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Exploring Experiential Learning Techniques to Foster Visualization and Imagination Skills among Mechanical Engineering Students during the Teaching of Jigs and Fixture Concepts

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***Abstract*— Jigs and fixtures are essential tools for modern manufacturing and machining processes. They contribute to precision, efficiency, cost-effectiveness, and safety in various industries, ultimately impacting the quality and competitiveness of products in the market. This course improves the visualization, imagination and drawing skill of the students which are helpful to them to draw their ideas clearly and rapidly, to read the drawing drawn by others and to create successful design. Manufacturing process course includes Jigs and fixture topic in this topic it is expected to imagine, visualize and develop the engineering drawing as per given requirements which includes orthographic projections in which imagining 3D objects are required to convert in 2D drawing. The students of second year mechanical engineering find this task difficult due to no prior basic knowledge, poor imagination and visualization skill. These skills are improved by experiential learning. Hence the attainment of the course learning outcome related to these topics is recorded low. To overcome this problem, a experiential learning approach implemented along with classroom teaching in order to enhance the, visualization, imagination and technical drawing skill of second year engineering students. In this article, the author has presented the efforts taken to improve the visualization, imagination and drawing skill through active engagement of students for learning in the classroom and outside of classroom. Due to systematic implementation of experiential learning, student's engagement towards learning, attainment of the course outcomes (COs) and overall exam result of the course have been improved**

***Keywords*— Course Learning Outcome, Jigs and fixtures, Drawing, Experiential learning.**

***JEET Category*—Pedagogy in teaching learning**

I. INTRODUCTION

Jigs and fixtures are essential tools used in manufacturing and machining processes to ensure accuracy, consistency, and efficiency in the production of parts and products. They play a crucial role in various industries, including automotive, aerospace, electronics, and more. Here's a brief overview of jigs and fixtures. Jigs are devices designed to hold and guide a tool or work piece during a manufacturing operation, such as drilling, milling, or welding. Fixtures are devices used to securely hold and locate a work piece during manufacturing, assembly, or inspection. Jigs and fixtures help achieve tight tolerances and minimize variations in product dimensions, reducing setup times and minimizing rework, these tools enable faster production. They contribute to reduced scrap rates and enhanced overall product quality, leading to cost savings. Jigs and fixtures provide a stable and safe working environment for operators. Jigs and fixtures are indispensable components of modern manufacturing processes, contributing to higher efficiency, better product quality, and cost-effective production. They are tailored to specific manufacturing needs and help ensure consistent and precise results across various industries.

The article emphasizes the importance of incorporating experiential learning techniques into economics education to enhance students' understanding of economic principles and their ability to apply them in real-world contexts. It provides insights and recommendations for educators interested in adopting these techniques to create more dynamic and effective learning experiences in the field of economics (Hawtrey, 2007).

The foundation for understanding and implementing experiential learning in educational settings. His emphasis on reflection, active engagement, and the holistic development of students has had a lasting impact on educational practices and continues to shape modern approaches to teaching and learning (Chickering, 1977)

Kolb (2013) emphasizes that learning is an ongoing, iterative process. Learners continually cycle through these stages as they engage in new experiences and integrate them into their existing knowledge and skills. Additionally, Kolb suggests that individuals may have preferences for certain stages of the cycle, which can influence their learning styles. Some individuals may be more inclined toward concrete experience and active experimentation, while others may lean toward reflective

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observation and abstract conceptualization. Kolb's experiential learning model provides a framework for understanding how adults learn from their experiences. It highlights the importance of reflection and active experimentation in the learning process and recognizes that individuals have diverse learning styles. This model has been widely applied in educational and professional settings to facilitate effective learning and development.

Gosen & Washbush (2004) provides a comprehensive overview of the existing literature on the assessment of experiential learning. Experiential learning is an educational approach that emphasizes learning through hands-on experiences and reflection. This review article aims to synthesize the various methods and approaches used to assess the effectiveness of experiential learning programs.

A. Y. Kolb & Kolb (2005) explore the connection between learning styles and physical learning environments in the context of higher education. The authors delve into the importance of experiential learning and its potential enhancement through tailored learning spaces. The article emphasizes the importance of experiential learning and how it can be optimized by aligning learning styles with appropriate learning spaces. Their work offers valuable insights for educators and institutions looking to enhance the quality of higher education through thoughtful design and pedagogical strategies.

Suryawanshi & Deshpande (2020) provided insights into how students' learning experiences can be understood in the context of product development, with a focus on the perspective of Project-Based Learning (PBL). Soundattikar & Naik (2016) conducted a case study during the teaching of a Total Quality Management course and discovered that case studies serve as an effective tool for engaging students with diverse learning styles. Gundry & Kickul (1996) emphasized the use of experiential methods to enhance students' creative thinking and behavioral skills. The importance of creativity in entrepreneurship education is growing, given the challenges that students and entrepreneurs face, requiring more holistic solutions. Various experiential techniques, encompassing both conceptual and practical aspects, are explored, along with recommendations for incorporating them into entrepreneurship courses. Huang (2019) implemented a game-based learning activity that involved creating and answering RAT (Remote Associates Test) questions. To evaluate the usability of the system and its impact on learning, experiments were conducted with a group of 36 students. During post-activity interviews, the students indicated that the incorporation of "genuine" stimuli in an authentic setting enhanced the effectiveness of their learning. Furthermore, the findings showed that the process of generating questions had a more substantial influence on the outcomes compared to the act of answering them. The Love (2023) recommendation was to ensure clear and explicit communication with students, to align all elements of the laboratory experience constructively, and to incorporate hands-on participatory activities whenever feasible. Jingxiao et al. (2019) developed a novel framework that leverages experiential learning (EL) in combination with customized activities in a BIM (Building Information Modeling) capstone course for project planning and execution. This framework encompasses four key components: concrete experience, reflective observation, abstract conceptualization, and active experimentation. It facilitates the seamless integration of experiential learning, the BIM planning guide, and teaching methods specific to capstone courses. It empowers instructors to oversee and manage learning activities based on the BIM planning guide while also allowing them to test hypotheses through practical experiments.

Jigs and fixtures can indeed be challenging concepts for second-year students to grasp. To help students understand these concepts, it's essential for them to first grasp several fundamental principles:

1. Design of the Part: Students should have a clear understanding of the part they are working with. This includes its geometry, dimensions, and specific features that may require special attention during machining or assembly.
2. Reference for Location: In the context of jigs and fixtures, establishing a reference point or location is critical. Students should learn how to identify and mark reference points on the work piece or part to ensure accurate and consistent positioning during manufacturing processes.
3. Locating Element: This is a fundamental component of jigs and fixtures. Students need to understand that a locating element is responsible for precisely positioning the work piece in the fixture. It often involves features like pins, holes, or slots that match corresponding features on the work piece.
4. Clamping Element: Clamping is crucial to secure the work piece in place. Students should learn about various clamping mechanisms such as clamps, screws, or pneumatic devices used in jigs and fixtures. Understanding how to apply the right amount of clamping force without damaging the work piece is essential.
5. Tool Guiding Element: Tool guiding elements assist in guiding cutting tools or other machining instruments during manufacturing processes. Students should grasp how these elements ensure that the tool follows the desired path, resulting in accurate and precise machining.
6. By elaborating on these basic concepts and providing practical examples and exercises, educators can help second-year students develop a deeper understanding of jigs and fixtures. Hands-on activities and real-world applications can be particularly effective in reinforcing these concepts and making them more accessible to students.

   Enhancing the visualization and imagination skills of second-year mechanical engineering students through traditional classroom teaching poses a significant challenge for instructors. Additionally, learning about jigs and fixtures becomes more challenging due to students' limited prior technical knowledge and a deficiency in visualization and imagination skills. This deficiency often leads to unsatisfactory course outcomes and a higher rate of failure in the tool engineering course. To address these issues, the author adopted an experiential learning approach during the teaching of tool engineering. This article outlines the systematic measures taken to boost students' visualization and imagination skills by actively engaging them in the learning process, both within and outside the classroom. Methodology and implementation

II. Methodology and Implementation

The methodology employed in this teaching approach involves a structured sequence of steps to help students understand and apply the concepts of jigs and fixtures effectively. Here's a breakdown of the methodology statement:

1. Introduction to Jigs and Fixtures:
   Initial Explanation: The instruction begins by introducing students to the fundamental concepts and significance of jigs and fixtures in manufacturing processes.
2. Engaging Alumni and Entrepreneurs:
   Alumni and Entrepreneur Involvement: To provide practical insights, alumni and entrepreneurial individuals who have experience with jigs, fixtures, and relevant drawings are invited to participate.
3. Active Learning Activities:
   i. Part Drawing Activity: Students were given a component drawing as depicted in Fig.1 from an industry and asked to reproduce it, fostering the ability to interpret industry-standard drawings.
   ii. Verification through Actual Component: Once the students have attempted to draw the component based on the industry drawing, they are presented with the actual components part as depicted in Fig. 3. They are tasked with cross-referencing their drawings with the physical part to assess their accuracy and identify any discrepancies.
   iii. Designing Jigs and Fixtures: With a clear understanding of the component, students are then challenged to design jigs and fixtures that facilitate specific operations on the part. In this process, students must make critical decisions regarding
   iv. Reference Surface Selection: Identifying the appropriate surface to mount the work piece securely.
   v. Locating Element: Determining the locating elements required to ensure precise positioning of the component.
   vi. Clamping Element: Choosing the clamping mechanisms necessary to securely hold the work piece in place.
   vii. Tool Guiding Element: Selecting the elements that guide the tools or instruments during the manufacturing process.
4. Guidance and Support:
   Industry Expert and Author Assistance: Throughout the exercise, industry experts and the author are readily available to the students as shown in Fig. 2 They provide guidance, address doubts, and offer insights to assist students in their learning journey.

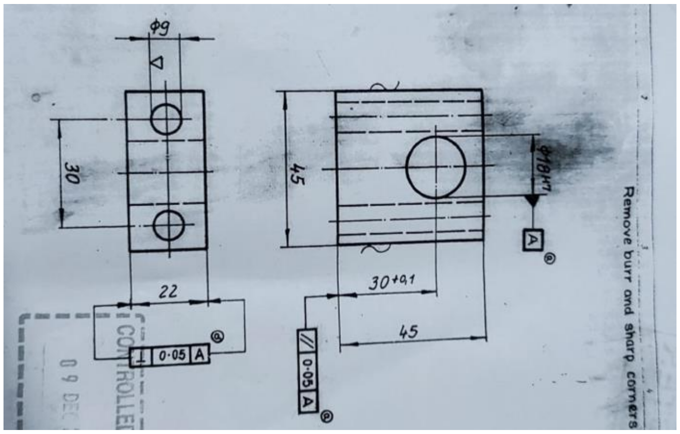

Fig. 1. Components Drawing

These activities are addressing the COs which are shown in Table I.

TABLE I
COURSE OUTCOMES RELATED TO JIGS AND FIXTURE (COs)

CO	Statement
CO4	Design the jigs and fixture for the given components

After students finish the exercise, they were given the opportunity to examine real-world jigs and fixtures shown in Fig. 4

Fig. 2. Industry expert discussion with students

This process helps identify areas where their designs may be incorrect or where their understanding needs improvement. Following this, videos demonstrating various jigs and fixtures used in practical applications are created and shared with students as valuable resources for further learning and reference.

This methodology fostering an active learning environment, allowing students to gain practical experience in understanding and applying jigs and fixtures in real-world scenarios. It promotes critical thinking, problem-solving, and hands-on learning while benefiting from the knowledge and experience of industry professionals and educators.

Fig. 4. Real-world jigs and fixtures

III. Result and Discussion

The observations and results are recorded and discussed in this section. Total 62 students participated in the activity and submitted there drawing.

After conducting the activity, the feedback of the students was taken by asking the questions related their understanding. The feedback was taken on the google form on the same day. The questions asked in the feedback are depicted in the Table II.

TABLE II
QUESTIONS USED FOR FEEDBACK OF THE STUDENTS

Sr. No	Question Statement
[1]	Have you understood the importance of locating elements and its relationship with Accuracy of operation
[2]	Have you understood the role of clamping elements and importance of quick clamping
[3]	Have you understood how to select tool guiding element
[4]	Have you understood the working of jigs and fixture and importance in industry

According to the data presented in Fig. 5, it is evident that a significant portion of students comprehended various important aspects related to manufacturing processes:

1. Locating Elements and Accuracy: Approximately 87.79% of students demonstrated a clear understanding of the significance of locating elements and how they relate to the accuracy of operations in manufacturing.
2. Clamping and Quick Clamping: Figure 5 indicates that a substantial 89.76% of students grasped the concept of clamping and recognized the importance of quick clamping techniques in manufacturing processes.
3. Jigs and Fixtures: Impressively, a high percentage of 82.47% of students felt confident in their understanding of how jigs and fixture's function and their vital role in the industrial context.
4. Tool Guiding Element Selection: Furthermore, as illustrated in Fig. 5, a noteworthy 93.97% of students demonstrated the ability to appropriately select tool guiding elements for specific manufacturing tasks.

In summary, the data from Fig. 5 highlights the students' strong comprehension of key principles and concepts crucial to the manufacturing industry, including the importance of locating elements, clamping techniques, the role of jigs and fixtures, and the selection of tool guiding elements. These findings indicate a high level of knowledge and awareness among the surveyed students in these areas of manufacturing.

The aim of this activity is to enhance the visualization, creativity, and technical drawing skills of first year engineering students. The assessment of the activity is carried out with rubrics as shown in Fig. 2

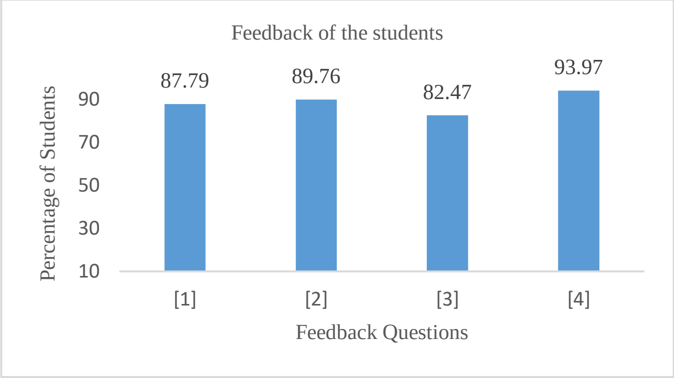

Fig. 5. Feedback of students

In the end-of-semester exam (ESE), the design of jigs and fixtures is assigned a weightage of 15 marks, contributing to the achievement of the course outcome, specifically focusing on the ability to design jigs and fixtures for designated components. Notably, the data presented in Table III indicates an improvement in students' average marks by 3.32 marks compared to the previous year. This improvement in scores directly corresponds to an enhanced level of achievement in the course outcome, demonstrating that students have made significant progress in their ability to design jigs and fixtures for specified components.

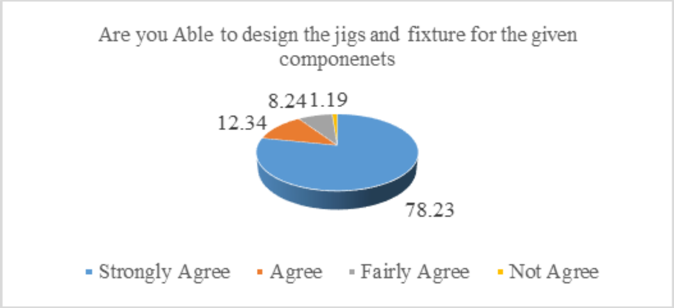

Fig. 6. Course end survey report

Table IV presents data on the average achievement of the course outcome (CO) related to jigs and fixtures. The data clearly indicates a substantial improvement in the attainment level of

CO4 when compared to the previous year when traditional instructional methods were in use. Specifically, for the academic year 2022-2023, there was a notable increase of more than 10.37% in the attainment of CO4 as compared to the academic year 2021-2022. This improvement highlights the effectiveness of the instructional approaches adopted in the current year in enhancing students' performance in understanding and applying concepts related to jigs and fixtures.

TABLE III
AVERAGE MARKS OF THE STUDENTS IN VARIOUS EXAMS

Exam	Max Marks	Average Marks 2020-21	Average Marks 2021-22	Increase in Average Marks
ESE	15	9.46	12.78	3.32

Upon conducting a course-end survey, as represented in Fig. 6, the results indicate that a significant portion of students expressed a high level of agreement regarding their ability to design jigs and fixtures for designated components. Specifically, 78.23% of students strongly agree, 12.34% agree, and 8.4% fairly agree with their capability in this regard. Only a minimal percentage, 1.19% of students, falls into the "not agree" category. This data underscores that an impressive 99% of students actively engaged in the learning process, demonstrating a strong level of participation and confidence in their acquired skills for designing jigs and fixtures.

TABLE IV
ATTAINMENT OF CO4

CO	Attainment 2021-22	Attainment 2022-23	% Increase in Attainment
CO4	65.56	72.36	10.37

Fig. 7 illustrated the feedback collected from students immediately after the activity, and it reveals that an overwhelming majority, exceeding 95% of the students, expressed agreement regarding two key aspects. Firstly, they enjoyed the activity, and secondly, they believe that this activity will significantly contribute to their understanding of the concepts related to jigs and fixtures.

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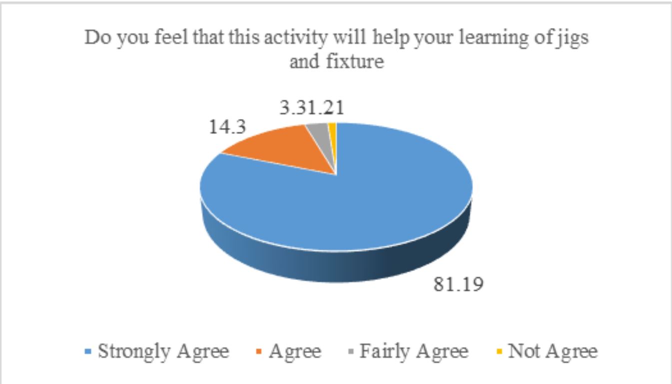

Fig. 7. Feedback of activity

IV. Conclusions

The activity, which was integrated into the tool engineering course for second-year mechanical students, was executed effectively with the aim of enhancing the visualization and imagination skills of engineering students. The outcomes of this initiative have been thoroughly examined and are presented within this article. Furthermore, the article includes a comparison of the course outcome attainment and the end-of-semester exam (ESE) results in relation to past performance. Drawing upon these observations, the following conclusions have been formulated. The engagement of students towards learning of design of jigs and fixtures improved due to implemented activity. Through the implementation of this activity, the instructor was able to assess and categorize students based on their levels of imagination and visualization skills. Those students identified with lower skill levels were given personalized encouragement and targeted training to help them enhance their visualization capabilities. This approach aimed to address individual learning needs effectively.

1. In comparison to the previous year, the average marks achieved by students in the design of jigs and fixtures during the End Semester Exam (ESE) showed improvement. This improvement directly contributed to an overall enhancement in the final grades of the students. It suggests that the activity positively impacted their understanding and application of the course content.
2. Notably, there was a substantial increase of 10.37% in the attainment of the CO related to the design of jigs and fixtures when compared to the previous academic year. This rise in attainment levels reflects the effectiveness of the teaching and learning strategies employed, demonstrating that students gained a deeper grasp of the subject matter.
3. Most significantly, this activity led to significant enhancements in the students' visualization and imagination skills. Additionally, their engagement in the learning process improved significantly. These outcomes collectively signify the success of the activity in fostering not only improved academic performance but also the development of valuable cognitive skills and increased student participation in their education.

In summary, the activity had a positive impact on students' academic performance, course outcomes, and essential skills, including visualization and engagement, ultimately contributing to a more successful and effective learning experience.

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