, B038)

Furthermore, the following sample list of projects completed in the current (odd) semester of AY 2025-26 is from the Artificial Intelligence

1. Dual Arduino UV Monitoring and Alert System (No39, N040, N041)
2. Traffic Light Simulator (N043, N044, N045)
3. Smoke and Gas Detection (N056, N057, N058)
4. Self-Watering Plant Pot (N065, N066, N067)
5. Smart Door Lock System (N062, N063, N064)

In addition, the below sample list of interdisciplinary Projects completed in the odd (current) semester of AY 2024-25 by the MBA Tech Computer Engineering Dept.

1. Earthquake detector (B035, B037, B037)
2. Digital Multimeter (B046, B038)
3. Power Meter with Data Logger (B055, B056, B057)
4. Temperature-controlled FAN (B065, B067, B068)
5. Water level Indicator (B048, B061)

Additionally, the sample list of interdisciplinary Projects completed in the current (odd) semester of AY 2024-25 by the MBA Tech Computer Engineering Department is provided below.

1. GenAI-based emergency light indicator for metal detector (C013, B003, B002)
2. GenAI-based water level indicator (D012, N051, N050)
3. Smart Waste Segregation System (N011, N012, C032)
4. Acoustic Distance Measurement Tool (B011, D002, D004)
5. Basic Home Automation/Security System (B050, B061, N020
6. Solar-Powered Automatic Irrigation System (C023, D045)
7. Automated Water Level Indicator and Alarm (N010, C010, C045)
8. Earthquake/Vibration Sensing Alarm System (B055, N041, N043)
9. Automated Material Handling System (D063, N011)
10. Water Quality Monitoring System (B057, C024, C025)

Fig. 6. A sample Mini Project submitted on MS Teams platform by student group of MBA Tech Computer Engineering for odd semester of AY 2025-26.

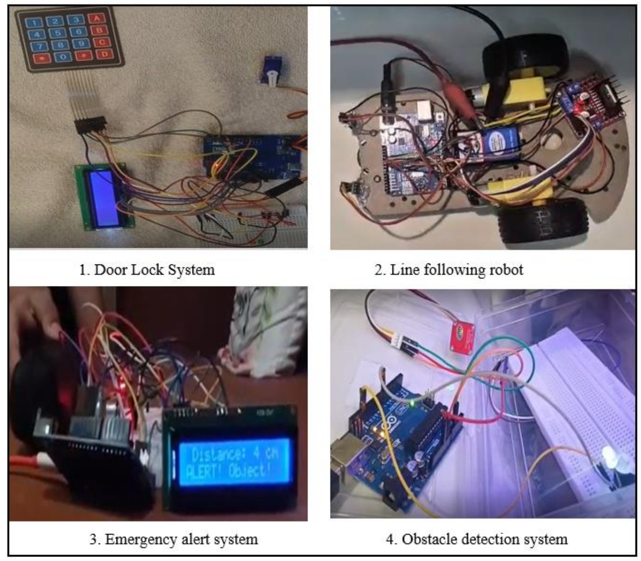

Fig. 7. Sample list of Mini Projects submitted by student groups on MS Teams for odd semester (fig. 1 and 2) of AY 2025-26 and even semester of AY 2024-25 (fig 3 and 4).

To compute the overall performance, the data sources we have used are as follows -

1. Library WEB-OPAC checkout logs (records of components borrowed).
2. Project reports and versioned repositories (Iteration records).
3. Faculty Assessment Report (FAR) with rubrics (innovation scoring).
4. Project Completion records (Final submission + demonstration).
5. Team composition records (Inter-Departmental affiliation of team members).

To compute each evaluation metric, we have presented the definition and use of each term for the result analysis.

1. Average Iteration Frequency (AIF)

We have defined the AIF parameter as the number of prototype versions which were tested in laboratory or on field for each project. Here, three different prototype versions (V1→ 1, V2 → 2 and V3 → 3) considered which are Concept Prototype (V1) and Development Prototype (V2) (post-test revision) and Functional Prototype (V3) were tested.

Reference source: Project ppts and versioned code/hardware files.
Version value: Integer ≥ 1.
Cumulative metric: arithmetic mean across projects.
The iteration frequency for n projects (n=40) can be represented as shown in “(1)”.
$I = \{i_1, i_2, i_3, i_4, \ldots\ldots i_n\}$
Then pre-lending sum is $= \sum_{k=1}^{n} i(k)$ (1)

Pre-lending components from CCS (40 projects) —

a) Iteration frequency:1,2,4,3,2,1,3,4,3,2,1,2,2,1,3,4,…

   a. …for 40 projects. Only 14 of these projects completed all prototype versions (V1-V3) by utilizing CCS facility. For illustration, we have shown the iteration frequency of a selected subset of projects rather than all 40.

Post lending components from CCS (40 projects) —

b) Iteration frequency: 3,4,5,4,6,2,5,4,4,5,1,3,4,2,4,5… …….for 40 projects. Of these, 34 projects successfully completed all prototype versions (V1-V3) with support of lending components from CCS facility.

The computation of average iteration frequency as follows -

1. Pre-lending sum = 1+2+4+3+2+1+3+4+3+2+1+2+2+1+3+4+……. = 65
2. Pre-lending mean = 65 / 40 = 1.6
3. Post lending sum = 3+4+5+4+6+2+5+4+4+5+1+3+4+2+4+5+…... = 135
4. Post lending mean = 135/ 40 = 3.3

The percent improvement is shown "(2)" as follows –

Percentage Improvement =

$$\frac{\text{(Post lending mean)} - \text{(Pre lending mean)}}{\text{(Pre lending mean)}} \times 100\% \quad (2)$$

$$\frac{(3.3 - 1.6)}{1.6} \times 100\% = 106.25\ \%$$

which means +106.25% improvement. Thus, post-lending using CCS there is significant improvement in the average prototype versions for enhancing hardware prototyping.

2. Project Completion Rate (PCR)

The project Completion Rate (PCR) is the *p*ercentage of project initiated and meets the predefined criteria (deliverables + working demo + report) or completed within given time limit i.e. by end of the semester.

Source: Project reports (status- Completed / Not Completed)

1. *Aggregate metric:* (Completed Projects / Total Initiated Projects) × 100%.
2. Pre-lending Aggregate metric: 14 completed / 40 initiated = 35%.
3. Post-lending Aggregate metric: 26 completed / 40 initiated = 65%.
4. Percent improvement = [(65% − 35%) / 35%] × 100% = [(30%) ÷ (35%)] x 100%
5. To compute improvement: 30 ÷ 35 = 0.8571 → ×100 = +85.71% improvement.

Thus, it has been observed that there is a 85.71% increase in project completion rate using CCS. Due to the easy availability of components in the CCS, it encourages and motivates students to participate in PjBL and PBL to enhance rapid prototyping.

3. Innovation Quality Score (IQS)

We have defined the rubric scores for faculty assessment report (FAR) on the scale 1–10. The rubric components define such as: 1. Novelty (0–2), 2. Technical depth (0–2), 3. Robustness (0–2), 4. Usability (0–2), 5. Documentation & Reproducibility (0–2) → total 0–10.

Source: The data received from individual faculty members by the mean rubric score assigned to each project.

1. The faculty mean score Pre-lending = 5.7
2. The faculty mean score Post lending = 8.5
3. Difference = 8.7 − 5.7 = 2.8
   Relative improvement = 2.8 ÷ 5.7 = 0.4912 → ×100 =
4. 49.12%

The 49.12% improvement in project innovation after post-lending is due to the easy access to components for prototyping and testbed implementation, which improves project quality improve students project-based learning.

4. Interdisciplinary Participation (IP) - Team Count

The team count of Interdisciplinary Participation indicates the number of projects that include students from other departments.

Source: Team roster maintained by each faculty member.

1. Pre-lending of components in CCS: 9 interdisciplinary teams active.
2. Post: 17 interdisciplinary teams active.
3. Difference = 17 − 9 = 8
4. Relative improvement = 8 ÷ 9=0.88 → ×100 = +88 % increase.

CCS facilitates interdisciplinary team formation by providing a centralized facility with a web OPAC for component lending. Thus, open-ended problem statements floated by faculty members encourage interdepartmental students to participate in PjBL and PBL. There is 88% increase in interdisciplinary participation based on above results using CCS.

TABLE I
SUMMARY OF PERFORMANCE METRIC

Evaluation Metric	Pre-Lending Model	Post-Lending Model	Improvement (%)
AIF	1.6	3.3	(+106.25%)
PCR	35%	65%	(+85.71%)
IQS	5.7/10	8.5/10	(+49.12%)
IP - Team Count	9	17	(+88%)

Fig 5 present the sample mini project submitted by the MBA Tech Computer Engineering student group (Roll no. B035, B037 and B039) for earthquake detector. The project successfully progresses through all development stages - Concept prototype (V1), Development Prototype (V2) including post-test revision and Functional Prototype (V3) were completed within the stipulated timeline, i.e. by end of the semester. The team achieved a score of 8/10 on Innovative Quality Score (IQS), despite having no interdisciplinary participation. Approximately, 35% projects were interdisciplinary and completed within the given time frame. This enabled by the support of CCS which provided timely access to the required components. The CCS significantly reduced prototyping delays, number of iteration cycles and strengthen students' ability to convert design ideas into functional hardware prototype.

We have highlighted two research questions, noting that the CCS is a transformative extension of academic libraries—shifting their role from traditional book lending processes to dynamic, hands-on innovation for rapid prototyping. Based on evaluation parameters, the library-integrated CCS has the potential to create a measurable impact on student-led project outcomes, from increasing project completion rates (post lending) to enhancing technical and creative skill sets. The CCS also act as an active innovation hub, fostering interdisciplinary collaboration, nurturing entrepreneurial ventures, and aligning academic outputs with real-world problem-solving needs. In essence, CCS-equipped libraries can become catalysts for a culture of continuous experimentation, innovation, and skill development within higher education.

CONCLUSION

This study demonstrates that transforming academic libraries into innovation hubs through equipment lending—exemplified by integrating a Common Component Studio (CCS)—can substantially enhance outcomes in engineering education project-based learning (PjBL). The findings confirm that when libraries evolve beyond their traditional roles of information repositories to also serve as hands-on resource centres, they can significantly accelerate innovation cycles, improve project quality, and foster interdisciplinary collaboration.

Comparative analysis between pre and post lending of hardware components shows significant improvements in PjBL outcomes, including a 106% increase in average Iteration Frequency (IF), an 85% rise in Project Completion Rates (PCR), and a 49% enhancement in Innovation Quality (IQ) enriched engineering education by making PBL more hands-on, iterative, and innovation-driven. Pedagogically, the CCS model is strongly aligned with constructivist pedagogical values, in which knowledge is constructed through experimentation, active engagement, and reflection.

Our performance parameters show an initial evaluation and do not claim a statistically validated correlation between IF and student motivation. In future work, we plan to conduct evidence-based motivation studies using student motivation surveys, feedback forms, interviews based on interdisciplinary student groups, and performance engagement metrics.

ACKNOWLEDGEMENT

The authors would like to sincerely thank the anonymous reviewers for their constructive and valuable comments, which helped us to refine the methodology and strengthen the results section.

REFERENCES

AlAli, R. (2024). Enhancing 21st century skills through integrated STEM education using project-oriented problem-based learning. *Geo Journal of Tourism and Geosites*, 53(2), 421-430.

Akers, E., Keshmiripour, S., & Knox, B. (2024). Expanding equipment lending: Addressing accessibility and curriculum gaps. *Journal of Access Services,* 21(1), 1-13.

Awati, J., Waghmode, M., Shukla, M., & Desai, S. (2025). Optimizing Cognitive and Analytical Skills in Engineering Undergraduates: A Comprehensive Case Study on Problem-Based Learning in Fuzzy. *Journal of Engineering Education Transformations*, 532-539.

Chang, Y., Choi, J., & Şen-Akbulut, M. (2024). Undergraduate students' engagement in project-based learning with an authentic context. Education Sciences, 14(2), 168.

Doulougeri, K., Vermunt, J. D., Bombaerts, G., & Bots, M. (2024). Challenge-based learning implementation in Engineering education: A systematic literature review. *Journal of Engineering Education*, *113*(4), 1076-1106.

Dzaiy, A. H. S., & Abdullah, S. A. (2024). The use of active Learning strategies to foster effective teaching in higher education institutions. *Zanco Journal of Human Sciences*, *28*(4), 328-351.

Helker, K., Bruns, M., Reymen, I. M., & Vermunt, J. D. (2025). A framework for capturing student learning in Challenge-based learning. *Active Learning in Higher Education*, *26*(1), 213-229.

Hussin, M., Usmledi, U., Masdi, H., Simatupang, W., Fadhilah, F., & Hendriyani, Y. (2025). Project-based problem learning: Improving problem-solving skills in higher education engineering students. RISE, 14(1), 62-84.

Jaleniauskiene, E., & Venckiene, D. (2025). Project-based learning for language education in higher education: A scoping review. *Interdisciplinary journal of problem-based learning.*, *19*(1), 1-25.

Kolmos, A., Holgaard, J. E., Routhe, H. W., Winther, M., & Bertel, L. (2024). Interdisciplinary project types in engineering education. *European Journal of Engineering Education*, *49*(2), 257-282.

Marcinauskas, L., Iljinas, A., Čyvienė, J., & Stankus, V. (2024). Problem-Based Learning versus Traditional Learning in Physics Education for Engineering Program Students. *Education Sciences,* 14(2), 154.

Naseer, F., Tariq, R., Alshahrani, H. M., Alruwais, N., & Al-Wesabi, F. N. (2025). Project based learning framework integrating industry collaboration to enhance student future readiness in higher education. *Scientific Reports*, *15*(1), 24985.

O’Connor, S., Power, J., Blom, N., & Tanner, D. (2025). Engineering students’ perceptions of problem and project-based learning (PBL): comparing online and traditional face-to-face environments. *Australasian Journal of Engineering Education*, 1-25.

Rogers, A., Leduc-Mills, B., O'Connell, B. C., & Huang, B. (2015, June). Lending a hand: Supporting the maker movement in academic libraries. In 2015 ASEE Annual Conference & Exposition (pp. 26-1081).

Safitri, R., Wahyuri, A. S., & Ockta, Y. (2024). The impacts of the project-based learning and problem-based learning models with self-confidence on students’ learning outcomes. *Indonesian Research Journal in Education| IRJE|*, *8*(1), 269-283.

Sheaffer, K., & Vinson, C. (2023). Technology equipment lending in an academic library: Understanding patron usage and proficiency through quantitative assessment. *The Journal of Academic Librarianship*, *49*(2), 102655.

Sukackė, V., Guerra, A. O. P. D. C., Ellinger, D., Carlos, V., Petronienė, S., Gaižiūnienė, L., ... & Brose, A. (2022). Towards active evidence-based learning in engineering education: A systematic literature review of PBL, PjBL, and CBL. Sustainability, 14(21), 13955.

Tait, E., Martzoukou, K., & Reid, P. (2016). Libraries for the future: the role of IT utilities in the transformation of academic libraries. *Palgrave Communications*, *2*(1), 1-9.

Wijnia, L., Noordzij, G., Arends, L. R., Rikers, R. M., & Loyens, S. M. (2024). The effects of problem-based, project-based, and case-based learning on students’ motivation: A meta-analysis. Educational Psychology Review, 36(1), 29.