

North East University Bangladesh

Department of Computer Science and Engineering



Virtual Class Venture

By

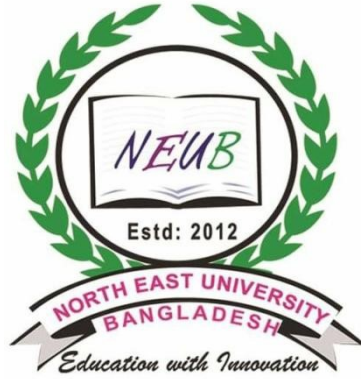
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17th February 2021



A Project submitted to the Department of Computer Science and Engineering,
North East University Bangladesh, in partial fulfillment of the requirements for
the degree of Bachelor of Science in Computer Science and Engineering

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Recommendation Letter from Project Supervisor

These students, *Syed Nadir Ahmed, Md. Asif Muntasir*, their project entitled “*Virtual Class Venture*”, is under my supervision and I agree to submit for examination.

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Project Title: Virtual Class Venture

This is to certify that the project is submitted by the student named above in February, 2021. It is qualified and approved by the following persons and committee.

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Abstract

The world is now facing a pandemic situation. People are not far from this situation also. Almost all types of institutions are closed for Covid-19. In continuation of this, the educational institutions are also closed. Teachers are not able to attend classes in classrooms and students are not able to attend classes in their classrooms. In this pandemic situation, education institutions are conducting their educational activities through various online platforms. Here we have built a system that is actually a browser-based meeting platform (WebRTC) only for educational institution. Here teacher will be able to create online meeting using our platforms. By using our platform, student will be able to join online meeting by clicking the link which was already created by teacher. Our platforms also provide some features like audio mute-unmute, camera or video play-stop, participate list, chat during class time, screen share, recording which is already providing various meeting platforms. But sometimes screen share and recording system is not work correctly. We wanted more of that the admin will be able to monitoring the whole system. But due to lack of sufficient time we could not do these things. However, our project completely different from zoom and classroom because these two platforms provide individual solution. Note that Zoom is only a video conferencing platform and Google Classroom is a resource sharing platform. That's why we wanted to build a complete solution such as a combined system these are video conferencing and resource sharing platform. But due to lack of time we have only built a video conferencing application. We have deployed our webrtc (which was we discussed in above) section in Heroku server. For live test [Click Here](#).

Keywords: Online education platform, create meeting, WebRTC, Audio mute-unmute, Video play-stop, Screen share, Record stream.

Table of Contents

Abstract	i
Table of Contents.....	ii
List of Figures.....	v

Chapter 1

INTRODUCTION	1-2
1.1 Objective	1
1.2 Existing Environment Problem	1
1.3 Features	2

Chapter 2

BACKGROUND STUDY	3-7
2.1 Skype	3
2.2 Zoom	4
2.3 Zoom	5
2.4 Zoom	6
2.5 Google Meet	7

Chapter 3

FEASIBILITY STUDY	8-9
3.1 User and Admin Site Feasibility	8

3.2 Developer's Site Feasibility	9
----------------------------------	---

Chapter 4

REQUIREMENT ANALYSIS	10
----------------------	----

4.1 Requirement of the System	10
-------------------------------	----

4.1.1 Functional Requirements	10
-------------------------------	----

4.1.1 Non-Functional Requirements	10
-----------------------------------	----

Chapter 5

APPLICATION DIAGRAM	11-13
---------------------	-------

5.1 Activity Diagram	11
----------------------	----

5.2 Use Case Diagram	12
----------------------	----

5.3 ERD Diagram	13
-----------------	----

Chapter 6

USER INTERFACE DESIGN	14-40
-----------------------	-------

6.1 User Interface	14
--------------------	----

Chapter 7

TESTING	41-45
---------	-------

7.1 Overview	41
--------------	----

7.2 Testing Levels41
7.3 Limitation and Future Work45
 Chapter 8	
TOOLS USED46
8.1 Overview47
8.2 Compatibility48
 Chapter 9	
CONCLUSION45
 REFERENCE46

List of Figures

Figure 2.1 Skype	3
Figure 2.2 Google Meet	4
Figure 2.3 Zoom	5
Figure 2.4 Google Classroom	6
Figure 2.5 Facebook Video Call	7
Figure 5.1 Activity Diagram of VCV	11
Figure 5.2 Use Case Diagram of VCV	12
Figure 5.3 ERD Diagram	13
Figure 6.1 Admin Panel Dashboard	14
Figure 6.2 Today's Classes Interface in Admin Panel	15
Figure 6.3 Participate List Monitoring by Admin	15
Figure 6.4 Teachers Activity	16
Figure 6.5 Taken Classes List Monitoring by Admin	16
Figure 6.6 Teacher Profile can see by Admin	17
Figure 6.7 Teacher Profile Details Monitoring by Admin	17
Figure 6.8 Teacher Profile Edited by Admin	18
Figure 6.9 Student Profile	18
Figure 6.10 Student Profile Details	19
Figure 6.11 Student Profile Edited by Admin	19
Figure 6.12 Course Registration Form	20
Figure 6.13 Teacher and Student Registration Form	20
Figure 6.14 Teacher Profile Setup	21
Figure 6.15 Student Profile Setup	21
Figure 6.16 Teacher and Student Login	22
Figure 6.17 Create Class by Teacher	22
Figure 6.18 Course List for Teacher After Login	23
Figure 6.19 Archive Video	23
Figure 6.20 Create Assignment	24
Figure 6.21 Assignment Details Given by Teacher	24
Figure 6.22 Resource Given by Teacher	25
Figure 6.23 Exam Making by Teacher	25

Figure 6.24 Participate Student List Accessed by Teacher.....	26
Figure 6.25 Announcement Created by Teacher	26
Figure 6.26 Teacher's Profile	27
Figure 6.27 Profile Edit by Tearcher	27
Figure 6.28 Join Class by Student	28
Figure 6.29 Class Enrolled by Student	28
Figure 6.30 Class Activity for Student	29
Figure 6.31 Assignment Submitted by Student	29
Figure 6.32 Assignment Details for Student	30
Figure 6.33 Resource Accessed by Student	30
Figure 6.34 Exam Paper for Student	31
Figure 6.35 Student Participate List	31
Figure 6.36 Student Get Announcement	32
Figure 6.37 Student Profile	32
Figure 6.38 Profile Edited by Student	33
Figure 6.39 Contact Us	34
Figure 6.40: Pop-up window for host first time connection	34
Figure 6.41: Pop-up window for a new user first time connection	35
Figure 6.42: When multiple users will be connected to video streaming	36
Figure 6.43: When host turn off his mic	36
Figure 6.44: When host turn off his camera	37
Figure 6.45: When the host and a user turn off their camera	37
Figure 6.46: Participants List both for Host and User	38
Figure 6.47: Chat for both Host and User	38
Figure 6.48: Host start the screenshare	39
Figure 6.49: Other users with shared screen	39
Figure 6.50: Video recording by the host	40
Figure 6.51: After video recorded	40

Chapter 1

INTRODUCTION

Virtual Class Venture allows educational institutes to arrange classes in online. This is a browser-based web platform. Here we propose a system where host (teacher) will be able to connect with user(student) using webrtc. Host will be able to share any types of resources by using our platform. So, the goal of our project is to build a complete solution for online class. Here we consider two different thinking which are webrtc and resource sharing platform which gives us a complete platform as a solution. Due to time limitations, our main target was to complete webrtc related work like multi-person video calling, screen controlling, video on/off, audio on/off, screen sharing, video record, and download, chatting, participation list etc. After thinking about it, we have completed many of them.

1.1 Objective

The objective of the Virtual Class Venture is to build a system that will help an institute to do their teaching activities in online. By this application teacher can build a virtual classroom from anywhere at any time. Our proposed system goals to build an environment where an education institutes get a complete platform means that using the platform teachers can take their classes live and shared all type of class related resources with their student and also students are found these easily. Which is help them to continue educational activities in online.

1.2 Existing Environment Problems

- 1 In the case of an existing system like Zoom, Skype etc. the executable file of the environment has to be installed on the hardware of the PC.
- 2 For Video streaming and resource sharing, teachers have to use different environments like Zoom or Skype or Google Meet etc. for video streaming and Google Classroom for resource sharing.
- 3 Educational institutions have no control over the existing environment.
- 4 Teachers have to take data about student manually.

1.3 Features

1. Main Features:

- 1 Live video streaming class.
- 2 Full screen, half screen etc. control.
- 3 One to one, one to many, many to many video streaming mechanisms.
- 4 Screen sharing facility.

- 5 Microphone on off system.
- 6 Live video chat during the live class.
- 7 Video recording facility (recorded videos will be saved on the system automatically).
- 8 Participate student list view.
- 9 Multiple view mechanism (like: grid view).
- 10 Profile creation and maintenance.
- 11 Activities monitoring & control from admin panel.

2. Additional features:

- 1 Classroom creation.
- 2 File upload & download (like: video file, any text file).
- 3 Class commenting facility.
- 4 Dynamic attendance system.
- 5 Quiz exam facility.
- 6 Notice given system.
- 7 Assignment taking system.

Chapter 2

BACKGROUND STUDY

For background study, we use similar meeting applications in our pc to analyze the management system of those applications. We also analyzed the User Interface and functionality of those applications which they provide.

2.1 Skype

Skype is a telecommunications application that specializes in providing video chat and voice calls between computers, tablets, mobile devices, and smartwatches over the Internet. Skype also provides instant messaging services. Users may transmit text, video, audio and images.

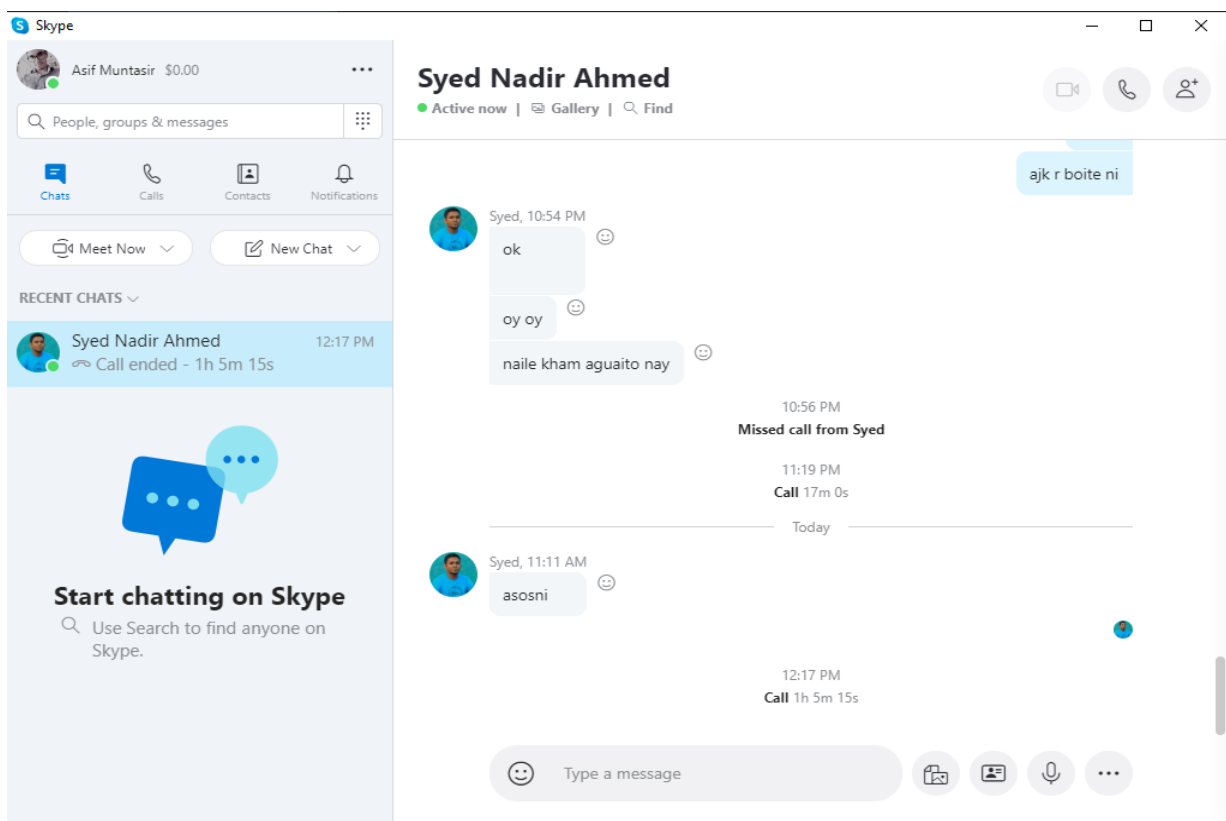


Figure 2.1: Skype

We actually study about interface of camera or video during communication. During chat we also consider that how many types of file user can send to other. We try to pick each important point which we have found during background study.

2.2 Google Meet

We work our project on a free open-source project called WebRTC provided by Google. And based on this project or framework Google have made a video conferencing application called Google meet. We have followed Google Meet for our project. We have used it to collect information during communication.

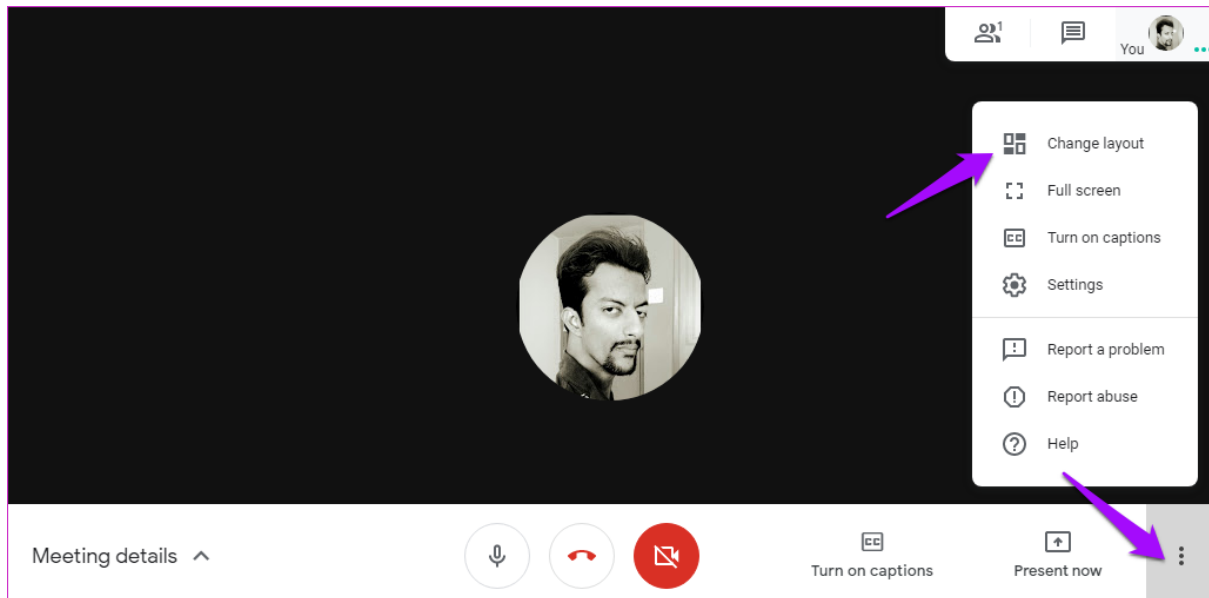


Figure 2.2: Google Meet

We have collected information about camera or video interface, screen share, mute-unmute, camera play-stop and so on. Have tried to see which types of facilities it is providing and which not.

2.3 Zoom

Zoom is a video communications platform between computers, tablets, and android smartphones over the internet. It provides videotelephony and online chat services through a cloud-based peer-to-peer software platform and is used for teleconferencing, telecommuting, distance education and social relations.

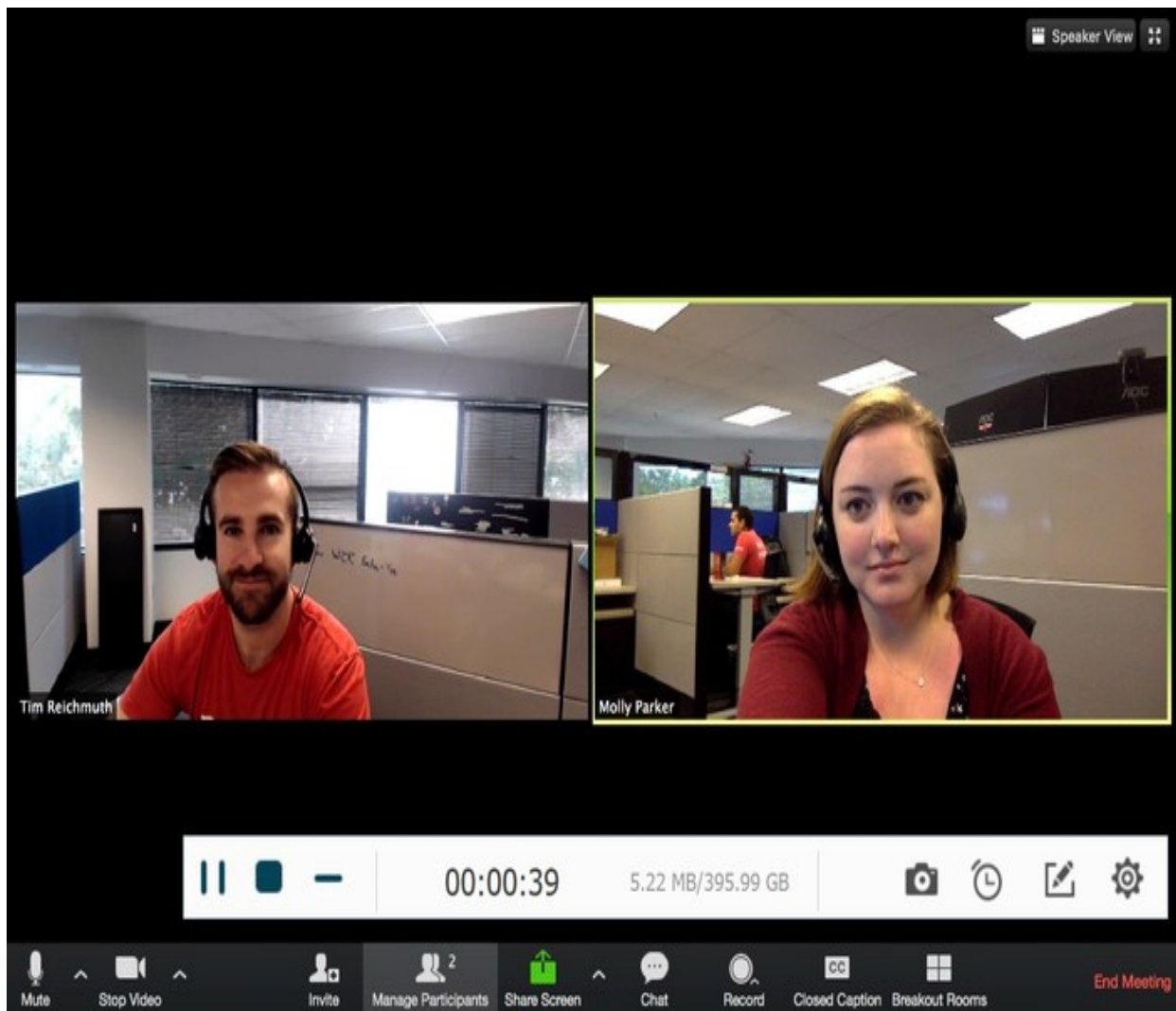


Figure 2.3: Zoom

Now a days Zoom is a very popular video conferencing desktop-based application. We also study about that and try to note each part of this application for our project. But all this are not possible to implement on our project because webrtc is a new idea.

2.4 Google Classroom

Google Classroom is a free web service developed by Google for schools, colleges and universities that aims to simplify creating, distributing, and grading assignments. The primary purpose of Google Classroom is to streamline the process of sharing files between teachers and students.

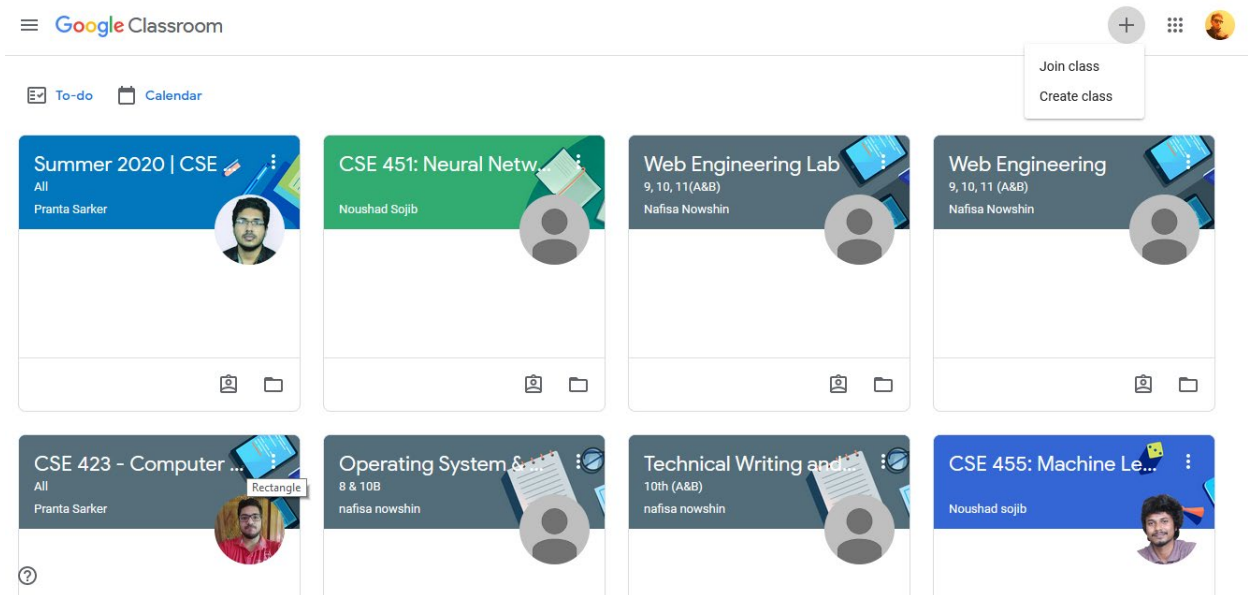


Figure 2.4: Google Classroom

With **Google Classroom**, **teachers** can: Streamline how they manage classes. For example, if teacher post an assignment with a due date, it's automatically added to the class calendar for his/her students to see. Digitally organize, distribute, and collect assignments, course materials, and student work.

Note: Here we use some information about each platform as a small introduction from Wikipedia.

2.5 Facebook Video Calling

Facebook video calling feature is a real-life example of webRTC. We also use Facebook video calling system for our background study to use collected information in our project. We look over the interface during communication, screen share, mute-unmute, camera play-stop and so on.



Figure 2.5: Facebook Video Call

Actually, we have followed that which types of facilities are providing during communication.

Chapter 3

FEASIBILITY STUDY

The Feasibility study divided into two sites:

- User and admin site
- Developer's site

3.1 User and Admin Site Feasibility:

1. Technical Feasibility:

To use this web application, users need a desktop or laptop-based web browser with the following hardware like-

- Windows Version- Latest Version
- Browser Version- Latest Version
- RAM- 4GB (min)
- Front Camera Resolution: 2 Megapixel (min)

2. Financial Feasibility:

For this web application, some amounts will be spent like-

- Internet Bills

This application will follow freeware software standards. No costs will be charged from the potential users.

3. Resource Feasibility:

Resources those are required for this application

- A desktop or laptop computer
- A webcam and microphone
- Broadband or mobile internet connection

4. Risk Feasibility:

- Users will get all facilities that are needed for this application.
- They will get all the requirements to use this application.

3.2 Developer's Site Feasibility:

1. Technical Feasibility:

This application has been created by using web technology in VS Code on a laptop or desktop. The hardware needs-

- Processor: Intel Core i3 3rd generation (or Above)
- RAM: 4 GB (min)
- Hard Disk: 50 GB (or Above).

So, the project is technically feasible.

2. Financial Feasibility:

This assessment typically involves a cost analysis. For this project, some amount will be spent like-

- Internet Bills

3. Resource Feasibility:

Resources that are needed like-

- Laptop/Desktop
- A webcam with microphone

4. Risk Feasibility:

- The tools which are needed to develop the project are all available and free source to use.
- The project is being an 8-month project. We have divided our work into several sections and hopefully we will complete the project in time and deliver.

Chapter 4

REQUIREMENT ANALYSIS

We have done our requirement analysis part with the following steps:

- Arrange meeting with our classmates and teacher
- Installed and analyzed similar video conferencing app
- Analyzed webrtc based video conferencing app to get idea
- Analyzed that information to find different types of requirements
- Analyzed software requirements specification (SRS) by all aspects

4.1 Requirements of the system:

1. Functional Requirements
2. Non-Functional Requirements

4.1.1 Functional Requirements:

- Live video class with screen controlling facility, chat, microphone mute-unmute facility.
- Video recording facility (recorded videos will be saved on the system automatically).
- Participate student list view.
- Multiple view mechanism (like: grid view).
- Profile creation and maintenance.
- Activities monitoring & control from admin panel.
- Teacher can create classroom.
- File upload & download (like: video file, any text file).
- Class commenting facility.
- Dynamic attendance system.
- Quiz exam facility.
- Notice given system.
- Assignment taking system.

4.1.2 Non-Functional Requirements:

The system is able to perform the following characteristics-

- **Usability:** The system can be operated from any kind of laptop and desktop-based web browser.
- **Reliability:** The system can perform all the user needs, which user wants.
- **Performance:** The system will be optimized but it will be performed well with a good connection of the internet.
- **User interface:** The user interface will be user friendly which is easy to use.

Chapter 5

APPLICATION DIAGRAM

Here we will describe the application diagrams of the project. In Figure 5.1 we have showed an activity diagram for student activity.

5.1 Activity Diagram

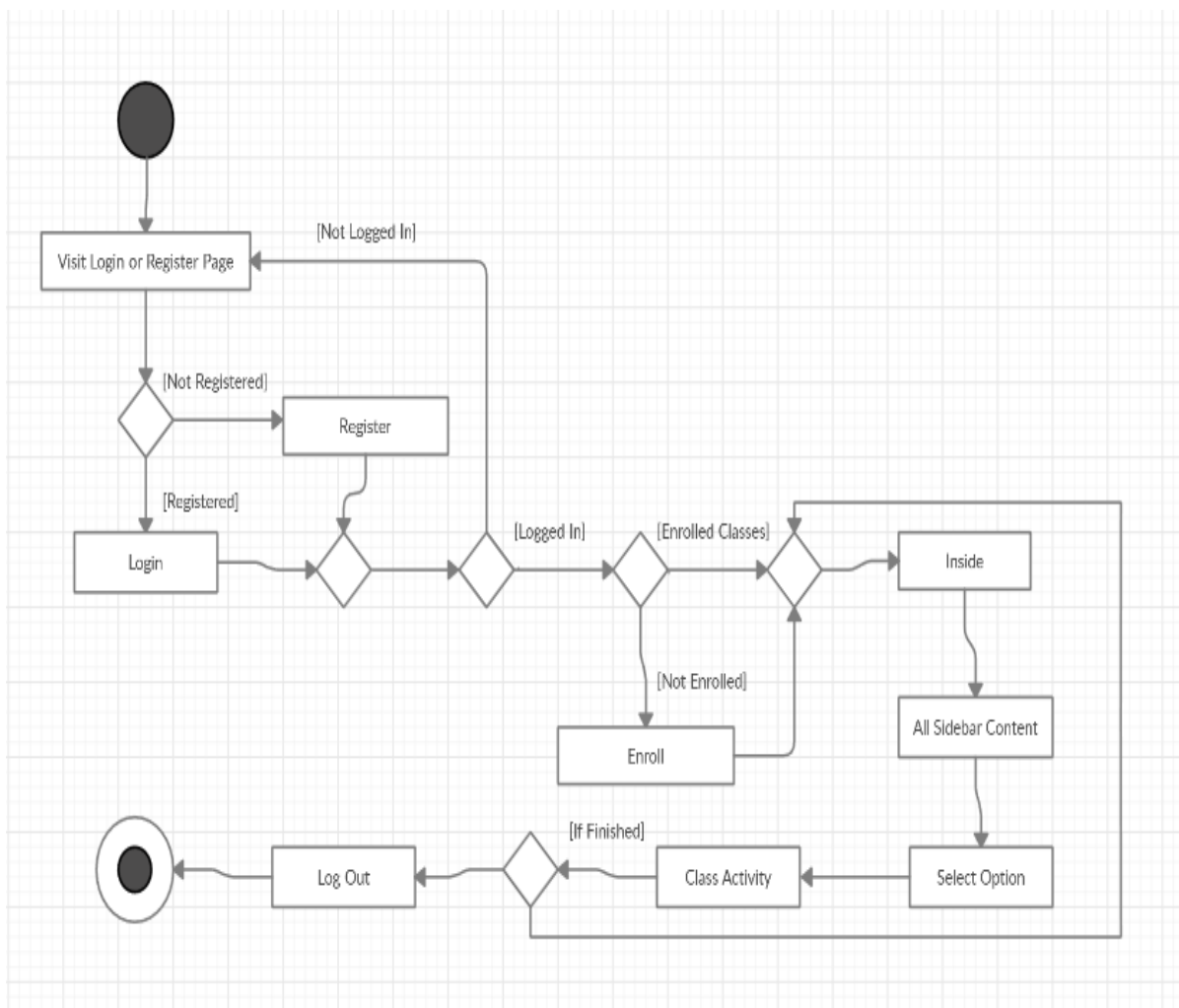


Figure 5.1 Activity Diagram of Virtual Class Venture.

(We have used www.creatly.com to make the Activity Diagram).

5.2 Use Case Diagram

In Figure 5.2 we have showed a use case diagram for both teacher and student.

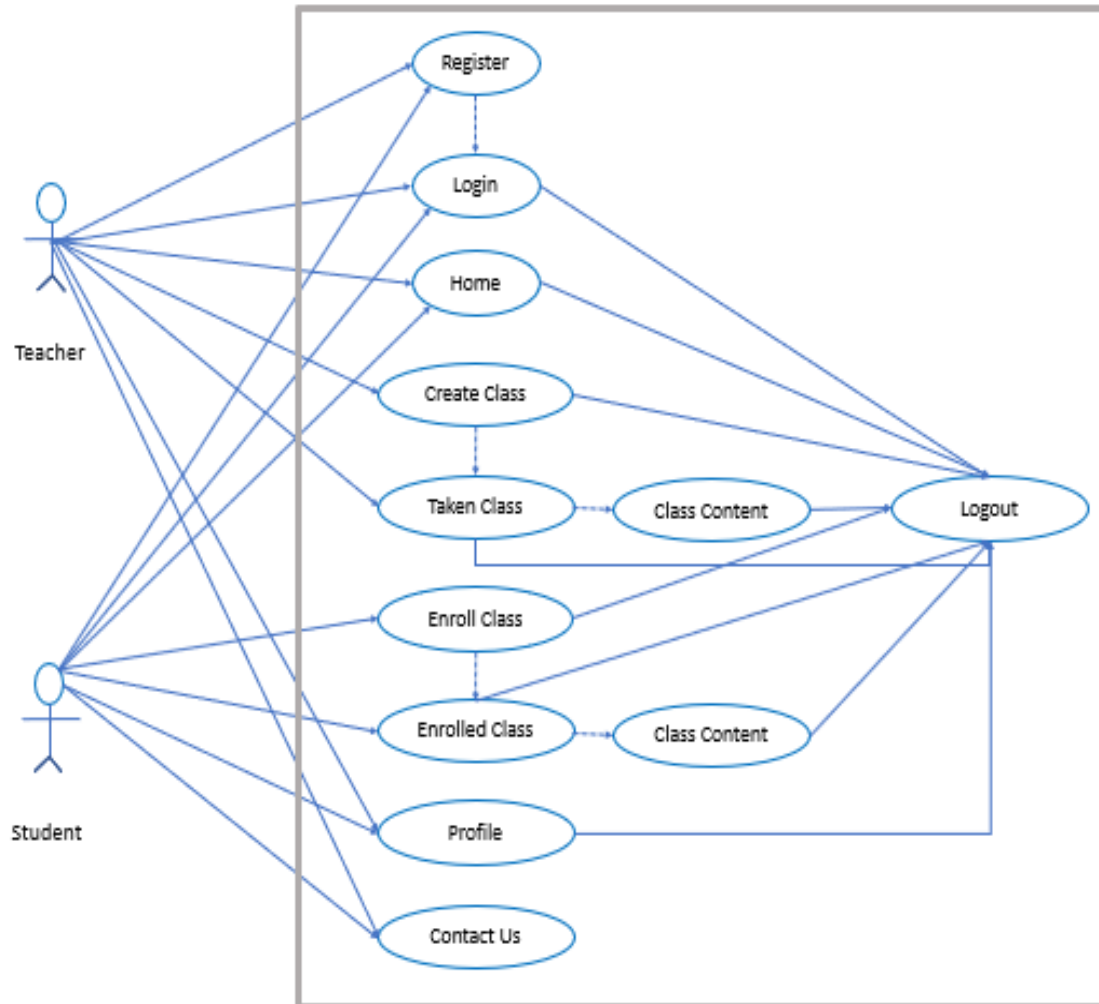


Figure 5.2 Use Case Diagram of Virtual Class Venture

5.3 ERD Diagram

We also have made an ER Diagram for our project which is given below in Figure 5.3.

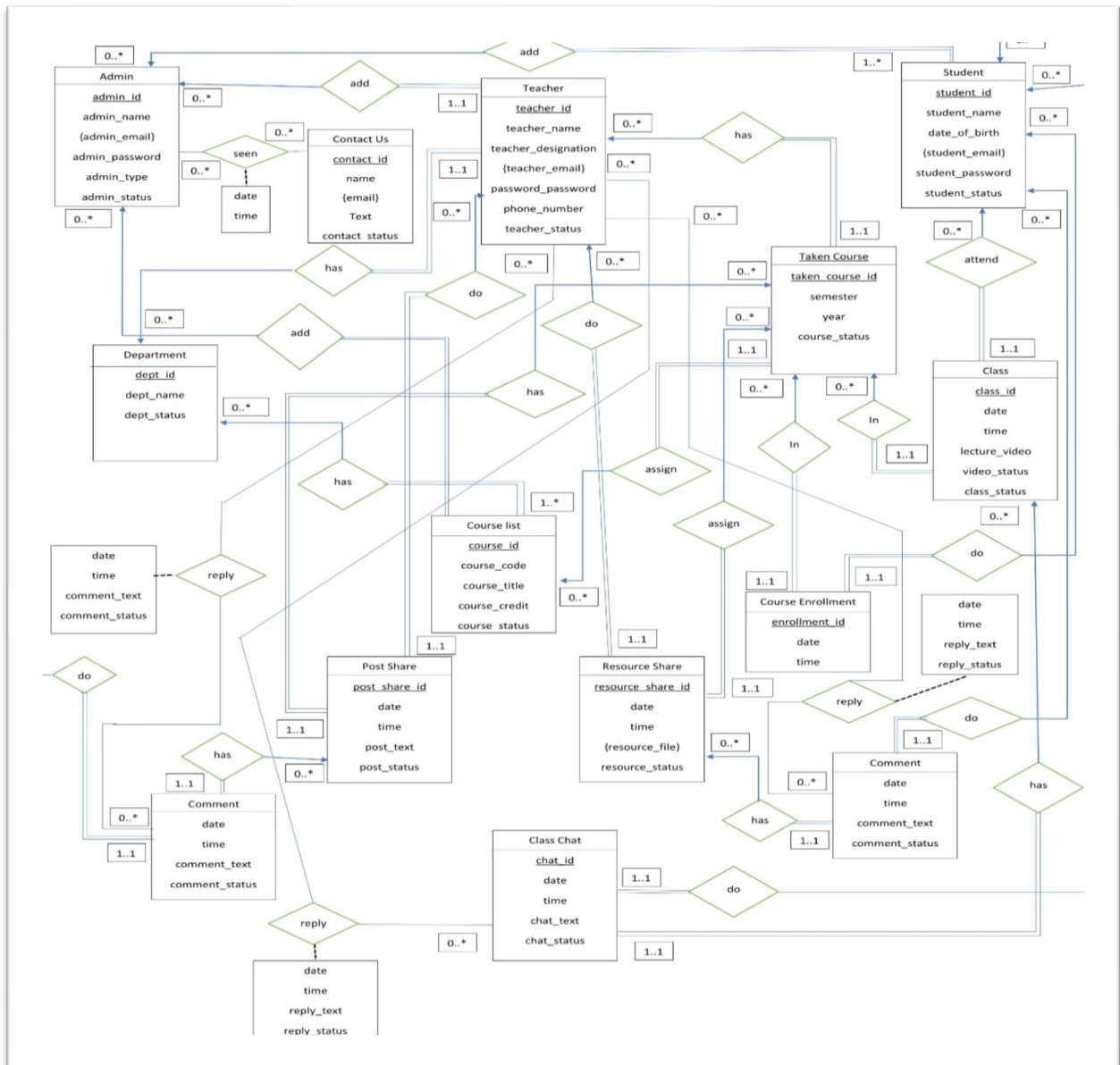


Figure 5.3 ERD Diagram

The database was not working due to lack of sufficient time.

Full ERD link: [Final Year Project ERD](#)

Chapter 6

USER INTERFACE DESIGN

6.1 User Interface

We build a learning environment which is called Virtual Class Venture. User's of this application are teachers and students.

6.1.1 Admin

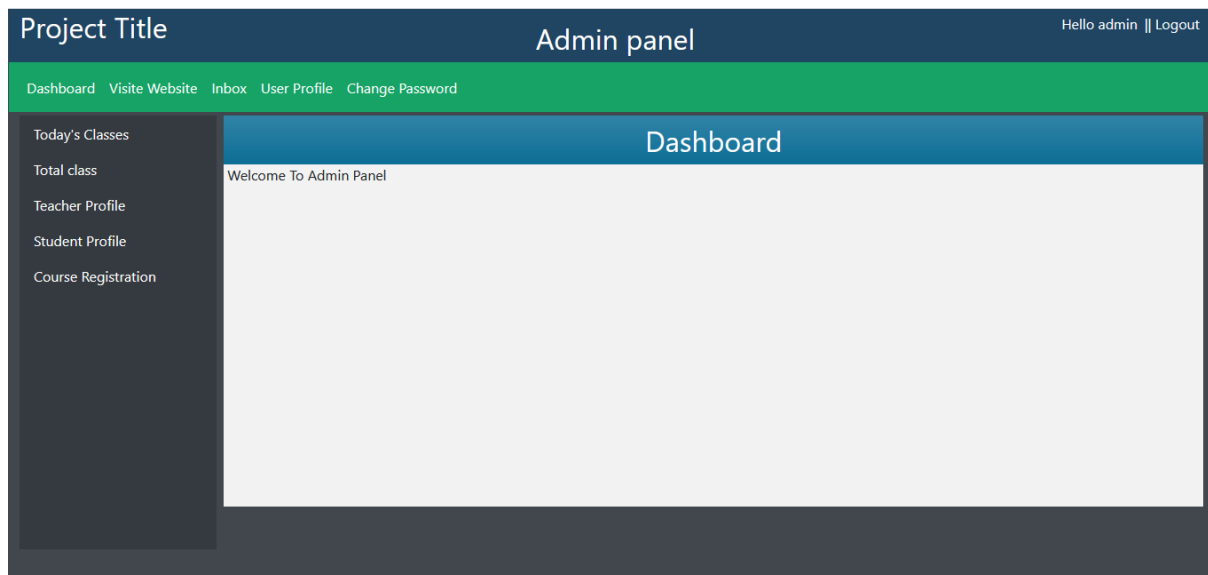


Figure 6.1 Admin Panel Dashboard

This is the admin dashboard and here admin will see that page after complete the login step. From here admin will be able to control the whole system which we want to create. The admin dashboard is given in Figure 6.1 above.

6.1.2 Today's Classes

Project Title Admin panel Hello admin || Logout

Dashboard Visite Website Inbox User Profile Change Password

Today's Classes

Total class

Teacher Profile

Student Profile

Pages

Settings

5

Department Teacher mm / dd / yyyy Check

SL	Semester No.	Course Code	Course Title	Course Teacher	Class Time	Participate Students	Status	Action
1	11th	CSE-400	Thesis/Project I	MLR	8.00pm	See participate list	Running End	Checked Delete
2	11th	CSE-400	Thesis/Project I	MLR	8.00pm	See participate list	Running End	Checked Delete
3	11th	CSE-400	Thesis/Project I	MLR	8.00pm	See participate list	Running End	Checked Delete

Figure 6.2 Today's Classes Interface in Admin Panel.

From Figure-6.2 admin can see the class status of current date. Here class status means that is the class running or end and which teacher is taking the class and how many students is attending the class. After the end of class admin will also be able to delete the record.

6.1.3 Participate List

Project Title Admin panel Hello admin || Logout

Dashboard Visite Website Inbox User Profile Change Password

Today's Classes

Total class

Teacher Profile

Student Profile

Pages

Settings

5

SL	Semester No.	Course Code	Course Title	Registration No.	Student Name	Profile
1	11th	CSE-400	Thesis/Project I	170103020000	XYZ...	See Profile
2	11th	CSE-400	Thesis/Project I	170103020000	XYZ...	See Profile
3	11th	CSE-400	Thesis/Project I	170103020000	XYZ...	See Profile

Figure 6.3 Participate List Monitoring by Admin

This page will be able to view from another two page which is Total Class and Today's Class page.

6.1.4 Teachers Activity

The screenshot shows the 'Teachers Activity' section of the Admin panel. The top header displays 'Project Title' and 'Admin panel' with a user greeting 'Hello admin || Logout'. A navigation bar below the header contains links: 'Dashboard', 'Visite Website', 'Inbox', 'User Profile', and 'Change Password'. The left sidebar lists navigation options: 'Today's Classes', 'Total class', 'Teacher Profile', 'Student Profile', 'Pages', and 'Settings'. The main content area features a 'Teachers Activity' title, a dropdown menu set to '5', and filter fields for 'Department', 'Teacher', 'Course', and a date format 'mm / dd / yyyy', followed by a 'Check' button. Below these filters is a table with the following data:

SL	ID	Semester	Course Code	Course Title	Course Teacher	Class Time & Date	Number Of Taken Class	Action
1	005	11th	CSE-400	Thesis/Project I	MLR	4.00pm - 20.07.20	24	Checked Delete
2	005	11th	CSE-400	Thesis/Project I	MLR	4.00pm - 20.07.20	24	Checked Delete
3	006	11th	CSE-413	Web Engineering	NNP	4.00pm - 20.07.20	24	Checked Delete
4	006	11th	CSE-413	Web Engineering	NNP	4.00pm - 20.07.20	24	Checked Delete

Figure 6.4 Teachers Activity

From Figure-6.4, admin can see the teacher's activity by using filtering as department, teacher name, course name date accordingly. Admin can delete teacher's activity.

6.1.5 Taken Classes

The screenshot shows the 'Taken Class List' section of the Admin panel. The top header displays 'Project Title' and 'Admin panel' with a user greeting 'Hello admin || Logout'. A navigation bar below the header contains links: 'Dashboard', 'Visite Website', 'Inbox', 'User Profile', and 'Change Password'. The left sidebar lists navigation options: 'Today's Classes', 'Total class', 'Teacher Profile', 'Student Profile', 'Pages', and 'Settings'. The main content area features a 'Taken Class List' title, a dropdown menu set to '5', and filter fields for 'Department', 'Teacher', 'Course', and a date format 'mm / dd / yyyy', followed by a 'Check' button. Below these filters is a table with the following data:

SL	ID	Semester	Course Code	Course Title	Course Teacher	Class Time & Date	Participate Students	Action
1	005	11th	CSE-400	Thesis/Project I	MLR	4.00pm - 20.07.20	See participate list	Checked Delete

Figure 6.5 Taken Classes List Monitoring by Admin

In this page admin can see how many classes have been done and how many students have been attended in the class and this page is linked up with total class page.

6.1.6 Teacher Profile

Project Title Admin panel Hello admin || Logout

Dashboard Visite Website Inbox User Profile Change Password

Today's Classes
Total class
Teacher Profile
Student Profile
Pages
Settings

Teacher Profile

5

Department Teacher Check

SL	Id No.	Name	Position	Details
1	005	MLR	Lecturer	See more

Figure 6.6 Teacher Profile can see by Admin

In teacher's profile page, admin can see the registered teacher's name and by clicking the see more button admin will be able to see the details about teachers.

6.1.7 Teacher Profile Details

Project Title Admin panel Hello admin || Logout

Dashboard Visite Website Inbox User Profile Change Password

Today's Classes
Total class
Teacher Profile
Student Profile
Pages
Settings

Teacher Profile

Teacher Full Name

Position

Department

Phone No.

Email address

Ok Edit Delete

Semester Statistics

5

Course Semester Check

SL	Course Code	Course Name	Number of taken classes
1	CSE-400	Thesis/Project	13
2	CSE-413	Web Engineering	15

Figure 6.7 Teacher Profile Details Monitoring by Admin

After click the 'see more' button admin can see it and will also see the course list, number of taken class by teacher and so on.

6.1.8 Teacher Profile Edit

The screenshot shows the 'Teacher Profile' edit page within an 'Admin panel'. The top navigation bar includes 'Project Title', 'Admin panel', and 'Hello admin || Logout'. A secondary navigation bar lists 'Dashboard', 'Visite Website', 'Inbox', 'User Profile', and 'Change Password'. A left sidebar contains links for 'Today's Classes', 'Total class', 'Teacher Profile', 'Student Profile', 'Pages', and 'Settings'. The main content area is titled 'Teacher Profile' and 'Teacher Full Name'. It contains four input fields: 'Position', 'Department', 'Phone No.', and 'Email address'. A green 'Save' button is located at the bottom of the form.

Figure 6.8 Teacher Profile Edited by Admin

From teacher's details page, if admin click the 'Edit' button then admin can edit the teacher's profile.

6.1.9 Student Profile

The screenshot shows the 'Student Profile' page within an 'Admin panel'. The top navigation bar includes 'Project Title', 'Admin panel', and 'Hello admin || Logout'. A secondary navigation bar lists 'Dashboard', 'Visite Website', 'Inbox', 'User Profile', and 'Change Password'. A left sidebar contains links for 'Today's Classes', 'Total class', 'Teacher Profile', 'Student Profile', 'Pages', and 'Settings'. The main content area is titled 'Student Profile'. It features a dropdown menu with the value '5'. Below this are three input fields: 'Department' (a dropdown), 'Session', and 'Student Registration No.', followed by a red 'Check' button. A table displays student data with columns: SL, Session, Registration No., Semester, Name, and Details. The table contains one row with the following data: SL: 1, Session: Spring-17, Registration No.: 170103020000, Semester: 11th, Name: XYZ..., and Details: See more.

SL	Session	Registration No.	Semester	Name	Details
1	Spring-17	170103020000	11th	XYZ...	See more

Figure 6.9 Student Profile

From Figure 6.9, it is the student profile page. Here admin will be able to see registered student list. By clicking the 'See more' button admin can see the details of registered student.

6.1.10 Student Profile Details

The screenshot shows the 'Student Profile' page in an 'Admin panel'. The page has a dark blue header with 'Project Title' and 'Admin panel' on the left, and 'Hello admin || Logout' on the right. Below the header is a green navigation bar with links: 'Dashboard', 'Visit Website', 'Inbox', 'User Profile', and 'Change Password'. On the left side, there is a sidebar with links: 'Today's Classes', 'Total class', 'Teacher Profile', 'Student Profile', 'Pages', and 'Settings'. The main content area is titled 'Student Profile' and 'Student Full Name'. It contains a form with the following fields: 'Department', 'Birthday' (with a date picker showing 'mm/dd/yyyy'), 'Session', 'Semester', 'Registration No.', 'Phone No.', and 'Email address'. Below the form are three buttons: 'OK' (green), 'Edit' (yellow), and 'Delete' (red). Below the form is a section titled 'Semester Statistics'. It has a dropdown menu for 'Semester' and a 'Check' button (red). Below this is a table with the following data:

Sl.	Course Code	Course Name	Number of classes present
1	CSE-400	Thesis/Project	13
2	CSE-413	Web Engineering	15

Figure 6.10 Student Profile Details

After click the 'see more' button admin can see Student Profile Details which is shown in Figure 6.10 above and will also see the course list, number of attended class by student and so on.

6.1.11 Student Profile Edit

The screenshot shows the 'Student Profile' page in an 'Admin panel' for editing. The page has a dark blue header with 'Project Title' and 'Admin panel' on the left, and 'Hello admin || Logout' on the right. Below the header is a green navigation bar with links: 'Dashboard', 'Visit Website', 'Inbox', 'User Profile', and 'Change Password'. On the left side, there is a sidebar with links: 'Today's Classes', 'Total class', 'Teacher Profile', 'Student Profile', 'Pages', and 'Settings'. The main content area is titled 'Student Profile' and 'Student Full Name'. It contains a form with the following fields: 'Department', 'Birthday' (with a date picker showing 'mm/dd/yyyy'), 'Session', 'Semester', 'Registration No.', 'Phone No.', and 'Email address'. Below the form is a 'Save' button (green).

Figure 6.11 Student Profile Edited by Admin

From student's details page, if admin click the 'Edit' button then admin can edit the student's profile.

6.1.12 Course Registration

The screenshot shows an 'Admin panel' interface. At the top, there's a dark blue header with 'Project Title' on the left and 'Hello admin || Logout' on the right. Below this is a green navigation bar with links: 'Dashboard', 'Visite Website', 'Inbox', 'User Profile', and 'Change Password'. On the left side, there's a dark sidebar with a menu: 'Today's Classes', 'Total class', 'Teacher Profile', 'Student Profile', and 'Course Registration' (which is highlighted). The main content area is titled 'Course Registration' in a blue header. Below this, there's a blue button labeled 'Upload Excel File For Course Registration'. The main form is titled 'Registration Form' and contains two sections: 'Registration No.' with a text input field labeled 'Student Registration No.', and 'Add Course' with a text input field labeled 'Course Code'. Below the 'Add Course' section, there's a table with two rows: 'CSE-400' and 'CSE-401', each with an 'X' in the second column. At the bottom of the form is a green 'Save' button.

Figure 6.12 Course Registration Form

Here course registration will be added which already has been done by student. Admin will also be able to add student's manually. Admin can register multiple student at a time by uploading csv file.

6.1.13 Registration

The screenshot shows two registration forms side-by-side. The left form is titled 'Teacher Registration' and has two input fields: 'Name' (labeled 'Enter Your Full Name') and 'Email' (labeled 'Enter Email'). Below these is a teal 'Next' button. The right form is titled 'Student Registration' and has two input fields: 'Registration No.' (labeled 'Enter Registration No.') and 'Birthday' (labeled 'mm / dd / yyyy'). Below these is a teal 'Next' button. At the top right of the page, there are two blue buttons: 'Login' and 'Contact Us'.

Figure 6.13 Teacher and Student Registration Form

Here Teacher will complete the form by using his/her name and email. Student will have to complete the form by using his/her registration number with birthdate.

6.1.14 Profile Create

After complete the registration both teacher and student have to setup their profile which is shown in Figure-6.14 and Figure-6.15 below.



The image shows a web interface for 'Teacher Profile Setup'. At the top right, there is a blue 'Contact Us' button. The main form is a green box with a title bar 'Teacher Profile Setup'. Inside the form, there are six input fields with labels: 'Full Name', 'Position', 'Department', 'Phone No.', 'Email address', and 'Set Password'. Each label is in yellow text. Below the input fields is a red 'Save' button.

Figure 6.14 Teacher Profile Setup

In Figure 6.14 above, teacher will have to filled-up this form to create the profile.

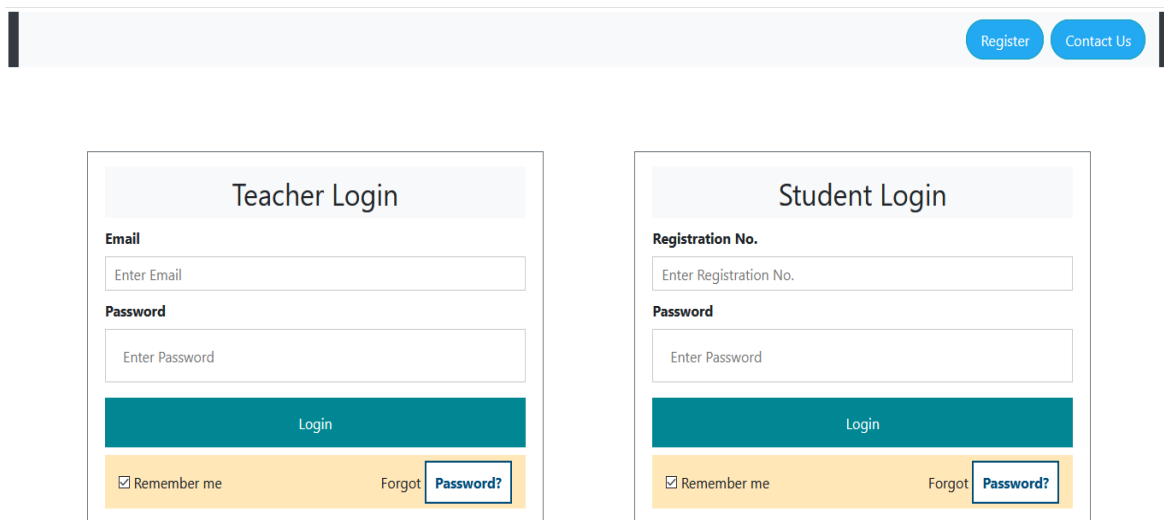


The image shows a web interface for 'Student Profile Setup'. At the top right, there is a blue 'Contact Us' button. The main form is a green box with a title bar 'Student Profile Setup'. Inside the form, there are eight input fields with labels: 'Full Name', 'Birthday', 'Department', 'Session', 'Semester', 'Registration No.', 'Phone No.', and 'Email address'. The 'Birthday' label is in yellow text, and the input field has a date format hint 'mm/dd/yyyy'. Below the input fields is a red 'Save' button.

Figure 6.15 Student Profile Setup

In Figure 6.15 above, here student will have to filled-up this form to create profile.

6.1.15 Login

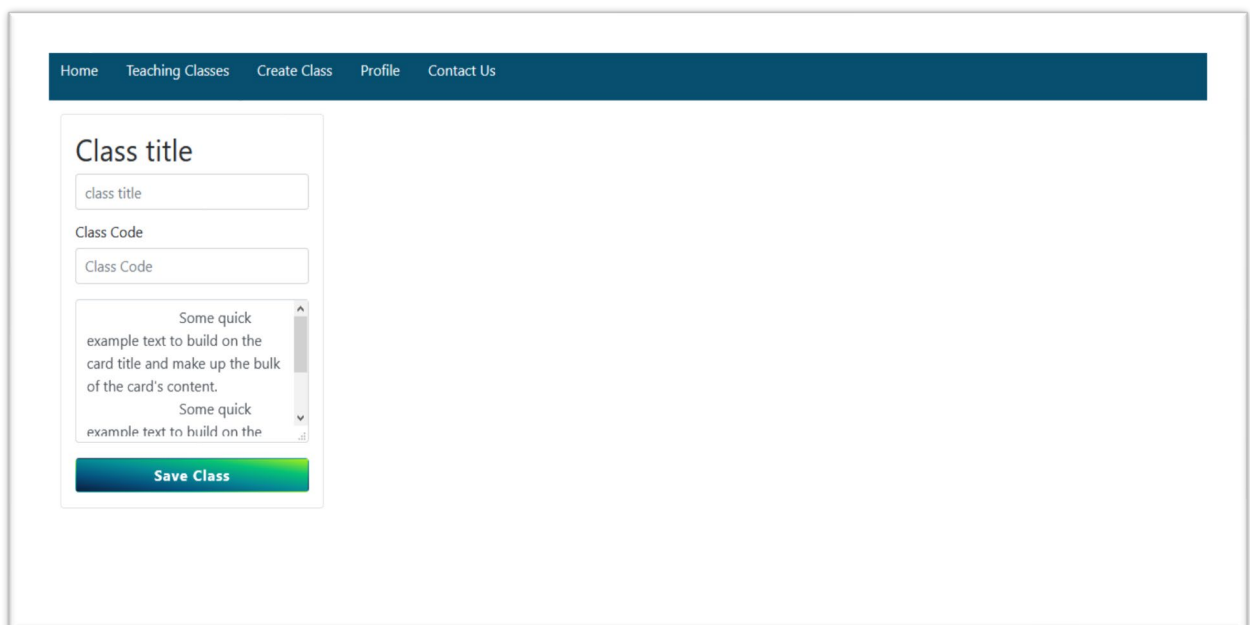


The image shows two login forms side-by-side. The top navigation bar has 'Register' and 'Contact Us' buttons. The 'Teacher Login' form has fields for 'Email' and 'Password', a 'Login' button, and a footer with 'Remember me', 'Forgot', and 'Password?' links. The 'Student Login' form has fields for 'Registration No.' and 'Password', a 'Login' button, and the same footer links.

Figure 6.16 Teacher and Student Login

After complete the profile setup now teacher and student both will be able to login to the system.

6.1.16 Create Classes



The image shows a 'Create Class' form within a navigation bar. The form includes fields for 'Class title', 'Class Code', and a text area for description. A 'Save Class' button is at the bottom.

Figure 6.17 Create Class by Teacher

In this page, here teacher can create a class with course title, course code and a short description of the course.

6.1.17 Teacher Home Page

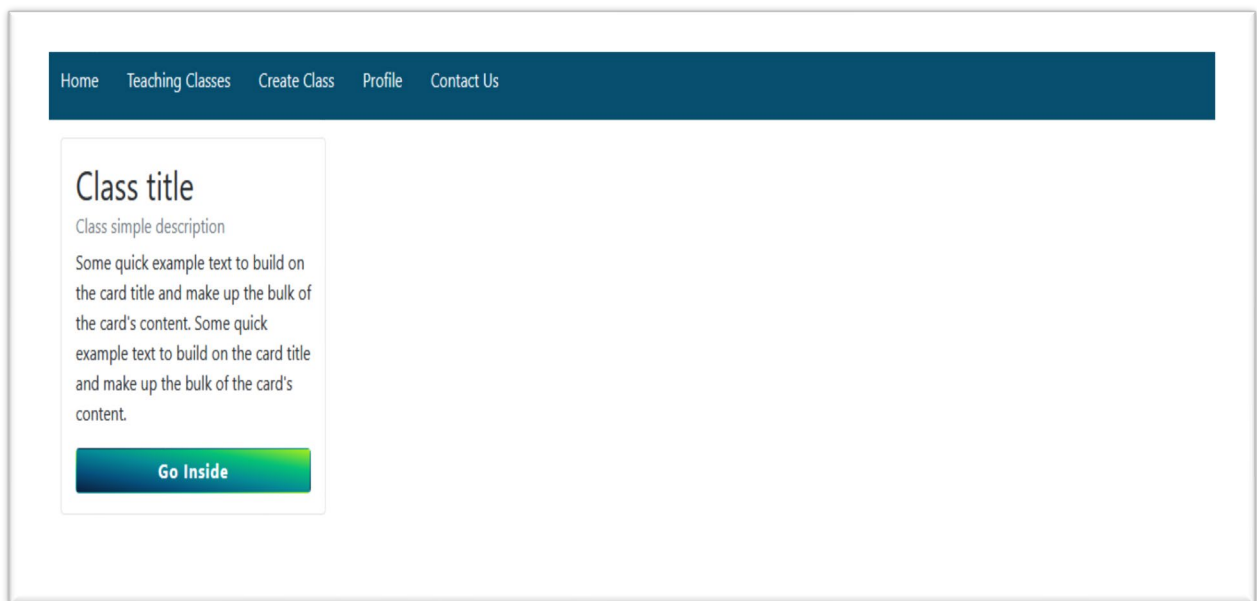


Figure 6.18 Course List for Teacher After Login

Here teacher can see all the classes that has already created by he/she. After click the 'Go Inside' button teacher's will be able to see their activity which they have to do by using our platform. Like start live class, archive video, create assignment, resource sharing, make exam, see student list and make an announcement.

6.1.18 Archive Video

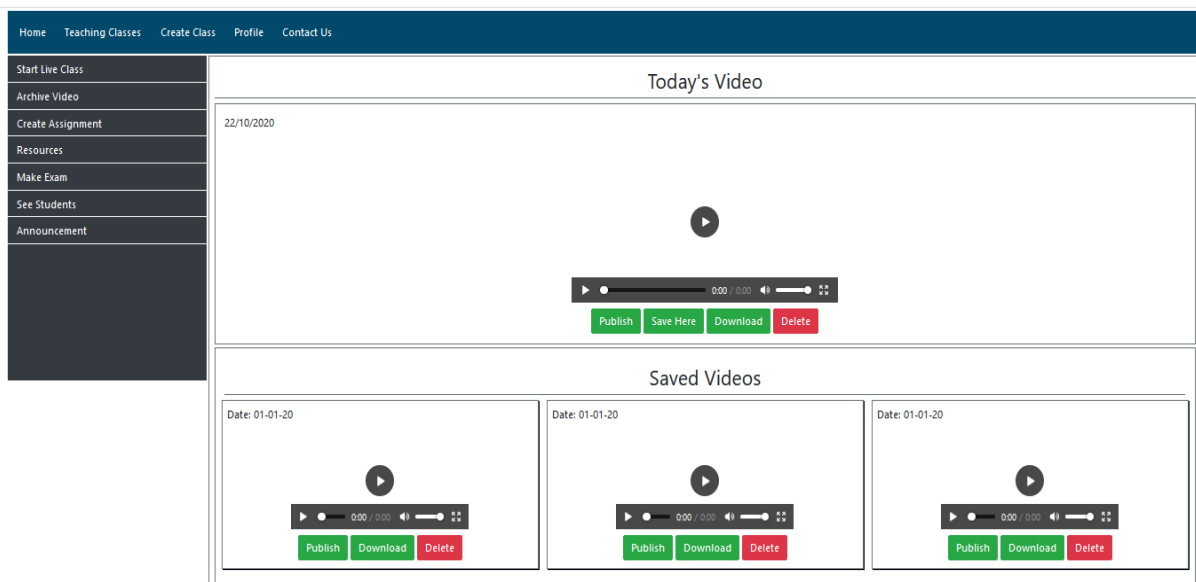


Figure 6.19 Archive Video Section for Recorded Class

Here teacher will be able to store recorded video in the system. Teacher can download,

publish and delete the video from the system.

6.1.19 Create Assignment

The screenshot shows a web application interface for creating an assignment. On the left is a sidebar with navigation links: Home, Teaching Classes, Create Class, Profile, and Contact Us. Below these are links for Start Live Class, Archive Video, Create Assignment, Resources, Make Exam, See Students, and Announcement. The main content area is titled 'Assignment Title' and contains a text input field. Below this is an 'Instruction' section with a larger text area and a 'Choose File...' button. To the right of the instruction field are 'Marks' and 'Due' fields. The 'Due' field has a date picker showing 'mm/dd/yyyy'. Below the form is a blue 'Submit' button. Underneath the form are two tables. The first table, 'Previous Published Assignment', has columns for SL, Assignment Title, Date & Time, Due On, See details, and Delete. It contains two rows of data. The second table, 'Submitted Assignment', has columns for SL, Assignment Title, Submit Date & Time, Due date, Student Registration No., Student Name, and Download. It also contains two rows of data.

SL	Assignment Title	Date & Time	Due On	See details	Delete
1	Lorem ipsum dolor sit amet...	01.01.20 - 9:10pm	11.01.20 - 11:59pm	See details	Delete
2	Lorem ipsum dolor sit amet...	05.01.20 - 11:10pm	15.01.20 - 11:59pm	See details	Delete

SL	Assignment Title	Submit Date & Time	Due date	Student Registration No.	Student Name	Download
1	Lorem ipsum dolor sit amet...	01.01.20 - 9:10pm	11.01.20 - 11:59pm	17010302000	XYZ...	Download
2	Lorem ipsum dolor sit amet...	01.01.20 - 9:10pm	11.01.20 - 11:59pm	17010302000	XYZ...	Download

Figure 6.20 Create Assignment by Teacher

From Figure-6.20, teacher can create assignment with proper title, mark, submission date, instruction and can see previous published assignment and submitted assignment.

6.1.20 Assignment Details

The screenshot shows the 'Assignment Details' page. The sidebar is the same as in Figure 6.20. The main content area has a title 'Assignment Title' and a 'Marks - 20' label. The 'Due' date is '01.01.20 - 11:59pm'. Below this is a large text area containing Lorem Ipsum placeholder text. At the bottom of the text area is a blue 'Edit' button.

Figure 6.21 Assignment Details Given by Teacher

Teacher will be able to see Figure-6.21 page if he/she click the ‘See details’ button on previous published assignment list in create assignment page.

6.1.21 Resources

SL.	File Name	Date & Time	Download	Edit	Comments	Delete
1	xyz.docx	01.01.20 - 9:10pm	Download	Edit	Comments(2)	Delete
2	abc.pdf	01.01.20 - 9:10pm	Download	Edit	Comments(2)	Delete
3		01.01.20 - 9:10pm	Download	Edit	Comments(2)	Delete

Figure 6.22 Resources Given by Teacher

From Figure-6.22, here teacher can upload new file by clicking the ‘Upload New File’ button. Teacher will be able to see comment, can delete the previous uploaded file, can download the upload file etc.

6.1.22 Make Exam

Exam Title

Add Questions [Add](#)

Question

Selection Type

☐ Checkbox ☐ Radio

Quiz Exam

1. Lorem Ipsum is simply dummy text of the printing and typesetting industry

2. Lorem Ipsum is simply dummy text of the printing and typesetting industry

3. Lorem Ipsum is simply dummy text of the printing and typesetting industry

Figure 6.23 Exam Making by Teacher

Here teacher can make an exam form by adding exam title, question, selection type and so on.

6.1.23 Participate Student List

Home	Teaching Classes	Create Class	Profile	Contact Us		
Start Live Class	SL	Semester No.	Registration No.	Student Name	Registration Status	Remove Student
Archive Video	1	11th	170103020000	XYZ...	Yes/Not/Not Yet	X
Create Assignment	2	11th	170103020000	XYZ...	Yes/Not/Not Yet	X
Resources	3	11th	170103020000	XYZ...	Yes/Not/Not Yet	X
Make Exam						
See Students						
Announcement						

Figure 6.24 Participate Student List Accessed by Teacher

In 'See Student' page teacher can see the participate student list of enrolled students which is given in Figure 6.24 above.

6.1.24 Announcement

Home	Teaching Classes	Create Class	Profile	Contact Us
------	------------------	--------------	---------	------------

Start Live Class
Archive Video
Create Assignment
Resources
Make Exam
See Students
Announcement

22/10/2020

Create New Announcement

Write Something

Publish

Published Announcement

Date:- 01.01.20

Lorem Ipsum is simply dummy text of the printing and typesetting industry. Lorem Ipsum has been the industry's standard dummy text ever since the 1500s, when an unknown printer took a galley of type and scrambled it to make a type specimen book. It has survived not only five centuries, but also the leap into electronic typesetting, remaining essentially unchanged. It was popularised in the 1960s with the release of Letraset sheets containing Lorem Ipsum passages, and more recently with desktop publishing software like Aldus PageMaker including versions of Lorem Ipsum

Student Name
This is a test message Oct-20
Teacher Reply
This is a test message Oct-20

Comment

Add Comment

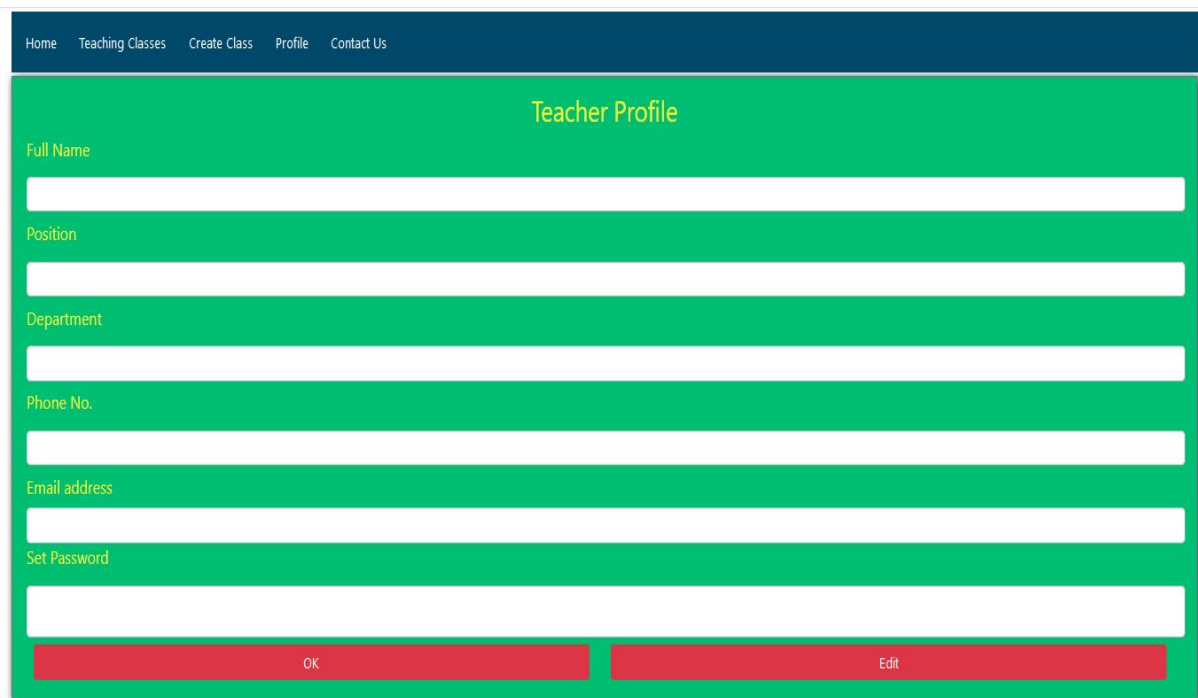
Edit

Delete

Figure 6.25 Announcement Created by Teacher

Here teacher can create any type of announcement, can see the published announcement, comment of student and can reply the comment also.

6.1.25 Teacher's Profile

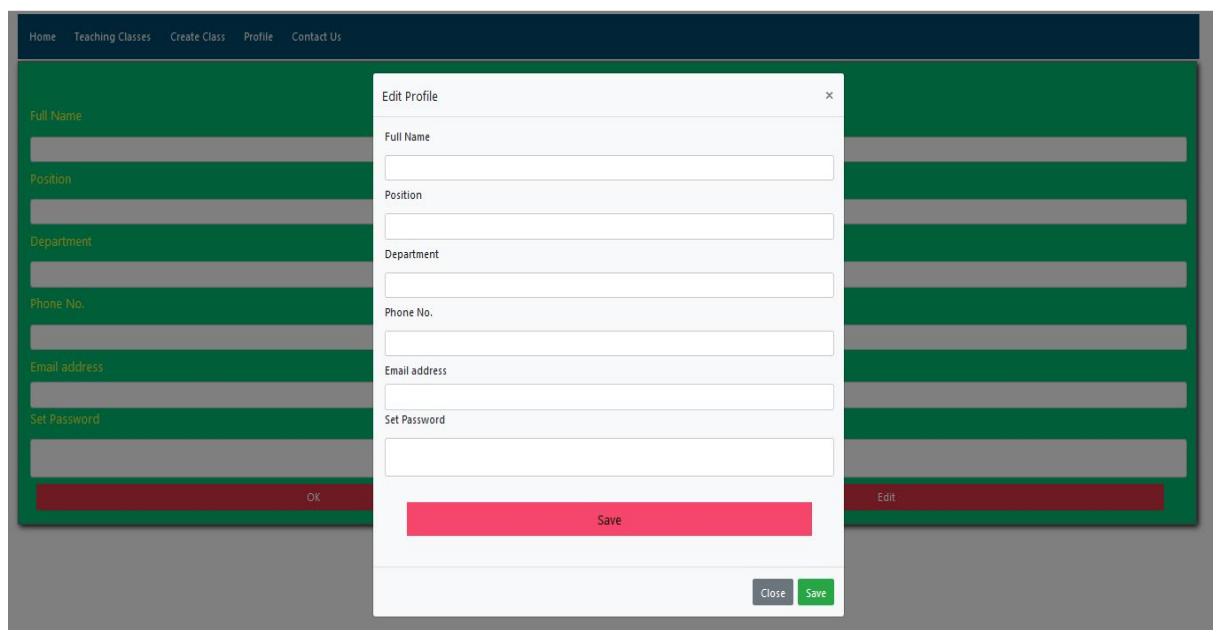


The image shows a web form titled "Teacher Profile" with a dark blue header containing navigation links: Home, Teaching Classes, Create Class, Profile, and Contact Us. The form itself has a green background and contains several input fields: Full Name, Position, Department, Phone No., Email address, and Set Password. At the bottom of the form are two red buttons labeled "OK" and "Edit".

Figure 6.26 Teacher's Profile

Here teachers will be able to see his/her profile and will be able to edit his/her profile.

6.1.26 Teacher's Profile Edit



The image shows the same "Teacher Profile" form as in Figure 6.26, but with an "Edit Profile" modal window open. The modal window has a white background and a title bar with a close button (X). It contains the same input fields as the main form: Full Name, Position, Department, Phone No., Email address, and Set Password. At the bottom of the modal is a large red "Save" button. Below the "Save" button are two smaller buttons: "Close" and "Save". The background form is dimmed and shows the "OK" and "Edit" buttons.

Figure 6.27 Profile Edited by Teacher

Figure-6.27 is the profile edit form where teacher will be added update information which he/she wants to show his/her profile.

6.1.27 Join Class

Home Join Class Enrolled Classes Profile Contact Us

Search Class

Department Teacher Search

Class title
Class simple description
Some quick example text to build on the card title and make up the bulk of the card's content. Some quick example text to build on the card title and make up the bulk of the card's content.

Enroll

Figure 6.28 Join Class by Student

After complete the login, student will be able to join the class which is given in Figure-6.28 above. Here he/she can find class by using filter as department name, teacher name accordingly.

6.1.28 Class Enroll

Home Join Class Enrolled Classes Profile Contact Us

Class title
Class simple description
Some quick example text to build on the card title and make up the bulk of the card's content. Some quick example text to build on the card title and make up the bulk of the card's content.

Go Inside

Figure 6.29 Class Enrolled by Student

After click the ‘Enroll’ button student will be able to see all the enrolled courses which he/she has been taken and after click the ‘Go Inside’ button student will go to the dashboard (given below in Figure-6.30) page where he/she will see the all facility of our platform.

6.1.29 Student Dashboard

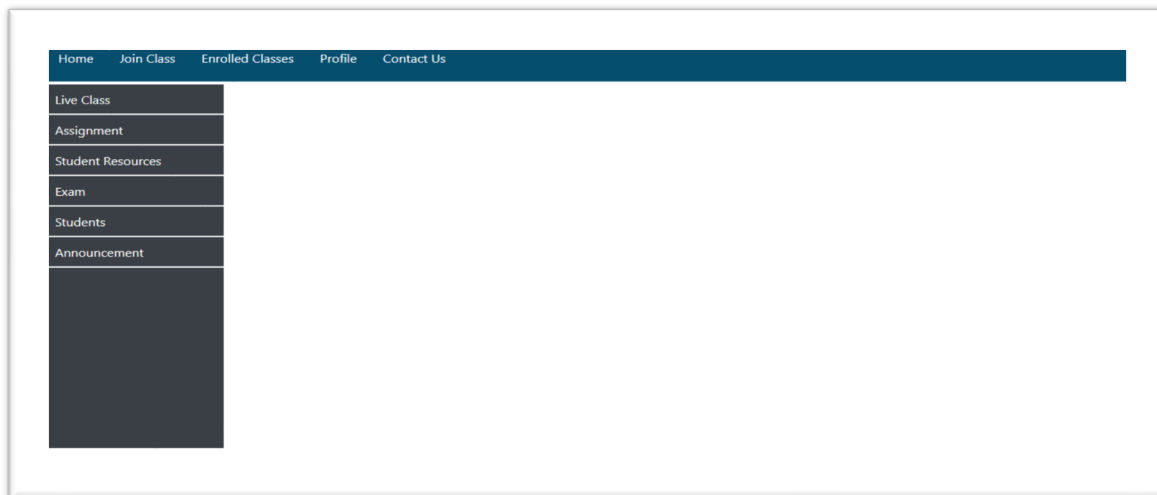


Figure 6.30 Class Activity for Student

6.1.30 Assignment Submission

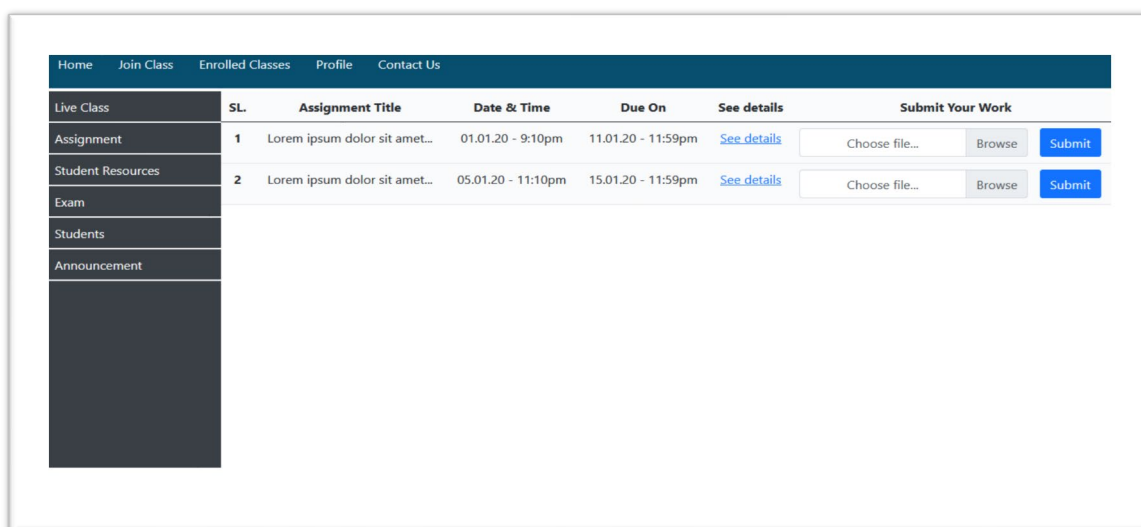


Figure 6.31 Assignment Submitted by Student

From Figure-6.31 student will be able to see the assignment which was published by the teacher and he/she can submit the assignment from this page.

6.1.31 Assignment Details

Home Join Class Enrolled Classes Teaching Classes Create Class Profile Contact Us

Live Class
Assignment
Files
Video Files
Exam
Students
Announcement

Assignment Title

Marks - 20 Due: 01.01.20 - 11:59pm

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Submit Your Work

Choose file...

Submit

Figure 6.32 Assignment Details for Student

By clicking the ‘See Details’ button of previous assignment submission page students will be able to see about details of published assignment. From Figure-6.32, student can also be able to submit the assignment.

6.1.32 Student Resources

Home Join Class Enrolled Classes Profile Contact Us

Live Class
Assignment
Student Resources
Exam
Students
Announcement

File Type mm / dd / yyyy Search

SL.	File Name	Date & Time	Download	Comments
1	xyz.docx	01.01.20 - 9:10pm	Download	Comments(2)
2	abc.pdf	01.01.20 - 9:10pm	Download	Comments(2)
3		01.01.20 - 9:10pm	Download	Comments(2)

Figure 6.33 Resources Accessed by Student

From Figure-6.33, here student will be able to access all kinds of resources like video, pdf file, pptx, doc file, txt file etc.

6.1.33 Attend Exam

The screenshot shows a student's exam interface. On the left is a sidebar with navigation links: Live Class, Assignment, Student Resources, Exam, Students, and Announcement. The main area is titled 'Quiz Exam' and contains five questions, each with four radio button options. A progress bar at the bottom indicates the current question number.

Quiz Exam

1. Lorem Ipsum is simply dummy text of the printing and typesetting industry

☐ Cras justo odio

☐ Dapibus ac facilisis in

☐ Morbi leo nisl

☐ Porta ac consectetur ac

☐ Vestibulum at eros

2. Lorem Ipsum is simply dummy text of the printing and typesetting industry

☐ Cras justo odio

☐ Dapibus ac facilisis in

☐ Morbi leo nisl

☐ Porta ac consectetur ac

☐ Vestibulum at eros

3. Lorem Ipsum is simply dummy text of the printing and typesetting industry

☐ Cras justo odio

☐ Dapibus ac facilisis in

☐ Morbi leo nisl

☐ Porta ac consectetur ac

☐ Vestibulum at eros

4. Lorem Ipsum is simply dummy text of the printing and typesetting industry

Explain below:

5. Lorem Ipsum is simply dummy text of the printing and typesetting industry

☐ Cras justo odio

☐ Dapibus ac facilisis in

☐ Morbi leo nisl

☐ Porta ac consectetur ac

☐ Vestibulum at eros

Progress bar: 1 2 3 4 5

Figure 6.34 Exam Paper for Student

From above in Figure-6.34, student will be performing the exam which was created or announced by course teacher.

6.1.34 Student Participate List

The screenshot shows a table with the following data:

Home	Join Class	Enrolled Classes	Profile	Contact Us
Live Class	SL	Semester No.	Registration No.	Student Name
Assignment	1	11th	170103020000	XYZ...
Student Resources	2	11th	170103020000	XYZ...
Exam	3	11th	170103020000	XYZ...
Students				
Announcement				

Figure 6.35 Student Participate List

From Figure-6.35, here student can see the other's students who are participated in the classes.

6.1.35 Get Announcement

Figure 6.36 Student Get Announcement

In announcement page from Figure-6.36, student can see the published announcement by the teacher and can comment and reply into the announcement.

6.1.36 Student Profile

Figure 6.37 Student Profile

From Figure-6.37, here student can see his/her profile and can edit that also.

6.1.37 Student Profile Edit

The screenshot displays a web application interface. At the top, a dark blue navigation bar contains links: Home, Join Class, Enrolled Classes, Profile, and Contact Us. The main content area has a green header with the text 'Student Profile'. Below this, there are two forms. On the left is a form for viewing the profile, and on the right is a modal window titled 'Edit Profile' with a close button (X). Both forms contain the following fields: Full Name, Birthday (with a date picker showing mm/dd/yyyy), Department, Session, Semester, Registration No., Phone No., Email address, and Set Password. At the bottom of the main form is a red button labeled 'OK'. At the bottom of the 'Edit Profile' modal is a red button labeled 'Save' and a green button labeled 'Close'.

Figure 6.38 Profile Edited by Student

From Figure-6.38, when student click the edit button a popup window will be shown. Here student can edit his/her necessary information which he/she wants to add into the profile.

6.1.38 Contact US

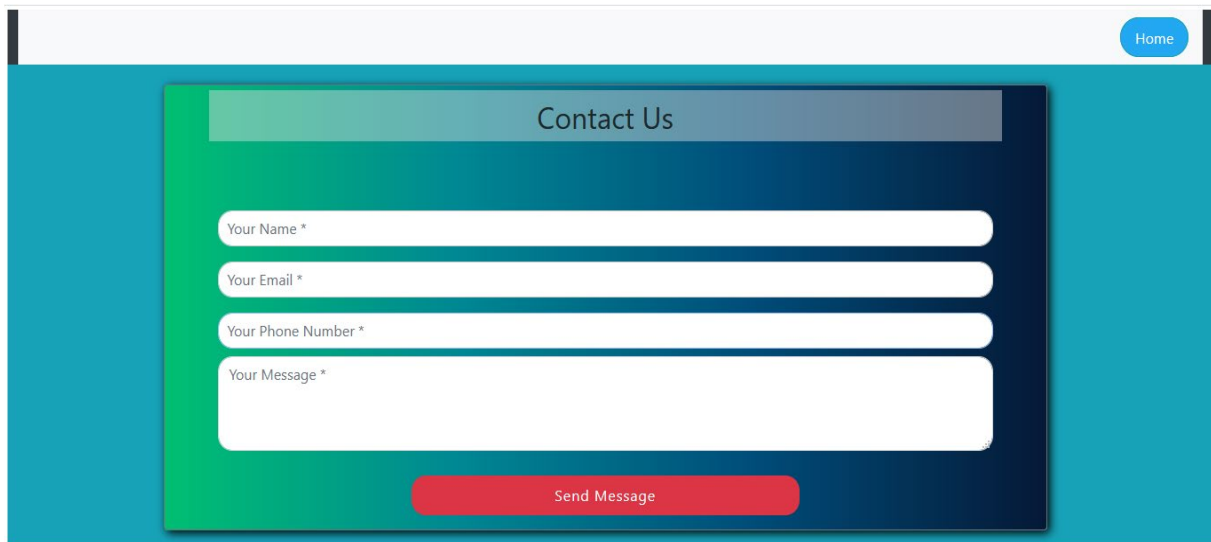
A screenshot of a web application's 'Contact Us' form. The form is centered on a teal background. It has a title bar 'Contact Us' at the top. Below the title bar are four input fields: 'Your Name *', 'Your Email *', 'Your Phone Number *', and 'Your Message *'. At the bottom of the form is a red 'Send Message' button. A 'Home' button is visible in the top right corner of the page.

Figure 6.39 Contact Us

Contact page can use both student and teacher. By using this form teacher and student will be able to contact with admin for any kind of query.

6.1.39 WebRTC Host Interface

From here, we are added our newly completed works screenshots.

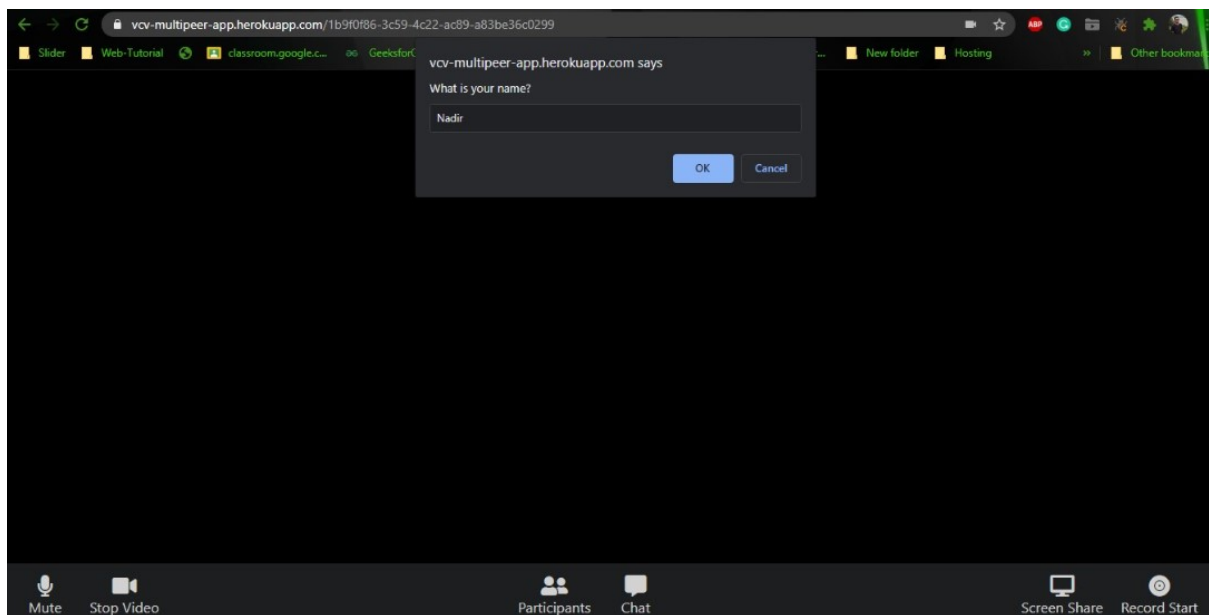


Figure 6.40: Pop-up window for host first time connection

From above in Figure-6.40, when host first time start visit our application link, he got a pop-window for put his/her name in the video streaming. After that, his/her streaming will be start.

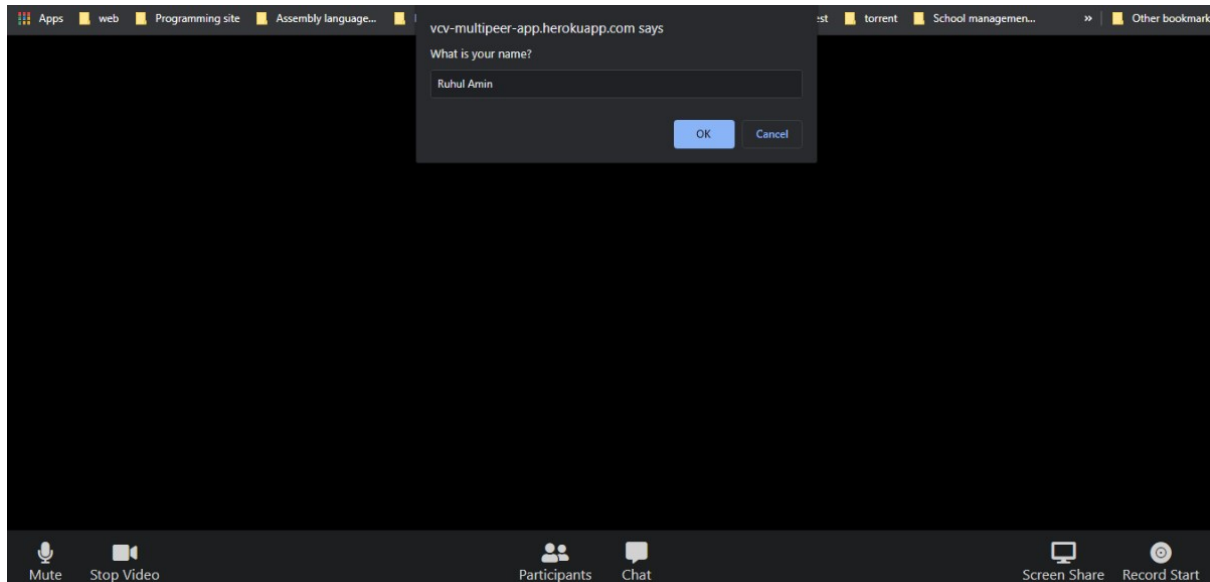


Figure 6.41: Pop-up window for a new user first time connection

When a new user wants to join video streaming, he/she will receive a pop-up like a host from Figure-6.41. After putting his/her name then they will be able to join the video streaming.



Figure 6.42: When multiple users will be connected to video streaming

From Figure-6.42, this is what the host or user's browser window will look like when multiple users are connected to video streaming. And, everyone will see each other clearly.



Figure 6.43: When host turn off his mic

When the host turns off his mic, other users will not be able to hear him. But other users will be able to talk with them without the host which we can see that from Figure-6.43.

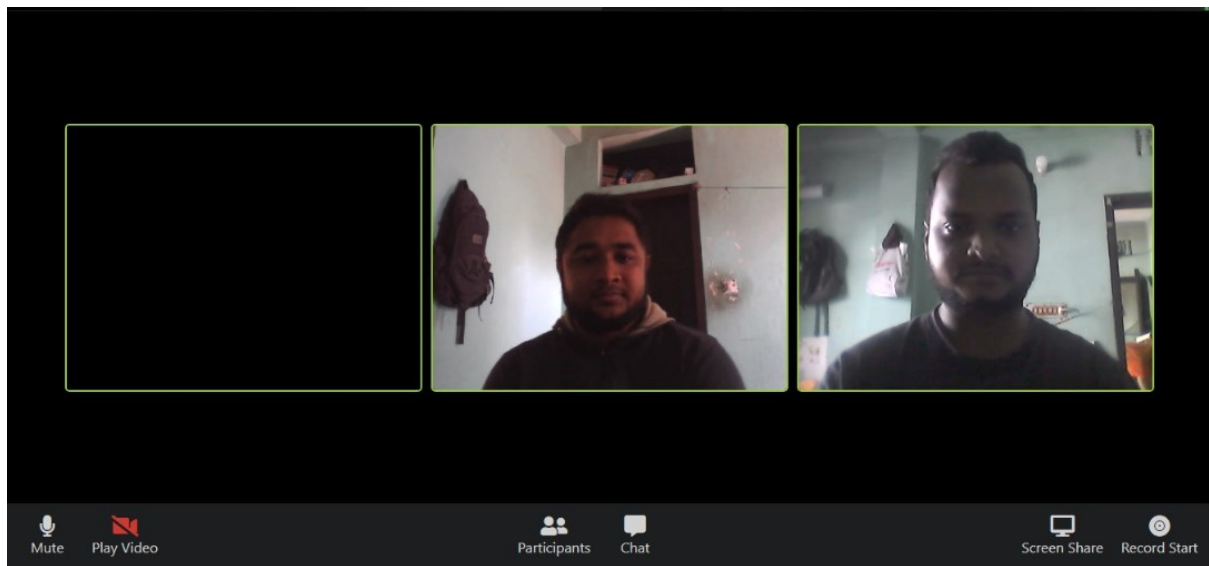


Figure 6.44: When host turn off his camera

Figure-6.44 we can see that when the host turns off his video, other users will not be able to see him. But other users will be able to talk with them without the host video.

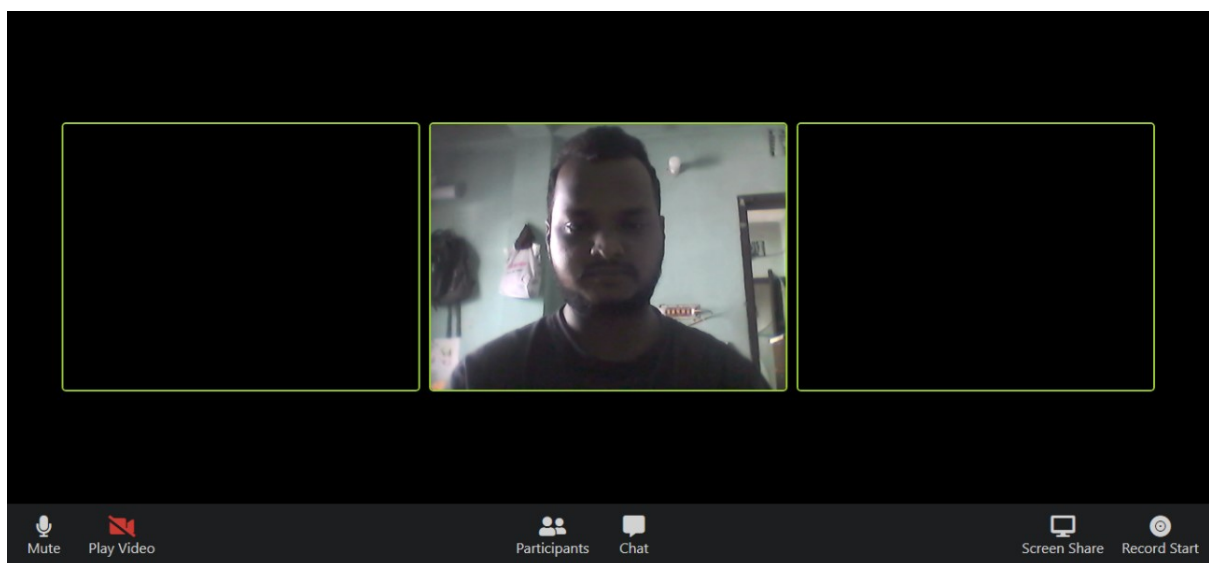


Figure 6.45: When the host and a user turn off their camera

From Figure-6.45 when the host and a user turn off their video then other users will not be able to see them. But other users will be able to talk with them without the host and user video.

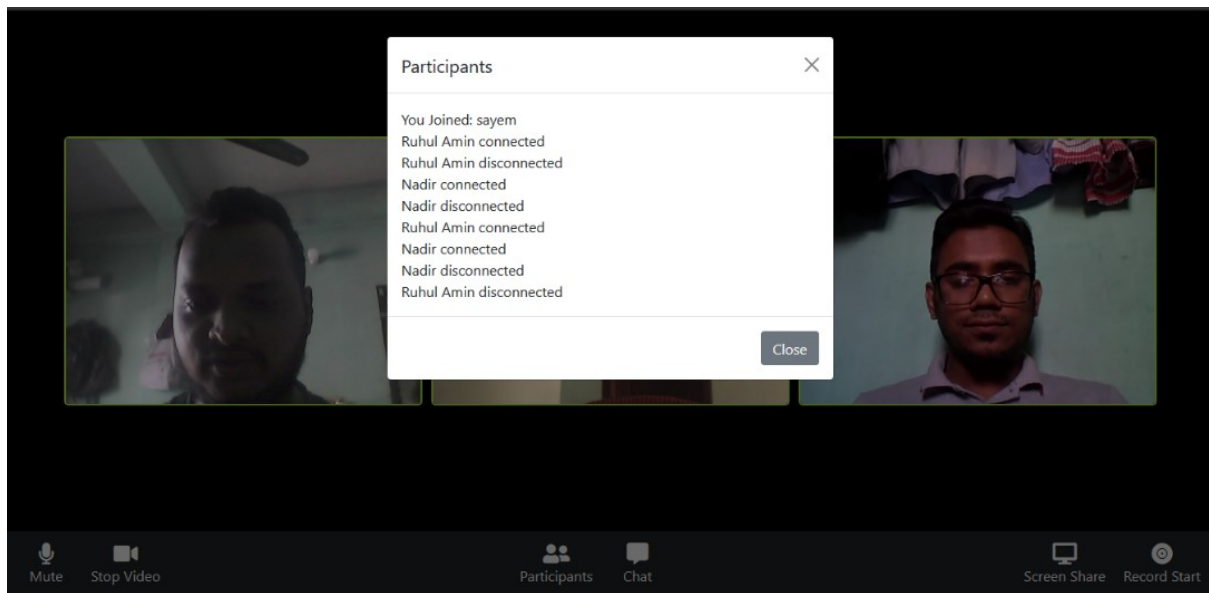


Figure 6.46: Participants List both for Host and User

Participate list will be showable when users or hosts clicked the participant's button. From Figure-6.46 the user and host will be able to see all the users, whose are connected or disconnected in the video streaming.

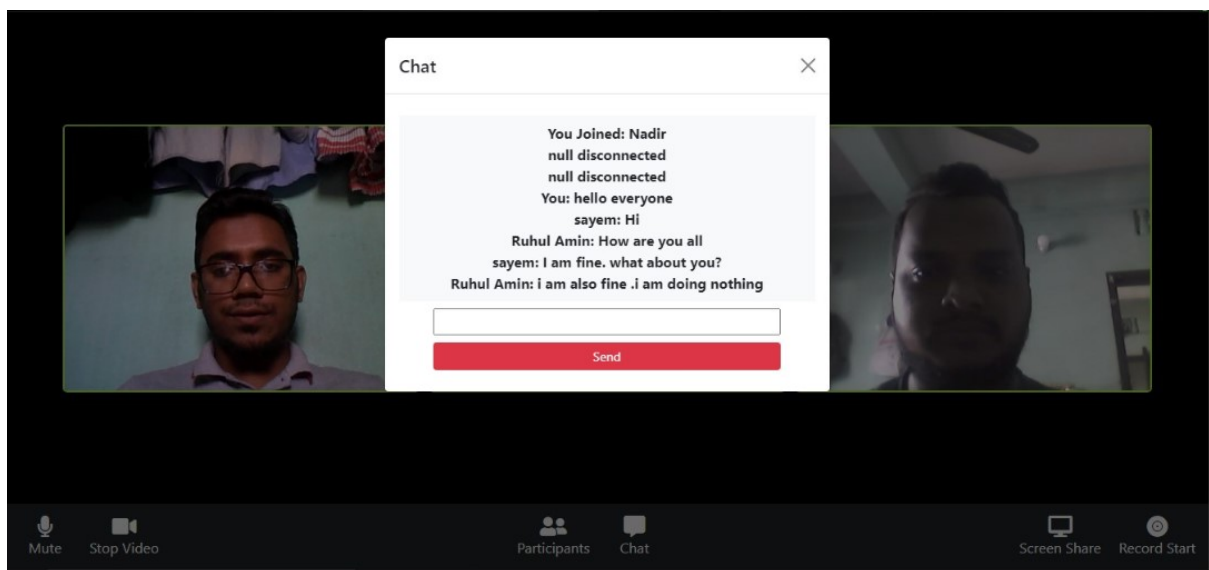


Figure 6.47: Chat for both Host and User

Chat window will be showable when users or hosts clicked the chat button. In Figure-6.47 here the user and host will be able to chat with all of them during the video streaming.

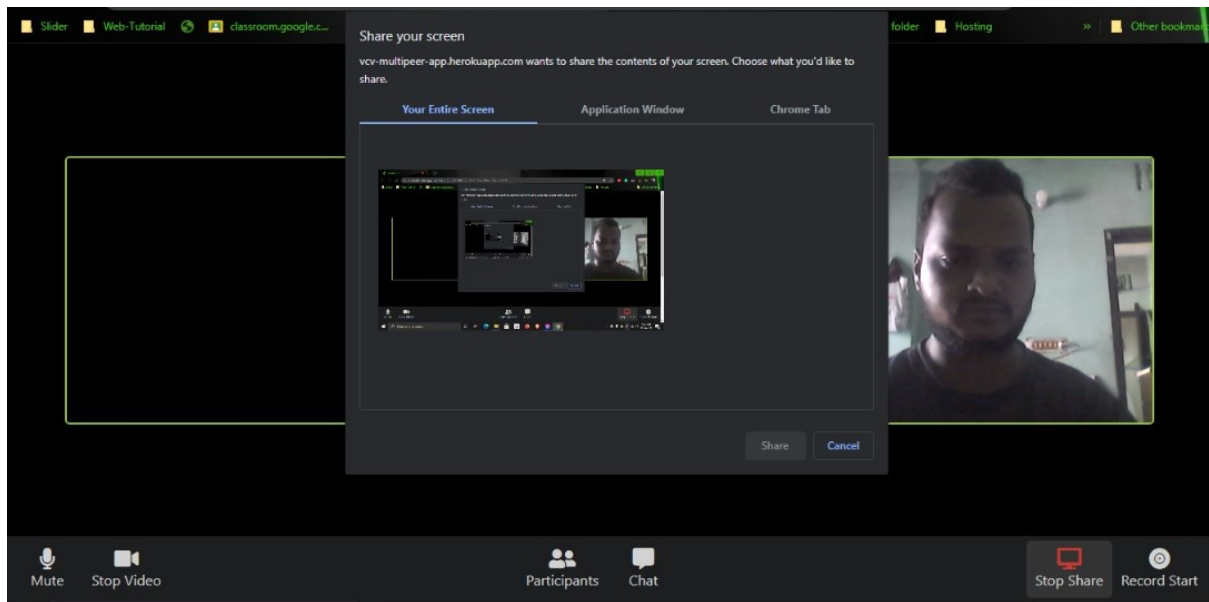


Figure 6.48: Host start the screenshare

From Figure-6.48 When the host tries to start screen sharing, a pop-up will appear in front of the host from the browser. Other users will be able to see the screen after selecting the desired window for sharing.



Figure 6.49: Other users with shared screen

When the host starts the screen share then other users will be able to see the host share screen beside their screen. In Figure-6.49 we can see that after host or user share their screen.

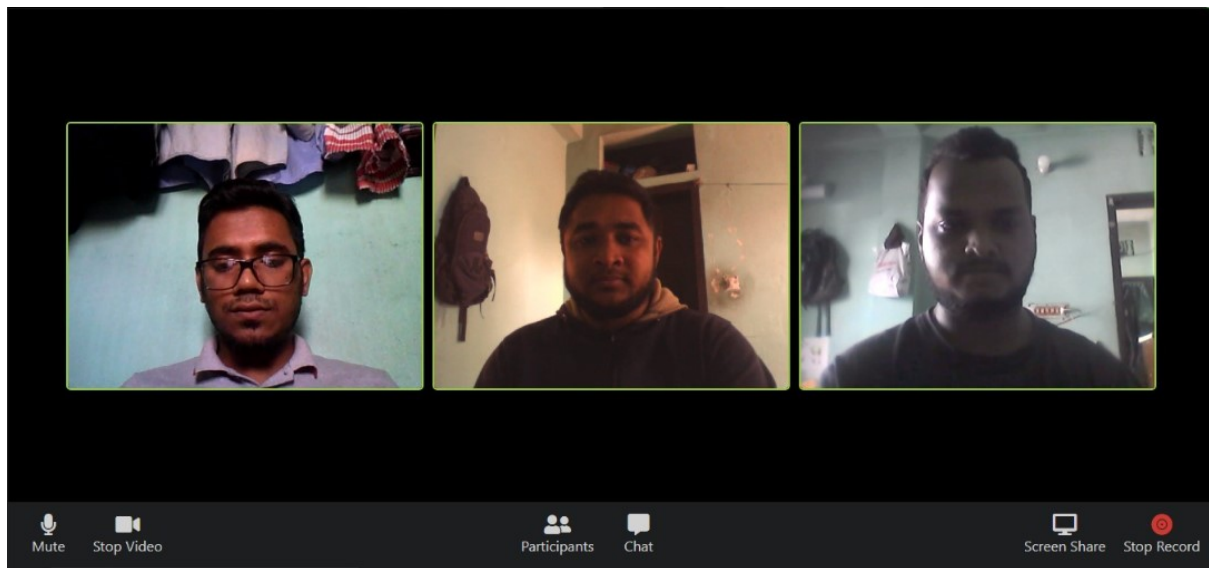


Figure 6.50: Video recording by the host

From Figure-6.50 when the host clicked the video record button the video recording will be starting from the host screen.

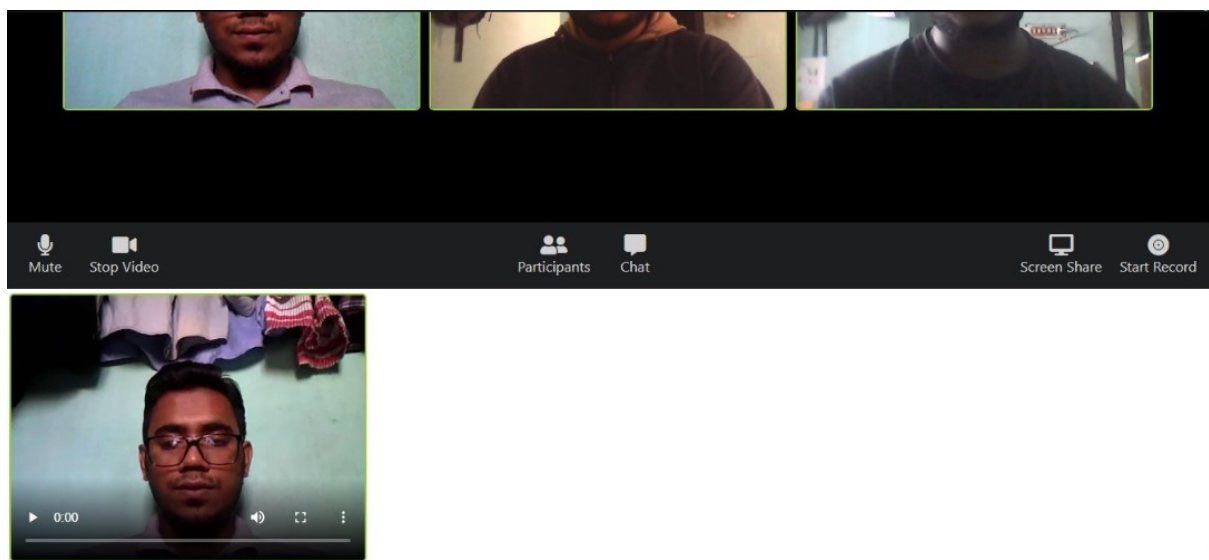


Figure 6.51: After video recorded

When the video recording is finished, the video will be saved at the bottom of the main application window which is given in Figure-6.51 above. For live test (we only deploy our RTC app) [click Here](#) .

Chapter 7

TESTING

7.1 Overview

After completing the requirement analysis, design and coding phase then most important phase is testing. Where we test our project to find bugs in code, system acceptance, environment level etc. After that we have fixed those bugs and again test the current fixed functionalities to check the new changes are fit with our project. After works, in testing phase we have tested our application with every possible situation which works correctly or not.

7.2 Testing Levels

1. **Unit Testing:** Unit testing involves the testing of each unit or an individual component of the software application. It is the first level of testing done before integration. Depends on this definition we have tested each unit of our application to find bugs or functional error.
2. **Integration Testing:** In this testing, units or individual components of the application are tested in a group. The focus of the integration testing level is to expose limitation at the time of interaction between integrated components or units. Here we have tested our integrated application which is the combination of each unit of our application.
3. **System Testing:** System testing is performed on a complete, integrated system. It allows checking the system's compliance as per the requirements. Depends on this definition, in system testing phase we have tested our full application to reached final decision going to acceptance testing.
4. **Acceptance Testing:** Acceptance testing is formal testing based on user requirements and function processing. Where we have tested our project requirements full or not.

7.2.1 Unit Testing

Our webrtc application has some different unit like as multipair video stream with audio, participant list, chat, screen share, record stream and download recorded stream. We have tested each unit individually. After that, we have found tested result as we discuss below.

1. **Initial Attempt:** When host or any user visit the application link first, he/she has to provide their name. After that host or user will be able to see his/her face on window and a unique link will be provide or generate automatically in search bar. For example: <https://vcv-multipeer-app.herokuapp.com/9dan09y4rndoas90hfaphhh0034>. This link will be sharable. When any user visits this link, which is provided by the host then they will be connected with each other via our application. We have tested our application over 6 multiple user and it has worked correctly.

Result: Dynamically generated link which will be created after host name confirmation then host shared the link with another user. When user visit this link, they connect with host successfully. They can see each other in their browser window.

2. **Audio Mute/Unmute:** During stream host and user will be able to listen their audio or voice whatever they want to say. Even during stream both can mute and unmute their audio by clicking microphone button.

Result: Audio, mute/unmute works successfully.

3. **Camera Start/Stop:** During stream host and user will be able to see each other. Even during stream both can stop and start their video by clicking camera button.

Result: Video, start/stop works successfully.

4. **Participants List:** During stream host and user will be able to see participant list. List will be showable by a pop-up window when user or host clicked the participant button.

Result: Participant list window works successfully.

5. **Chat:** During stream hosts and users can send messages to each other. The chat window will work when hosts or users click the chat button. After clicking the button, a pop-up window will be showed and their users or hosts can type their text and send it to each other.

Result: Chat window works successfully.

6. **Screen Share:** During stream hosts and users both can share their screen with each other. When hosts or users click on the screen share button a pop-up window will be showed. This window gives them some option like which window they want to share. After select the window permission, they will be able to see shared screen via our application.

Result: Screen Share works successfully.

7. **Record Stream:** During stream hosts and users both can record their streaming. It will work when user or host click on the record button. After stop the recording, the recorded stream or video will be showed in a video frame and even when they will be able to download this video also.

Result: Record and download function works successfully.

7.2.2 Integration Testing

In this phase we have integrated each unit of our application. As we discuss in unit testing phase, when host visit the application link host will get a prompt(pop-up) where host has to enter his/her name a unique link will be generated. When host shared this link with users, they also need to put their name into prompt. After that both will be able to start communication.

Our application interface has two section one for user and host interface another is menu or button section. In interface section, here both can see their camera or video interface where they share their activity also like as screen share and so on. In the button section, there is another three section. One for audio, video(camera) one for participant list, chat another for screen share and record section.

During stream if users or hosts click on audio button once then the voice of users or host will be mute. For unmute users or hosts need to click once also.

Hosts or users will be able to stop their camera or video by clicking video button. When users or host click on the video button then the video is stop. For play video it will be need to click video button once again.

Users or host both can see the participant list who are attend in stream. For this they need to click on participant button. When they click it, a modal will be showed where they can see the list. For close the modal they also need to click outside the close button.

During stream users and host can chat with each other. For chat they need to click on chat button. When users or host click on it, a modal will be showed where they can put their text on input filed and click on the submit button. This text can see both of users or host with sender name. To close the modal both, need to click the close button on top of the model.

Screen share is also an important part of our application. Users and host both can share their screen activity during stream. For that both will be needed to click on the screen share button. When they click it, a modal will be showed by browser where they need to select a window which they want to share. After that screen capturing will be started and they will be able to see the shared screen from users or host. To stop the screen capturing or share they need to click the stop share button. If they click on it then the screen capturing will be stopped.

Our application also provides recording facility. Users or host both can record their activity during stream. For that they need to click on record start button. When users or host click on it recording will be started automatically. Normally it records the users or host activity during stream. To stop recording users or host need to click on stop record button. When they click on it, recording will be stopped and a recorded stream will be showed in a div which is on the bottom of our application. Host can download the recorded video also.

Bugs in Integration Testing:

1. In unit testing phase for only communication or streaming our application works correctly. It has done only in one to one communication. But in integration phase for multipair communication sometimes users have to refresh their browser window because sometimes our live server missed the new user's data. When a new user reloads his/her own window then he/she joined in the streaming. We didn't be able to identify where is the actual problem for occurring this error. We have tested our application over 6 multiple user and it has worked correctly.
2. Participate list works correctly as well as unit testing phase. But here we have found an error and it is when a new user connects in the streaming, he/she cannot see the t participant who already attend in the streaming. New users only can see the participants who have attended in the stream after him. It is a bug that we have found during integration testing. It is occurring because we didn't store user's information in the database.
3. In integration phase we have also found a bug in chat portion. It gives an error to new user when he/she connect during stream. It is occurring because we didn't store information of every user in database. If we store user's information then we think that it will be works.
4. Screen share works correctly in unit testing face but in integration phase we have found an error during stream. When hosts or users click on the screen share button the video or camera becomes stop. screen share works correctly. But the error occurs when the user or host click the video button screen share becomes stop automatically and the users or hosts interface becomes freeze. Another error is when a new user joins the meeting during stream, he/she can't be able to see the latest sharable screen by the host or user.
5. We have found an error for record stream in integration phase. It occurs when users or hosts share their screen otherwise it works correctly. Here MediaRecorder can't be able to convert the MediaStream into MediaStreamTrack.
6. In integration phase sometimes recorded video can't be downloaded well.

7.2.3 System Testing

Our main goal was to work with webrtc which is an open source framework provided by Google. It works in web browsers and mobile application with real time communication. But we have only worked for web browser. From the idea we have completed most of the features that we have declared as main features. Some of the main features we unable to complete. We have tested our application over 6 multiple user and it has worked correctly. A large amount of time we have spent to work with webrtc related feature. For this reason, we can't be able to move on other side of our project.

7.2.4 Acceptance Testing

We have tried to complete our main features that we have collected from the end user. From the webrtc part we tried our best to implement it. But here we have found limitation. It did not fully meet user requirements.

7.3 Limitation and Future Work

Due to time constraints we could not reach on the database related work. We could not work of some webrtc related work like as screen control and we did not get to our additional features. In Future we believe that which works we didn't complete yet its will be completable in future, and we want to work with this project in future.

Chapter 8

TOOLS USED

8.1 Overview

In this chapter, we will discuss the tools used to develop the application.

- **Hardware**
 - ✓ Desktop Computer
 - ✓ Laptop Computer

- **Software**
 - ✓ Visual Studio Code
 - ✓ Notepad++
 - ✓ Pixi
 - ✓ Light Shot
 - ✓ Web browser

- **Language**
 - ✓ HTML
 - ✓ CSS
 - ✓ Bootstrap5(Alpha Version)
 - ✓ JavaScript
 - ✓ Nodejs

- **Network**
 - ✓ Have a good internet connection

8.2 Compatibility

This application is compatible with all browser which have current windows version or above.

Chapter 9

CONCLUSION

“Virtual Class Venture” is a web-based video conferencing platform for educational institution. Our main goal is to create an application that will helps an educational institution to continue learning online as well as offline. We have already completed full frontend part and also have completed most of the part of multi-peer connection. In multi-peer connection, we have completed multi person video calling, mic on/off, video on/off, chatting, participation list, screenshare facility, video recording and save it on under the main application. We have tested our application over 6 multiple user and it has worked correctly. Though we have tried to completed most of the (RTC)real-time communication part but here we have found some error of our project. After making this, we believe that, in learning level this project helps everyone. Due to time constraints we could not reach on the database related work. We could not work of some webrtc related work like as screen control and we did not get to our additional features. In future we will try our best to complete this project properly which we were declared first.

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Books:

[1] Roger S. Pressman, (2009). Software Engineering: A Practitioner's Approach (7th ed.).

McGraw-Hill Education

[2] Ian Sommerville, (2010). Software Engineering (9th ed.). Addison-Wesley

Website Link:

- **Stack Overflow:** <https://stackoverflow.com/>
- **Zoom:** <https://zoom.us/>
- **Skype:** <https://www.skype.com/en/>
- **Google Classroom:** <https://classroom.google.com/h>
- **Google Meet:** <https://apps.google.com/meet/>
- **Facebook Video Call:** <https://www.facebook.com/videocall/>
- **WebRTC:**
 - ✓ WebRTC: <https://webrtc.org/>
 - ✓ PeerJS: <https://peerjs.com/>
 - ✓ HTML Rocks: <https://www.html5rocks.com/en/tutorials/webrtc/basics/>
 - ✓ JS Library: <https://sipjs.com/>
 - ✓ Real Time Communication with webrtc:
<https://codelabs.developers.google.com/codelabs/webrtc-web/#0>
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