

Focusguard Student Learning Activity Monitoring System Based on Camera and IoT

Andika Pratama¹, Apriansyah², Kemas Muhammad Wahyu Hidayat³

^{1,3}Department of Information Technology, University of Muhammadiyah Palembang, South Sumatra

²Information Technology Study Program, Faculty of Engineering

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ABSTRACT

The development of information and communication technology has brought real changes in the world of education, especially in the way the learning process is designed, implemented, and evaluated. Universities no longer only focus on delivering material, but are also required to ensure that students remain actively involved during the learning process. Student involvement is one of the important indicators of learning success because it is directly related to the attention, participation, and quality of students' understanding of the material presented. With that, the researcher utilizes technology which is a solution to help monitor and improve the quality of learning. Information technology, especially the Internet of Things (IoT), allows physical devices to connect with digital systems so that the monitoring process can be carried out in real-time and continuously a monitoring system for student learning activities that is able to work in real-time, is non-invasive, and is easy to implement. Therefore, this study proposes FocusGuard, which is a camera-based student learning activity monitoring system and the Internet of Things (IoT). This system is designed to monitor the general state of classroom activities through visual observation, detect passive conditions in a certain time span, and provide alerts as indicators of declining learning activities. It is hoped that this system can help lecturers and educational institutions in supporting the implementation of smart learning and improving the quality of the learning process in higher education.

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Corresponding authors:

Andika Pratama
Department of Information Technology
Faculty of Engineering
University of Muhammadiyah Palembang
South Sumatra, Indonesia
Email: andikapratama7230@gmail.com
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1. Introduction

The development of information and communication technology has brought real changes in the world of education, especially in the way the learning process is designed, implemented, and evaluated. Universities no longer only focus on delivering material, but are also required to ensure that students remain actively involved during the learning process. Student engagement is one of the important indicators of learning success because it is directly related to student attention, participation, and quality of understanding of the material presented [1], [8].

In practice, maintaining student involvement and focus on learning is not an easy thing. Various studies show that students' learning concentration can decrease due to fatigue, mental conditions, monotonous

learning methods, and a less supportive learning environment [6], [7], [12]. This decrease in focus is often characterized by reduced learning activities, lack of interaction, and passive conditions in the classroom that have an impact on the overall effectiveness of learning [11].

Along with the development of the concept of smart education and smart learning, the use of technology is one of the solutions that is widely studied to help monitor and improve the quality of learning [9], [27]. Information technology, especially the Internet of Things (IoT), allows physical devices to connect with digital systems so that the monitoring process can be carried out in real-time and continuously [15], [28]. The application of IoT in the educational environment has been proven to be effective in supporting activity monitoring systems, data management, and information-based decision-making [16], [22].

Several previous studies have developed smart devices to support learning activities, such as study desks with time reminders and IoT-based smart study desks [3], [4]. The research shows that the integration of technology in learning media can help improve discipline and learning comfort. However, the system developed still focuses on time reminder or ergonomic aspects, and has not specifically monitored the level of student learning activity as a direct focus indicator.

On the other hand, the use of cameras as sensors for activity monitoring has been widely used in various fields, such as security systems and activity monitoring based on digital image processing [5], [14], [18], [19]. Camera technology allows the observation of the visual conditions of an environment without direct contact with the object being observed. Research related to activity monitoring using cameras also shows that visual systems are able to detect active and passive conditions effectively in a room [29], [30]. In fact, recent research has developed a computer-based classroom attention monitoring system to observe the level of learning engagement in real-time [20].

However, there are still limitations of research that integrates camera technology and IoT in a simple and applicative way to monitor student learning activities as a focus indicator, especially without individual identification. Some existing systems tend to be complex, require high computing, or focus on specific individual analysis, making them less suitable for implementation as an initial solution in a general learning environment.

Based on these problems, a monitoring system for student learning activities is needed that is able to work in real-time, is non-invasive, and is easy to implement. Therefore, this study proposes FocusGuard, which is a camera-based student learning activity monitoring system and the Internet of Things (IoT). This system is designed to monitor the general state of classroom activities through visual observation, detect passive conditions in a certain time span, and provide alerts as indicators of declining learning activities. It is hoped that this system can help lecturers and educational institutions in supporting the implementation of smart learning and improving the quality of the learning process in higher education.

2. Research Methods

The research method employed in the development of the FocusGuard system is the Research and Development (R&D) method. This method was selected because the objective of the study is not limited to theoretical investigation but also includes the design, development, implementation, and evaluation of a functional system intended to monitor student learning activities and concentration levels during classroom sessions. Research and Development is widely recognized as an appropriate approach for studies that aim to produce practical products, prototypes, or technological innovations that can be directly utilized by end users. Through this method, researchers are able to develop a system iteratively, evaluate its performance, and implement improvements based on testing results and user feedback [13].

The application of R&D methods in the field of information technology has been extensively adopted in studies involving software and hardware development. Previous research has demonstrated that this approach is effective because it supports systematic product creation through a sequence of structured stages, allowing continuous refinement and validation throughout the development process [24]. Consequently, the resulting system is not merely a conceptual model but a functional product that can be tested under real-world conditions to assess its effectiveness, reliability, and usability.

In this study, the R&D method is implemented through several main stages, namely problem analysis, literature review, system design, system implementation, and system testing. The problem analysis stage focuses on identifying issues related to declining student engagement and reduced learning focus during classroom activities. Data are collected through observation and discussions with relevant stakeholders to understand the factors contributing to these challenges. The literature review stage is conducted to establish a strong theoretical foundation by examining previous studies related to student engagement, learning behavior, computer vision technology, camera-based monitoring systems, and the implementation of the Internet of Things (IoT) in educational environments.

The system design stage involves the preparation of system architecture, workflow diagrams, database structures, and user interface designs. Following the design phase, the implementation stage is carried out by

integrating hardware and software components to develop the FocusGuard system. Finally, system testing is conducted to evaluate functionality, performance, and accuracy in monitoring student learning activities. The results obtained from testing are used to determine whether the developed system meets the predefined objectives and requirements, ensuring that FocusGuard can effectively support learning monitoring and improve student engagement in educational settings. [1], [8], [15], [28].

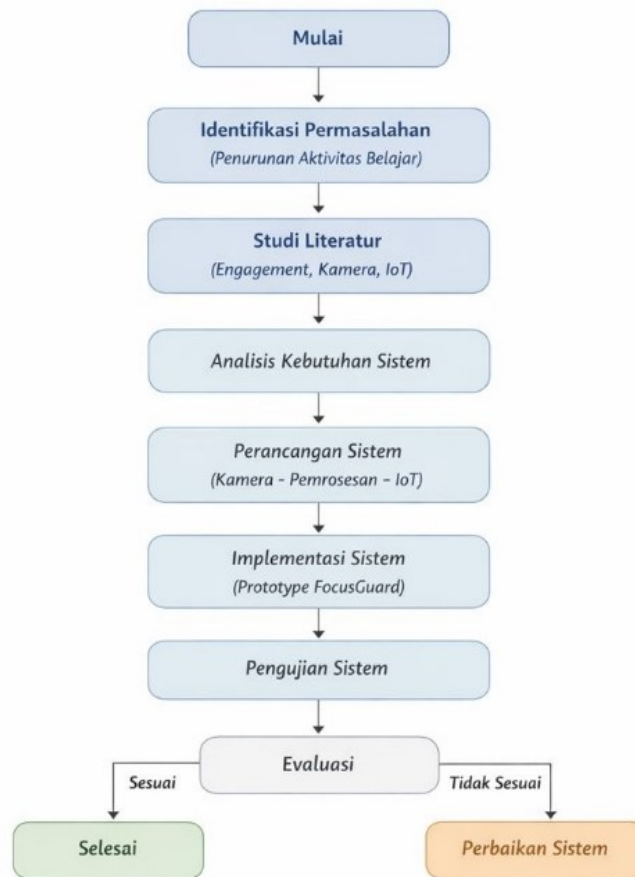


Figure 1. Research flowchart

The system design stage is focused on the preparation of the FocusGuard system architecture which includes the selection of cameras as the main sensors, activity data processing mechanisms, and the design of IoT-based warning systems. This design approach refers to previous studies that developed sensor-based and IoT-based monitoring systems to detect activity conditions in a timely manner. *Real-time* [21], [25]. Once the design stage is complete, the system is implemented in the form of a prototype which is then tested to ensure that each component functions according to the research objectives.

The system was tested to determine the ability of FocusGuard to detect students' activities and passive conditions and provide alerts when learning activities decrease. The test results are used as the basis for system evaluation to ensure that the developed system is in accordance with the needs and objectives of the research. This testing and evaluation approach is in line with research on the development of technology-based monitoring systems and prototypes that emphasize the importance of validation of functions before the system is implemented more widely [23], [26]. By using research and development methods, it is hoped that the FocusGuard system can be developed systematically, tested, and applicative so that it can make a real contribution in supporting the monitoring of student learning activities and the application of *the concept of smart learning* in the higher education environment.

3. Results and Discussion

The implementation of the FocusGuard system demonstrates that camera-based monitoring can effectively identify the level of student activity during classroom learning sessions. The camera continuously captures visual data, which is then processed by the image analysis module to detect movement patterns and activity changes over a specified period. The results indicate that classes with frequent movement and interaction are classified as active, while classes with minimal movement are categorized as passive. This

classification enables teachers and educational administrators to obtain objective information regarding student engagement without requiring direct observation throughout the learning process.

Furthermore, the system successfully performs real-time monitoring and provides consistent activity assessments based on visual indicators. Testing results show that FocusGuard is capable of distinguishing different classroom conditions and generating monitoring data that can support teaching evaluations. The use of image processing technology also reduces the subjectivity commonly associated with manual observation methods. Overall, the findings suggest that FocusGuard can serve as an effective tool for monitoring learning activities, helping educators identify periods of low engagement and supporting efforts to improve classroom participation and learning effectiveness.

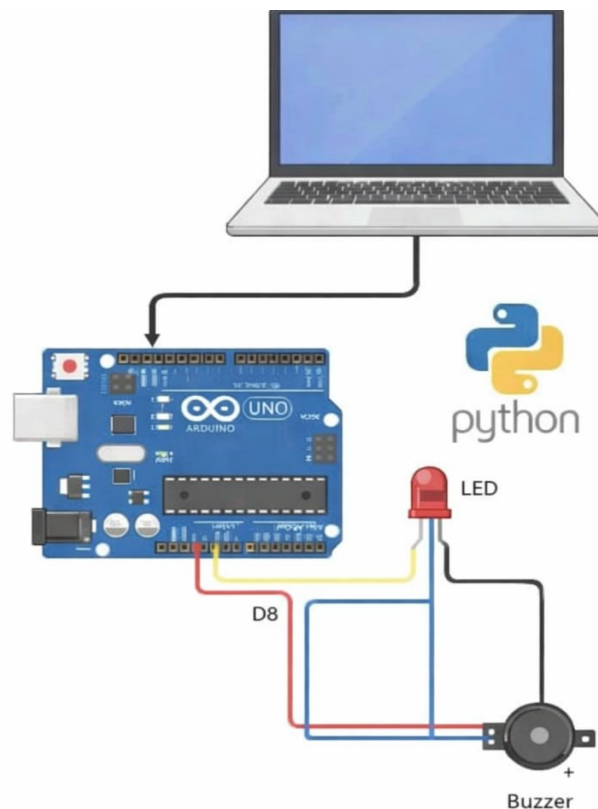


Figure 2. Schematics of the FocusGuard System

The way the FocusGuard system works starts with a camera that captures the visual conditions of student learning activities in the classroom. The visual data is sent to a laptop or PC to be processed using image processing software. At this stage, the system analyzes changes in visual activity over a given time span to determine whether the class is in an active or passive state [14], [20].

The FocusGuard system is activated through various algorithms that are incorporated into the program's code to enable such analysis processes. This code sets up the flow of image data capture, pre-processing, and retrieves relevant visual features from each video frame received. In the overall system architecture, the algorithms play a central role in ensuring that the monitoring process can be carried out accurately and efficiently. The captured image data is continuously processed in real time, allowing the system to observe student behavior during learning activities[21]. The pre-processing stage is particularly important because it improves image quality, reduces noise, and prepares the visual data for further analysis. After the image has been processed, the system extracts important visual characteristics that can be used to identify student activity patterns, such as attentiveness, movement, and the level of participation during the learning session. Through these processes, the system can distinguish between active and passive learning conditions and make decisions based on the observed behavior. The integration of these algorithms enables FocusGuard to function as an intelligent monitoring solution capable of supporting educational environments where continuous observation is required[22].

The result of this research is the realization of the FocusGuard system, which is a camera-based student learning activity monitoring system and Internet of Things (IoT). This system was developed to visually

monitor learning activities and provide alerts when passive conditions are detected within a certain time frame. The implementation of the research is carried out in accordance with the stages of the planned research method, starting from the design of the tool, the implementation of the system, to the testing of the system function[23]. Throughout the research process, each stage was carefully conducted to ensure that the resulting system met the intended objectives and operational requirements. During the design phase, the hardware and software components were identified and selected based on their compatibility and performance[24]. The implementation phase involved integrating all components into a unified system capable of capturing, processing, and analyzing visual information. Furthermore, extensive testing was performed to evaluate the reliability and effectiveness of the system under different operating conditions. The testing process focused on verifying that each component functioned correctly and that the overall system could successfully detect passive learning behavior and trigger appropriate alerts. The research results demonstrate that the proposed system can serve as a practical solution for monitoring student engagement and supporting learning supervision activities[25].

The design results are shown by the formation of the FocusGuard system in the form of a real device consisting of a camera, laptop or PC as a data processing unit, an Arduino Uno microcontroller, and an output device in the form of LEDs and buzzers. All components are assembled and implemented according to the schematic and block diagrams of the system that have been designed in the previous stage. The camera functions as the primary input device responsible for capturing visual data from the learning environment. The laptop or PC processes the captured data using the developed algorithms and determines whether the detected conditions indicate active or passive learning behavior. The Arduino Uno microcontroller serves as an intermediary controller that receives commands from the processing unit and manages the activation of output devices. LEDs provide visual indicators regarding the system status, while buzzers generate audible alerts when passive conditions persist beyond the predefined threshold. The integration of these hardware components with the software system creates a complete monitoring platform capable of operating in real time. As a result, FocusGuard successfully demonstrates the practical application of computer vision and IoT technologies in supporting educational monitoring and enhancing awareness of student learning engagement..

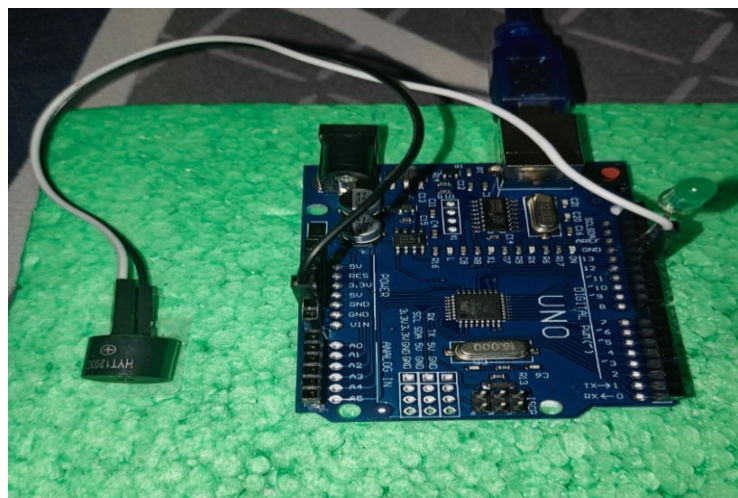


Figure 3. Results of FocusGuard System Design and Implementation

Based on Figure 3, the camera is used as the main sensor positioned facing the learning area to capture the visual condition of students' learning activities. The camera is connected to a laptop or PC that serves as a visual data processing unit. Data from the camera is processed using image processing software to detect any activity or idle conditions within a certain period of time.

The results of the visual data processing are then sent to the Arduino Uno microcontroller. The microcontroller serves as the controller of the system's output devices, i.e. LEDs and buzzers. LEDs are used as visual indicators, while buzzers serve as sound indicators to provide alerts when the system detects a passive condition in a learning activity. All components are connected using cables and supporting components so that they form a single system that can work in an integrated manner.

System testing shows that when learning activities are detected, the system is in normal condition and the output device is inactive. Conversely, when no activity is detected within a predetermined time, the system identifies the condition as a passive condition. In this condition, the LED and buzzer are active as warning indicators. Once activity is detected again, the system returns to normal and alerts are disabled. These results show that the system is able to work consistently and repeatedly in monitoring learning activities.

Based on the results of the research implementation, it can be concluded that the FocusGuard system has been successfully implemented in accordance with the research objectives. The integration of cameras, data processing, and IoT devices allows the system to monitor learning activities in real-time and provide alerts when there is a decrease in activity. This system is not intended to monitor individuals specifically, but rather to monitor the general conditions of learning activities. Thus, FocusGuard can be an initial solution that is applicable in supporting the monitoring of student learning activities and the application of *the concept of smart learning* in the higher education environment.

4. Conclusion

Based on the results of the design, implementation, and testing that has been carried out, it can be concluded that the FocusGuard system has been successfully developed as a monitoring system for camera-based student learning activities and *the Internet of Things* (IoT). This system is able to visually monitor the condition of learning activities and detect passive conditions in a certain period of time as an indicator of declining learning activities.

The integration of the camera as a visual sensor, data processing on a laptop or PC, and the use of an Arduino Uno microcontroller as an output device controller allow the system to work automatically and *in real-time*. When learning activities are detected, the system is in normal condition, while when no activity is detected, the system is able to provide alerts through LEDs and buzzers.

These results show that FocusGuard can function according to the research objectives that have been formulated. The FocusGuard system is designed to monitor learning activities in general without individual identification, making it non-invasive and easier to implement in an educational environment. With these characteristics, this system can be an initial solution in supporting the monitoring of student learning activities and the implementation of the concept *of smart learning* and *smart campus* in universities.

Acknowledgments

Although the FocusGuard system has been successfully implemented, this study still has some limitations that can be developed in future research. The learning activity monitoring system developed still uses a simple visual activity detection approach, so that the level of detection accuracy can be affected by environmental conditions, lighting, and camera position.

Further research is suggested to develop more complex data processing methods, for example by adding more detailed analysis of activity patterns or integrating artificial intelligence techniques to improve the accuracy of learning activity detection. In addition, the system can be developed by adding other notification media, such as web-based applications or mobile devices, so that alert information can be accessed more flexibly.

From an implementation perspective, system testing can be expanded to include more variety of learning conditions and longer observation durations. This aims to obtain more comprehensive evaluation results of system performance. With further development, the FocusGuard system is expected to be a more optimal learning activity monitoring solution and contribute to improving the quality of the learning process in the educational environment.

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