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Vape Detector and Monitoring System for Student Health In Public School through IoT

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Abstract— **This project aims to address the increase in vaping behaviour of teenagers in schools. The main objective is to develop a Vape Detection System using an MQ135 sensor to accurately identify harmful substances associated with vaping, enabling rapid identification of vaping incidents without burdening teachers. An IoT-based real-time monitoring system will provide immediate notification to authorized discipline teachers, facilitating timely intervention and action in potential vaping incidents. The integration of student identification tools, such as camera modules, will enable customized actions to prevent vaping and identify individuals involved in vaping events. Using the MQ135 sensor and IoT technology, the system can efficiently detect vaping incidents, enabling rapid intervention and data-based decision-making. The successful implementation and findings of the project provide a valuable foundation for creating safer and healthier learning environments and developing evidence-based policies to combat adolescent vaping in the school community.**

Index Terms—**IoT, sensor fusion, Vape Detection, school, substance, gas detection**

I. INTRODUCTION

This project has been developed to address the rising concern about teen vaping behaviour, including that of those who are over 12 and those who are under 18 and more specifically in school sites. It is urgently necessary to create a system that can detect and keep track of vaping activities in school settings, given the popularity of e-cigarettes, often known as electronic cigarettes or vapes.

Teenagers who are over the age of 12, as well as those under the age of 17, have increased their use of e-cigarettes significantly. Vape smokers have rapidly increased in number among secondary school students because of this concerning trend. The school's teachers at one of the public schools, namely SMK Perda, have spoken about events where students routinely use the toilet to vape, which may cause problems to others using the toilet. However, it has proven to be a difficult effort for the teachers to pinpoint the precise students who are vaping. The school is therefore faced with the critical task of successfully tackling and minimising this problem with the goal of reducing student vaping behaviour during school hours.

As the usage of e-cigarettes among teens rises, it has become increasingly difficult to prevent pupils at public schools from vaping. The inability of the school disciplinary system to recognise the pupils engaging in vaping behaviour makes it harder for them to carry out focused interventions and disciplinary measures. This vague identification not only makes it difficult for the school to enforce a no-vaping policy but also puts the pupils' health in danger. To ensure a safer and healthier learning environment for all students, it is vital to build a comprehensive and efficient approach to detect and treat vaping situations swiftly.

The project's goals are to address the growing vaping issue among secondary school pupils, especially in Sekolah Menengah Kebangsaan Bandar Perda. The main objective is to create a Vape Detection System employing the MQ135 sensor that can precisely identify hazardous substances related to vaping. By putting in place this system, the teachers will no longer have to struggle to spot pupils who are vaping because the technology will quickly identify incidents. Additionally, the development of an IoT-based real-time monitoring system will make it possible to provide disciplinary teacher immediate notifications, allowing for quick action and intervention in the event of potential vaping occurrences. The system's effectiveness will be increased by integrating student identification methods, which will enable customised actions for preventing vaping at school and identify events of vaping with students.

The initiative also stresses how crucial data analysis and conclusions are. The school will receive useful data-driven insights regarding vaping incidents and trends among pupils by processing information gathered from the Vape Detection System. These observations will help school administrators create evidence-based policies and intervention plans, which will ultimately result in a safer and better learning environment. The project also acknowledges the value of privacy and compliance while processing student data. Sensitive information will be protected and access will be limited to authorised persons only if privacy laws are strictly followed and strong security measures are put in place. By doing this, the project efficiently addresses the issue of preventing pupils from vaping while upholding student anonymity.

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II. VAPE SENSOR AND IOT IMPLEMENTATION STUDY

Research paper on Mendelsohn et al. (2023) discusses the trend of youth vaping and thoroughly discusses the effect of vaping on health among students, primarily youth aged from 11-18 years old. The paper mentioned data from England states that at the age of 11-15 years old who had never smoked cigarettes, vaped frequently once or more weekly. The data also suggests that 61% of those who smoke frequently also vaped regularly [1]. This data can give insights into the trends among youth, suggesting a rising occurrence of vaping among teenagers. The author also did a comprehensive study on the effect of vaping on health, which states that vaping can be related to respiratory symptoms in teenagers; however, those teenagers were also involved in smoking nicotine products, thus these findings are uncertain at the moment. The paper also presents evidence that nicotine affects health problems, although in the short term, it improves mood, attention and memory, but its drawback can cause nicotine addiction that can lead to nicotine withdrawal and cause irritability, anxiety, and difficulty concentrating. Chemical compounds found in vape products contain harmful levels of nicotine, ethylene glycol, propylene glycol and diethylene glycol may can contribute to health problems if taken excessively [2].

On the topic of Internet of Things (IoT), another paper discusses challenges and potential of using this advancement methods. Due to the diversity and functionality of IoT devices, traditional IoT systems' static defence methods, including firewalls and anti-viruses, are becoming more and more difficult for device manufacturers to implement. Due to this, it is difficult to implement solid security measures. As a result, it is crucial to protect IoT apps for safe communications, and continuing research is looking into AI-based methods to improve intrusion detection systems [3]. The author emphasises crucial traits and factors to consider while choosing and assessing datasets for intrusion detection in IoT systems. Due to the high prevalence of IoT devices in this environment, the attention is mostly on the residential domain. For research purposes, the accessibility of datasets is essential, and examples of these datasets include simulated data from testbeds and real-world network traffic recorded from genuine devices. Data can be stored in log files with system-generated entries or formats like PCAP (which includes payload data). The datasets' total durations and network types are defined, and labels are used to differentiate between legitimate and malicious instances. To assess the adaptability of the intrusion detection system, the nature of data collection and the number of IoT devices included in each dataset are also recognised.

By correlating IoT and vape, the project was published in a previous paper. The paper by Saputra et al. (2019) successfully executed the project using different sensors such as MQ2, MQ7 and temperature sensors are needed to get accurate readings with the given dataset. The methods have an accuracy of 71.11% detecting the type of smokes released into the air [4]. The growing trend of youth vaping and its impacts on pupils between the ages of 11 and 18 are examined in the research paper by Mendelsohn et al. (2023).

Although the health effects of growing teen vaping are unknown, nicotine addiction and the potentially toxic ingredients in vape goods are alarming. In another study, problems with IoT system security are discussed, emphasising the necessity for AI- based intrusion detection techniques. For evaluating intrusion detection in IoT systems, dataset availability and selection parameters are essential. In a previous study, Saputra et al. (2019) used a variety of sensors to identify distinct types of smoke with an accuracy of 71.11%.

III. METHODOLOGY

A. Program Flowchart

There are three inputs and three outputs for this project. The Passive Infrared (PIR) sensor is used for detecting the motion of the student. The Raspberry Pi 5MP camera module is able to record the movement of the student when exiting the toilet. The MQ135 is the main input for measuring the ppm value of the vape smoke inside the toilet area. The output is a DC fan as a ventilation system for absorbing the smoke from the vaping area, while the recorded video from the camera module is stored in the Raspberry Pi as the next output. The Blynk software will be the communication medium between the system and the IoT cloud for user reference [5].

The flowchart shown in Figure 1 is the workflow for programming development using Python on the Raspberry Pi [6], [7]. Firstly, the system will start by detecting any movement or motion occurring inside the toilet by facing this sensor to the door as the input. The PIR sensor will immediately read the motion and display “motion detected” to the Blynk interface, while “No motion detected” is displayed if no students are entering. During this process, the MQ135 sensor continuously reads the ppm value of the surrounding atmosphere to identify if there is any presence of vape smoke inside the toilet. Three conditions will be chosen based on the threshold value of the gas sensor. For a threshold less than 200ppm, the DC fan will start operating at 20% speed only for energy efficiency, as this ppm value determines the normal air surrounding. When the threshold value rises above 200 ppm but below 220 ppm, the DC fan will operate at 40% speed as this state starts to identify the presence of vape smoke and the MQ135 can measure more smoke particles. The last condition is when the threshold value is above 220 ppm, meaning that the MQ135 has detected the existence of vape smoker inside the toilet. This sensor will instantly send an alert to the Blynk and display the “vape detected” warning to the user. The DC fan will continuously operate at 80% speed for absorbing more smoke into the sensor for assurance and to trigger the camera module to start recording for 15 seconds for capturing the vaper’s face. Finally, the system will start from the beginning after each vaping activity is recognized.

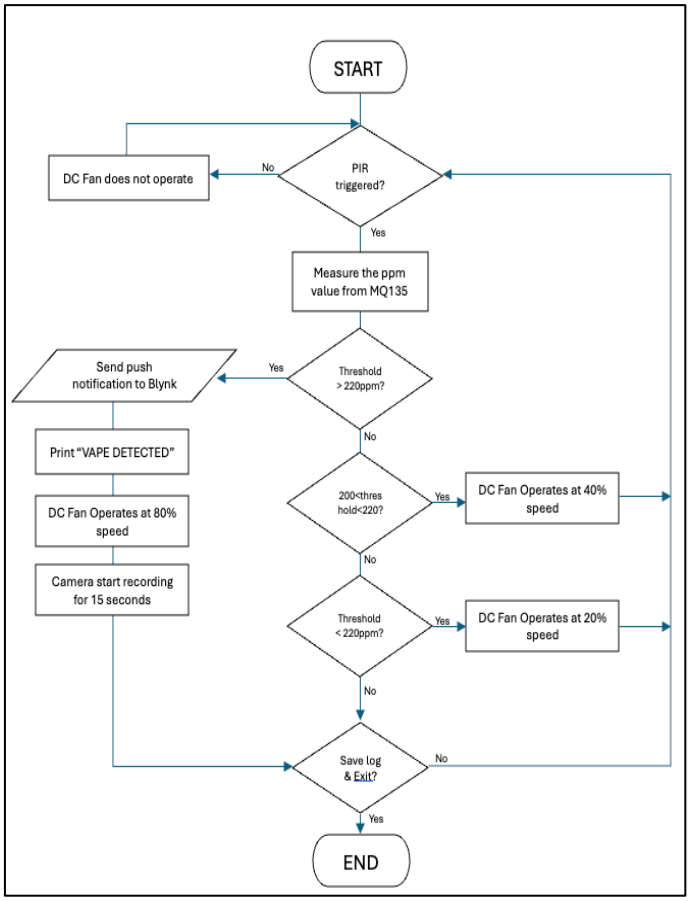


Fig. 1. Flowchart of the Vape Detection System.

B. Programming code

Fig. 2 shows the full line Python programming code implemented on the project based on the previous flowchart. From the top line, the code imports the necessary libraries for the Raspberry Pi's GPIO (RPi.GPIO), MCP3008 ADC (Adafruit_GPIO.SPI and Adafruit_MCP3008), time-related functions (time), Blynk IoT platform (BlynkLib), PWM output for the fan (gpiozero), and the PiCamera module (picamera). The BLYNK_AUTH variable contains the authentication token for this project, which was obtained from the Blynk IOT website. The PiCamera object is initialized, and the camera's image rotation is set to 180 degrees. The GPIO pins for the PIR sensor (PIR_PIN1), MQ135 sensor (DO_PIN), and the fan (FAN_PIN) are set up for input and output accordingly. The SPI communication pins CLK, MISO, MOSI, and CS for the MCP3008 ADC are defined, and the MCP3008 object is created using those pins at line 26 to 30. The PWM (Pulse Width Modulation) output is initialized on GPIO pin 18 (FAN_PIN) at a frequency of 200 Hz. The initial duty cycle is set to 90% where the fan initially off. Two functions, 'start_recording( )' and 'stop_recording( )', are defined to control the camera recording. The 'start_recording( )' function starts recording video for 15 seconds using 'time.sleep( )' and print "Recording Started" if it's not already recording, and the 'stop_recording( )' function stops the recording if it's already recording. The 'camera.start_recording' will trigger the camera and the location stated in the bracket is where the video is stored after stop recording. The main loop of the program begins at line 58. It continuously runs and checks for sensor readings and updates the Blynk app with the analog_value from the MQ135 sensor. The first condition is when the motion is detected by the PIR sensor and the analog value (MQ135 reading) is less than 200 (vape not detected), the fan starts operating at 20% duty cycle for 3 seconds. Next condition is when the motion is detected by the PIR sensor and the analog value is between 200 and 220 (possible vape detected), the fan starts operating at 30% duty cycle for 3 seconds. However, if the analog value is greater than 220 (vape detected), a notification is sent to Blynk, and the fan starts operating at 80% duty cycle for 5 seconds. Additionally, the 'start_recording()' function is called to initiate video recording. Finally, the fan turns off (0% duty cycle) for half a second before looping back to the beginning of the main loop if no motion is detected.

```
1  import RPi.GPIO as GPIO
2  import Adafruit_GPIO.SPI as SPI
3  import Adafruit_MCP3008
4  import time
5  import BlynkLib
6  from gpiozero import PWMOutputDevice
7  from picamera import PiCamera
8
9  BLYNK_AUTH = '_b8GWcG28-zynuMtqaAW40e_nLVj4zYo'
10
11 blynk = BlynkLib.Blynk(BLYNK_AUTH)
12
13 camera = PiCamera()
14 camera.rotation = 180  # Rotate the image by 180 degrees
15
16 GPIO.setwarnings(False)        #Disable GPIO warning
17 GPIO.setmode(GPIO.BCM)
18 PIR_PIN1 = 4
19 DO_PIN = 17
20 FAN_PIN = 18
21 GPIO.setup(PIR_PIN1, GPIO.IN)
22 GPIO.setup(DO_PIN, GPIO.IN)
23 GPIO.setup(FAN_PIN, GPIO.OUT)
24
25 # Set up MCP3008 ADC
26 CLK = 11
27 MISO = 9
28 MOSI = 10
29 CS = 8
30 mcp = Adafruit_MCP3008.MCP3008(clk=CLK, cs=CS, miso=MISO, mosi=MOSI)
31
32 pwmOut = GPIO.PWM(18, 200)
33 pwmOut.start(90)
34 dutyCycle = 0
35
36 print("PIR Module Test (CTRL+C to exit)")
37 time.sleep(0.15)
38 print("Ready")
39
40 recording = False
41
42 def start_recording():
43     global recording
44     if not recording:
```

```
        recording = True
        camera.start_recording('/home/pi/Desktop/video.h264')
        print("Recording Started")
        time.sleep(15)  # Record for 15 seconds
        stop_recording()

def stop_recording():
    global recording
    if recording:
        recording = False
        camera.stop_recording()
        print("Recording Stopped")

try:
    while True:
        blynk.run()

        # Read digital value from MQ-2 sensor
        digital_value = GPIO.input(DO_PIN)

        # Read analog value from MCP3008 channel 0
        analog_value = mcp.read_adc(0)

        # Print the digital and analog values
        print("Analog Value:", analog_value)
        blynk.virtual_write(4, analog_value, "ppm")

        time.sleep(0.25)

        if GPIO.input(PIR_PIN1) and analog_value < 200:
            print("Motion Detected!")
            blynk.virtual_write(5, "Motion detected")
            dutyCycle = 20
            pwmOut.ChangeDutyCycle(100 - dutyCycle)
            time.sleep(3)

        elif GPIO.input(PIR_PIN1) and 200 < analog_value < 220:
            print("Motion Detected!")
            blynk.virtual_write(5, "Motion detected")
            print("DC Fan start operate")
            dutyCycle = 30
            pwmOut.ChangeDutyCycle(100 - dutyCycle)
            time.sleep(3)

        elif analog_value > 220:
            print("Send notification to Blynk")
            blynk.log_event("vape_detected")
            dutyCycle = 80
            pwmOut.ChangeDutyCycle(100 - dutyCycle)
            time.sleep(5)
            start_recording()

        else:
            print("No Motion Detected!")
            blynk.virtual_write(5, "No Motion Detected")
            dutyCycle = 0
            pwmOut.ChangeDutyCycle(100 - dutyCycle)
            time.sleep(0.5)
        time.sleep(0.1)

except KeyboardInterrupt:
    print("Exiting...")
    stop_recording()
    GPIO.cleanup()
```

Fig. 2. Project's Coding in Python.

C. *Hardware Design*

The MQ135 sensor has four output pins, Vcc, Ground, Digital Out, and Analogue Out, while the MCP3008 has 16 pins. The digital out of the MQ135 is connected directly to the GPIO pin 17 for digital value reading. From MCP3008, there are two pin for the voltage source and two pins for ground that are connected to the Raspberry Pi through PCB board [8]. The GPIO pins 8, 9, 10, and 11 are connected to the Chip Selector (CS), MISO, MOSI and CLK where the pins at MCP3008 are 10, 11, 12, and 13 respectively. These pin are important for setting up the MCP3008 ADC where it writes the analogue value of the sensor on the microcontroller.

The PIR sensor is directly connected to the Raspberry Pi pin without using the PCB board to prevent any connection problem and for instant sensor reading. The PIR sensor has three pins only: Vcc, Gnd and the Digital out pin. The Vcc pin is attached to a 5B pin while the Gnd pin is attached to the ground pin on the Raspberry Pi. Lastly, the digital out is connected to the GPIO 4 pin as declared in the coding [9].

The final design of this project is shown in Figure 3, where the miniature is made based on the toilet schematic plan in SMK Bandar Baru Perda. The project component consists of the microcontroller and the sensors are put inside a box for protection and attached below one of the toilets, where the hotspot for students to smoke vape. Inside the box, there is the DC fan to help the circulation of the vape smoke into the box, while the MQ135 is attached to the top of the fan for measuring the ppm value. The PIR sensor is attached to the wall and facing the door. Several jumpers are used to extend the cable length of this sensor. For the camera module, the flex cable was replaced with a 1-meter length cable as the camera needs to be attached outside the toilet by facing the toilet. A wall cable cover is used for better cable management.

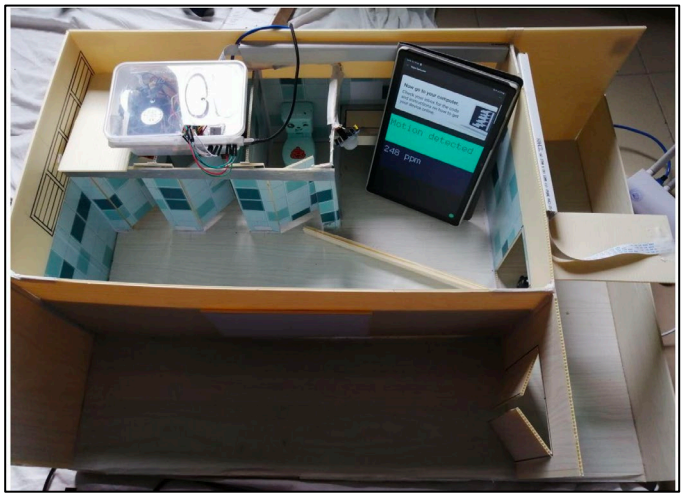


Fig. 3. Miniature setup of the system in a public school.

IV. Results and System Performance

The vape detection and monitoring system was implemented to address the rising concern of teenage vaping within school premises. This section discusses the results obtained from the vape detection and monitoring system and its effectiveness in

curbing vaping incidents.

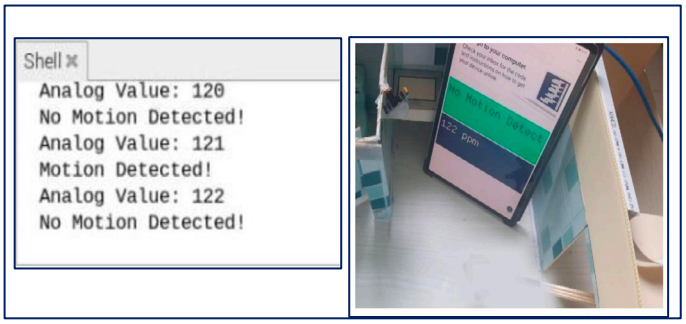


Fig. 4. Result of motion and vape detector output – no vape and motion.

Figure 4 shows the results of the motion and vape detector output i.e relative value, without vape presence, in the Python shell and via Blynk. Based on the results in Python and Blynk software, it shows that since no student entered the toilet, the PIR sensor could not detect any motion and "No Motion Detected" message will be sent to both Python shell and Blynk. The threshold value is below 200ppm since the MQ135 does not detect the surrounding vape substance. At the same time, the DC fan will not be operated.

The results in this section show that when the PIR sensor has detected the movement of the student entering the toilet. The output simulation in Python in Figure 3.3 shows Motion Detected. As the coding in Python has been set with Blynk software, so Blynk has also shown the same results as Python, as shown in Figure 3.4. There is still no vape smoke detected in the toilet because the threshold value is below 200ppm. However, the DC fan will start operating in 20% speed only to save energy because this ppm value determines the normal surrounding air. Currently, Blynk software users can only monitor the movement of students entering the toilet when the user opens the software. Only PIR sensor, MQ135 sensor and DC fan were operated at this condition.



Fig. 5. Result of motion and vape detector output – motion detected.

In this section, it shows that the value of the threshold value increases above 200 ppm but below 220 ppm, as shown in Figure 5. At this time, the DC fan was operated at 40% speed because this condition starts to identify the presence of vape smoke and the MQ135 can measure more smoke particles. In this situation, Blynk software users can also only monitor it by opening the software because no notification will be sent to the user.

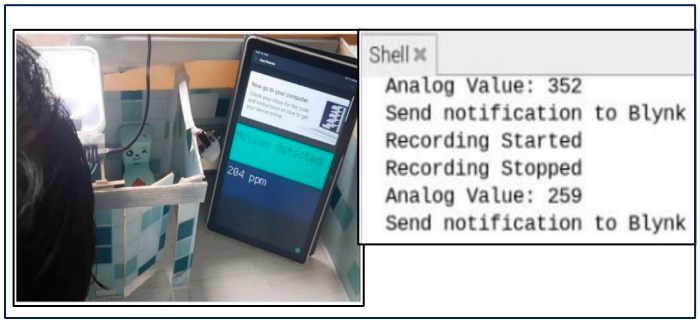


Fig. 6. Result of motion detector output – vape detected

Figure 6 illustrates the simulation results triggering the system when the threshold value exceeds 220ppm. This shows that the MQ135 sensor successfully detects the presence of vapers in the toilet. Once the threshold is exceeded, the program displays its value and triggers the action "Send notification to Blynk," indicating that a notification will be sent through the Blynk software.

Furthermore, the program starts the recording process with a 15-second video clip, as indicated by the output "Recording started." Once the "Recording Stopped" message appears, video recording stops. Figure 7 displays the notification sent through the Blynk software to inform the user of vape detection.



Fig. 7. Notification sent through the Blynk.

Additionally, push notifications are sent to the user's smartphone as shown in Figure 8 to further increase awareness.

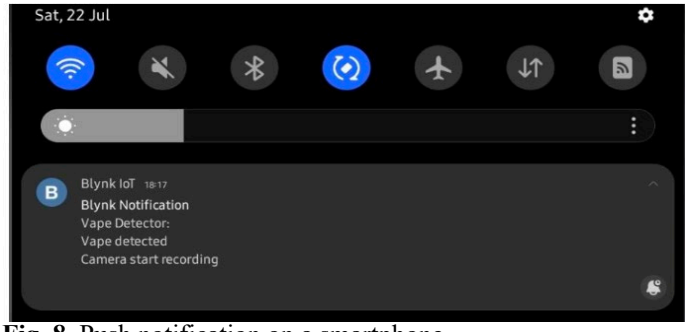


Fig. 8. Push notification on a smartphone.

Meanwhile, the DC fan operates at 80% speed to increase the absorption of smoke into the sensor and trigger the camera module to record a 15-second video recording of the vaper's face. The recorded video can be accessed via a VNC desktop

like in Figure 9. After each vape detection event, the system resets and prepares for the next detection.

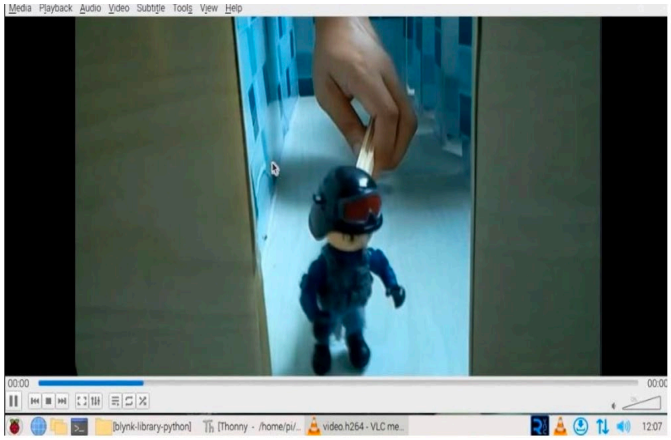


Fig. 9. Recorded video that can be accessed remotely.

V. CONCLUSION & FUTURE WORKS

The vape detection and monitoring system at SMK Bandar Perda Baru has made a big difference in the safety, health and culture of the school. The project is a response to growing teacher concerns about students using pods and vaping, especially in small places like school toilets. Based on the study conducted, there are a few health concerns among youth regarding vaping, ranging from the most frequent mild health problems, such as throat and mouth irritation, dry cough, and nausea to potential long-term effects on brain development, whereas small doses of nicotine substance can greatly affect brain development, cognitive issues, and addiction [10].

By placing the vape detection and monitoring system in places where people vape, such as school toilets, the project acts as a proactive safety measure, preventing fires and other accidents that may be caused by vaping. When a student enters the area, the system's motion sensor turns on the fan for ventilation and tracking, and a gas sensor quickly picks up particles from the vape product. In the case of vaping, the sensor alerts the teacher which have the software, so they can take immediate action to avoid accidents, injuries or other unsafe situations.

Additionally, the system makes a huge difference in children's health and happiness. Students are less exposed to harmful substances because the project notifies school staff quickly and discourages the use of vaping in hidden places. This protects their physical and mental health during this important time of growth. This system actively discourages students from vaping, which helps create a healthier school environment free from the harmful effects of nicotine and other substances found in vaping products.

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