K.E. Society's
Rajarambapu Institute of Technology,
Rajaramnagar

Quality Circle
2021-22

Report on

Development of Virtual Laboratory for CAD Modeling Lab course

By
M-CAD Quality Circle Team
Department of Mechanical Engineering

Chapter 1

Introduction

Coronavirus (COVID-19) has disrupted normal life cycle of human activities including teaching & learning process of going to schools/colleges. Due to COVID-19 whole world is locked in their homes and were not allowed to move outside their home. But this restrictions of movements of people including students should not hamper the teaching learning process. As the world has come closer due

to internet and availability of various meeting software, theory courses were taught online. But the problem came with the practical courses. It was difficult to visualize the students about the experiments throughonline and perform the experiments.

Virtual Laboratory concept has enabled the students to perform the experiments at home despite the unforeseen circumstances of COVID-19 pandemic comfort and safety of their home. During pandemic period online practical were conducted but students were unable to perform the practical online. To solve this problem development of Virtual Laboratory was required for each lab course by the department. To begin the development of Virtual Laboratory, it was decided to develop Virtual Lab for one practical course of Part-II of 2021-22.

This report is divided in to chapters and the following chapters are reserved to explain: chapter 1 on introduction, chapter 2 on the Online practical problems, chapter 3 on Virtual Lab development and implementation, chapter 4 on results, chapter 5 result analysis and recommended measures, chapter 6 conclusion and future work and references.

Chapter 2

Online Practical Problems

Laboratory courses were identified in which problems were faced while taking online practical during COVID-19 pandemic, analyzed and selected for the Best Practices activity for the academic year 2021-22.

2.1. Laboratory Identification: The laboratory identified through faculty's brainstorming are listed below:

Sr No	Laboratory Course Name	Class
1	Microcontroller Lab	SY B Tech (Mechatronics)
2	CAD Modeling Lab	SY B Tech (Mechatronics)
3	Kinematics & Dynamics of Machines Lab	SY B Tech (Mechatronics)
4	Object Oriented Programming Lab	SY B Tech (Mechatronics)
5	Workshop Practice-II	SY B Tech (Mechatronics)
6	Applied Thermodynamics Lab	SY B Tech (Mechanical)
7	Machine Drawing Lab	SY B Tech (Mechanical)
8	Computer Programming C++ Lab	SY B Tech (Mechanical)
9	Workshop Practice-II	SY B Tech (Mechanical)
10	Thermal Engineering Lab-III	TY B Tech (Mechanical)
11	NX-CAD	TY B Tech (Mechanical)
12	NX-CAM	TY B Tech (Mechanical)
13	MATLab	TY B Tech (Mechanical)
14	Software Development with C++	TY B Tech (Mechanical)

Out of 14 laboratory courses identified from Part-II of 2021-22, 8 laboratories courses were chosen based on the requirement of licensed software which is costly and students can't install and practice on their laptop/desktop/mobile phones, availability of open source software for the development of Virtual Lab, ease of installation& ease of use by students on their mobile/laptop/desktop and availability of expert in the team to develop the Virtual Lab which are shown in table 2.1.

Table 2.1: Laboratory identified with categories

Sr. No:	Laboratory	Licensed Software Required	Availability of Open Source Software	Ease of installation of by students
1	CAD Modeling Lab	Yes	Yes	No
2	Object Oriented Programming Lab	No	Yes	Yes
3	Machine Drawing Lab	Yes	Yes	Yes
4	Computer Programming C++ Lab	No	Yes	Yes
5	NX-CAD	Yes	No	No
6	NX-CAM	Yes	No	No
7	MATLab	Yes	No	No
8	Software Development with C++	No	Yes	Yes

2.1. Laboratory Selection: After identifying the 8 laboratory as mentioned in section 2.1, Rating method was used on the categorized problems for selecting the problem with each member rating on a scale of 1 to 5 where 1 or 2-representing less importance, 3-average importance, 4-high importance and 5- very high importance.

Table 2.2: Rating of individual team member on identified laboratory.

Sr. No	Problem	UMN	SBK	RAM	RVP	AKP	Total
1	CAD Modeling Lab	5	5	4	5	4	23
2	Object Oriented Programming Lab	3	3	4	4	4	18
3	Machine Drawing Lab	5	4	4	4	4	19
4	Computer Programming C++ Lab	5	4	3	3	4	19
5	NX-CAD	5	4	4	4	5	22
6	NX-CAM	3	4	4	3	3	17
7	MATLab	4	4	4	5	3	20
8	Software Development with C++	4	4	4	4	4	20

After collecting the individual rating of each member for each problem, the aggregate rating is considered for problem selection. From the ratings provided in the table 2.2, Student's online teaching-learning problem & requirement of CAD modeling skill of laboratory course was identified as a problem to be handled under best practices activity for the year 2021-22 which has scored the highest aggregate rating.

2.2. Problem Identification: The engineering students understand the engineering concepts effectively when they conduct the experiments in the laboratory. The COVID-19 pandemic has brought uncertainty in educational response, skilling methods, and training practices among teachers and institutions. In context of suspended face-to-face teaching, virtual laboratory is a powerful educational tool that ensure the continuity of teaching–learning, providing alternative ways for skill training from home. In view of the pandemic situations there is need to develop the virtual labs in engineering education.

In Mechanical Engineering Department, Students as well as faculty members has faced more difficulties while delivering the modeling software, as students were not having the sufficient facilities of laptop, PC, Internet connectivity, and license copy of software.

2.3. Problem Analysis: It is observed that the effective student engagement for lab courses beyond the classroom is dependent on various factors which needs to be addressed together. The following information is collected using 4W-1H principle shown in figure 2.1 regarding the causes for poor engagement beyond classroom through brainstorming, analyzed them and categorized into causes related to students, faculty and environment.

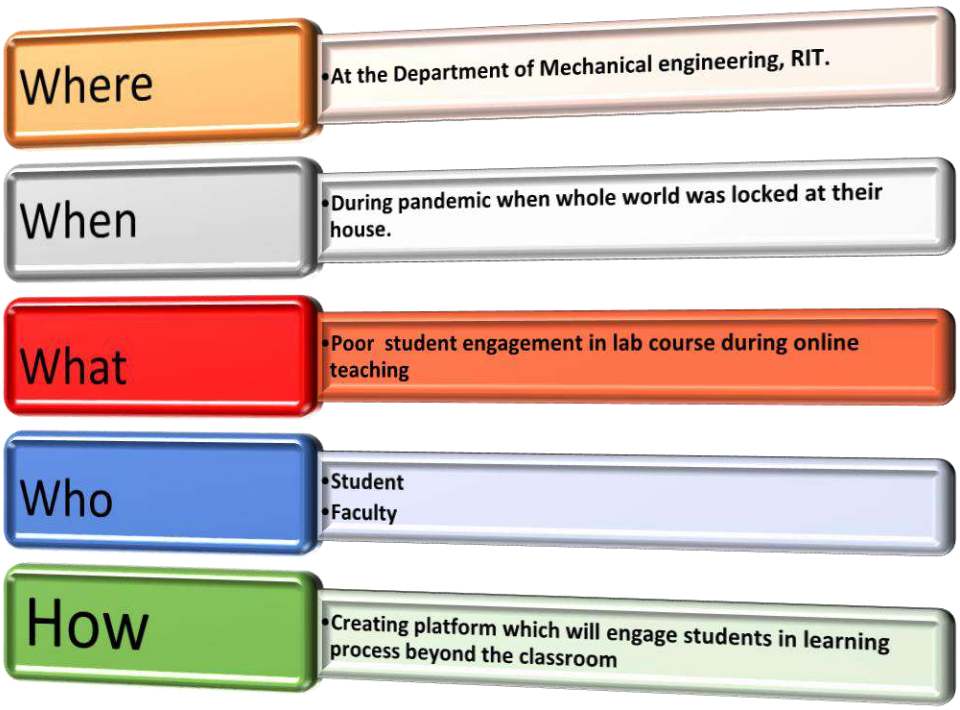


Figure: 2.1. Problem Analysis: 4W-1H principle.

There are several causes for students' low involvement in online learning modes. Unsurprisingly, the online learning environment presents several problems as well as numerous benefits to student learning. Many authors have undertaken various research on this subject. The most often reported

obstacles in the study literature fall into two major categories: challenges caused by a mismatch between students' individual learning style preferences and the online learning environment, and communication challenges. Concerning difficulties resulting from a mismatch between students' particular learning style preferences and the online learning environment.

According to Cavanaugh et al (2008) 's [4] analysis of the research, extroverted students analysis of the research, extroverted students may lack face-to-face connection with classmates in an online environment, while students who do not have strong verbal/reading skills may be at a disadvantage in a text-heavy online environment.

According to Li and Beverly's (2008) [5] review of the research, the online learning environment may not be ideal for students who struggle to stay motivated or lack self-discipline, students who are less independent or dislike working independently, students who require more hands-on assistance, students who lack basic computer skills or are uncomfortable with technology, and students who lack advanced communication, time management, and organizational skills.

With respect to challenges in communication, Li and Beverly (2008) [5] observed that there is a significantly greater potential for misinterpretation in the online environment, particularly in the effect of e-mail correspondence (e.g., students can sometimes come across as too informal and even rude, and instructors can sometimes come across as overly harsh or critical).

Dykman and Davis (2008) [6] have observed that there are less opportunities for informal contacts between students and between teacher and student in an online classroom, which serve to reinforce expectations and explain misunderstandings. Furthermore, when communication breaks down in an online learning setting, the situation can occasionally develop without either party realizing it until it is too late.

2.2. Cause and Effect Analysis: The reasons with respect to students, faculty and infrastructure are expressed through the cause and effect diagram in figure 2.2. The text boxes under each category indicates the causes for poor engagement of students in online learning of practical courses.

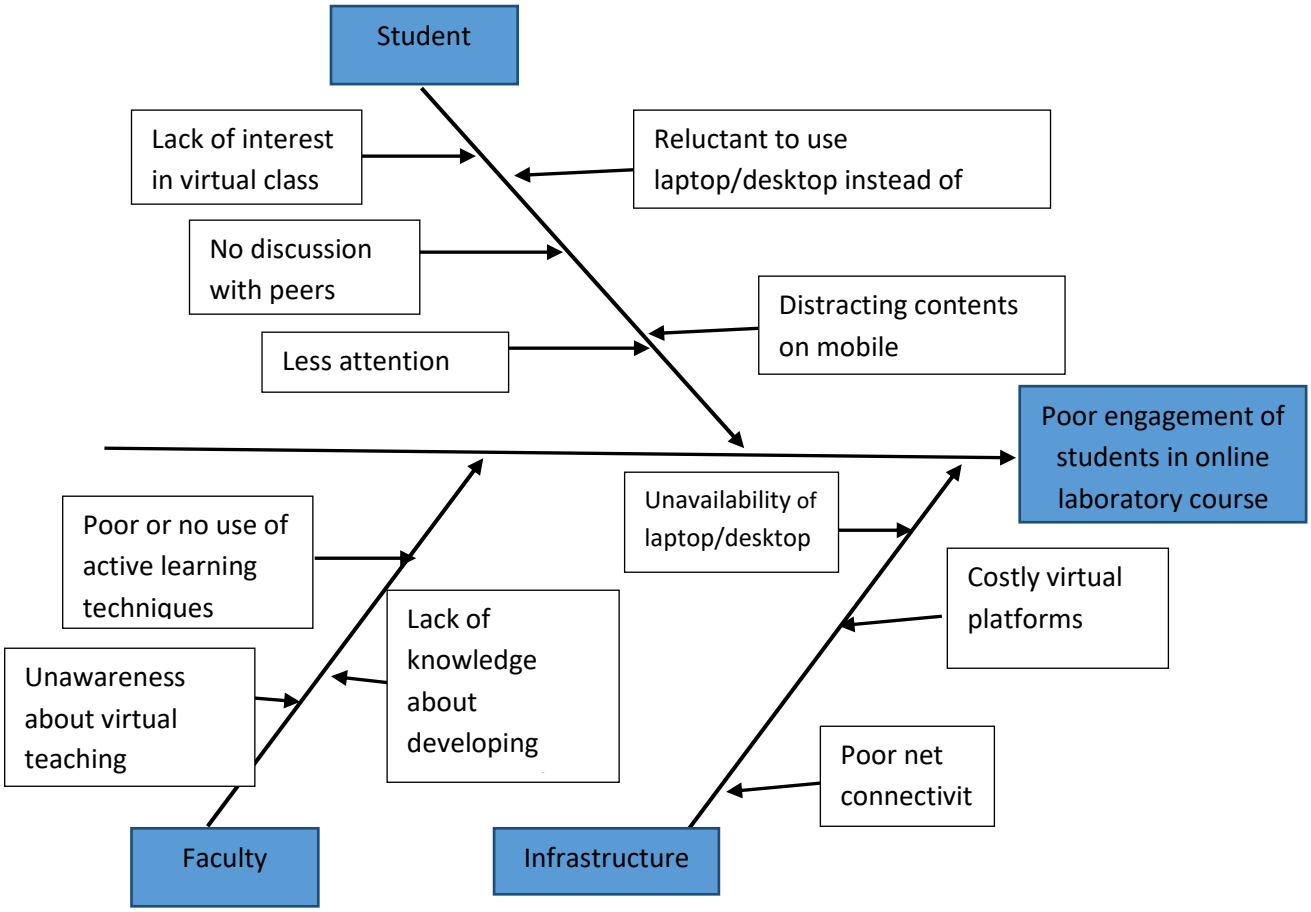


Figure: 2.2. Cause and Effect Analysis: Cause and Effect Diagram

Cause and effect analysis gave various root causes for the poor engagement of students in online lab class as shown in fig. 2.2.

2.3 Proposed Solutions: The following alternative solutions were proposed based on the route causes mentioned in the section 2.7. They are:

1. Calling students to the laboratories in short batches during COVID-19 pandemic.
2. Preparing lab videos using Assistants and sharing with students.
3. Motivating students for self-learning.
4. Development of virtual lab platform using available free sources and making it available for students to use it remotely.

Table 2.3: Rating of individual team member on alternate solutions.

Sr. No	Problem	UMN	SBK	RAM	RVP	AKP	Total
1.	Calling students to the laboratories in short batches during COVID-19 pandemic.	4	4	4	4	5	21
2.	Preparing lab videos using Assistants and sharing with students.	5	4	4	5	5	23
3.	Motivating students for self-learning.	4	4	4	4	4	20
4.	**Development of virtual lab platform using available free sources and making it available for students to use it remotely.**	5	5	5	5	5	25

The alternate solutions mentioned above were identified to improve the active engagement of students in learning the lab courses. From the rating method applied on alternate solutions, it was observed that all the solutions are necessary and implementing any one solution may not result in the improvement of learning in virtual mode. The alternate solution: "**Development of virtual lab platform using available free sources and making it available for students to use it remotely**" gained the highest score.

Chapter 3

Proposed Solution and Implementation

In this chapter, the proposed solution to the problems faced during online teaching/learning process of lab courses and its implementation is discussed.

3.1.Proposed Solution: To solve the problems of teaching online lab courses, it was decided to develop Virtual Lab for CAD Modeling Lab course by forming a team of faculties from Mechanical Department under the best practices activity of Quality Circle. For better coordination while developing Virtual Lab, tasks were given to the team members

Table 3.1: Portfolios identified.

Sr. No	Faculty Name	Task
1	Prof UM Nimbalkar	Coordinator
2	Prof SB Khot	Development of WordPress Website
3	Prof RA Magdum	Developing solution for VL
4	Prof RV Pawar	Documentation& Data collection
5	Prof AK Patil	Google Form generation &data collection

Figure 3.1 shows the flow chart for developing Virtual Laboratory by using open source software FreeCAD. The activities proposed are progressive and iterative. The development of Virtual Laboratory includes data collection, resources available, testing and implementation.

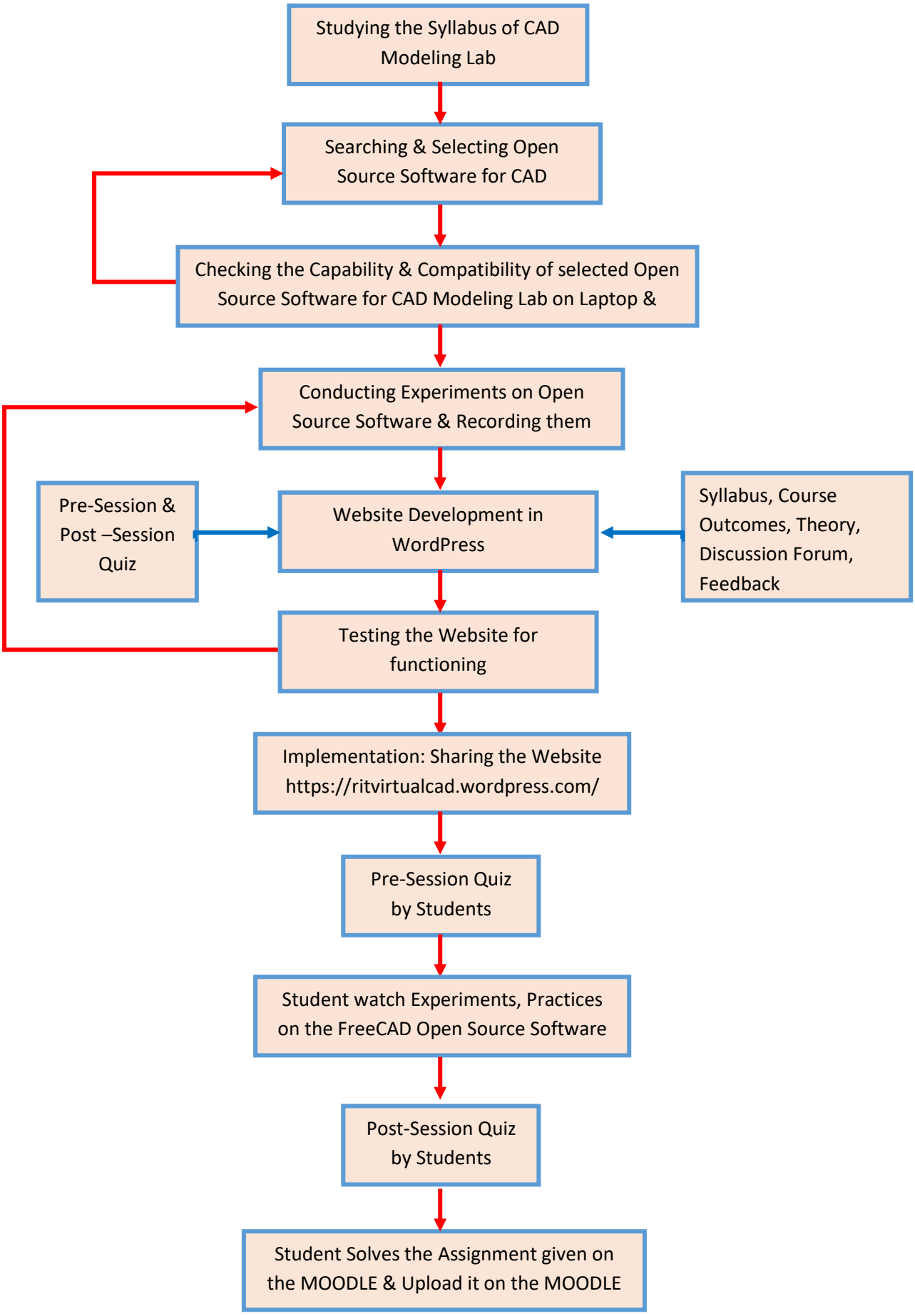


Figure 3.1: Overview of Proposed Solution.

3.2.Studying the syllabus of CAD Modeling Lab Course: The syllabus of CAD Modeling Lab of SY B Tech Mechatronics is studied and experiments are grouped into sketcher and modeling categories depending upon the capability of open source software:

1. **Sketcher part 1:** Drawing of Line, Triangle, Rectangle, Circle, Ellipse and other standard components.
2. **Sketcher part 2**: Constraints: Dimensioning of the sketch, use of Geometrical constraints, dimensional constraints.
3. **Sketcher part 3:** Sketching of Industrial components
4. **Part Design 1:** 3D Modeling basic commands
5. **Part Design 2:** Use of Transformation features for 3D Modeling
6. **Part Design 3:** Creating 3D Model of Industrial component

The same experiments can be used for TY B Tech Mechanical having 02 divisions A & B in Part-I of the next academic year 2022-23.

3.3.Searching & Selecting Open Source Software for CAD: During Online search for open source CAD Modeling software which has the capabilityfor sketching &modeling the mechanicalcomponents, following software are available:

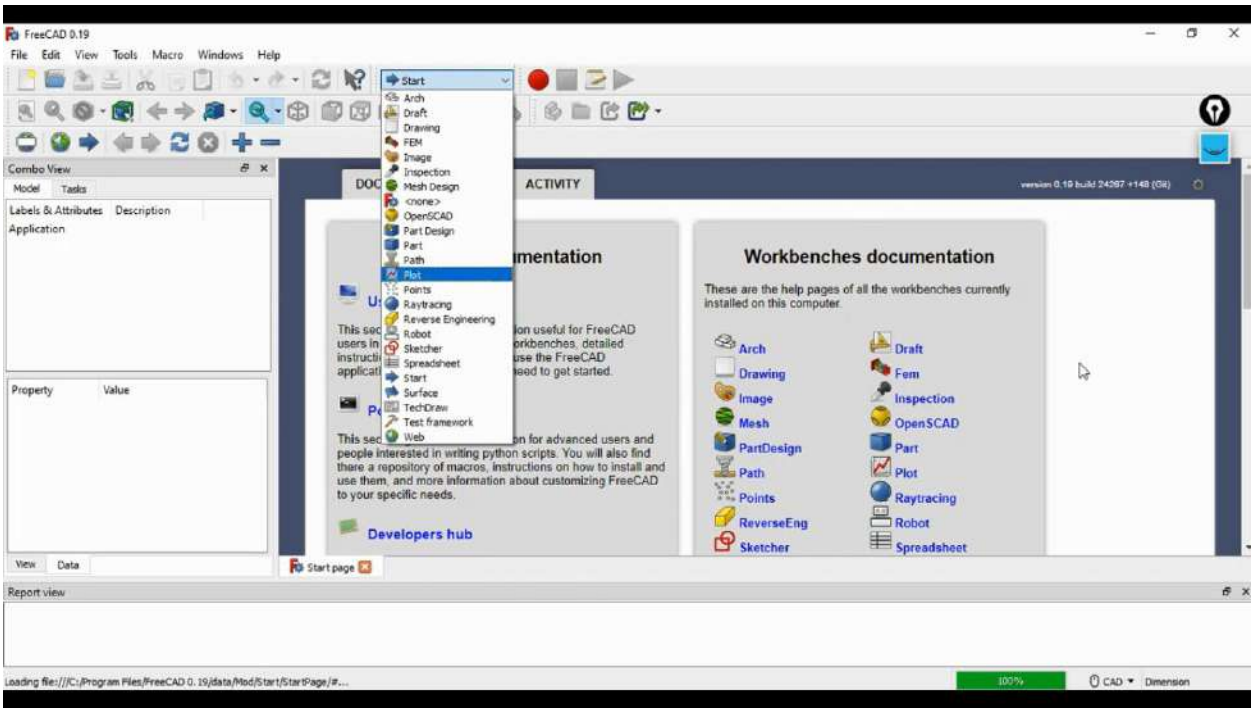
1. FreeCAD
2. Blender
3. OpenSCAD
4. Wings 3D
5. OpenCascade Technology
6. SolveSpace
7. QCAD

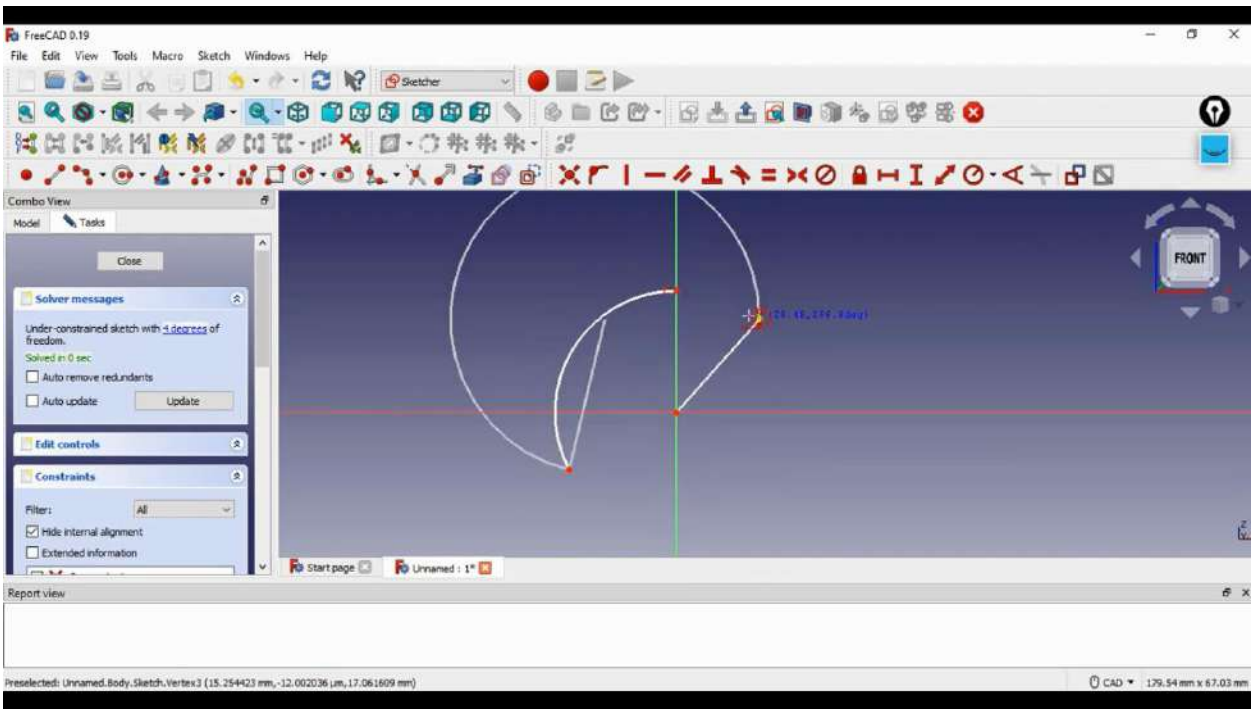
3.4. Checking the Capability & Compatibility on Laptop & Mobile: After evaluating the capabilities and compatibility of above open source CAD software on laptop & mobile phone, FreeCAD open source software is selected for development of Virtual Laboratory of CAD modeling Lab course. FreeCAD open source is selected on following points:

1. It is flexible, has simple design process and intuitive interface.
2. Used professionally for design solution.
3. FreeCAD makes 3D design easier.
4. Easily available, less memory required.
5. Mobile app is available for Android mobile phones.

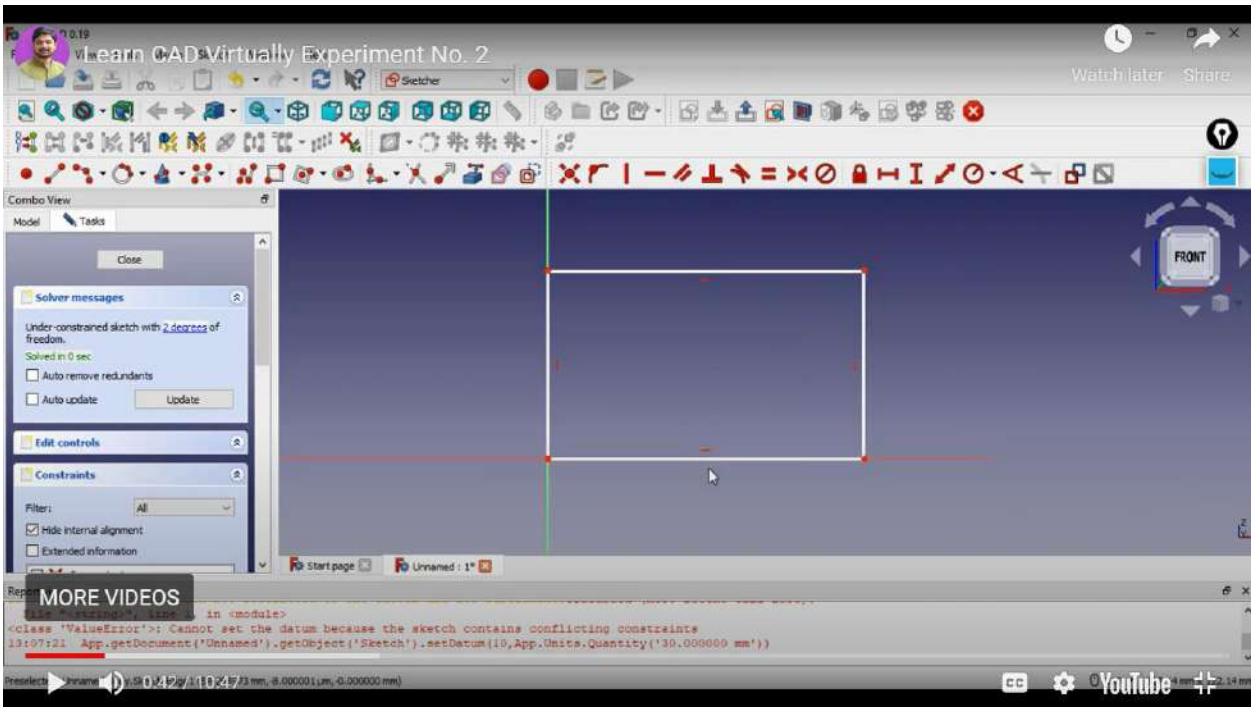
3.5. Conducting Experiments on FreeCAD Open Source Software and Recording: Experiments conducted on FreeCAD open source software as per the list mentioned in 3.2 and were recorded simultaneously.

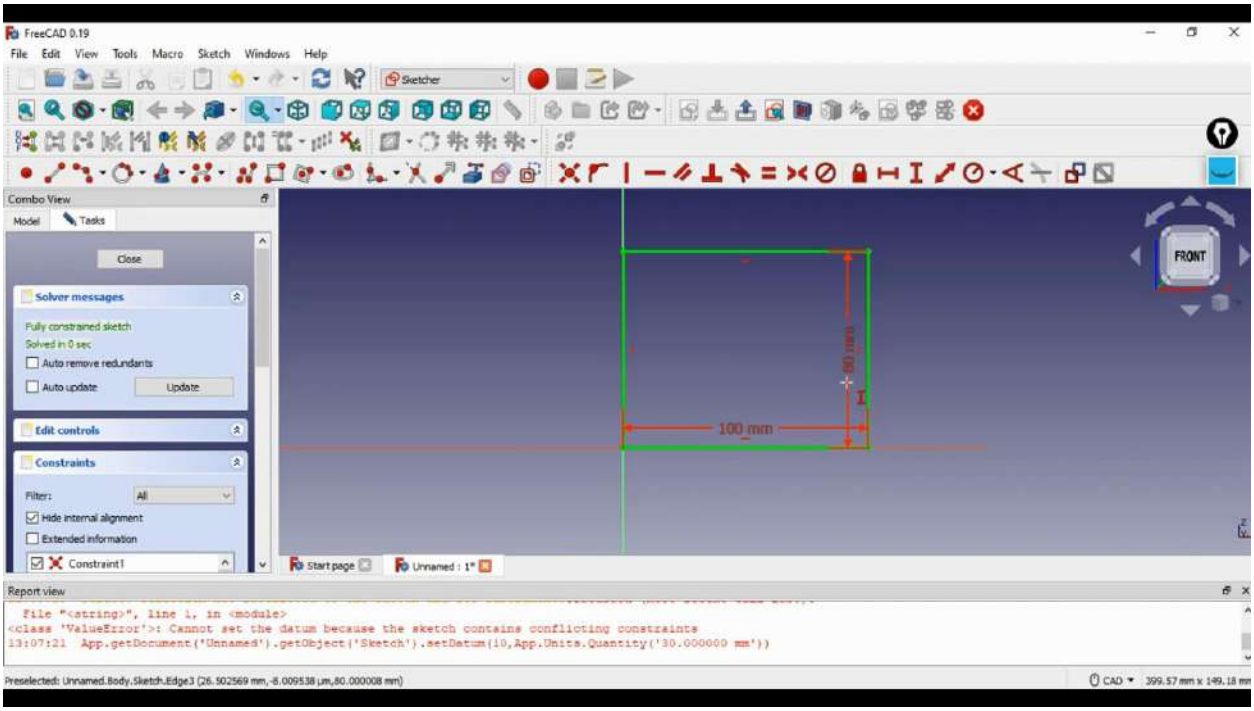
1. **Sketcher part 1:** Drawing of Line, Triangle, Rectangle, Circle, Ellipse and other standard components.



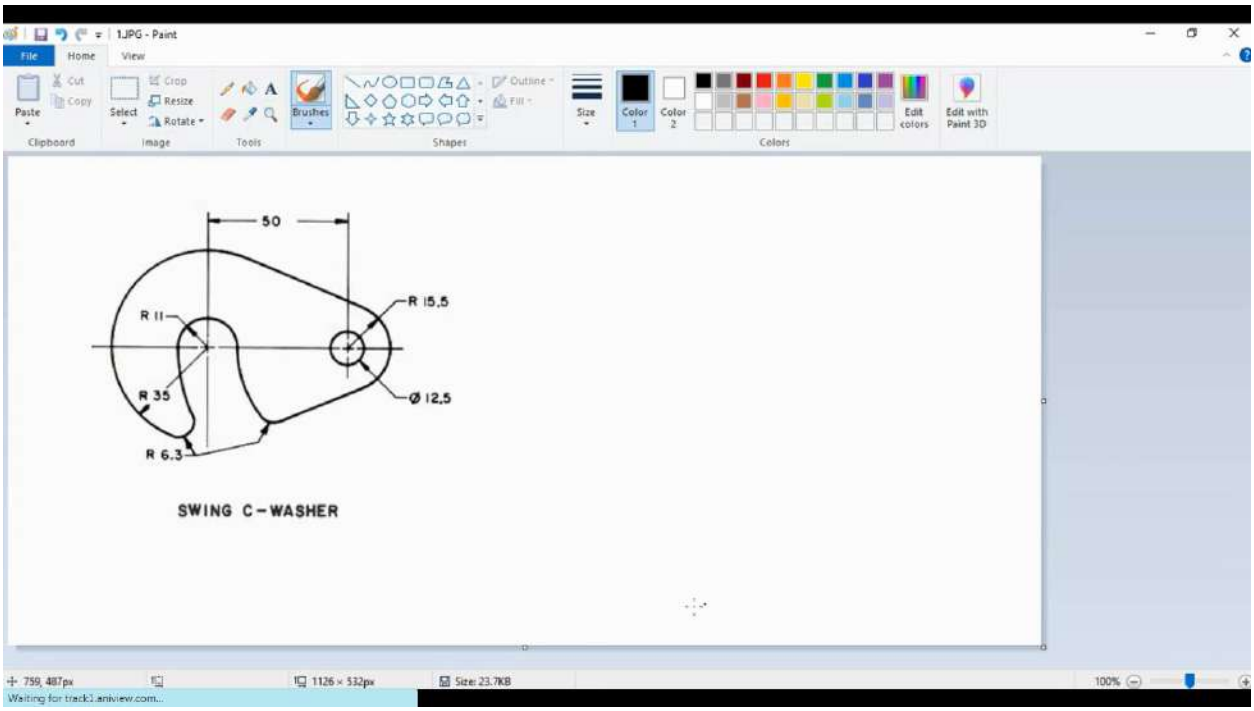


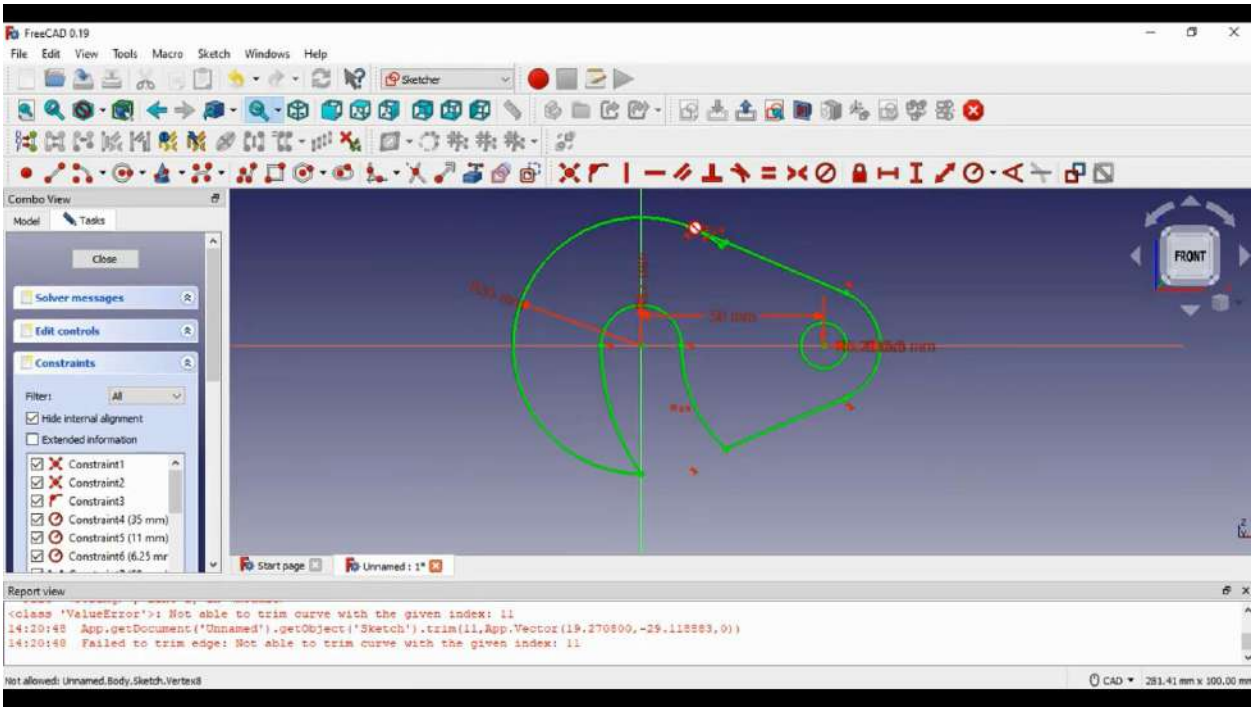
2. **Sketcher part 2**: Constraints: Dimensioning of the sketch, use of Geometrical constraints, dimensional constraints.



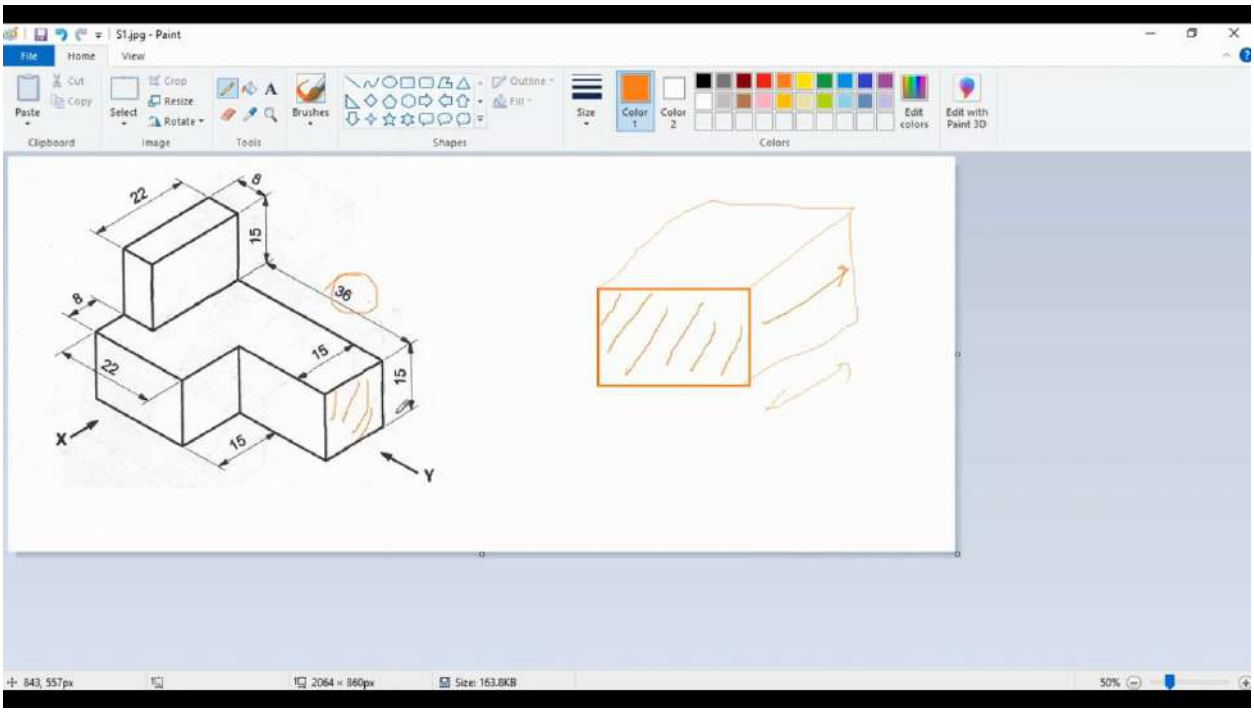


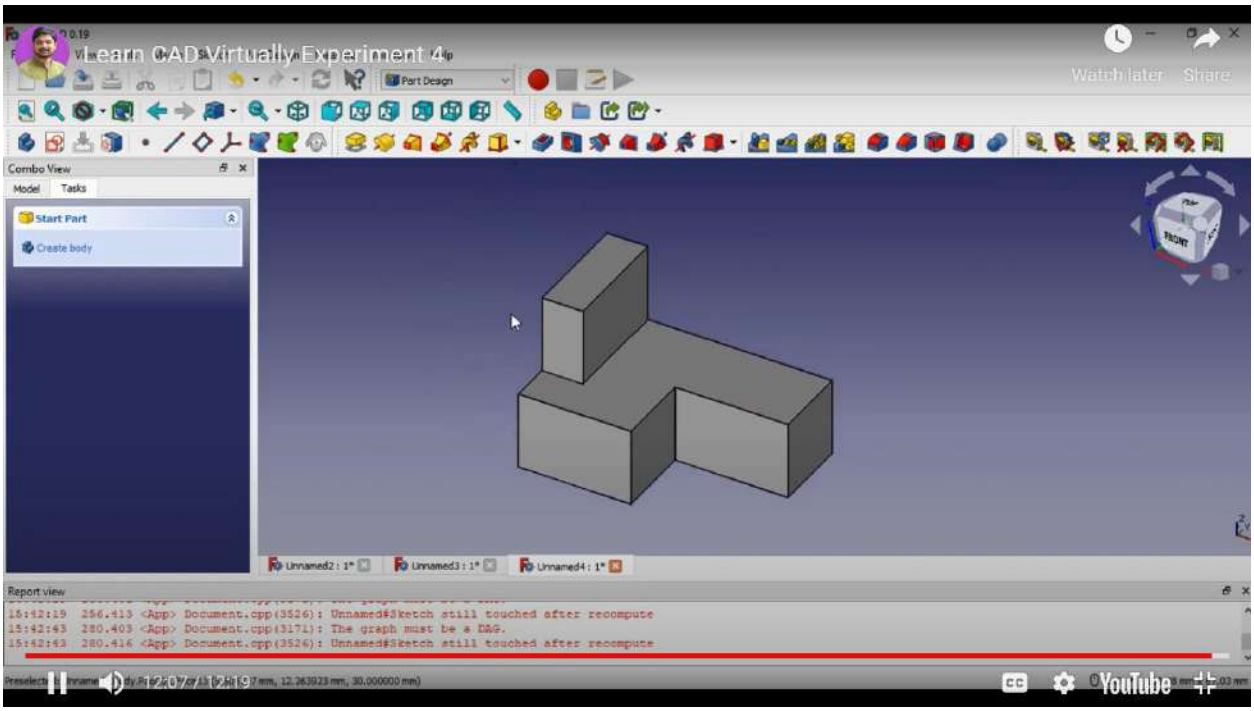
3. **Sketcher part 3:** Sketching of Industrial components



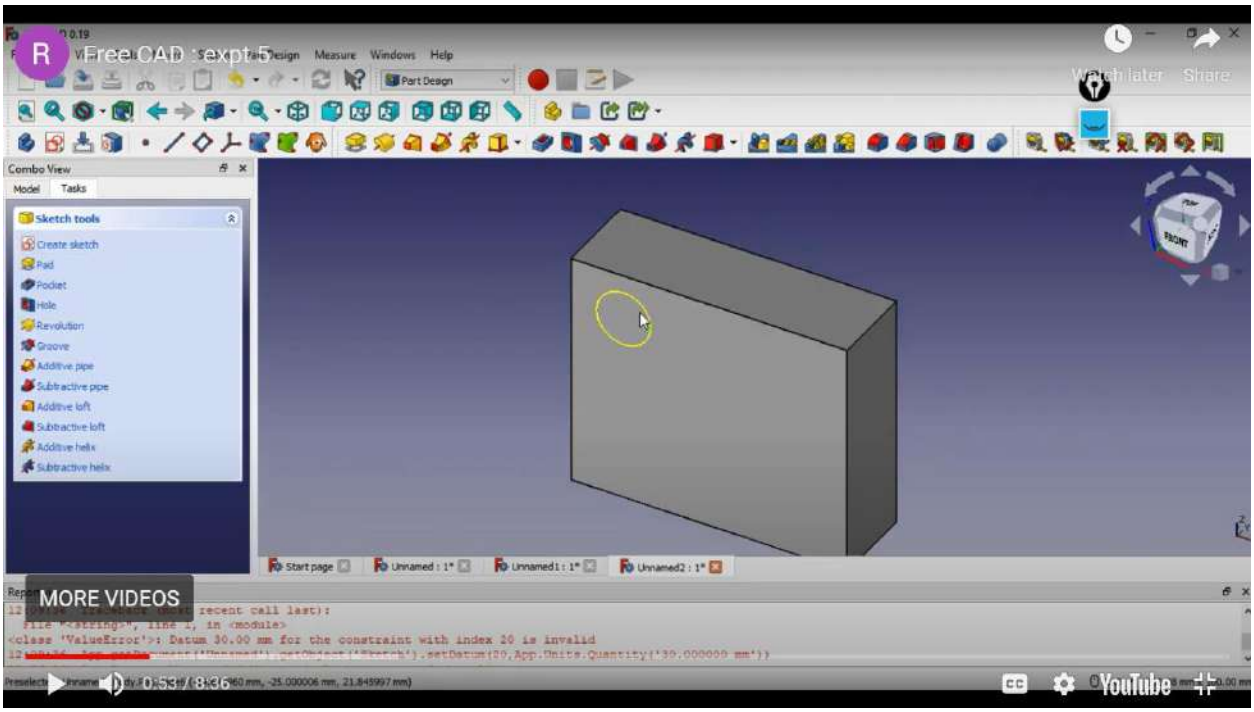


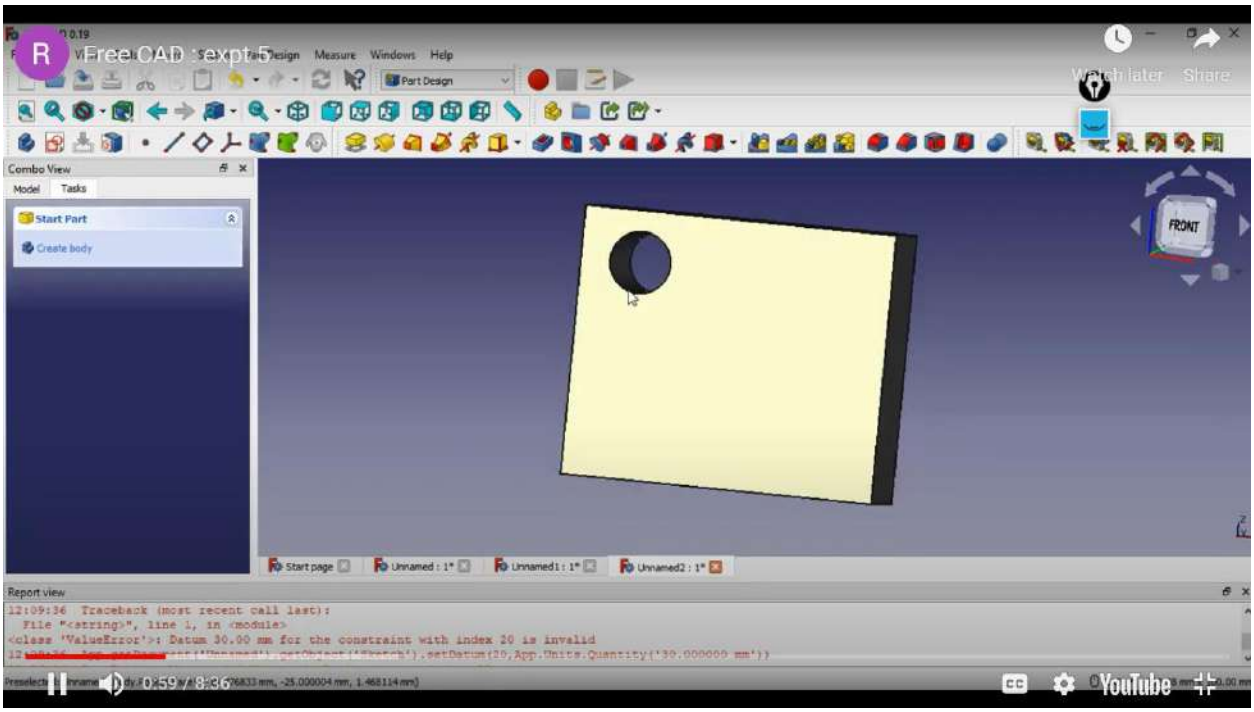
4. **Part Design 1:** 3D Modeling basic commands



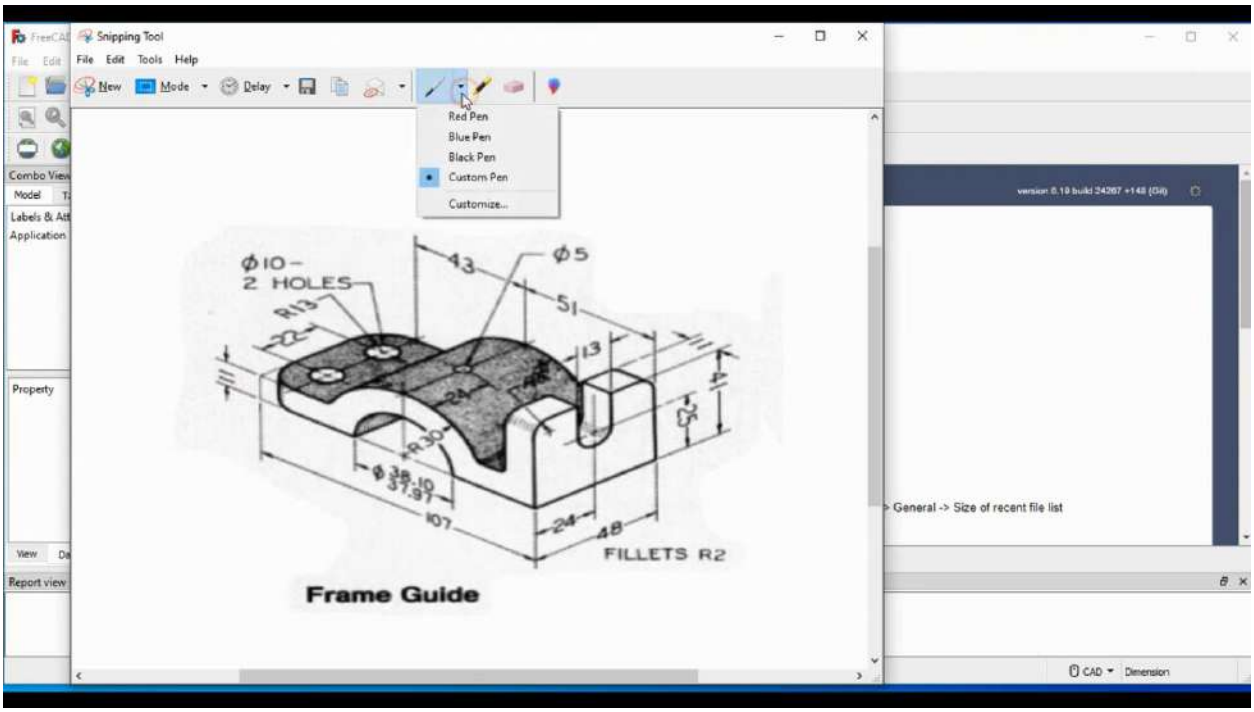


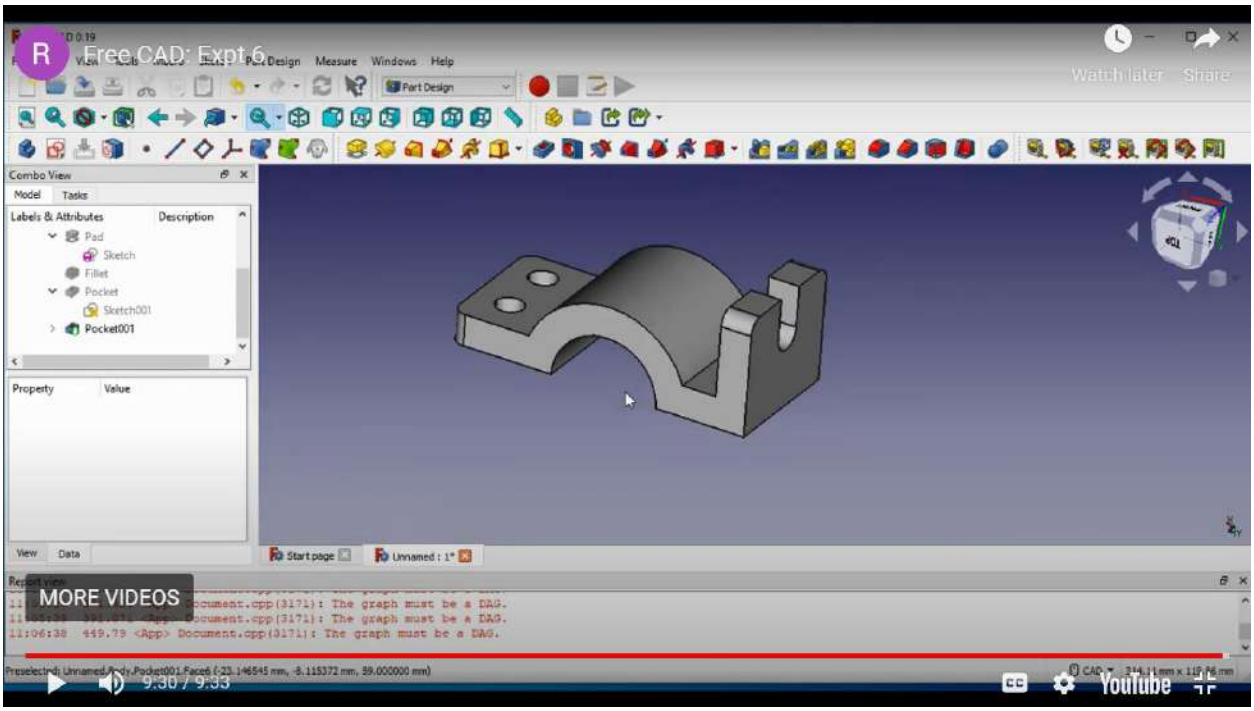
5. **Part Design 2:** Use of Transformation features for 3D Modeling





6. **Part Design 3:** Creating 3D Model of Industrial component



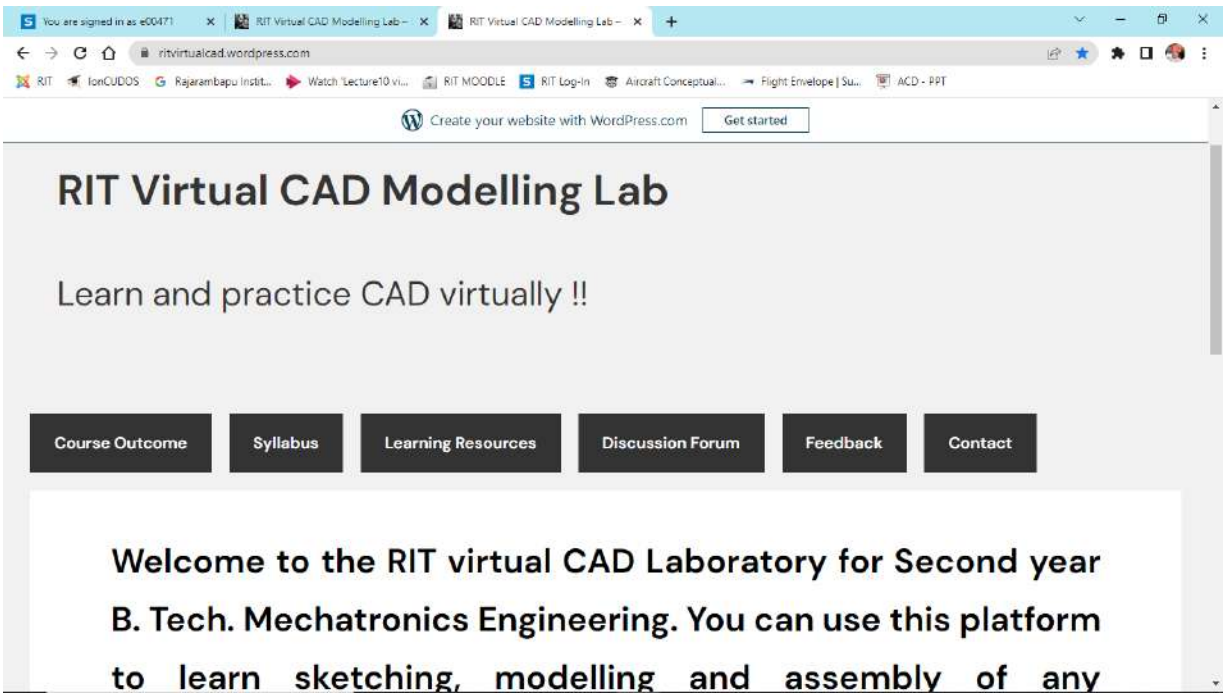


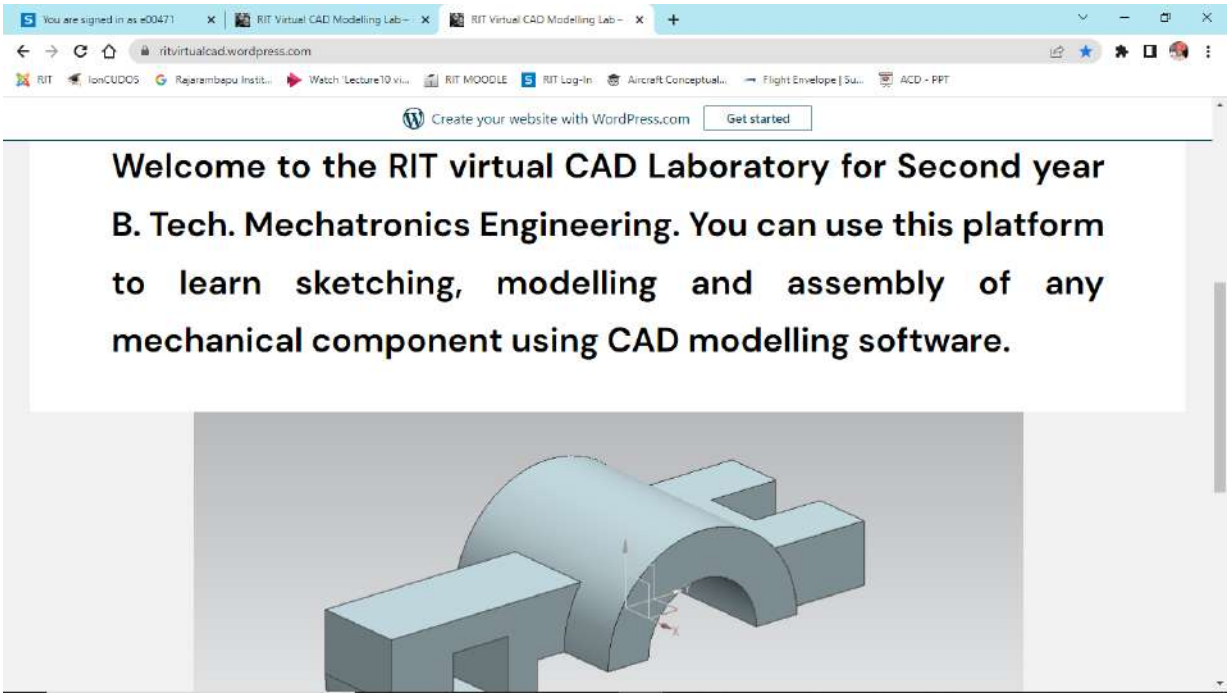
3.6. Website Development in WordPress Open Source Software: Website "https://ritvirtualcad.wordpress.com/ " is developed in WordPresswhich is also Open Source Software for the website development.

The website can be accessed from desktop or laptop or mobile phone The website has 6 buttons which are linked to their appropriate information. The 6 command buttons are as follows:

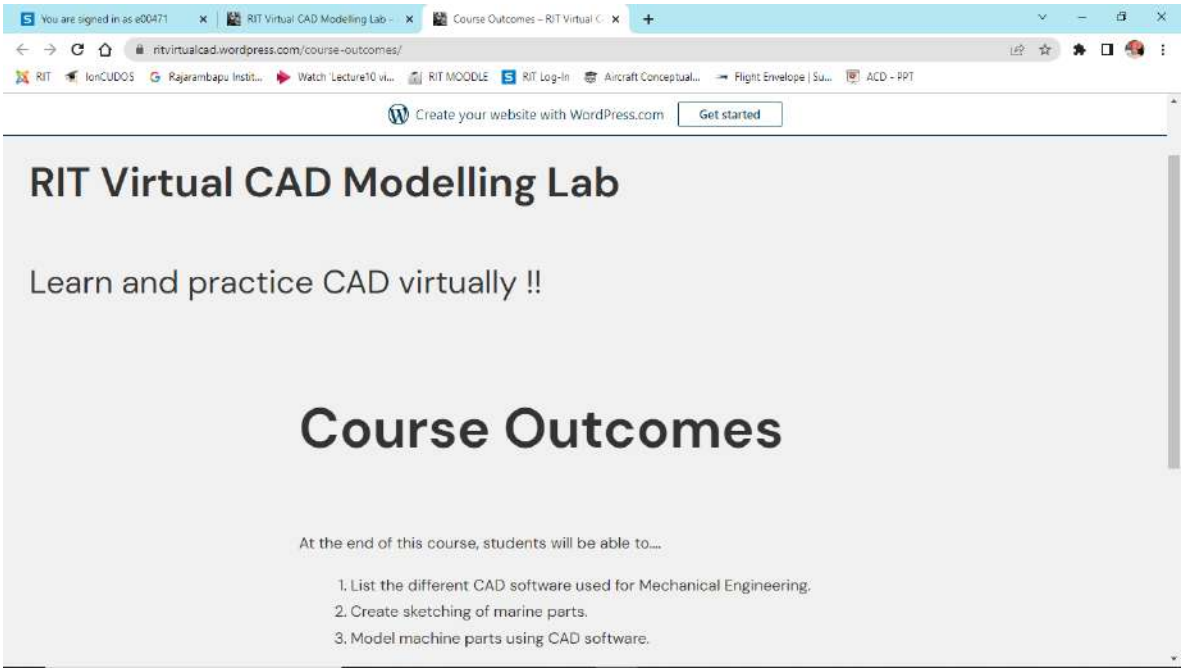
1. Course outcomes
2. Syllabus
3. Learning Resources with Pre-Session Quiz & Post-Session Quiz
4. Discussion Forum
5. Feedback
6. Contact

Website Home Page:



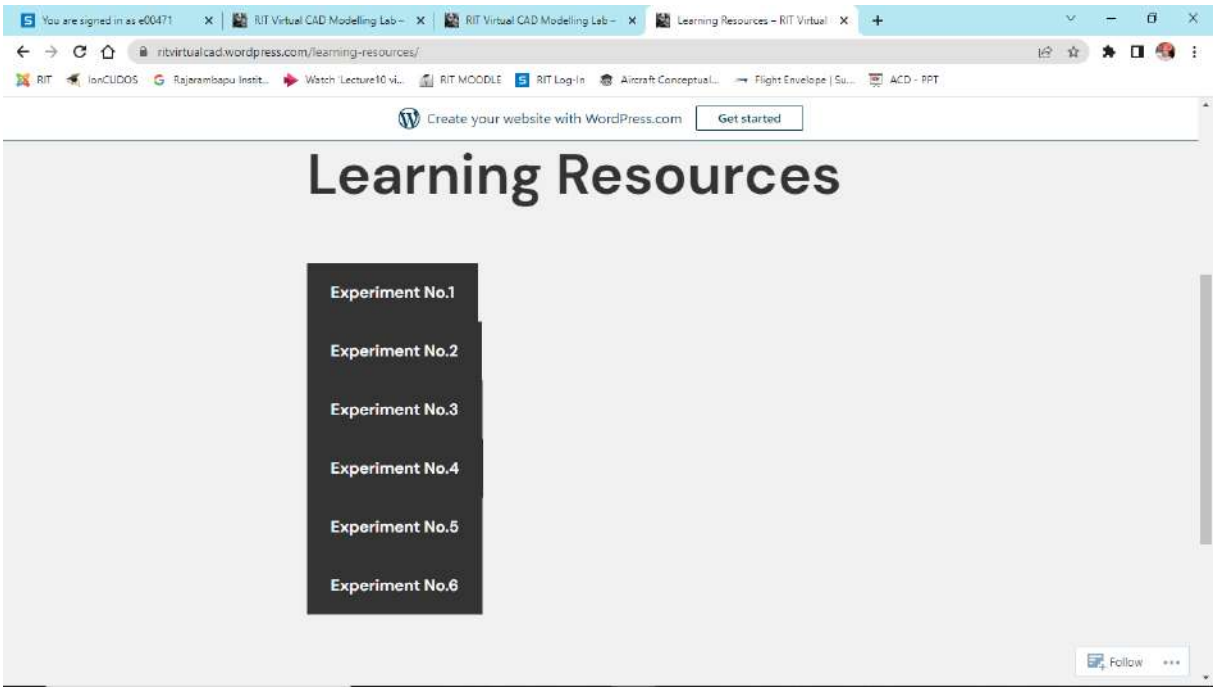


1. Course Outcomes:

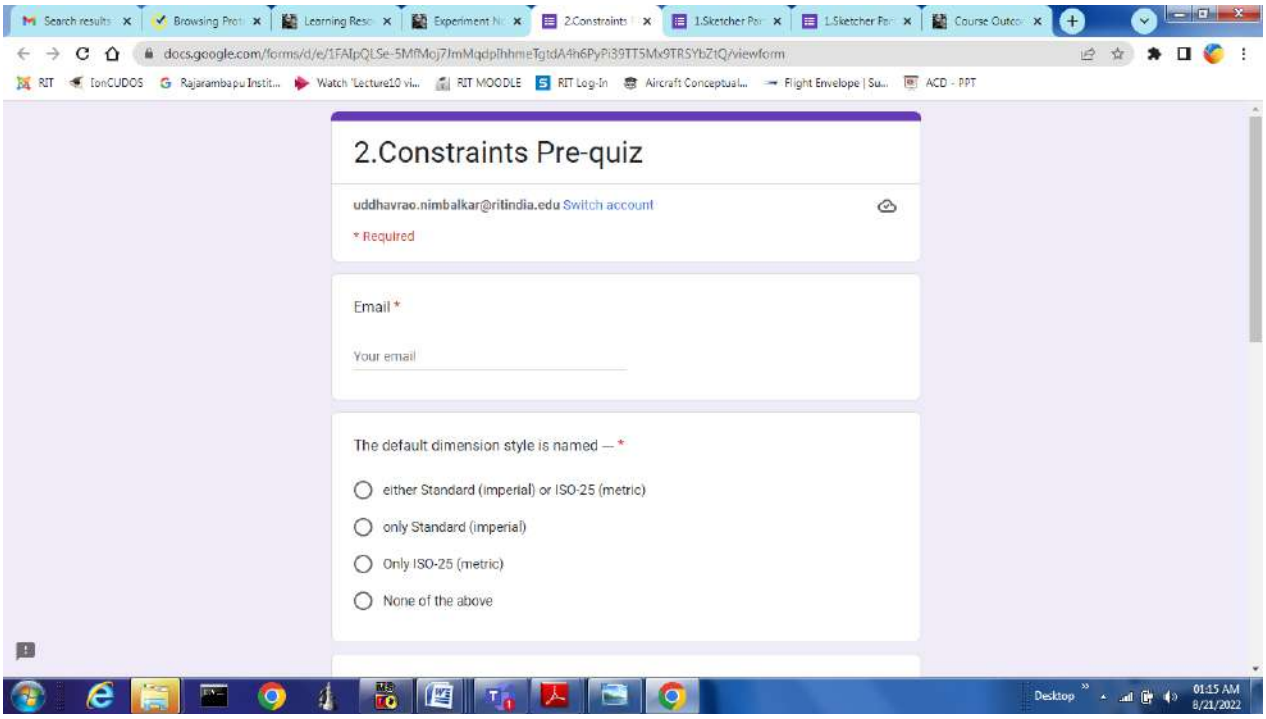


2. Syllabus:

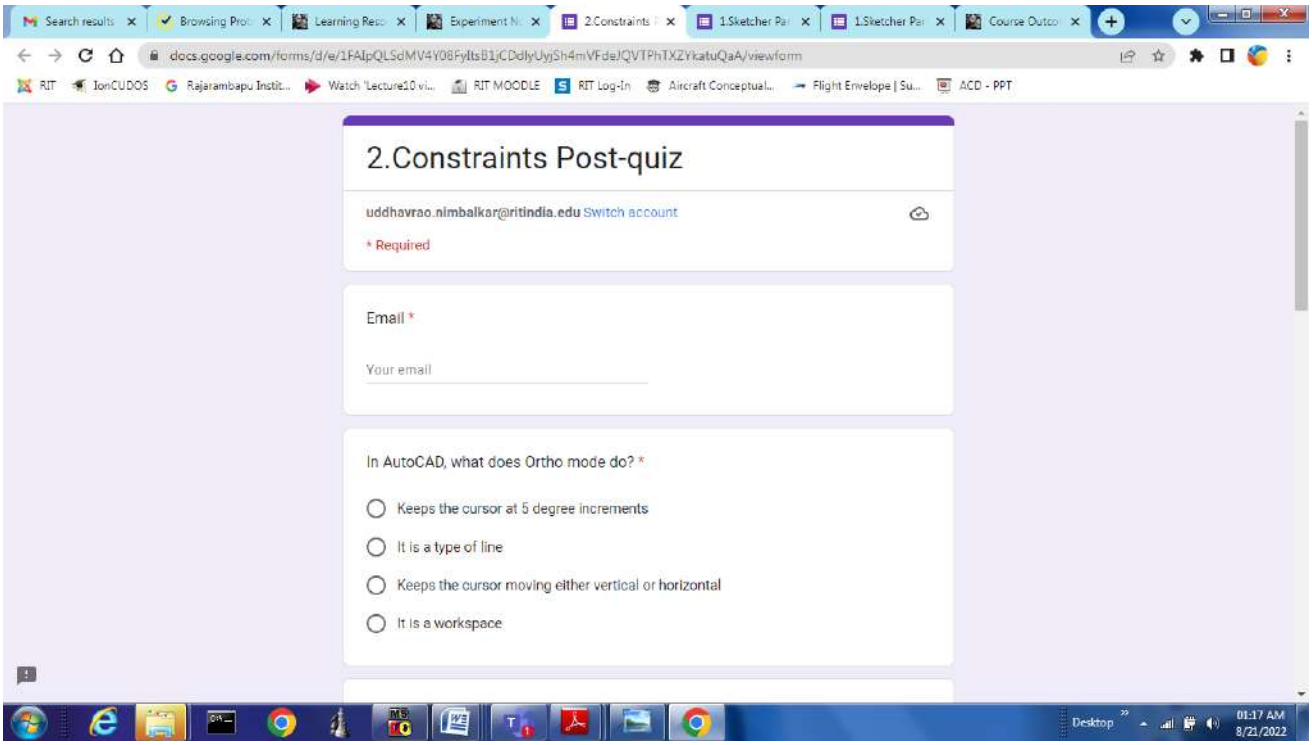
3. Learning Resorces:



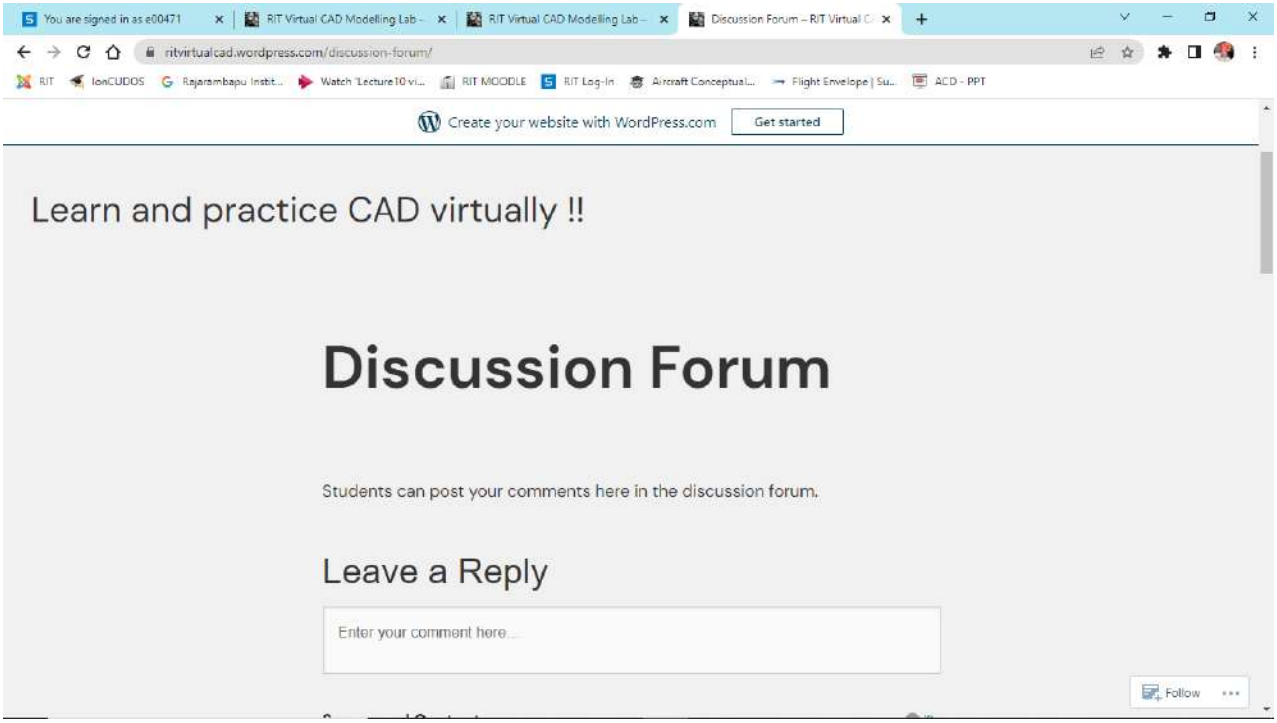
3.1 Pre-SessionQuiz: Experiment No 2 Dimensioning & Constraints

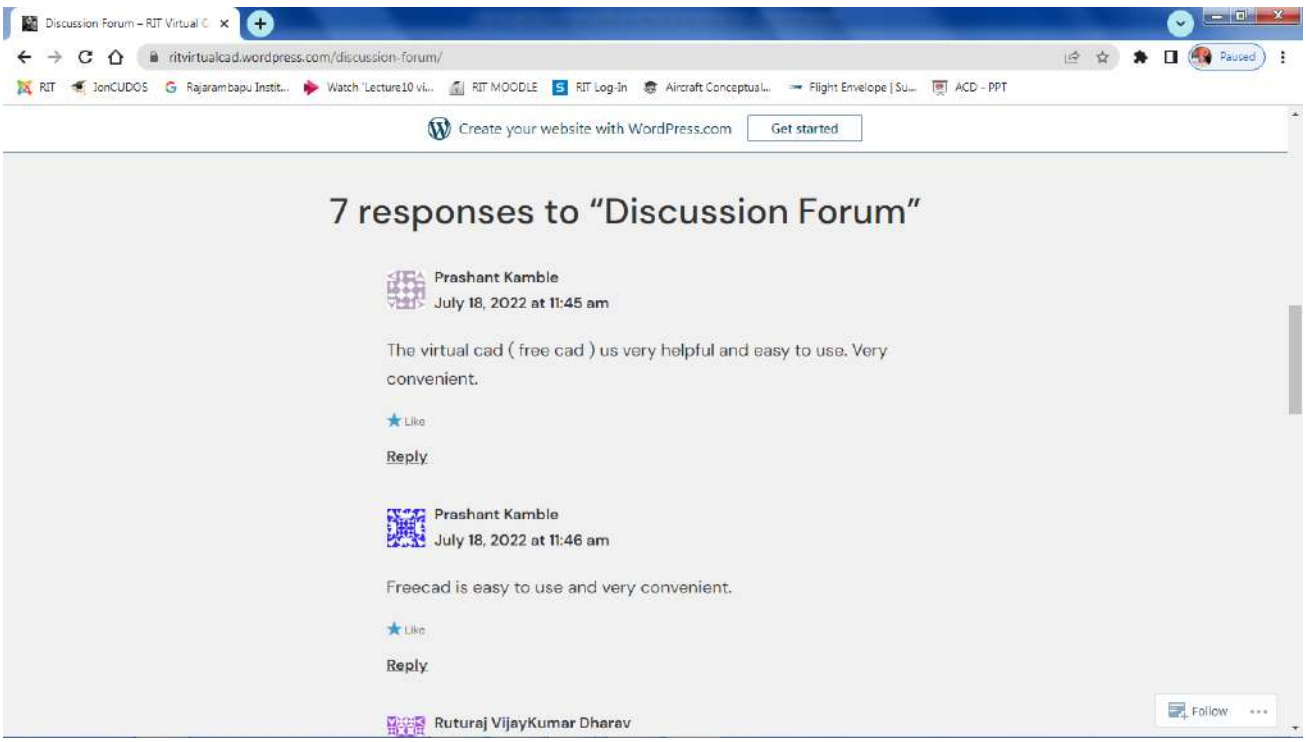


3.2 Post-SessionQuiz: Experiment No 2 Dimensioning & Constraints

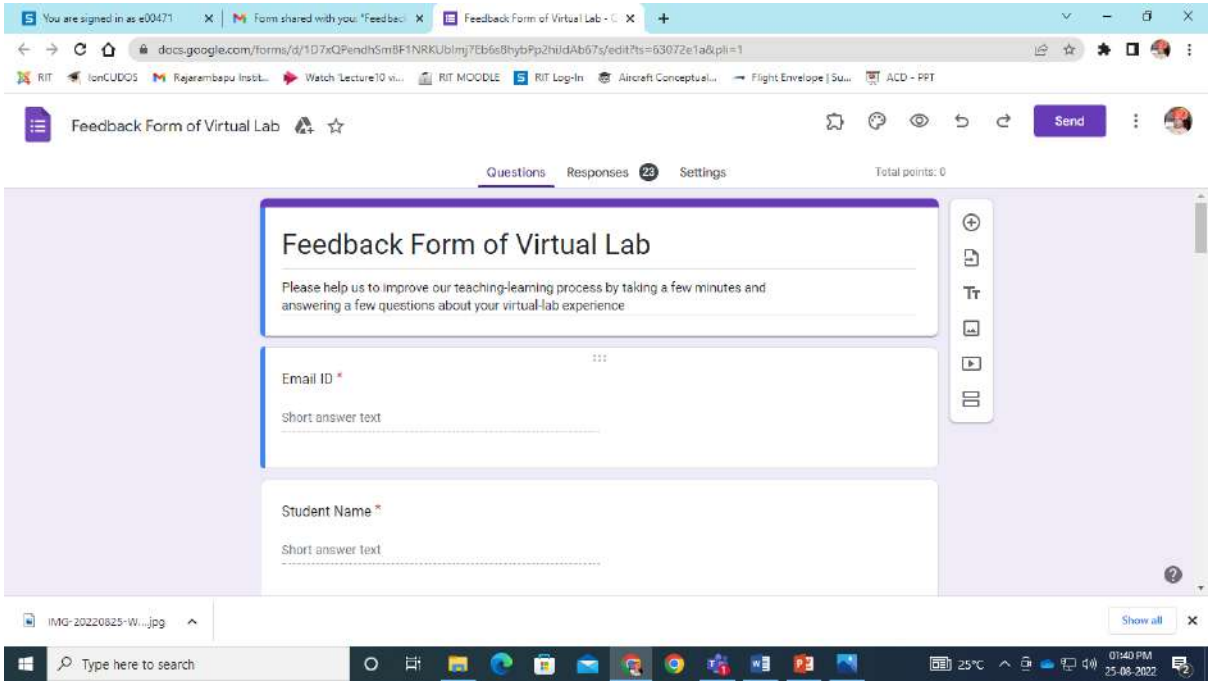


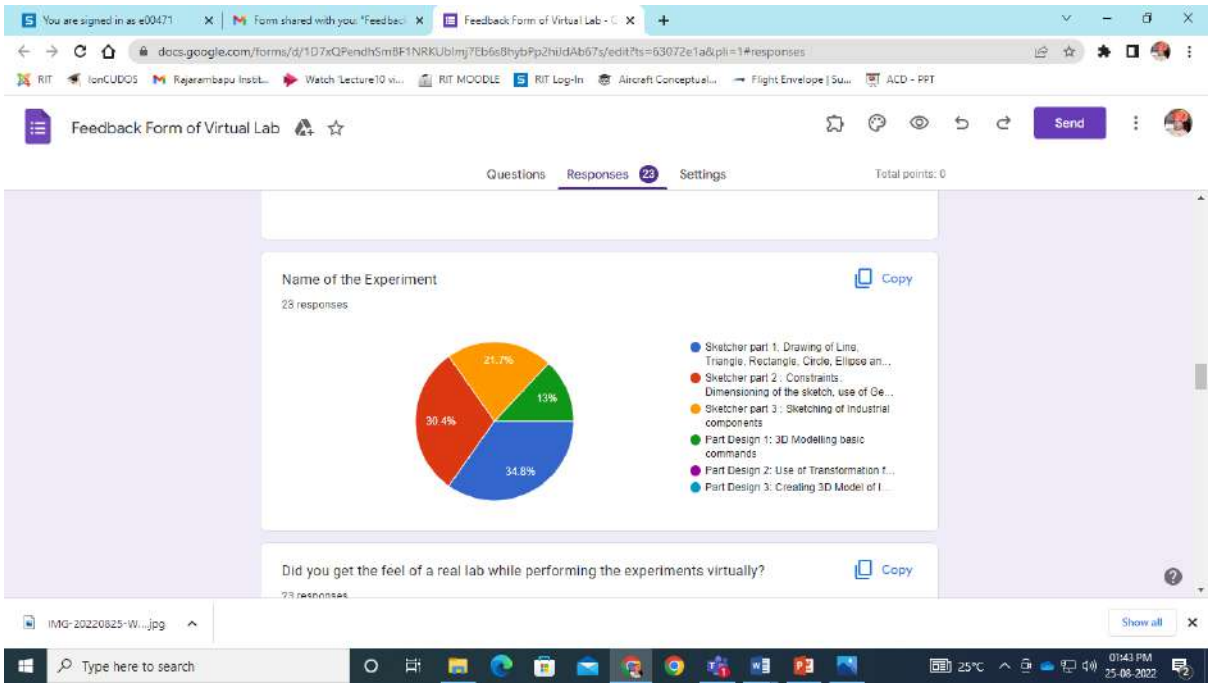
4. Discussion Forum:

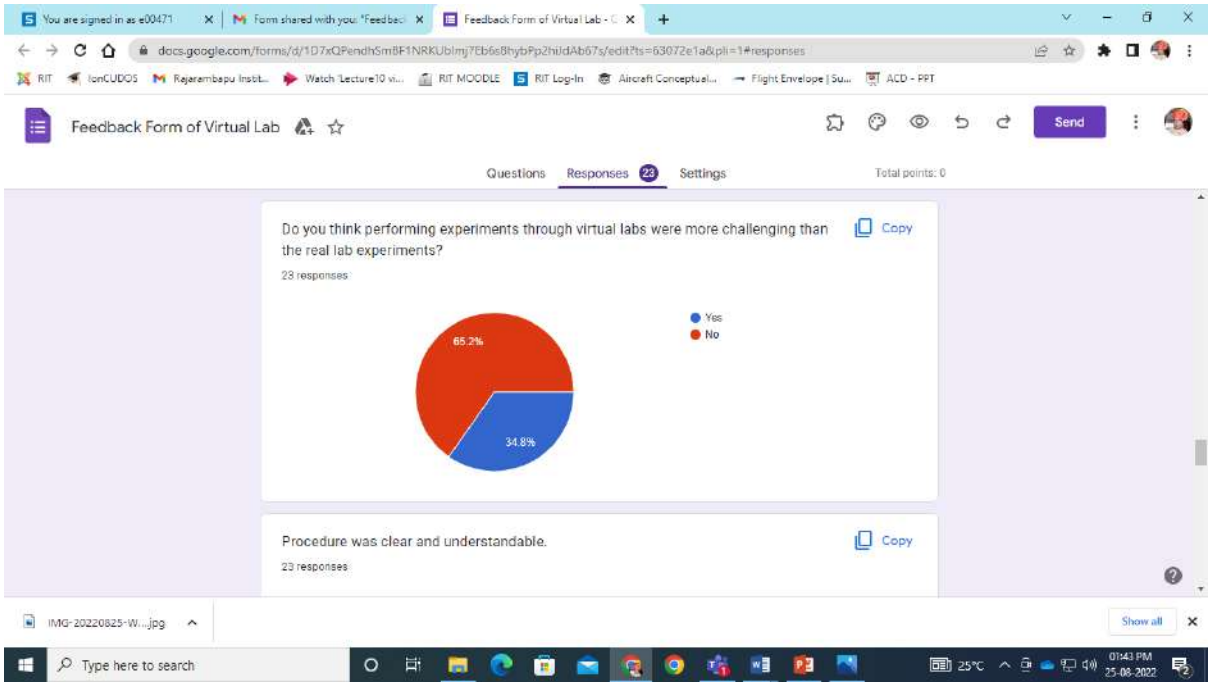




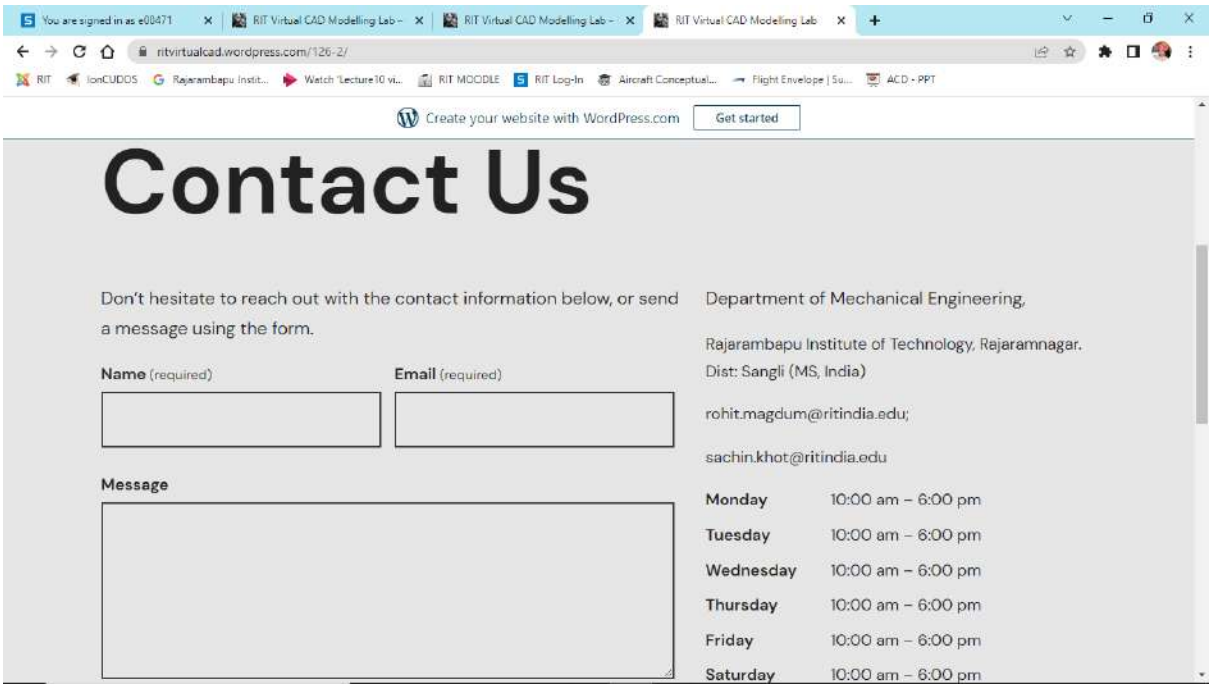
5. Feedback Form:






Feedback Form of Virtual Lab
Send
Questions
Responses 23
Settings
Total points: 0
Do you think performing experiments through virtual labs were more challenging than the real lab experiments?
23 responses
Copy
65.2%
34.8%
Yes
No
Procedure was clear and understandable.
23 responses
Copy

6. Contach Us:


Create your website with WordPress.com
Get started
Contact Us
Don't hesitate to reach out with the contact information below, or send a message using the form.
Name (required)
Email (required)
Message
Department of Mechanical Engineering,
Rajarambapu Institute of Technology, Rajaramnagar.
Dist: Sangli (MS, India)
rohit.magdum@ritindia.edu;
sachin.khot@ritindia.edu
Monday 10:00 am – 6:00 pm
Tuesday 10:00 am – 6:00 pm
Wednesday 10:00 am – 6:00 pm
Thursday 10:00 am – 6:00 pm
Friday 10:00 am – 6:00 pm
Saturday 10:00 am – 6:00 pm

3.7. Testing of Website: The functioning of website was tested by few QC members and some suggestions were given for the refinement of the website. The process of refinement is still going on.

3.8. Sharing Website Address with SY BTech C3& C4 Batches of Mechatronics students for Testing purpose: The website address "https://ritvirtualcad.wordpress.com/" was shared with 38 students for testing of the website. Students are encouraged to learn FreeCAD through Virtual Lab, submit Pres-session quiz, post-session quiz and submit the assignment

3.9. Assignment on Virtual Lab: Students were given assignment based on the FreeCAD topic of Virtual Laboratory CAD Modeling Lab. They solved the given assignment and submitted on the MOODLE.

Chapter 4

Results

The website link was shared with 38 out of 77 students of the SY B Tech C3 & C4 batches of Mechatronics for online learning of FreeCAD software. The total number of students who visited the website https://ritvirtualcad.wordpress.com/ submitted pre-session quiz, learned CAD Modeling Experiments on FreeCAD and submitted post-session quiz is given below in Table No 4.1.

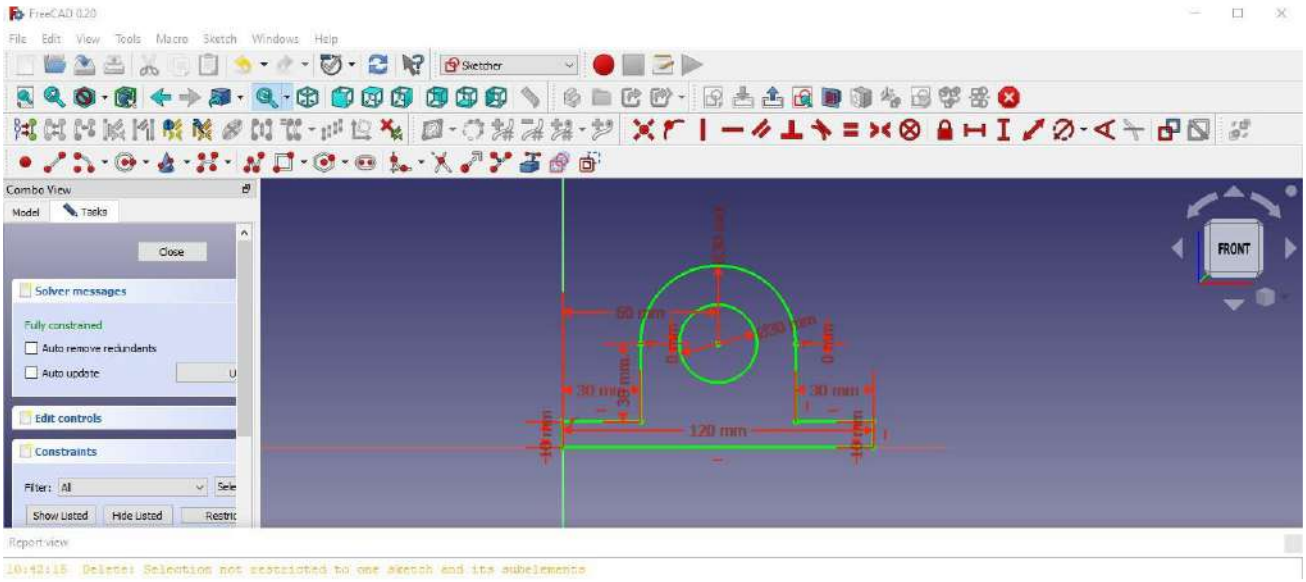
Table No. 4.1

Number of students learned FreeCAD & submitted Pre-Session & Post-Session Quiz

Exp. No	Name of the Experiment	Pre-Session Quiz link	Pre-Session Quiz Submitted	Post-Session Quiz link	Post-Session Quiz Submitted
1	**Sketcher part 1**: Drawing of Line, Triangle, Rectangle, Circle, Ellipse and other standard components.	**https://forms.gle/aeEnY6w6SAnYDTpY8**	30	https://forms.gle/z1wx9RuNJqRMrxVw9	30
2	**Sketcher part2** : Constraints: Dimensioning of the sketch, use of Geometrical constraints, dimensional constraints.	**https://forms.gle/CN5sU6TdxfiknqE16**	30	https://forms.gle/mYpsffmJ2yV5fV5y9	29
3	**Sketcher part3 :** Sketching of Industrial components	**https://forms.gle/CNfy6p7AycQbr4yM9**	28	https://forms.gle/v4YJxGnM157xSbU9A	29
4	**Part Design 1:** 3D Modeling basic commands	**https://forms.gle/oDfyQWW7zjDdKerm6**	29	https://forms.gle/9cTiECKisJWatxkm8	29
5	**Part Design 2:** Use of Transformation features for 3D Modeling	**https://forms.gle/Yn7QgfF5UpZtwdKt6**	28	https://forms.gle/Jb9ED2Q7WHXbRzJc9	27
6	**Part Design 3:** Creating 3D Model of Industrial component	**https://forms.gle/f9dtzYTnKDBeEjx99**	26	https://forms.gle/NXUULtKTfAhZsnRH8	29
		Average Students	**29**	**Average Students**	**29**

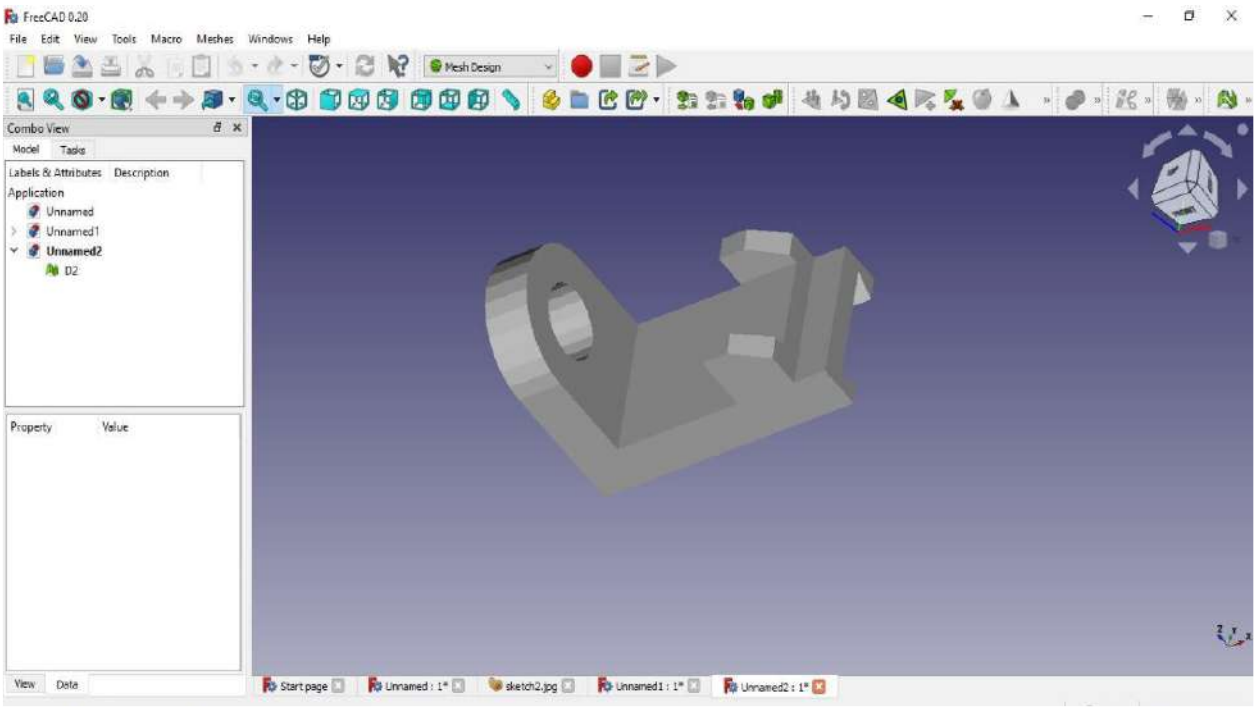
Assignments: Following 2 assignments were given to the students on MOODLE Server to check how much students have learned through Virtual Lab and they were asked to submit the assignments on MOODLE server through student's log-in.

Assignment No 1&2: Based on Sketcher Part-1 to check students knowledge about the sketching commands and Sketcher Part-2 to check students knowledge about constraints and dimensioning.



Assignment No 3 &4 :

Based on Part Design-1 to check students knowledge about 3D Modeling basic commands and Part Design-2 to check students knowledge about use of transformation features in 3D Modeling.



Total 19 out of 19 students submitted Assignment No 1 & 2 on MOODLE from SY BTech C3 Batch

C3 batch assignment submission

C3 batch ISE submission

Visible groups: All participants

Grading summary

Hidden from students	No
Participants	77
Submitted	19
Needs grading	19

User picture	First name / Surname	ID number	Email address	Status	Grade	Edit	modified (submission)	File submissions
	Ruturaj Dharav 2015042		2015042@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 12:43 PM	Part design.pdf 18 July 2022, 12:43 PM sketcher.pdf 18 July 2022, 12:43 PM
	2165003 2165003		2165003@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 12:44 PM	ise cad_2165003.pdf 18 July 2022, 12:44 PM
	2165002 2165002		2165002@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 12:48 PM	part1.pdf 18 July 2022, 12:48 PM sketcher.pdf 18 July 2022, 12:48 PM
	2165001 2165001		2165001@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 12:58 PM	part.pdf 18 July 2022, 12:58 PM sketch.pdf 18 July 2022, 12:58 PM
	2165004 2165004		2165004@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 12:58 PM	ise cad_2165004.pdf 18 July 2022, 12:58 PM

Total 19 out of 19 students submitted Assignment No 3 & 4 on MOODLE from SY BTech C4 Batch

C4 batch assignment submission

C3 batch ISE submission

Visible groups: All participants

Grading summary

Hidden from students	No
Participants	77
Submitted	19
Needs grading	19

User picture	First name / Surname	ID number	Email address	Status	Grade	Edit	modified (submission)	File submissions	Submission comments
	2165024 2165024		2165024@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 12:45 PM	ise cad_2165024.pdf 18 July 2022, 12:45 PM	Comments (0)
	2165020 2165020		2165020@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 12:50 PM	2165020.pdf 18 July 2022, 12:50 PM	Comments (0)
	2165031 2165031		2165031@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 12:51 PM	Free part 1.odt 18 July 2022, 12:51 PM Free sketcher 1.odt 18 July 2022, 12:51 PM Part free 2.odt 18 July 2022, 12:51 PM Sketcthet 2.odt 18 July 2022, 12:51 PM	Comments (0)
	2165028 2165028		2165028@ritindia.edu	Submitted for grading	Grade	Edit	Monday, 18 July 2022, 1:00 PM	part 2.pdf 18 July 2022, 1:00 PM part.pdf 18 July 2022, 1:00 PM sketcher.pdf 18 July 2022, 1:00 PM	Comments (0)

From above data it is observed that out of 38 students, 29 students learned FreeCAD CAD Modeling software through Virtual Laboratory on CAD Modeling Lab course as they submitted Pres-Session Quiz and Post-Session Quiz. Remaining 9 students might have learned FreeCAD CAD Modeling through Virtual Laboratory on CAD Modeling Lab but did not submit Pres-Session Quiz and Post-Session Quiz. Learning percentage is 76%.

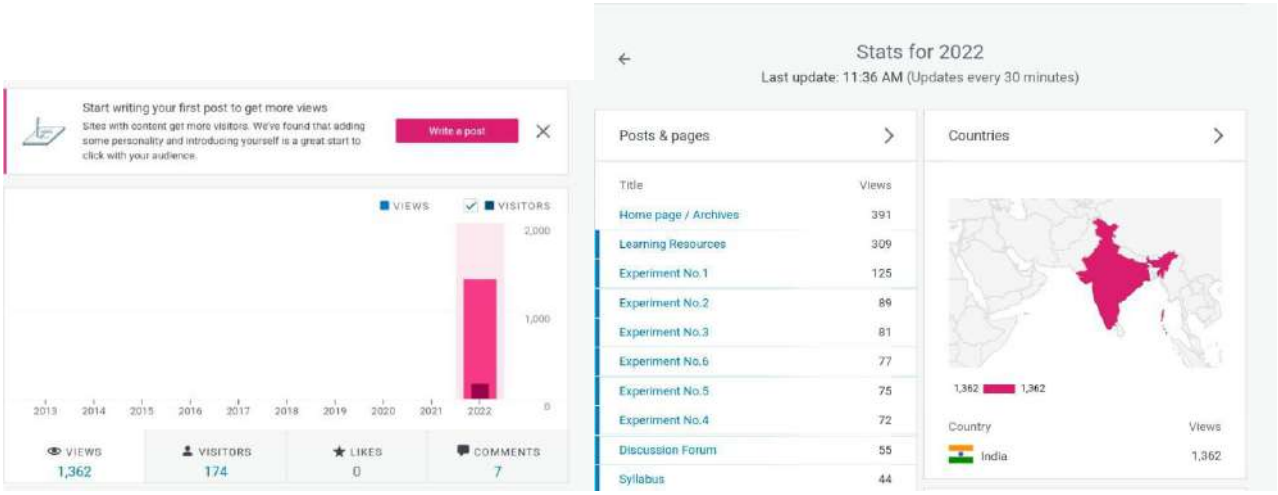
SY-C3 batch of 19 was given Assignment 1 & 2 and all 19 students successfully submitted the same on MOODLE Server.SY-C4 batch of 19 was given Assignment 3 & 4 and all 19 students successfully submitted the same on MOODLE Server. From the data of assignment, again it can be concluded that learning and understating percentage is also 100%.

Chapter 5

Result Analysis and Recommended Measures

5.1 Result Analysis:

1. Virtual Lab for CAD Modeling Lab Course is successfully implemented for SY B Tech Mechatronics as Online Assignment submission was 100%.
2. Total number of views received is more than 1300 which reflects students interest and increased engagement in the Virtual Laboratory
3. From above results it can be concluded that objectives:
    a) "To develop the virtual lab for the software course"
    b) "To test the effectiveness of implementation of virtual lab" has been achieved.



5.2 Recommended Measures

1. Virtual Lab on CAD Modeling Lab course will be implemented for TY B Tech Mechanical CAD Modeling Lab Course.
2. Virtual Lab on CAD Modeling Lab course will be recommended for Automobile and Diploma students.
3. Virtual Lab can be developed for other software courses of Mechanical Engineering.
4. Inclusion of course expert in the team of Virtual Lab Development must be included.

Chapter 6

Conclusion and Future Work

It is concluded that students can learn Laboratory courses online through Virtual Lab using Open Source Software. Licensed software are not required since they are costly, required more memory and cant installed by the students on their desktop/laptop/mobile. The Virtual Lab developed can be quite handy to the students as they developed on Open Source Software and are available freely, on their mobile phones.

For initial learning of any Lab course such Virtual Lab can be developed, encouraged students to learn through Virtual Labin their free time, do the practice on their desktop/laptop/mobile and submit their assignments.

Future work for Virtual Laboratory for CAD Modeling Lab course can be modified for Machine Drawing Lab course.

References:

[1.] Case Study: “Energy Conservation by using energy efficient lamp in RIT” 2017.

[2.] CATIA Manual

[3.] Syllabus of SY B Tech Mechanical, SY B Tech Mechatronics & TY BTech Mechanical Part-II 2021-22

[4.] Cavanaugh et al (2008) 's Analysis of the research, extroverted students, Journal of Advanced Academics, Volume: 21 issue: 4, page(s): 662-712, Article first published online: August 1, 2010; Issue published: August 1, 2010

[5.] Li and Beverly's (2008) An overview of online education: attractiveness, benefits, challenges, concerns and recommendations, College Student Journal(Vol. 42, Issue 2), Publisher: Project Innovation Austin LLC

[6.] Dykman and Davis (2008) Online Education Forum Part Two - Teaching Online Versus Teaching Conventionally Journal of Information Systems Education (JISE), Volume 19 Number 2, Pages 157-164

Software Used:

- FreeCAD
- Microsoft Excel
- Google form
- Mobile App
- Open source software’s
- Website development – WordPress
- YouTube