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Pi Class – A Revolutionary Step Forward in Hybrid Class Management System

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Abstract - The COVID-19 pandemic has caused widespread disruptions globally, resulting in a state of health emergency with numerous deaths reported and an overall implementation of quarantine and isolation. Strict lockdowns have been implemented to curb the spread of the virus, requiring social distancing and limiting physical interactions. These measures had far-reaching impacts on all aspects of life, including education. Education was one of the most affected sectors, with difficulty delivering quality education in schools, colleges, and universities. It was hard to provide quality education, a basic need of humanity. In this research paper, we propose an adequate solution to overcome the difficulties of maintaining educational quality during and after the COVID-19 pandemic and its multiple variants. The proposed solution is a hybrid model for an autonomous lecture recording system that facilitates students to attend physical classes and attend lectures virtually. The solution proposed is a cost-effective and convenient way for students to access lectures. The application involves hardware and software components that record and preserve lectures' audio and visual aspects. The system will allow lectures to be delivered directly to the students' devices. The major modules of the project include Python scripting, model training, UI/UX design, and app development.

Keywords— Remote education, online lecturers, lecture backups, self-generated lecture links, cloud-based class management, automated recordings, smart applications, hybrid classrooms.

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1. INTRODUCTION

The traditional classroom setting is a challenging environment for both students and teachers. With many students against one instructor, it becomes difficult for the instructor to maintain the lecture quality and individual attention to each student. Students who cannot attend physical classes miss essential lessons for multiple reasons, the most mentionable being observing quarantine. Those who learn best through visual, oral, or hands-on approaches may get bored or frustrated in a traditional setting. This project aims to provide students with an efficient way to access lectures from any device and maximize their productivity by allowing them to learn from their preferred location. It will enable

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students who cannot attend physical lectures to learn from home. The system will enable teachers to evaluate their presentation skills and improve them accordingly. The project aims to develop an automated lecture recording system to solve outdated learning problems efficiently. Lecture recording is a crucial aspect of e-learning and remote education. It will focus on recording both audio and visual components of lectures. The purpose of the system is to capture and preserve audio, video, or multimedia content from lectures, presentations, or meetings for later playback or distribution. The recorded content can be used for various purposes, such as for students who missed the lecture to catch up, for students to review material, for remote participants to access the content, for educational or training purposes, or for archival purposes.

Traditional classroom learning is challenging for students, especially when discussing professional education, be it medical, engineering, law, or business, due to multiple students in a single classroom. Each student has a different learning style and academic strengths and weaknesses, which requires a tailored approach to improve their education. Instructors may face time restrictions and must meet course learning objectives per lecture. This may result in missing critical parts of the lecture when repeating the lecture for the set of students later.

The main goal of this proposed solution is to revolutionize education by bridging the gap between traditional classroom teaching and technology-based learning. It aims to create an inclusive platform that provides students easy access to lectures, study materials and other educational resources while enhancing their learning experience and promoting collaboration among students and teachers. Technology will make education more affordable, accessible, efficient, and long-lasting. They allow learners from all walks of life to participate and grow their knowledge. The project also seeks to improve teachers' presentation skills and provide them with more tools to evaluate their effectiveness in the classroom. Ultimately, this solution will significantly shift how education is delivered, making learning as accessible as possible and a convenient experience for everyone.

The core objectives of the paper are as follows:

- Make cost-effective hardware.
- Effective use of time.
- A system facilitating distant learning.
- Availability of lectures to the students for revision & maintaining the quality of lectures.

This project aims to give students an accessible and convenient way to review lectures and stay engaged in their studies. The ability to record and store lectures on the cloud will ensure that students can access them anytime and from any location. The email broadcasting feature through the app will provide a streamlined lecture distribution and notification approach. The project's scope will help address the limitations of traditional classroom learning and provide students with a more personalized learning experience.

An automated lecture recording system solves these issues by allowing students to access the recorded material at their own pace and time, providing the flexibility they need to excel. Additionally, students who cannot attend traditional in-person classes can still access the material. Students who live far from their educational institute can save on costly travelling and living expenses. E-learning is also more cost-effective than traditional learning, making education accessible to a broader range of students.

2. LITERATURE REVIEW

With the advancement of technology, the traditional educational technique has lost its validity. From correspondence to training, innovation benefited us in every aspect of our lives. A new teaching approach based on instructional resources, 3D vision platforms, and films has been devised, and all prestigious institutions have adopted this philosophy. At Osnabruck University, a student survey was being done, and groups had access to both conventional learning and recorded lectures. Students' responses were fascinating since they revealed that recorded lessons were more valuable to them than traditional learning [12].

Single-board devices like the Raspberry Pi are built to enhance education and provide cost-effective alternatives for promoting education in underdeveloped countries, particularly in rural places where necessary resources are unavailable [3,7]. Raspbian is a specific operating system (OS). However, it can also run other operating systems. Heat test devices have an irregular RAM of 1 GB, a 1.3GHz CPU, an all-inclusive serial communication port, an

internet port, and a scaled-down power connection for power on an HDMI connector. The external memory of 32 GB is used, and noobs are stored in it [4]. These devices will employ a USB mouse and keyboard through a port to enable remote meetings. Due to their effectiveness, compactness, and dependability in operating and monitoring sensitive equipment, SBCs (single-board computers) have become more critical in many fields, from arts and games to education and from producing applications to severe applications. SBCs (single-board computers) aid in advancing computer instruction, AI, cloud computing, IOTs, object-oriented programming, robotics, and other technological implementation sectors in the education sector. Our strategies resemble remote video conferencing in which the teacher moves around the camera. The Raspberry Pi computer has a system chip that houses all single board circuits, including CPU, GPU, and I/O pins, necessary for technology to advance. SBCs (single-board computers) are practical and valuable tools for hardware modelling, control, and programming electronic devices [10]. Additionally, it automatically combines audio with video and operates without any assistance from teachers. A creative application of SBCs (single board computers) in developing nations is Rachel-pi, a programming and advanced algorithms course taught to secondary pupils in India [9].

With a system and a wide variety of Smart Thinking Tools, the Integrated Learning approach provides students with various backgrounds and propels considerable levels of comprehension. Utilizing educational innovation can result in significant change in training. Web and e-learning tools may transform the aesthetics of the study hall. Future education will frequently involve using computers, the internet, and hybrid media devices. The many media activities of the day are currently available [20]. Several nations offer STEM education based on SBCs (single-board computers) to help local economies and solve regional and local issues. The lecture recording system has been established and is being used at most colleges worldwide, although most of them do not operate in real-time; instead, they are edited by editors before being uploaded or aired online.

UCISA (Universities and Colleges Information Systems Association) survey received responses from 71% of the institutions [2]. Based on the retrieved and researched information, the framework provides even more information on how satisfied the students are with the talk quality. A multinational company responsible for improving educational quality conducts surveys for approval reasons. "They documented 13 more discussions delivered by four other student groups, ranging in size from 5 to 18. Comparing framework yields and the understudies' critique allowed us to evaluate the framework accuracy, reduced from 70.7 per cent" [17] to 83.9 per cent. In the last two decades, there has been a growing political acceptance of education as a significant force in promoting a society that is even more conscientious, socially just, and equitable. This is demonstrated by a few national and international political developments and understandings. For instance, the United Nations said in 2005 that UNESCO had been this decade's driving force behind and facilitator.

Additionally, it reaffirmed its plan for educating for sustainable development in 2011 and had the support of political leaders [18]. In Tel Aviv, 50 out of 76 students participated in a research study. Due to the absence of these pupils for a week, this time slot was reserved for online classes [11]. Not only can lecture recording benefit students, but it also enables instructors to evaluate their methods [19]. After watching their recorded lectures, they can improve their teaching abilities.

3. SYSTEM ARCHITECTURE

Technological improvement creates a greater desire for simple learning with high-quality teaching techniques. Research conducted in Jordan found that E-learning improves students' learning abilities, scores and engagement in studies [1]. Today, practically all universities have abandoned the chalk-and-board teaching approach to provide each faculty member with a laptop or desktop computer. Projectors are mounted in each classroom to display the information on the screens [5]. The total spending on installing amenities at each school is awful and a significant waste of money. SMART Education has transformed education, particularly online and remote learning. Most of them are captured by a camera operator or a static camera [4].

In this project, we present an automatic lecture recording system as depicted in Figure 1. The setup shows the use of Raspberry Pi to automatically blend the teacher's audio and video by processing it and saving it to an SD card. A unique identifier static IP is issued to the LCD through Raspberry Pi to establish a connection and display results. It is like the machine's MAC address, which consists of 4 rather than 6 bytes. Modern technology innovation has offered new stages for individuals to enhance their education and learning while improving their practical and analytical abilities [8]. Because of the potential benefits it brings to pupils. E-learning has already achieved a lot of appeal among

students and teachers. The pace of the course can be set according to the needs of the students, lowering the cost of learning, increasing the availability of information and data to remote learners, and facilitating regular updating of the learning content, which is not possible in traditional education due to the high cost of learning material. As a result of this study's findings, e-learning appears to be considerably superior to formal learning [6].

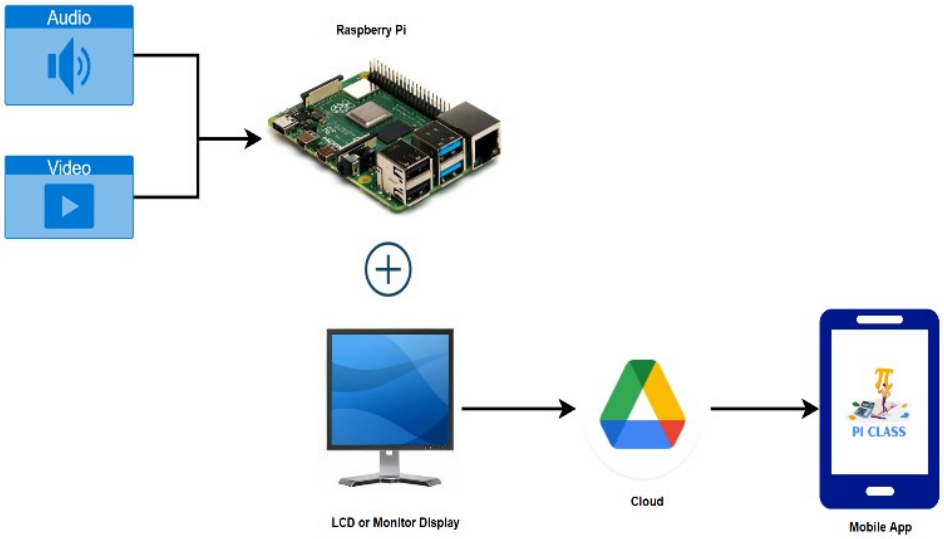

Figure 1. System Architecture Diagram

Recording lectures improves students' interest in studying. Additionally, it offers pupils many approaches to problem-solving [13]. The opinions of medical students toward recorded lectures and conventional learning were investigated in a study. Based on the lecture's topic, they chose whether to attend [14]. The ability to review lectures thanks to lecture recording gives students the impression that it can help them perform better. Students believe that the number of questions they asked during the lecture was unaffected by the lecture recording. Additionally, studies have revealed no differences in discipline when lectures are recorded [15].

3.1 Existing Systems Description

The Pi class is the solution which provides two types of main functionalities: the lecture recording with brilliant features like zoom to screen and on the other hand the mobile application which notifies the students about the lecture; so if we consider these features, we have different applications that can be compared to our solution, but due to certain lapses, Pi-class is preferred over them.

The applications that are already in use for online conduction:

- Microsoft teams
- Zoom
- Google Meet

3.2 Problems in the Existing Systems

Table 1 depicts a comparative analysis between the Pi class and the other already existing systems. The following table gives us a brief comparison of existing systems & the problems in those systems. The illustration of Table 1 clearly shows that the Pi class is unique regarding self-generated notifications with links to the participants and the key feature of screen-splitting to represent the lecture better. The notification is communicated through the mobile app, and an email is sent to all the recipients enrolled in a lecture (creating flexibility in the number of students enrolling for a lecture).

Table 1. Comparative Analysis Between Online Class Management Systems

Attributes of Online Soft wares				
FEATURES	***PI CLASS***	***GOOGLE MEET***	***MICROSOFT TEAM***	***ZOOM***
TIME LIMIT	Depends on Storage	45 min	60 min	40 min
PARTICIPANTS	Everyone can watch	100	100	100
APP TYPE	Free	Paid	Paid	Paid
DRIVE UPLOADING	Yes	Yes	No	No
NOTIFICATION	Yes	No	No	No
SCREEN SPLITTING	Yes	No	No	No

4. RESEARCH METHODOLOGY

The project will utilize hardware and software components to achieve its objectives. The hardware components include the Raspberry Pi 4 Model B, with options for 8GB or 4GB of memory, a Raspberry Pi 16mm Telephoto Lens for high-quality camera footage, a 12.3 Megapixel Sony IMX477 sensor, a tablet LCD panel or monitor, and various other accessories such as microphones and cables (see Figure 2).

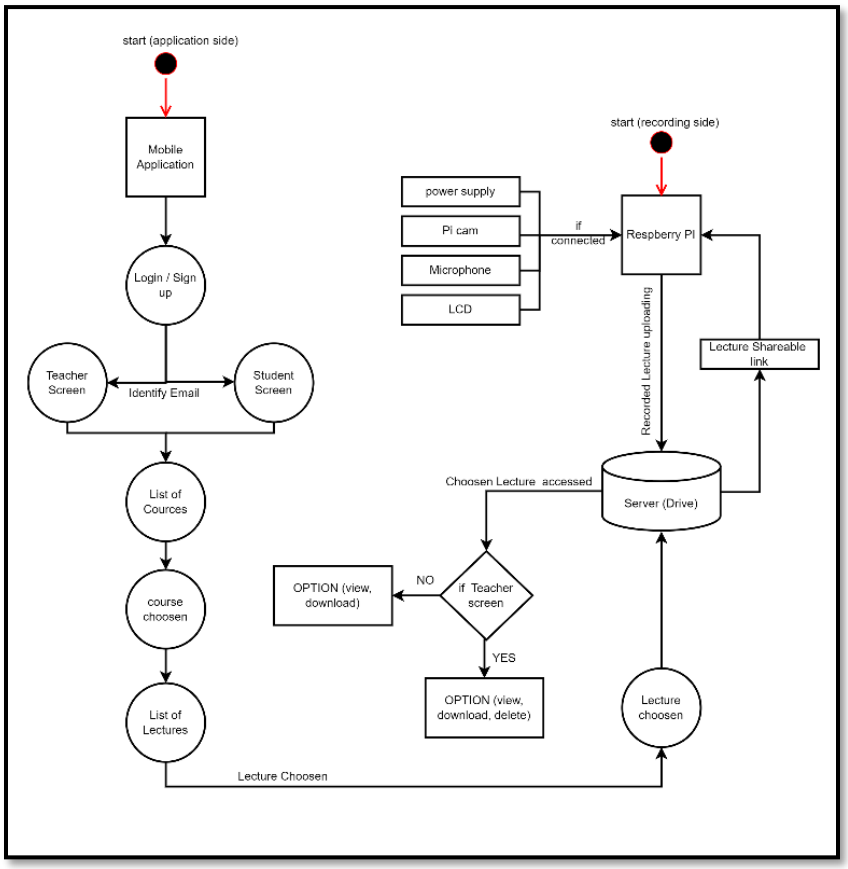

Figure 2. Workflow Diagram of Pi Class

The software components consist of Python Scripting that connects the Raspberry Pi with the camera. It includes scripts for recording audio and video separately, mixing the audio and video using muxing, and uploading the video to a required drive to generate a shareable link.

The software components consist of Python as the backend language, TensorFlow and OpenCV as frameworks, Flutter for app development, and Google Drive and API integration. These hardware and software components will work together to provide a whole experience for capturing, recording, and sharing lectures.

4.1 Model Training

The Model Training phase focuses on using deep learning techniques to train the model to accurately detect and classify the gestures made by a teacher in video recordings. This involves several key steps: data acquisition, preprocessing, feature extraction, model development, and implementation.

4.2 UI/UX Design

We started the UI/UX design process with research to understand the needs and preferences of the target audience. We did the surveys at our university and collected data about how users interact with technology and what features are most important to them.

4.3 Survey

Our survey is a combination of qualitative and multiple-choice questions. It consists of two types of questions: Interrogative and choice-based questions. Interrogative questions are designed to seek a binary response, with answers limited to "Yes" or "No". The remaining questions are choice-based, offering multiple options for respondents. Both questions aim to gather valuable insights and data through a qualitative approach. Based on the survey results, we designed the system's UI. We also added features that the audience required. As a result, the application is responsive and works efficiently on your mobile. It provides instant notifications after the lecture is uploaded. Table 2 shows the results against specific questions asked in a survey to evaluate the need for an online class system for students even after the COVID-19 situation.

Table 2. Student Consent For A Hybrid Lecture System

Survey Results		
Questions	Yes	No
Do you want the BUKC Portal to be in the form of a Mobile APP?	96.3%	3.7%
Do you want Recorded Lecturers for your daily classes?	97.4%	2.6%
Do you want live streaming for your daily classes?	70%	30%

4.3.1 Interrogative Questions:

The results of this survey can be categorized into many formats, including speed of accessibility in terms of real-time values, hourly basis, daily basis, and weekly basis, as depicted in Table III. The results proved the students were most comfortable with being able to view the lecture daily, with a leading value of 37.4%.

4.3.2 Multiple Choice Question:

The numerous questions are listed in Table 3. The mode of session recording is shown in Table 4. A variety of students studying different trades were questioned on the environment they would prefer in case of an online setup. With an outburst of technology and improved storage in cyberspace. We still have inquired about the duration of lecture availability, as shown in Table 5. leaving room for improvement in the lecture and a personal touch on the lecture concerning the instructor's instinct and knowledge.

Table 3. Accessibility Speed Of A Lecture

How fast do you want to access your recorded lectures?	
Options	Percentage
Instantly	35.5%
Within One Hour	14.2%
Within a Day	37.4%
Within a Week	12.9%

Table 4. Environment Of Recorded Lecture

Which recorded section do you prefer?	
Options	Percentage
Recorded lecture by the teacher (in home or office)	45.7%
On the spot Recorded lectures of daily classes	54.7%

Table 5. Duration Of Lecture Availability

How long do you want to access the recorded lectures?	
Options	Percentage
Access till the degree has been completed	45.7%
On the spot Recorded lectures of daily classes	54.7%

Not only did we survey the need for a different online platform, but we also looked at the limitations the students face in the already existing platforms. The results of this survey can conveniently be observed in Table 6.

Table 6. Limitations Of Already Existing Online Platforms

What issues have you faced with recorded lectures during Covid-19?	
Options	Percentage
Quality issues	43.7%
Voice issues	30.5%
Issues in receiving lectures on time	25.8%

Finally, a set of questions was designed with several proposed design options for the user interface that would be most user-friendly for students from different trades of education. Table 7 gives a quick glimpse of the results of the proposed four design options.

Table 7. User Interface Designs Options

Choose the UI for the application.	
Options	Percentage
Design 1	17.9%
Design 2	22.1%
Design 3	20.5%
Design 4	39.5%

5. APP DEVELOPMENT

Pi Class is revolutionizing the way students learn. With a user-friendly interface and robust security features, our app makes it easy for teachers to deliver lectures and for students to access them on the go. The app features two panels, one for teachers and one for students, ensuring seamless communication and a personalized experience. Figure 3 Shows how the mobile app will proceed on the student end. Once the students log in to the registered setup, the app will prompt the student.

On accepting the prompter, the student connects with the administrator panel to view the desired lecture. If the students fail to log in, access to the desired lecture gets deleted.

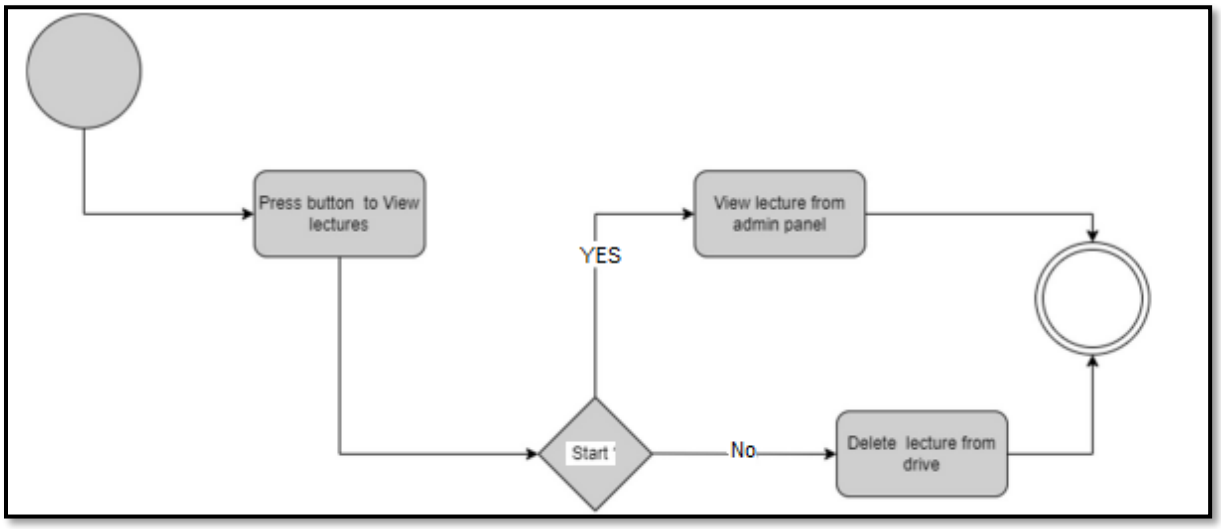

Figure 3. Activity Diagram Of Pi Class.

6. DATA ANALYSIS

6.1 System Requirements

Pi class is designed to cater to two types of users: the presenter and the Viewer. The presenter is responsible for delivering the presentation or lectures using the tools provided by the Pi class, as shown in Figure 4. On the other hand. The viewers can attend the courses on their mobile devices using the viewer end of the Pi class. This allows for a convenient and efficient way for clients, customers, and users to access and engage with lectures. In Figure 4, the Viewer is a student registered in any specific course who sends their query, which the server receives. The server, our system, stores this query for the desired action. The role of the admin played by the Instructor/Teacher is to be able to view the queries sent by the student.

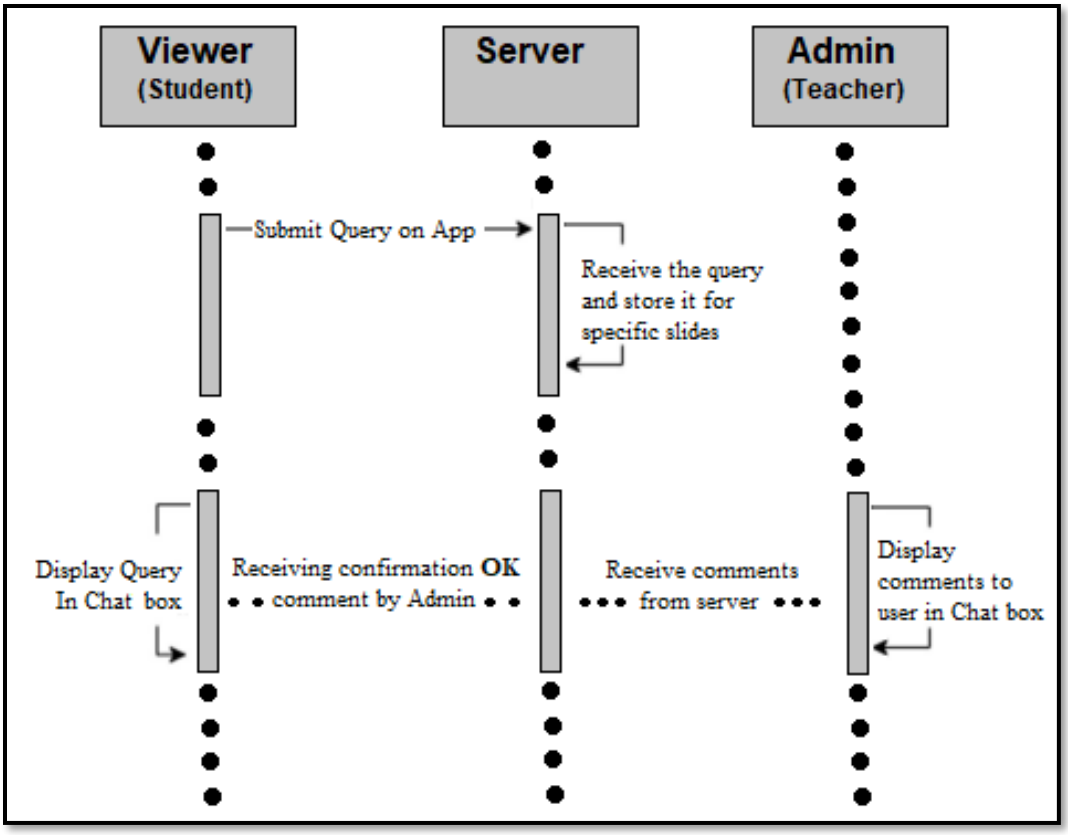

Figure 4. Viewer Query/Reply Sequence Diagram

6.2 Resource Requirements

Resource requirements for deploying a system are essential to ensure its proper functioning. In addition to hardware and software, the system requires a physical room for deployment, a stable internet connection, and users with Android or IOS devices to access the application. Resources such as expert opinion and logistics should also be considered to ensure the system's smooth operation. These resources are vital in determining the system's success and must be carefully evaluated and managed.

6.3 Data Requirements

The data requirements for the Pi-class system include the collection of emails for group creation and the data necessary for data modelling for the model training module. Email information is essential for the teacher to create and manage the groups. At the same time, the data for model training is required to train the system's models and make accurate predictions. So, we have collected and processed data properly to ensure that the Pi-class system functions as intended and produces correct results. The data is carefully managed and maintained to ensure the success of the Pi-class system.

6.4 Non-Functional Requirements

The Non-Functional Requirements for the system include Usability Requirements, which focus on the user's experience when interacting with the system. US - 1 states that the user interfaces have been designed to be simple and intuitive. US - 2 indicates that a comprehensive user manual is always available to assist users. Finally, US - 3 notes that the screen layouts and colours have been carefully chosen to appeal to users. These Usability Requirements aim to ensure that the system is easy to use and navigate and that users have a positive experience when interacting. These requirements are crucial to the system's overall success and should be carefully considered during its development and implementation.

6.5 Reliability Requirements

Reliability Requirements are critical for the project's success, as they ensure that the system is dependable and performs as intended. The system's reliability depends on the hardware and software components; RE - 1 states that the Raspberry Pi is more reliable than a traditional controller in integrating with other devices. RE - 2 highlights the reliability and compatibility of the Pi cam with the Raspberry Pi. RE - 3 notes the use of buffered mice to improve the reliability and audibility of the voice quality. Finally, RE - 4 states that lectures should be saved on the Raspberry Pi in case of internet connectivity issues. These reliability requirements aim to ensure that the system operates effectively and consistently and that users can rely on the system to deliver accurate and dependable results.

6.6 Security Requirements

Security is a top priority when accessing files and information in the education program. To ensure the security of students' and teachers' files, the students have been given access only to the required folders and not the entire teacher's drive. To use the program effectively, the users must log in first. This also helps ensure that only authorized users can access the program. Additionally, the program has been designed so that users can only view their related courses, ensuring that they can access only the relevant information. These security requirements are in place to maintain confidentiality and protect sensitive data.

6.7 Performance Requirement

Performance requirements are critical in ensuring a smooth and continuous experience for the education program's users. The first requirement, PE-1, states that changing slides after users swipe for the next or previous slide should be less than 3 seconds. This ensures that the user can navigate the slides easily and without lag time. The second requirement, PE-2, states that the lag time between the audio and video muxing should be minimal to ensure quality lectures. The audio and video should be synced correctly and played promptly, providing a seamless user experience. These performance requirements are essential to guarantee a high-quality user experience.

6.8 Maintainability Requirements

Maintainability requirements are a crucial aspect of any software development project as they ensure the longevity and smooth functioning of the software over time. In this case, MA-1 specifies the requirement for proper maintenance of lectures on the drive, considering the teachers and courses. Meanwhile, MA-2 outlines the requirement for regular updates to the lectures on the app, with the added convenience of notifications for users. These requirements are essential to ensure that the software remains relevant and functional and that users can access the most up-to-date information. The development process focuses on creating a unified experience, focusing on feature development, feature integration and quality assurance. The result is a mobile app that offers students and teachers a convenient and secure platform to access lectures and resources. App Development involves developing an application with two panels for students and teachers and proper authentication. The lecture will be delivered to the student's mobile devices through the Pi Class mobile app.

7. RESULTS AND DISCUSSIONS

The proposed solution addresses the maintainability requirements by utilizing a Raspberry Pi to remotely capture audio and video during lectures. The Raspberry Pi is configured to process and store the data asynchronously before merging the audio and video recordings into one complete file. This file is then transmitted to a preferred cloud storage location, which can be uploaded to a learning management system (LMS) for students to access. The solution benefits students who could not attend the lecture and provides a review option for those who were present. Additionally, the teacher can easily update the lecture by refreshing the link and sending notifications to students' mobile devices. With this approach, students can stay up to date with the latest lecture content and have access to the information they need to succeed. Figures 5 (a) – (c) show the different UIs of the mobile app created for the system.

Figure. 5(a) represents the admin (Teacher) Dashboard, which, in this case, shows the URL of a lecture being created after the recording. Thus, the link for that lecture is created in the designated course folder. Figure 5(b) shows the Viewer's dashboard for a course with the lecture title.

Figure 5(c) depicts the chat box interface for the Viewers to share their comments and queries with the instructor.

These were just glimpses of the multiple interfaces created for the mobile app. To increase the effectiveness of the system, we recommend opting in future.

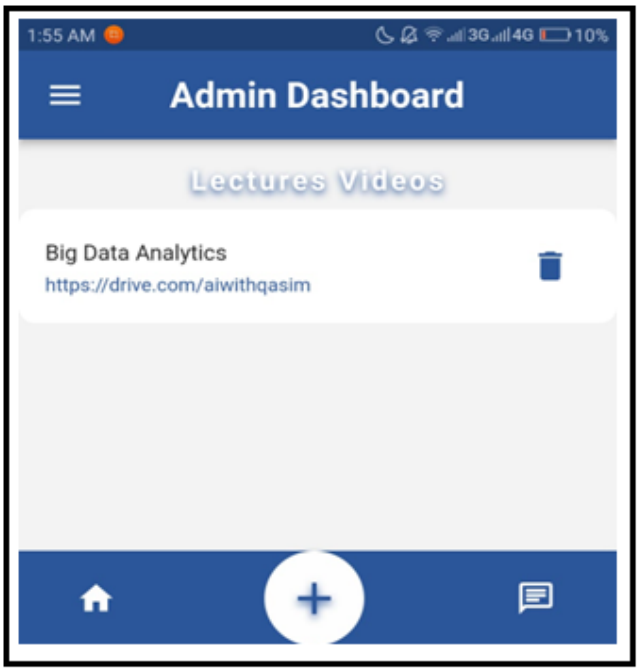

Figure 5(a). Mobile App UI of Admin Dashboard

Figure 5(b) Mobile App UI of Viewer Dashboard

Figure 5(c). Mobile App UI of Viewer Chatbox

8. CONCLUSION

Pi Class uses recording techniques that capture and archive the audio and visual aspects of a lecture, workshop, or seminar. The process is accomplished through advanced hardware and software technology, working in tandem to produce a high-quality recording. Upon completion, the recording is saved to a disk and made available through a shared link, providing convenient access for those seeking to revisit the material. Several future improvements can be made to the lecture recording process. For example, live streaming the lecture to make it available in real-time to remote attendees, providing instant notifications to students when a new lecture is recorded, implementing AI-based evaluations of classwork, and offering an intranet facility for easy access to recorded lectures. These future developments would enhance the lecture recording experience and make it even more convenient and accessible to students and educators.

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AUTHOR CONTRIBUTIONS

Qasim Hassan: Conceptualization, Data Curation, Methodology, Validation, Writing – Original Draft Preparation; Nabiha Faisal: Project Administration, Writing – Review & Editing.
Ayesha Anees Zaveri: Project Administration, Supervision, Writing – Review & Editing.

CONFLICT OF INTERESTS

No conflict of interest was disclosed.

ETHICS STATEMENTS

Our publication ethics follow The Committee of Publication Ethics (COPE) guidelines. https://publicationethics.org/

Consent taken.

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