Smart Classroom: Interactive Approach to All Classroom Activities Using Computer Vision

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*Abstract*—This research paper explores the implementation and practical applications of a Smart Classroom project aimed at revolutionizing traditional educational methods. The project integrates innovative modules such as facial recognition attendance, behavioral analysis, Air Canva, Virtual PPT Presenter, and Shape Painter to enhance classroom interactivity and efficiency. Through interactive tools and real-time feedback mechanisms, educators can create dynamic learning environments, catering to diverse learning styles and needs. The project also supports remote learning, personalized learning experiences, and professional development for educators. Furthermore, it promotes data-driven decision-making in education. This paper discusses the practical uses and benefits of the Smart Classroom project in improving student engagement, teacher effectiveness, and overall learning outcomes.

Keywords—Smart Classroom, educational technology, interactivity, efficiency, facial recognition, behavioral analysis, Air Canva, Virtual PPT Presenter, Shape Painter, virtual learning, student engagement.

# Introduction

In today's rapidly evolving educational world, the integration of technology has become very important in shaping modern teaching and learning practices. Traditional classrooms, once characterized by static instruction and limited interaction, are undergoing a profound transformation into dynamic learning environments fuelled by innovative technologies. And the base for this revolution is the Smart Classroom project, an ambitious initiative aimed at redefining the educational experience through the seamless integration of cutting-edge tools and digital resources. This research paper seeks to explore the complex aspects of Smart Classrooms, examining their diverse applications and profound implications for modern education.

One of the fundamental components of the Smart Classroom project is the incorporation of smart way of taking attendance which uses facial recognition technology for attendance management. By leveraging facial recognition technology based on computer vision, manual attendance taking becomes a thing of the past, as students' attendance is effortlessly recorded with a simple scan of their faces. This not only saves valuable lecture hours for educators but also minimizes administrative burdens for educators, allowing them to focus more on delivering quality instruction. Furthermore, facial recognition technology can be extended to behavioural analysis, providing educators with valuable insights into student engagement and participation levels during lessons. By analysing facial expressions and behavioural analysis result acquired through analysing student attentiveness cluster formed using the behavioural analysis, educators can adapt their teaching strategies to better meet the needs of their students, fostering a more inclusive and responsive learning environment.

Another key aspect of the Smart Classroom project is the implementation of interactive presentation tools such as the Air Canva and the Virtual PPT Presenter. These tools empower educators to create immersive and engaging presentations, incorporating interactive multimedia elements and real-time annotations. With Air Canva, educators can transform any surface into a digital whiteboard with use of just a laptop/pc and projector, facilitating seamless collaboration and idea-sharing among students. Similarly, the Virtual PPT Presenter revolutionizes traditional slide presentations by offering gesture-controlled navigation, real-time annotations, and interactive features. Together, these tools enable educators to deliver dynamic and personalized lessons that cater to diverse learning styles and preferences, fostering deeper engagement and comprehension among students.

# Literature Review

Wiki study research information says *interactive whiteboard (IWB)* device can either be a standalone [computer](https://en.wikipedia.org/wiki/Computer) or a large, functioning [touchpad](https://en.wikipedia.org/wiki/Touchpad) for computers to use. Interactive whiteboards are widely used in classrooms, boardrooms, and training environments, providing an innovative way to share information, facilitate discussions, and enhance the overall learning or business communication experience. A [device driver](https://en.wikipedia.org/wiki/Device_driver) is usually installed on the attached computer so that the interactive whiteboard can act as a *Human Input Device (HID)*, like a mouse. The computer's video output is connected to a digital [projector](https://en.wikipedia.org/wiki/Video_projector) so that images may be projected on the interactive whiteboard surface, although interactive whiteboards with LCD displays also exist. The user then calibrates the whiteboard image by matching the position of the projected image in reference to the whiteboard using a pointer as necessary. After this, the pointer or other device may be used to activate programs, buttons, and menus from the whiteboard itself, just as one would ordinarily do with a mouse. If text input is required, user can invoke an on-screen keyboard or, if the whiteboard software provides for this, utilize [handwriting recognition](https://en.wikipedia.org/wiki/Handwriting_recognition). This makes it unnecessary to go to the computer keyboard to enter text.

The integration of technology in education has been extensively studied, with a plethora of research focusing on the advantages and hurdles accompanying its incorporation. *Davis\* et al2 (1999)* conducted a comprehensive study to assess the influence of technology on student engagement. They discovered that interactive learning environments, supported by technology, resulted in increased levels of student participation and motivation. This highlights the potential of technology to foster an environment conducive to active engagement and enhanced learning outcomes. Similarly, *Zhao\* et al5 (2005)* delved into the role of technology in classrooms and concluded that it improves student learning outcomes by providing access to a diverse array of resources. Their research emphasized the importance of technology in promoting active learning methodologies, thereby enhancing the overall educational experience for students. The better the experience is the better the effectiveness of the education received by the students.

Facial recognition technology has emerged as a promising tool for improving classroom management and student engagement. In their research, *Clowes\* et al2 (2016)* demonstrated the effectiveness of facial recognition systems in streamlining attendance tracking and reducing administrative overhead for educators. Also, *Kaur\* et al2 (2018)* investigated the use of facial recognition technology for behavioral analysis in classrooms and found that it provides valuable insights into student engagement levels, allowing educators to tailor their teaching strategies accordingly.

Interactive presentation tools, such as Air Canva and Virtual PPT Presenter, have also garnered attention in educational research. A study by *Sangra\* et al3 (2012)* examined the effectiveness of interactive presentations in promoting student engagement and found that they enhance comprehension and retention of information. Furthermore, *Liu\* et al5(2015)* explored the use of gesture-controlled presentation tools and concluded that they improve teacher-student interaction and facilitate collaborative learning experiences.

The importance of technology in schools cannot be ignored. Studies by *Raja\** *et al2 (2018)* have explored benefits of smart classrooms. Technology has certainly changed the way we live. It has impacted different facets of life and redefined living. Undoubtedly, technology plays an important role in every sphere of life. Several manual tasks can be automated, thanks to technology. Also, many complex and critical processes can be carried out with ease and greater efficiency with the help of modern technology. Thanks to the application of technology, living has changed, and it has changed for the better. Technology has revolutionized the field of education. The use of technology has made the process of teaching and learning more enjoyable. Additionally, Studies by *Saini\* et al2 (2021)* have explored benefits of smart classrooms. A wide range of research areas including information communication technology, machine learning, sensor networks, mobile computing, and hardware. Consequently, there have been several disparate reviews on various aspects of smart classrooms. Such piecemeal development is not sufficient for a pragmatic smart classroom solution.

# Problem Statement

The regular classroom environment often struggles to fully engage students and meet the diverse learning needs of today's learners. Traditional teaching methods, described by static instructional approaches and limited interactivity, may fail to effectively capture student attention, and promote deep understanding of subject matter. Moreover, administrative tasks such as attendance management and content delivery can be time-consuming and for educators, detracting from valuable lecture hours reserved time. While technological advancements offer promising solutions to these challenges, the integration of technology into classrooms presents its own set of obstacles. Issues such as limited access to appropriate educational technology, insufficient training for educators, and financial constraints hinder the successful implementation of technology-enhanced teaching methods. Considering these challenges, there is a pressing need to develop a comprehensive approach to the implementation of technology-enhanced teaching methods in classrooms, aiming to create a more interactive, engaging, and inclusive learning environment for all students.

# Methodology

## Introducing the Idea

The need for a hybrid mode of classrooms, combining both online and offline learning, has increased since COVID-19 era. This approach offers flexibility for students, enhances safety, provides a well-rounded learning experience, and ensures accessibility. It also optimizes resource management, improves assessment methods, encourages technology integration, and adapts to changing circumstances. Overall, smart classroom is crucial for meeting diverse educational needs and maintaining resilience in post-pandemic era.

To proceed with the concept of a hybrid classroom, we have undertaken the development of an application aimed at resolving various challenges associated with this setup. Our focus is to provide a simple yet efficient solution to address issues such as:

* Efficiency
* User friendliness
* Cost efficient.
* Time factor
* Time saving
* Contact less (health safety)

Effective problem solving in online classes requires active engagement, clear communication, technology integration, support mechanisms, and adaptability to meet unique challenges and opportunities of smart learning environment. The implementation performed to solve some of these challenges. So that work will be easy both for user of system as well as system itself.

What and how we addressed these problems using software / hardware:

| Sr. no. | Problems Addressed By Application | | |
| --- | --- | --- | --- |
| Problem | Method | Software  /hardware |
| 1 | Efficiency | Using Real-Time Database | Firebase |
| 2 | User friendliness | Give Gesture access for tools | Python3 |
| 3 | Cost efficient | Saves need of costly equipment | *OpenCV* |
| 4 | Time factor | Hosted so Accessible to all at any time-anywhere | LocalHost |
| 5 | Time saving | Taking attendance using Computer Vision | *OpenCV* |
| 6 | Contact less | Give lectures using Virtual PPT controlled using gestures and Virtual white board | BlazePalm  and  HandLandmark |

## Terminologies

Face Recognition Attendance System:

Developing face recognition attendance system involves several key steps to ensure its accuracy, reliability, and usability. Firstly, a diverse dataset of facial images representing the student population is collected, ensuring variability in lighting conditions, facial expressions, and poses. These images undergo preprocessing, including face detection, alignment, and noise removal, to enhance their quality and uniformity. Feature extraction techniques, such as deep learning with Convolutional Neural Networks (CNNs), are then applied to extract discriminative features from the facial images. Once trained, the model is integrated into an application designed for attendance management, with real-time face detection and recognition capabilities. Usability testing and performance evaluation are conducted to assess the system's accuracy and user-friendliness, with iterative improvements made based on feedback and evaluation results.

Behavioral Analysis System:

Initially, a dataset of facial images capturing various emotions and behavioral states is collected, ensuring diversity in expressions and cues. These images undergo preprocessing, including face detection, alignment, and normalization, to enhance their quality and consistency. Deep learning techniques, particularly Convolutional Neural Networks (CNNs), are then employed to extract features representing different emotions from the preprocessed images. The behavioral analysis model is trained on this dataset, utilizing a suitable deep learning architecture, and optimizing parameters to minimize loss and maximize accuracy. The aim is to develop a robust and reliable behavioral analysis system that can provide valuable insights for educators to enhance classroom management and student engagement.

Air Canva:

Air Canva, a virtual whiteboard application, begins with a thorough analysis of requirements and objectives, focusing on key features like ease of use and interactivity. Suitable technologies and frameworks are selected for platform compatibility and performance. The system architecture is designed are created, development starts with the frontend using web technologies and the backend with Python3. After thorough testing, user feedback sessions are conducted to refine the application. Documentation and training materials are provided upon deployment. Through this methodology, Air Canva aims to provide an intuitive and engaging platform for educators, enhancing the teaching and learning experience in hybrid classrooms.

Virtual PPT Presenter:

Developing the Virtual PPT Presenter begins with a detailed analysis of requirements, identifying essential features such as gesture-controlled navigation and real-time annotation. Suitable technologies and frameworks are then selected for compatibility and performance. The system architecture is designed, including components like the user interface. UI is created to visualize the presentation interface and interaction flow. Gesture recognition algorithms are integrated to enable gesture-based navigation and annotation on slides. Thorough testing ensures compatibility across devices and browsers. Upon deployment, comprehensive documentation and demo video are provided for users, and the application is continuously monitored for performance and feedback. Through this methodology, the Virtual PPT Presenter aims to offer an intuitive platform for educators to deliver presentations effectively in virtual classrooms.Top of Form

Shape Painter:

Developing the Shape Painter involves a detailed analysis of requirements, selecting suitable technologies, and designing an intuitive interface. The frontend is developed using graph technologies working services are implemented with Python3. Thorough testing ensures compatibility across devices and browsers. User feedback sessions inform refinements to enhance usability, and comprehensive documentation is provided for users upon deployment. Through this methodology, the Shape Painter aims to offer an intuitive platform for educators to create diagrams effectively as options for definite shape is given and no freehand drawing needed to be done in virtual classrooms making it way more useful and easier for educators.

## General Overview of Project

A diagram of a classroom

Description automatically generated

1. Student Side Features Summary:

Facial Recognition Attendance Taker:

Students can conveniently mark their attendance without the need for manual roll call, saving time and reducing administrative hassles.

Behavioural Analysis Module:

Students receive real-time feedback on their engagement and mood in class, allowing them to adjust their approach to learning accordingly.

Air Canva:

Students can view and interact with virtual whiteboard content created by teachers, enhancing visual learning and understanding of concepts.

Virtual PPT:

Students can follow presentations and lessons using hand gestures and fingertip recognition, promoting active participation and engagement.

Shape Painter:

Students can visualize concepts with shapes, tables, and diagrams, aiding in understanding and retention of course material.

1. Educator Side Features Summary:

Facial Recognition Attendance Taker:

Educators can effortlessly track student attendance, enabling them to focus more on teaching rather than administrative tasks.

Behavioural Analysis Module:

Educators receive insights into student engagement and mood, allowing them to adjust their teaching strategies to better meet student needs.

Air Canva:

Educators can create and annotate virtual whiteboard content, facilitating clearer explanations and visual demonstrations of concepts.

Virtual PPT:

Educators can deliver presentations and lessons with interactive elements, keeping students engaged and actively involved in the learning process.

Shape Painter:

Educators can create visual aids and diagrams to supplement their teaching, enhancing understanding and retention of information.

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##### References

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