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An Attempt to Enhance the Visualization, Imagination and Drawing Skill of Freshman Engineering Students through Problem Based Learning Approach

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***Abstract*— The Engineering Drawing is one of the important and compulsory course for all the engineering students in first year engineering. This course improves the visualization, imagination and drawing skill of the students which are helpful them to draw their ideas clearly and rapidly, to read the drawing drawn by others and to create successful design. Engineering Drawing course includes projection, section and development of solids in which students are expected to imagine, visualize and develop the drawing as per given conditions also it includes orthographic projections in which 3D objects are required to convert in 2D drawing. The students of first year engineering find this task difficult due to no prior basic knowledge of technical drawing, poor imagination and visualization skill. Hence the attainment of the course learning outcome related to these topics is recorded low. To overcome this problem, a problem based learning approach implemented along with classroom teaching in order to enhance the, visualization, imagination and technical drawing skill of first 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 problem based learning (PBL), 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, Engineering Graphics, Engineering Drawing, Problem Based Learning**

***JEET Category*—Engineering Education for sustainable development**

I. INTRODUCTION

Engineering drawing is a universal technical language of an Engineers which is globally accepted technical language to communicate between engineering professionals. Based on Engineering drawing skill Engineers can able to create designs, represents them on drawing sheet and finally prepare blue print before the manufacturing (Murthy et al., 2015). The ability to understand important topics in engineering drawing such as orthographic projection, isometric drawing, hidden views, and sectional views are very critical as it represents the fundamentals of engineering drawing education (Serdar and De Vries ,2020). Engineering drawing is the compulsory course in first year engineering class to improve the drawing and imagination skill of the students, however due to lack of prior basic knowledge of technical drawing, poor imagination skill of the students and time restrictions in the classroom teaching, it is challenging for the faculty members to train the students for good drawing skill with conventional teaching methodology. Hence many faculty members implemented innovative teaching methodologies. Murthy et al. (2015) implemented Augmented Reality (AR) as a tool for teaching Engineering Drawing and improved 3D visualization of the students. Chen et al. (2011) developed tangible and AR models for Engineering Drawing course to increase the learning interest of students and to improve the visualization of the students. Pucha and Utschig (2012) implemented learning-centered strategies like case studies and real-world problems for freshman engineering students while teaching Engineering Drawing course. Authors have presented the impact of the learning-centered strategies on students learning, engagement and performance. Soundattikar and Naik (2016) conducted case study while teaching Total Quality Management course. They found that case study is effective tool for engaging students with different learning styles. Perumaal (2018) created effective learning environment for the course Engineering graphics through different active learning activities to improve the spatial visualization of students. Govil (2021) introduced sketching as an iterative tool in engineering education to improve visual communication skill of the students. Shreeshail et al. (2021) implemented problem-based learning technique to impart engineering drawing standards. Zemke (2018) discussed case study on efforts taken to teach Engineering Graphics for blind students. The author has presented the progress of blind students while learning orthographic and isometric projections. Moyano et al. (2009) presented the case study on Engineering Graphics learning, author evaluated the prior knowledge and background of the freshman engineering students. Author concluded that the rate of students' cognitive development does not follow the efforts

taken by faculty member during teaching learning process, hence new suitable methodology could be developed to improve the cognitive abilities of the students. Potter and Merwe (2003) presented the efforts taken to improve the result of Engineering Graphics through different active learning techniques and instructional activities in their university. Serdar and De Vries (2015) observed that students usually face difficulties visualizing 2D orthographic views of an object and visualizing a 3D model from a 2D technical drawing. Surywanshi and Deshpande (2020) explained the learning experiences of the students through product development with perspective of PBL. Deborah et al. (2011) discussed, PBL alters the nature of teaching and learning, and many instructors embrace it despite the lack of clear, conclusive proof of its efficacy. In essence, they want to be free to operate in a new classroom paradigm, one in which students are engaged and in charge of their learning. Baek et al. (2008) discussed the PBL efficacy in terms of student learning outcomes, including acquisition and application of fundamental domain knowledge, retention of information and problem-solving abilities, higher order thinking, self-directed learning/lifelong learning, and self-perception.

To improve the visualization, imagination and technical drawing skill of the freshman engineering students through conventional classroom teaching is the challenging task to instructor. Learning engineering drawing is also more difficult for freshman engineering students due to a lack of prior basic knowledge of technical drawing, as well as poor visualization and imagination skills, resulting in poor attainment of respective course outcomes and increased failure in the engineering drawing course. To overcome this problem, author attempted problem based learning approach while teaching engineering drawing. So this article presents, the systematic efforts taken to improve the visualization, imagination and drawing skill through active engagement of students for learning in the classroom and outside of classroom.

II. Methodology and Implementation

Authors implemented two activities in the classroom which are discussed in this section. In both activities various problems in terms of physical/virtual objects and models are provided to individual student and group of students where they have to apply knowledge of engineering drawing. Both activity focusing on the student's problem solving ability through PBL. These activities are addressing the COs which are shown in Table I

TABLE I
COURSE OUTCOMES (COs)

CO	*Statement*	*Activity*
CO1	Draw the projections of line, plane and regular solids with respect to reference planes as per given conditions	Activity II
CO2	Generate sectional view, true shape of sections and development of lateral surfaces of regular solids	Activity II
CO3	Prepare orthographic views of engineering components	Activity I

The objective these activities is to improve the visualization, creativity, and technical drawing abilities of first-year engineering students.

Rubrics for Case Study Assessment

Course: Engineering Graphics

Criteria	Level 3 (5)	Level 2 (3-4)	Level 1 (0-2)
Planning of drawing and product parts	Excellent planning of drawing and more than 90% parts of product are considered.	Good planning of drawing and 60-90 % parts of product are considered.	Poor planning of drawing and at least 60% parts of product are considered.
Drawing Accuracy	All geometry in the drawing is continuous. Drawing Views provided are sufficient, correct and appropriate.	70% of all geometry in the drawing is continuous. Drawing views provided are sufficient, correct and appropriate.	30% of all geometry in the drawing is continuous. 30% drawing views provided are sufficient, correct or appropriate.
Dimensions	All dimensions are given as per ISO standards	Only few dimensions are given	No dimensions are given
Timely Submission	Drawing Sheet is submitted before due date.	Drawing Sheet is submitted on due date	Drawing Sheet is submitted after due date

Fig. 1. Rubrics sheet for case study assessment

TABLE II
PRODUCTS TO DEVELOP ORTHOGRAPHIC VIEWS

Sr. No.	*Name of Product*	*Sr. No.*	*Name of Product*	*Sr. No.*	*Name of Product*
1	Compass box	16	Water Purifier	31	Iron
2	Slate	17	Washing Machine	32	Gas Cylinder
3	Mixer Grinder	18	Cupboard	33	Calculator
4	Kettle	19	Dining table	34	Scissor
5	Bucket	20	Table Fan	35	Class room Bench
6	Mug	21	Table Lamp	36	Sharpener
7	Cooker	22	Fan	37	Gas Stove
8	Cricket Bat	23	Camera	38	Rock oil stove
9	Bed	24	Mobile	39	Saw
10	Telephone	25	Stool	40	Flat Files
11	Showcase	26	Computer Monitor	41	Milk Can
12	Hammer	27	DVD Player	42	Bench Vice
13	Spanner	28	Oven	43	Spur Gear
14	Lock	29	Refrigerator	44	Bicycle Wheel
15	Tea Kettle	30	TV Remote	45	Bench Vice

Activity-I

Authors implemented the Activity-I while teaching orthographic projection in Engineering Drawing to engage the students outside the classroom for learning, improve the imagination and drawing skill of the students and improve the course outcome attainment. After teaching the basics of the orthographic projection instructor introduced the case study

activity to the freshman engineering students. In this activity, students were asked to draw orthographic views of the products provided by instructor. Each student provided different product which is depicted in Table II. Students were instructed to find the product allotted to them and by taking measurements or assuming dimensions of the product, the orthographic views of the product was required to draw on A4 size sheet using AutoCAD software tool. All the guidelines to develop orthographic views provided to the students also the assessment methodology was explained by the instructor with rubrics sheet as shown in Fig. 1. For grading of the case study four criteria were considered, each criterion was considered for maximum 5 marks, the total 20 marks considered for the activity.

Activity-II

Authors implemented the model building activity while teaching projection of solids, section of solids and development of solid surfaces in Engineering Drawing to engage the students outside the classroom for learning, improve the imagination and visualization of the students. After teaching the basics of the projection of solids instructor introduced the model building activity to the freshman engineering students. In this activity, students were asked to prepare the models of different solids such as prism, pyramid, cone, cylinder, cube and tetrahedron of different sizes using hard card sheet paper. The models were prepared by cut section method, so it can be opened to see the sectional views and development of solids. The students were instructed to carry the models along with them during the class. The problem was displayed in the class after some basic introduction, student from each group were instructed to explain the problem with the respective model to their group members, which are depicted in Fig. 2. For every lecture of projection of solid, section of solid and development of solid surfaces this activity was conducted along with the students.

Fig. 2. Students working in groups

III. Result and Discussion

In this section the observations are recorded and discussed for two different activities.

Activity-I

After introducing the activity in the class, the sufficient time provided to the students and the drawing sheets of the students collected through Moodle for the grading. Total 45 students participated in the activity and submitted there drawing. The samples of the drawing depicted in the Fig. 3. In which the students developed orthographic views of the product allotted to them, for the drawing, students used AutoCAD as a tool. The case study drawing sheets graded as per rubrics shared with students which is shown in Fig. 1.

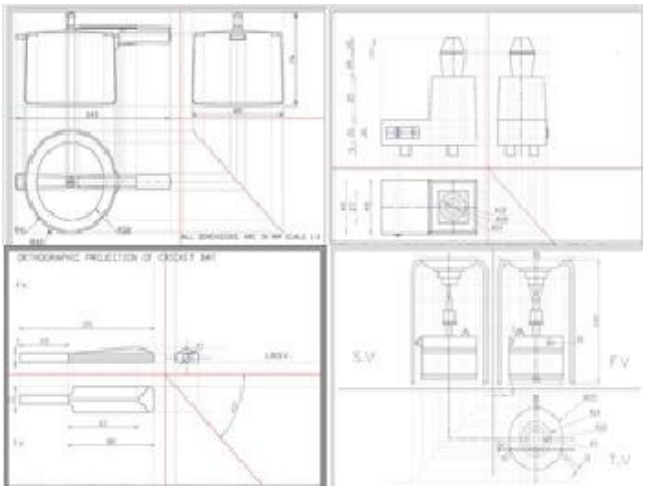

Fig. 3. Sample drawing sheets

The drawing sheets are graded and the marks of the students communicated along with common suggestions in the class. The result of the case study is analyzed and classified in the four group which is presented in the Table III. From the results it was cleared that the greater number of students earned marks in the range 11-15, and only 11 students got marks in the range 16-20. There were no students in between 0-5 marks. According to marks earned by students, they were categorized with poor, average and good skill of the drawing.

According to drawing skill of the students, they were motivated to improve the drawing skill, also task of drawing provided to the students. For the end semester exam (ESE), the weightage for the orthographic question is 24 marks which contribute to attain course outcome i.e., develop orthographic views of an object to convert pictorial view into two-dimension (2D) view. It is observed that the average marks of the students improved compared to previous two years which contributes to improve the attainment level of course outcome.

TABLE III
GRADING OF THE ACTIVITY-I

Sr. No.	*Range of Marks*	*No. of Students*	*Remark*
1	0-5	--	--
2	6-10	13	Poor skill
3	11-15	21	Average skill
4	16-20	11	Good skill

The Table IV. shows the average attainment of the course outcome which is related to orthographic projections. It is clearly observed that the attainment level of CO3 improved significantly compare to previous two years where conventional modes of instruction practiced. The attainment of CO3 for the academic year 2021-2022 improved more than 15% compare to academic year 2020-21.

TABLE IV
ATTAINMENT OF CO3

Sr. No.	*Academic Year*	*Attainment of CO3 (%)*
1	2019-20	68
2	2020-21	65
3	2021-22	75

At the end of course the course end survey had taken which is depicted in Fig. 4, it is cleared from the figure that 58.3% students are strongly agree, 38.9% students agree and 2.8% students fairly agree that they can able to develop orthographic views of an object to convert pictorial view into two-dimension (2D) view. None of the student in the not agree category. This cleared that the 100% involvement of the students in learning.

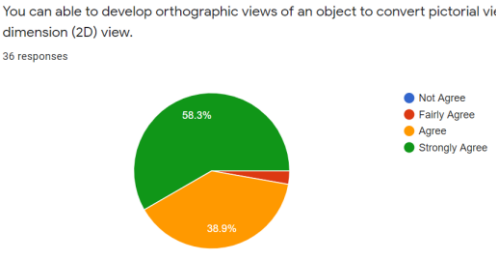

Fig. 4. Course end survey report

Activity-II

The impact of activity-II was observed in the Unit Test Exam(UT) and End Semester Exam.

The questions on the projection of solids, section of solids and development of solid surfaces were asked in the Unit Test I (UT I), Unit Test II (UT II) and End Semester Exam (ESE) for 10,25 and 39 marks respectively. In the test it was observed that there is significant improvement in the student's marks for the questions on projection of solids, section of solids and development of solid surfaces.

The marks obtained in the UT I, UT II and ESE in respective topics are compared with the previous two years result which is shown in Table V.

TABLE V
AVERAGE MARKS OF THE STUDENTS IN VARIOUS EXAMS

Exam	*Max Marks*	*Average Marks 2020-21*	*Average Marks 2021-22*	*Increase in Average Marks*
UT I	10	4.21	5.23	1.02
UT II	25	12.52	16.78	4.26
ESE	39	24.18	32.86	8.68

The average marks in the Q 2 of UT I (projection of solids) were increased from 4.21 to 5.23 in the 2021-22. There was 24.22% increase in the average marks of the students in the projection of solids in UT I. The average marks in UT II (Section and Development of solids) were improved from 12.52 to 16.78. In ESE also the average marks of the students increased from 24.18 to 32.86. Due to which attainment for this course learning outcomes for projection of solids, section and development of solids were increased by 9.96% and 4.73% respectively, as compared to previous year where conventional mode of teaching was practiced.

The Table VI shows the attainment of the COs related to projections of solids, section of solids and development of solid surfaces.

TABLE VI
ATTAINMENT OF CO1 AND CO2

CO	*Attainment 2020-21*	*Attainment 2021-22*	*%Increase in Attainment*
CO1	65.12	75.08	9.96
CO2	72.21	76.94	4.73

At the end of the course the feedback was taken for this activity which is depicted in the Fig 5. It is cleared from the feedback, 77.35% students are strongly agreeing, 19.28 % students agree and 3.47 students fairly agree that they can draw projections, sections and development of various solid according to given conditions. None of the student in the category of not agree. This cleared that the 100% engagement and involvement of the students in classroom for the projection, section and development of various solids.

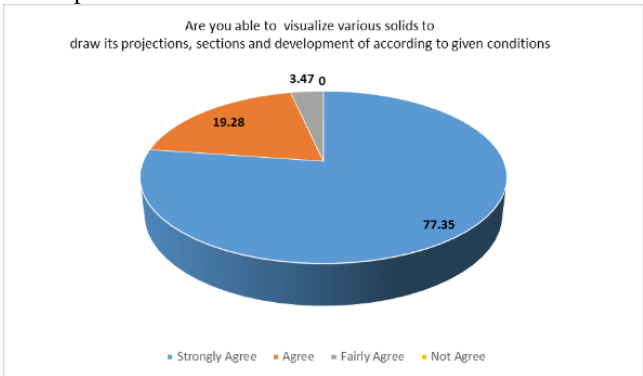

Fig. 5. Feedback Report

IV. CONCLUSIONS

The two different activities implemented successfully as a part of Engineering Graphics course to improve the technical drawing, visualization and imagination skill of freshman engineering students. The results are analyzed and presented in this article. Also, the attainment of CO and result of the ESE compared with the previous results. Based on the observations following conclusion are drawn.

1. The engagement of students outside the classroom towards learning of projection, section and development of solids as well as orthographic projection improved due to implemented activities.
2. Due to this activity instructor could able to categorize the students according to their imagination and visualization skill. The students who were in lower category separately motivated and trained for improving the visualization skill.
3. Average marks of the projection, section and development of solid surfaces in the UT I, UT II ESE improved compare to previous two years which contributed for improvement in final grades of the students.
4. Average marks of the orthographic projections in the end semester exam improved compare to previous two

years which contributed for improvement in final grades of the students.

5. The attainment of CO related to orthographic projections improved by 15% compare to previous year while the attainment of CO related to projection, section and development of solid surfaces 9.96% and 4.73% as compared to previous year.
6. Finally, the technical drawing skill, imagination skill and engagement of students in learning improved significantly.

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