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Integrated Educational Strategy with Case Studies and ICT Tools for the learning of Fluid and Turbo-Machinery Course

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***Abstract*— This research paper explores the implementation of a case study based and ICT integrated approach in the design and model testing of fluid machines, with the focus on turbines for hydroelectric power generation. The study engages students in practical learning by analyzing a specific dam, designing a suitable turbine. This method bridges theoretical knowledge with practical environment, deepening students' understanding of fluid mechanics and turbine design.**
The effectiveness of this approach is evident in the improved student performance from 2022-23 to 2023-24. A more balanced grade distribution and an 82% increase in average marks for complex questions highlight the positive impact of hands-on learning. Additionally, course outcomes for CO3 improved by 13.46%, and over 81% of students reported enjoying the activities, with no negative feedback, indicating a more engaging and productive learning environment.

***Keywords*— ICT Tools, water turbine, examination results, case study.**

I. INTRODUCTION

FLUID mechanics is a foundational area of study in engineering, particularly vital for designing and operating turbines in hydroelectric power generation. Engineers require a thorough understanding of fluid machinery design and model testing principles to meet industry demands. This research explores a Case Study Based (CSB) teaching methodology, combined with information and communication technology (ICT), to enhance learning. Students are assigned specific dam projects based on their roll numbers, guiding them through the turbine design process and model testing. This integrated approach presents the study on implementation abilities among the students such as critical thinking, and hands-on skills.

Case study teaching methodology bridge the gap between theoretical concepts and practical problem. Lena et. al. (2023) highlighted how CSB learning fosters a deeper understanding of engineering concepts, helping students apply theoretical principles to real-world challenges. Herreid (2011) emphasized its ability to promote active engagement, which enhances knowledge retention and problem-solving skills. Case studies not only improve individual understanding but also encourage teamwork and effective communication, critical for professional engineering practice.

Prince and Felder (2006) explored various Student-centered learning, including CSB learning, found it superior to traditional lecture methods. While requiring careful planning, it enables deep learning and significantly improves students' analytical abilities. Buch (2016) introduced the concept of case-based reasoning, showing how students can draw from past experiences to tackle new problems. This approach builds a repository of practical knowledge, equipping students to handle diverse engineering challenges effectively.

Yadav and Beckerman (2009) given empirical fact for the efficiency of case studies in science and engineering courses. It is seen that the critical thinking skills and ability to handle practical problem are enhanced than those of traditional teaching methods with Students taught using this CSB learning. Collaborative learning plays a pivotal role in the success of case study-based education. Flynn and Klein (2001) demonstrated that group discussions during case study sessions significantly enhance understanding and retention of material. Peer interactions encourage students to exchange ideas, clarify doubts, and collectively solve problems, leading to a deeper comprehension of engineering concepts.

Kaddoura (2011) noted similar findings in nursing education, which can be extrapolated to engineering. CSB prepares students for real-world challenges more effectively than traditional lectures by fostering critical thinking and practical problem-solving. The collaborative nature of case studies aligns closely with the teamwork required in professional engineering contexts.

A well-structured case study is essential for maximizing learning outcomes. Kim et al. (2006) provided a conceptual framework for developing teaching cases, emphasizing their relevance, challenge level, and alignment with learning

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objectives. Though initially designed for medical education, these principles are equally applicable to engineering.

Yin (2009) have done comparison of CSB and Project Based Learning (PBL), stress their shared emphasis on active, student-centered learning. Both approaches permit students to construct knowledge through experience and reflection. Williams (2005) supported the integration of case studies in education, particularly for teaching complex, context- dependent knowledge. Such methodologies prepare students for real-world engineering tasks by encouraging analytical thinking and adaptability.

Experiential learning complements case studies by engaging students in hands-on activities. Sawant et al. (2012) introduced a "learning by doing" approach, which involved model-building exercises to boost creativity, and visualization, drawing skills. Their study reported significant improvements in students' academic performance, particularly in unit tests and semester exams.

Deshpande et al. (2013) focused on second-year mechanical engineering students, using experiential learning techniques to enhance visualization and imagination skills. Traditional classroom teaching often falls short in these areas, especially for students with limited technical backgrounds. Incorporating experiential learning improved engagement, course outcomes, and overall exam results.

Case study-based learning extends beyond technical knowledge to foster critical thinking, collaboration, and professional skills. Ajay Kumar D. and Umadevi V. (2011) emphasized interdisciplinary approaches and collaboration to drive innovation in engineering education. Similarly, Routhe (2021) argued that such active learning techniques encourage students to take ownership of their education, constructing knowledge through interaction and reflection.

Shirish Shinde (2020) has found that the global demand for skilled engineers has led to a shift towards OBE, with revised accreditation models emphasizing this approach. In India, there is significant pressure from professional bodies and industries for engineering graduates to possess a broader set of skills, including professional, soft, and personal competencies Despite an increase in the number of engineering institutions, concerns about the quality of education persist, necessitating radical changes in curriculum and teaching methods. PBL has emerged as a relevant educational strategy, particularly in the context of Indian engineering education, which has traditionally relied on instruction-based pedagogy.

Originating at McMaster University in 1968, PBL has been adapted in various countries, but a model tailored to Indian conditions is essential to meet industry demands and accreditation standards set by bodies like the NBA and ABET.

Du, Xiangyun, Kolmos, Anette, (2013) This stsudy explores the development of process competencies among engineering students within a Problem and PBL environment, particularly focusing on the Aalborg University model. The authors claim that future engineers must have skills like cooperation, communication, and project management to thrive in diverse communal contexts. It emphasizes the need for a blend of analytical skills, creativity, and ethical standards, alongside the ability to solve complex problems and innovate in a globalized setting. The paper discusses the ongoing transformation in engineering education in Denmark, where institutions are adopting student-centered learning environments and new educational programs to meet future technological demands. This includes the introduction of PBL and case study-based as a core pedagogical approach. This model is posited as an active means to prepare students for professional competencies by fostering an active learning environment that encourages collaboration and self-directed learning.

Shinde and Vikas. (2014) presented an ample literature survey Targeting on the execution of PBL and case study-based in relation engineering education in India. The key points derived are: The literature indicates that Indian engineering graduates often lack critical employability skills, primarily due to a gap between industry demands and the skills imparted through existing curricula. Lot many survey conducted by government of India have pointed out that there is indicated lacunas in curriculum and teaching methodology. In this regard higher education board has adopted ABET learning outcomes and to implement it in successfully PBL and case study-based are finest tool. The literature emphasizes that understanding these components is crucial for addressing the identified gaps in engineering education.

Mohd Yusof, et. al (2013). explored the implementation and effectiveness of PBL and case study-based in various educational settings, particularly focusing on its application in engineering education. The key points derived are: PBL is highlighted as a teaching method that emphasizes real-world problems to enhance critical thinking, analytical skills, and teamwork among students. The paper discusses the importance of cultural relevance in problem selection for case study-based.

Studies like those by Kaddoura (2011) and Flynn and Klein (2001) demonstrate the impact of discussion-based and collaborative learning on retention and comprehension. These methods prepare students not only for academic success but also for professional environments that demand effective teamwork and problem-solving skills.

Integrating case study-based learning with experiential activities creates a comprehensive educational framework for engineering students. By combining theoretical concepts with real-world applications, this approach bridges the gap between classroom learning and professional practice. Collaborative learning enhances teamwork and communication, while hands-on methods strengthen technical skills, visualization, and creativity. Together, these strategies equip students with the tools they need to tackle complex engineering challenges and excel in their careers.

This pedagogical innovation aligns with modern educational goals, emphasizing active learning, critical thinking, and interdisciplinary collaboration to produce well-rounded engineers prepared for the demands of the field.

II. METHODOLOGY AND IMPLEMENTATION

The structured guide lines for implementing an integrated case study-based and ICT learning approach focused on the design of water turbines are as follows:

A) Role of facilitator

1. Explain the theory of model testing and prototyping.
2. Describe the purpose of case study.
3. Explain case study- procedure.
4. Make the group of 4 to 5 students, so that it is combination of slow learner and fast learner.
5. Assign dam and its location.
6. Ask students to gather information about dam- **internet** within one week.
7. Ask students to do the calculations-excel.
8. Facilitate students, if any extra is required.
9. Conduct industry visits to motivate the student.

B) Role of students

1. Listen the theory explained by facilitator
2. Write the equations of model testing
3. After forming groups, collect the information from **internet such as- capacity of dam, head etc.**
4. Assume overall efficiency of energy conversion
5. Find out the power developed by turbine by considering density, discharge of the dam, head available, overall efficiency etc.
6. Find the specific speed of turbine by using, power, chosen number of poles and speed etc.
7. Depending upon specific speed select the turbine
8. Determine the number of turbine units required
9. Assuming flow ration and continuity equation find the inlet and outlet diameter of turbine of actual turbine.
10. Do the model testing assuming $1/10^{th}$ scale and find the speed, head, and discharge of the model.
11. Satisfy the assumption made by using specific speed equation.

C) Detail procedure

1) Selection of Case Study

Identify Objectives: Define the learning outcomes related to turbine design that the case study should achieve.

Choose a Relevant Case: Assign each group a specific water dam to research. Each group should gather and present information on the dam as follows:

1. Introduction: Overview of the dam.
2. History: Historical context and development.
3. Location/Map: Geographical location and map.
4. Specifications: Capacity, available head, catchment area, etc.
5. Data Collection: Use websites like Wikipedia or other reliable sources, and if possible, visit the site for firsthand data.

2) Preparation

Pre-Reading: Provide background materials on turbine design and relevant hydrology principles. Case Study Distribution: Share details of the assigned dam and design tasks in advance, allowing time for review. Teacher's Role: Cover relevant syllabus content, prepare students for the case study, assign dam names, and provide a timeline for activities.

3) Introduction and Overview

Briefing: Introduce the case study's relevance and learning objectives. Context Setting: Provide necessary background to understand the case. Group Tasks: Students will focus on the hydraulic design of a water turbine, following these steps:

1. Determine Hydraulic Parameters: Flow Rate (Q): Assess the volume of water. Head (H): Measure the vertical height of the water column.
2. Select Turbine Type: Turbine Choice: Choose based on head and flow rate (e.g., Pelton, Francis, and Kaplan).
3. Calculate Design Parameters: Specific Speed (Ns): Determine for selecting efficient turbine configuration. Runner Dimensions: Define blade dimensions and shape.
4. Design Hydraulic Components: Runner Blades: Design blade shape and angle. Guide Vanes: Optimize for directing water flow. Draft Tube: Ensure smooth water flow and energy recovery.
5. Perform Hydraulic Calculations: Efficiency Analysis: Predict efficiency based on design. Flow Distribution: Ensure uniform water distribution.

4) Group Discussion

Form Groups: Organize students into small groups to discuss their findings. Guiding Questions: Provide questions to structure discussions and ensure thorough analysis. Collaborate: Allow groups to share insights and critique each other.

5) Class Discussion

Facilitate: Lead a discussion where each group presents their findings and solutions. Engage: Promote active class participation and debate. Clarify: Address misconceptions and deepen understanding with additional insights.

6) Assessment

Evaluate: Assess based on individual contributions and group work. Grade: Provide grades or feedback based on established criteria.

This structured approach helps students apply theoretical concepts to practical scenarios, enhancing their understanding and analyticsl skills in the design of water turbines.

In this study following ICT tools are used are shown in Table I.

TABLE I
DETAILS OF ICT TOOLS USED

Sr. No.	Activity	ICT Tool	Details
1.	Assign dam and location	Digital mapping tools	Google Maps to assign and share dam locations
2.	Information gathering about dams	Internet-based research	Wikipedia or official dam websites to gather information.
3.	Perform calculations	Spreadsheet software (Excel)	Calculations to determine efficiency and turbine dimensions, etc.

III. Result and Discussion

In this part of study, the results of using case study-based learning in the **Fluid and Turbo Machinery** course were discussed. The findings highlight significant improvements in student learning outcomes, participation, and satisfaction, comparing the academic years 2022–23 and 2023–24.

A) Comparison of result analysis

Comparison of results analysis of Fluid and Turbo Machinery course of the academic year 2022-23 and 2023-24 is shown in fig 1. The bar chart of 2022-23 shows its deviation with bell curve and shifted towards right of graph. It means more number of students are in low grades. Whereas in academic year 2023-24 the more number of students are shifted towards left of the graph and seems to be bell curve distribution.

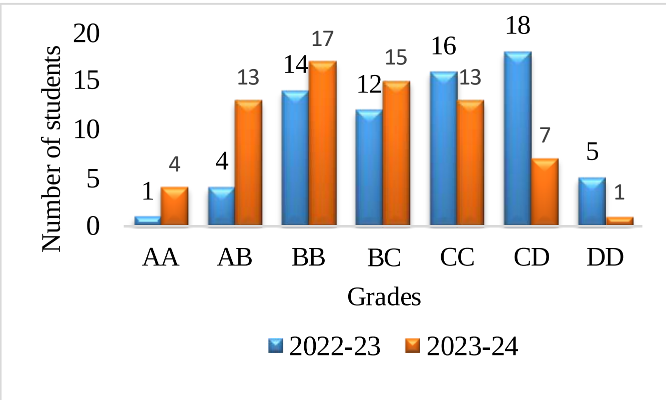

Fig. 1 Result analysis comparison of academic year 2022-23 and 2023-24

B) Comparison of CO Attainment

The table III shows the comparison of average marks obtained in the End Semester Exam (ESE).

TABLE II
COURSE OUTCOMES (CO)

CO	Statement	Activity
CO1	Explain different fluid and turbo machinery	Class room teaching
CO2	Analyze the performance of various fluid and turbo machinery	Class room teaching
CO3	Illustrate concept of model testing for performance of fluid and turbo machines	Learning by Doing
CO4	Solve problems on various fluid and turbo machinery	Group Activity

TABLE III
COMPARISON OF AVERAGE MARKS OF THE STUDENTS IN ESE

Test	Max Marks		Average Marks		
CO	2022-23	2023-24	2022-23	2023-24	% Increment
CO1	8	8	2.54	2.61	2.75
CO2	7	8	3.15	3.20	1.56
CO3	6	8	2.24	4.08	82.14
CO4	7	7	3.22	3.90	21.11

The questions asked on CO3 are for 6 marks and that too descriptive in 2022-23 and that of 2023-24 it is of 8 marks that too numerical and interpretation of result. From the comparison it seems that average marks obtained in 2022-23 was 2.24 and that of 2023-24 is 4.08, it shows 82% increment in marks. Table II shows the list of curse outcomes of Fluid and Turbomachinery course. The CO3 is addressed through Case Studies and ICT activity.

C) Comparison of CO Attainment

Table IV presents the percentage attainment of the course outcome for the Model Testing topic (CO3). It is evident that CO3 attainment has significantly improved over the previous year, which employed conventional teaching methods. During the 2023-2024 academic year, the attainment of CO3 saw a substantial increase of 13.46% compared to the 2022-2023 academic year.

TABLE IV
ATTAINMENT OF CO3

CO	% Attainment		
	2022-23	2023-24	% Increment
CO1	86.08	87.69	1.87
CO2	77.17	79.92	3.56
CO3	81.2	92.13	13.46
CO4	63.35	67.62	6.74

D) Feedback from course exit survey

The student learning index (SLI) feedback of student was taken with the end of instructions of course by using google form. The responses of the same are shown in fig 2, it seems more than 81% students are able enjoy the class activities of Fluid Turbo machinery course. The respective percentage of neutral, agree and strongly agree are, 4.3%, 14.5%, and 81.5% respectively.

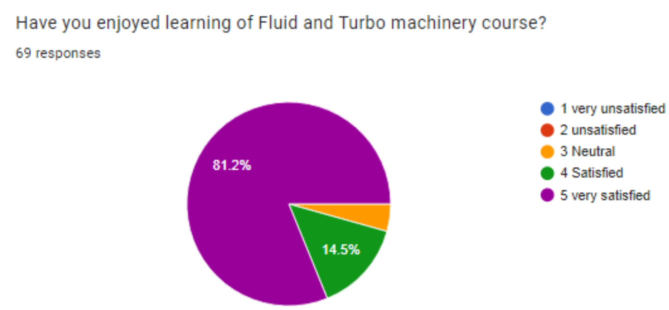

Fig. 2. SLI feedback of students

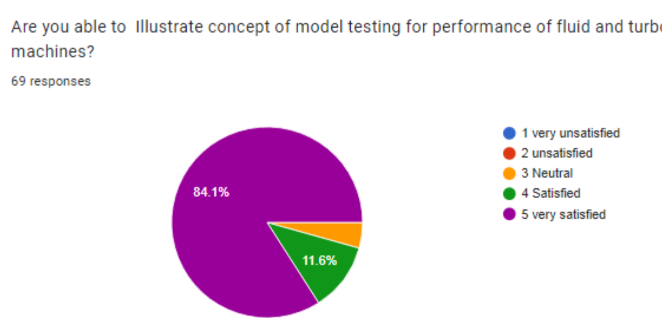

Fig. 3. Course end survey

From the responses it also to be noted that the students with strongly dissatisfied, dissatisfied responses are number stand zero. From the above analysis one can easily highlights that the students are actively participating in class room activities and are able to face the exams positively.

Every academic year ends with course end survey, the results of the same regarding Fluid and Turbo machinery course are shown in fig 3. More than 84% students are able to deal with questions related module testing.

E) Limitations of the study

Though the CSBlearning looks promising solution for learning, but it has limitation/hurdles as,

1. Motivation to student: The success of the CSBlearning lies in the student's active participation thought the activity. Less motivated students may not fully engage, which could affect overall group outcomes.
2. Time constrains: As this activity may not complete on one day, it may spread over a week or two weeks. In this period the students should not lose the focus.

Conclusions

This research paper features the effectiveness of the case study-based and ICT pedagogical approach in enhancing the learning experience of students in the design and testing of fluid machines, particularly turbines for hydroelectric power generation. By integrating real-world scenarios and hands-on model testing, this approach has demonstrated significant improvements in students' understanding and application of theoretical concepts.

While the shift from a skewed grade distribution in 2022-23 to a balanced bell curve in 2023-24 highlights improved academic outcomes, it could also reflect other factors, such as changes in assessment patterns or grading rubrics. The observed 82% rise in average marks for descriptive and numerical questions may partially be attributed to enhanced familiarity with question formats or alignment of teaching methods with student strengths.

The 13.46% improvement in CO3 attainment levels points to better understanding of specific course content, yet it may also indicate a curriculum that increasingly aligns with students' prior knowledge or capabilities. Similarly, the overwhelmingly positive student feedback could stem not only from the pedagogical approach but also from broader factors, such as improved classroom resources or a more motivated cohort.

In nut shell it indicates that the integration of the case study-based and ICT has proven to be a valuable tool in bridging the gap between theoretical knowledge and practical application, leading to improved academic performance and student satisfaction in the Fluid and Turbo Machinery course.

Future Scope

- Integrate simulation software (e.g., ANSYS, MATLAB) to validate theoretical findings and compare them with practical results for enhanced learning.
- Extend the case study methodology to other topics within fluid and turbo machinery, such as pumps, compressors, and wind turbines, to provide diverse learning experiences.

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