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THE FEASIBILITY OF USING METAL OXIDE SEMICONDUCTOR (MQ2) IN CREATING A GAS LEAK DETECTOR

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ABSTRACT

Gas leaks and the danger they bring with them remain a primary concern for many despite the advances in current technology. The challenges people face in preventing gas leakage in their environment are the knowledge about gas leaks and the expensive tools and countermeasures they need to purchase in return for their safety. Thus, the study utilized experimental research wherein the main objective of the study was to create a gas leak detector using a Metal Oxide Semiconductor (MQ2) as the primary component and interfaced with Arduino UNO to activate the alarm system of the device. The study's results proved the feasibility of the Metal Oxide Semiconductor sensor as the main component in making a gas leak detector in terms of the distance the device can detect gas leakage, detecting up to 2 meters. Second, the amount of time it takes for the sensor to detect a gas leak, with averages of 4.62 seconds for 0.5 meters and 9.39 seconds for 1 meter. The researchers determined that the gas leak detector can detect gas leaks up to 2 meters with an interval of half a meter, as all the trials that were done resulted in a passing rate.

KEYWORDS: Arduino UNO, Gas leak, Gas leak detector, Gas sensor, Metal Oxide Semiconductor (MQ2)

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INTRODUCTION

In today's world, using different types of gas is inevitable as they are needed to perform vital day-to-day duties such as cooking. Toxic elements, fires, and explosions are only some of the conflicts that gas distributors and their consumers could face when utilizing such a complex substance. The possibility of the occurrence of fire and explosions due to gas is the most important and unfortunate aspect that professionals rigorously try to minimize, as it could put an end to human life. A gas leak is a leak or the accidental release of gaseous particles within an environment when a gas line or any gas-burning appliance is damaged. Despite the extensive efforts and measures of the professionals, gas leak accidents remain frequent for various reasons, such as human errors or the inability to repair faults in gas systems. In households and small establishments where Liquified Petroleum Gas (LPG) tanks and Natural Gas tanks are often used, there are several reasons why these tanks could leak. Gas leaks could be caused by faulty or damaged rubber tubing, an essential component for connecting the gas source to the burner or appliance needing energy (Anchan, 2015). In addition, faulty piping and poor ventilation in the area where the gas source is placed increase the risk of common gasses such as carbon dioxide, natural gas, and propane gas leaking (Smith, 2019).

Gas leak cases are serious issues that should be considered, mainly because they occur in industrial places and residential homes, where hundreds of people's lives are at stake. The danger of a gas leak is not its ability to cause a fire but rather its characteristics of being odorless and colorless. One of the reasons gas leaks are challenging to detect with expert help is that they display no noticeable signs. These characteristics allow the gaseous particles to cause damage to one before one even detects the gas leak. Fifty thousand individuals experience the effects of gas leaks, such as severe fatigue, nausea, loss of consciousness, and suffocation that force them to visit the emergency room annually. At the same time, 413 unfortunate people die because of these effects (Centers for Disease Control and Prevention, 2020). Long-term exposure to gas leaks has a detrimental impact on the well-being of individuals and could lead to death.

Gas leak detectors are a vital part of safety systems as they are the first line of defense against possible disasters that could be brought up by gas leakage (Niazi, 2021). However, this type of device, application, and maintenance are costly, causing many to choose not to have it, putting money over their safety. Some of the recommended gas leak detectors in the current market are the Airthings View Plus, Google Nest Protect, and EG Air Propane and Natural Gas Detector, ranging from 200 QAR to almost 1100 QAR (Redmile, 2023). However, with these prices, the safety of one is still put in danger as they all need to be held close to the gas source for these devices to detect a probable gas leak. On the other hand, cheaper alternatives can be achieved by using scrap materials found at home to create a gas leak device that is as efficient as the mass-produced ones.

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Using the MQ2 gas sensor to create the device provides a cheaper alternative to mass-produced gas leak detectors. MQ2 gas sensor is a type of metal oxide semiconductor capable of detecting the changes in the concentration of gasses in the air. MQ2, also known as a chemical resistor, is an affordable device that has a particular sensing material capable of detecting the different gas particles present in the environment in which it is situated (Agarwal, 2019). The MQ2 sensor works by its sensing material, made from tin dioxide, detecting gaseous particles in the air, causing its resistance value to change, signifying that a gas leak is present in the surroundings. Specifically, the MQ2 gas sensor detects liquified petroleum gas, smoke, alcohol, propane, butane, methane, and hydrogen. MQ2 gas sensor is a cheap but durable and reliable device due to its high sensitivity, making it, when interfaced with Arduino, a great alternative to ready-made and expensive gas leak detectors (Trisnawan et al., 2019). In addition, it does not need to be held by an individual to detect a gas leak.

The objective of this study was to create a Gas Leak Detector by using a Metal Oxide Semiconductor (MQ2) and determine its maximum distance reached and average reaction time.

1.1. Research Questions

The objective of this study is to create a Gas Leak Detector using Metal Oxide Semiconductor. Specifically, it aims to answer the following questions:

1. How far can the gas leak detector detect a gas leak up to 2 meters in an interval of half a meter?
2. How long does the Gas Leak Detector take to detect a gas leak?

1.2. Hypothesis

H1: It is feasible to create a Gas Leak Detector using a Metal Oxide Semiconductor (MQ2).

2. METHODOLOGY

This study utilized the experimental type of research. Experimental research design is a form of research that follows a scientific approach and is conducted in a controlled manner to optimize the utmost precision to conclude the presence or absence of the effect of the independent variable on the dependent variable (Pubrica, 2022). In this study, the independent variable is the Metal Oxide Semiconductor, and the gas leak detector is the study's dependent variable. In addition, the quantitative method will be used to accurately examine the relationship of the study's variables through numeric patterns (Coghlan & Brydon-Miller, 2014). It is essential to use this method as it provides a high level of control over the variables that demonstrate an outcome and is advantageous in obtaining accurate, consistent, and precise results.

2.1. Research Locale

The study was conducted in the school of the researchers in Doha, State of Qatar, specifically in the Mesaimeer Area (Zone 56), Al Khulaifat Al Jadeeda Street.

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2.2. Data Gathering Procedure

The procedure shows how to make a gas leak detector using a Metal Oxide Semiconductor and how its effectiveness is tested.

2.2.1. Ensuring protection and maintaining safety

Precautionary measures were taken and proper wearing of protective gear such as gloves, safety glasses, and masks were observed.

2.2.2. Making the gas leak detector

Main materials such as the sensor, Arduino UNO, LED lights, 5v buzzer, safe plastic container, jumper wires, breadboard, and USB adapter were gathered in a safe working area. The metal oxide semiconductor was connected to the Arduino UNO by connecting the Ground pin of the sensor to the Ground of the Arduino, the Analog Output of the sensor to the Analog Output of the Arduino, and lastly, the VCC pin of the sensor to the 5v terminal of the Arduino. Other components were placed in the breadboard that is connected to the respective terminals of the Arduino board depending on the component.

2.2.3. Programming the Arduino UNO

The Arduino IDE software was utilized to program the components of the device. The components were programmed to activate an alarm when the sensor exceeded the set threshold value of 280.

2.2.4. Setting up the safe packaging

A food plastic container was used to cover the components to ensure its safety and durability. The container was painted red to symbolize an emergency and the universal gas leak symbol was placed in the center of the packaging. In the exterior, there are 4 visible holes covered with hairnet to allow the 5v buzzer to be more audible and more efficient in alarming the persons in the vicinity of the device in case of the event of a gas leak.

3. RESULT AND DISCUSSION

3.1 Maximum Distance between Gas Leak Detector and Gas Leak up to 2 meters in an interval of half a meter

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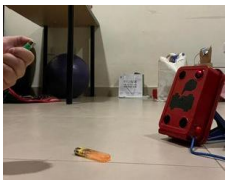
Table 1: Distance Between Gas Leak Detector and Gas Leak

Distance	Trial	Result	Photos
0 meter	1	Passed	
	2	Passed	
	3	Passed	
0.5 meter	1	Passed	
	2	Passed	

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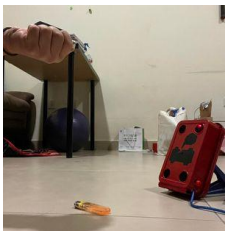
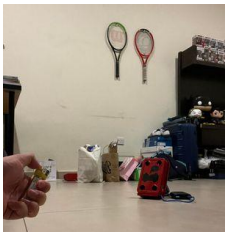
	3	Passed	
1 meter	**1**	Passed	
	2	Passed	
	3	Passed	
1.5 meter	**1**	Passed	
	2	Passed	

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	3	Passed	
2 meters	**1**	Passed	
	2	Passed	
	3	Passed	

Table 1 presents meters passed, and distances at which the gas leak detector can detect a gas leak. The results were obtained by placing the gas leak source in a fixed position while the gas leak detector was moved a certain distance from the leak each test, specifically 0.5 meters, 1 meter, 1.5 meters, and 2 meters, with three trials for each distance. If the gas leak detector detected gas from a certain distance and alarmed, it passed the test. If the device did not detect gas from a certain distance, it failed the test. In the testing procedure, it was found that at all distances of 0.5 meters, 1 meter, 1.5 meters, and 2 meters, the gas leak detector could detect a gas leak and alarm in a relatively short time. The distance of 0 meter passed all trials, therefore the device detected the gas leak. Trials 1,2, and 3 with 0.5-meter distance passed the testing procedure as well. Passed all three trials conducted as well as the 1-meter distance. Lastly, 1.5 and 2-meter distances passed all trials from 1 to 3.

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The maximum range of the gas leak detector away from the gas source is 2 meters. This is the ideal range from which the gas leak detector device is reliable and functional. The result is supported by a study that states that gas leak detectors are positioned close to possible gas leak sources and perform best within a monitoring radius of 0.5 to 2 meters (Emerson Electric Co., 2019). Gas leak detector systems should be installed near gas sources or probable gas leak sites to alert and reach the device instantly in case of a gas leak.

A similar study regarding a microcontroller-operated device has obtained results of the maximum distance range of the gas leak detector. The gas sensor's maximum distance range was tested for a total of three trials, 9.0cm, 8.0cm, and 8.0 cm, respectively, obtaining an average maximum distance of less than 10 cm (Galo et al., 2018). Despite this, the maximum distance range calculated for the gas leak detector is 2 meters, meaning that the gas leak detector can still detect a gas leak that is 2 meters away from the device, showing better and satisfactory effectiveness. The same study also concluded from a survey that the device users evaluated good scores on usability and functionality, with aesthetics having the lowest score, which shows good marketability for the device, significantly if the aesthetics are improved.

3.2 The time for the Gas Leak Detector to detect gas leak in terms of distance

Table 2: Time for the Gas Leak Detector to Detect Gas Leak

Table 2.1: 0.5-meter Distance Between Gas Leak and Gas Leak Detector

Trial	Time (in seconds)	Photos
1	4.01s	
2	3.20s	

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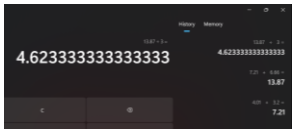
3	6.66s	
Average	4.62s	

Table 2.1 provides information on the real-time detection of the gas leak detector when identifying gas leaks within a 0.5-meter range. To ensure reliability and consistency, a series of three trials were conducted, and the average detection time was determined by summing the results of each trial and dividing the total by three. In trial 1, the time that the gas leak detector could detect the gas leak was 4.01 seconds when the gas leak detector was positioned 0.5 meters away from the gas leak. Subsequently, in trial 2, the gas leak detector could detect the gas leak in 3.20 seconds when the gas leak detector was 0.5 meters away from the gas leak. In trial 3, the time that the gas leak detector could detect the gas leak was 6.66 seconds when the gas leak detector was 0.5 meters away from the gas leak.

Analyzing the results, an average of 4.62 seconds was recorded for the gas leak detector to detect the gas leak from 0.5 meters of proximity. The trials indicate a quick detection time for the gas leak detector to detect a gas leak within a nearby area. It is anticipated that after the gas sensor is configured, the accuracy will approach 80%, and there will be a 0–10 cm gap between the gas sensor and the leaking point (Trisnawan et al., 2019). The results highlight the gas leak detector's promising potential, indicating that, with additional calibration and modification, the gas leak detector can provide a high degree of sensitivity and accuracy in identifying gas leaks within a small proximity range.

In processing the data, the gas sensor's detection time is directly proportional to how far it is separated between the sensor and the gas source (Rosli et al., 2022). The time it takes the gas leak detector to detect the presence of gas rises proportionally with the sensor's distance from the gas source. The concentration of gas surrounding the sensor is higher when it is close to the gas source, which speeds up the detection time. The dispersion of gas molecules in the air should be considered to explain the differences in the seconds it took for the gas leak detector to detect the gas leak.

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Table 2.2: 1-meter Distance Between Gas Leak and Gas Leak Detector

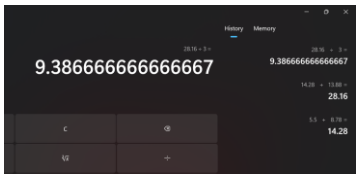
Trial	Time (in seconds)	Photos
1	5.50s	
2	8.78s	
3	13.88s	
Average	9.39s	

Table 2.2 provides information on the real-time detection of the gas leak detector when identifying gas leaks within a 1-meter range. To ensure reliability and consistency, a series of three trials were conducted, and the average detection time was determined by summing the results of each trial and dividing the total by three. In trial 1, the time that the gas leak detector could detect the gas leak was 5.50 seconds when the gas leak detector was positioned 1 meter away from the gas leak. Subsequently, in trial 2, the time that the gas leak detector could detect the gas leak was 8.78 seconds when the gas leak detector was 1 meter away from the gas leak. In trial 3, the time that the gas leak detector could detect the gas leak was 13.88 seconds when the gas leak detector was 1 meter away from the gas leak.

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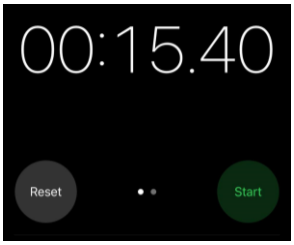
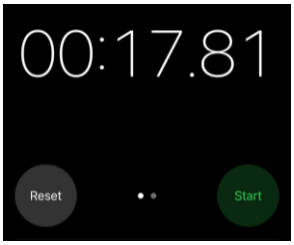
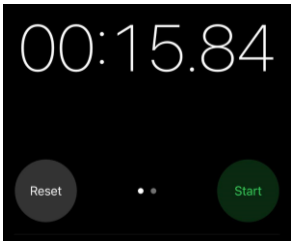
Examining the results, an estimated 9.39 seconds was recorded for the gas leak detector to activate upon the leakage of gas situated 1 meter away. Upon assessment, the results show a decent speed in detecting the gas leakage with a slight delay, resulting in a longer average speed time than the previous table of 0.5 meters. Several factors affect the response time of gas leak detectors, such as location, air flow, properties of the gas, and environmental conditions (Jan-Mar, 2019). The gas leak source was farther from the gas leak detector, causing a later detection time than the previous table, which should be considered in assessing the speed to detect the gas leak.

Desirable outcomes resulted from the trials as the average detection time was only 9.39 seconds, in which the detection time of gas leak detection systems could vary from seconds to minutes. In conclusion, the assessment shows that the gas leak detector is still effective, despite the gas leak source being farther away from the gas leak detector, which shows good effectiveness in a mid-range area spanning at least 1 meter.

Table 2.3: 1.5 meters Distance Between Gas Leak and Gas Leak Detector

Trial	Time (in seconds)	Photos
1	15.40s	
2	17.81s	
3	15.84s	

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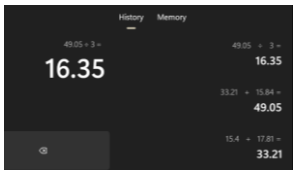
Average	16.35s	

Table 2.3 provides information on the real-time detection of the gas leak detector when identifying gas leaks within a 1.5-meter range. To ensure reliability and consistency, a series of three trials were conducted, and the average detection time was determined by summing the results of each trial and dividing the total by three. In trial 1, the time that the gas leak detector could detect the gas leak was 15.40 seconds when the gas leak detector was positioned 1.5 meters away from the gas leak. Subsequently, in trial 2, the gas leak detector could detect the gas leak in 17.81 seconds when the gas leak detector was 1.5 meters away from the gas leak. In trial 3, the time that the gas leak detector could detect the gas leak was 15.84 seconds when the gas leak detector was 1.5 meters away from the gas leak.

Assessing the results, an average of 16.35 seconds was recorded for the gas leak detector to activate upon the leakage of gas situated 1.5 meters away from the leak. Upon assessment, the results showed a slower speed in detecting the gas leakage. However, it maintained its precision, and it took a longer average speed time than the previous table of 1 meter. The results are backed up by a study stating that there is a significant link between the MQ-2 sensor's response time and the distance to the object being measured, with an apparent modest increase as the distance rises (Hannan et.al, 2018).

The experiments yielded the desired results because, although the detection time of gas leak detection systems increased by approximately 6 seconds from the previous table, the average detection time was just 16.35 seconds and is deemed acceptable to the fact that a study stated that the gas leak detector should be able to detect a gas leak within 30 seconds overall (Industrial Scientific, 2021). The evaluation concludes that the gas leak detector remains efficient even though the leak source is farther away. The detector operates well in a mid-range area that is at least 1.5 meters in length.

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Table 2.4: 2 meters Distance Between Gas Leak and Gas Leak Detector

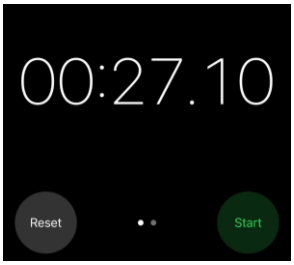
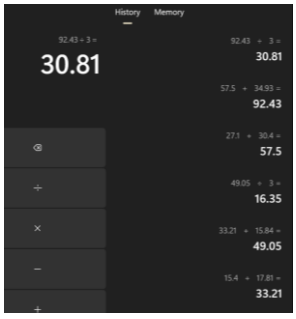
Trial	Time (in seconds)	Photos
1	27.10s	
2	30.40s	
3	34.93s	
Average	30.81s	

Table 2.4 shows the results of the three trials with the time the gas leak detector takes to detect the gas leak 2 meters away from the gas leak detector. To ensure reliability and consistency, a series of three trials were conducted, and the average detection time was determined by summing the results of each trial

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and dividing the total by three. In the first trial, the device detected the gas leak in 27.10 seconds; for the second trial, it took 30.40 seconds; and for the last trial, it detected the leak in 34.93 seconds. It garnered a total average of 30.81 seconds for all three trials.

Through the analysis of the results, the gas leak detector took an average of 30.81 seconds to detect the gas leak that was two meters away from it. These results show a much sluggish reaction time for the gas leak detector to detect the gas leak compared to the first table of 0 meters, which is due to the further distance between the source of the gas leak and the gas leak detector. Despite the results showing the slowest reaction time out of the four tables, the gas leak detector could still present a decent speed and precise detection times.

Satisfactory outcomes are given from the three trials, even with a two-meter gap between the gas leak detector and the source of the gas leak, which, in a real-life situation, isn't usually observed, as gas leak detection systems should usually be placed right where a leak could occur, usually the gas tank (RKI Instruments, 2021). In conclusion, the gas leak detector stays effective, considering the distance between it and the gas leak, making it efficient in detecting gas leaks at a great distance, especially at a 2-meter range.

3.4 Hypothesis

The researcher's alternative hypothesis, which states that it is feasible to create a Gas Leak Detector using a Metal Oxide Semiconductor (MQ2), is accepted. The researchers developed an effective Gas Leak Detector that successfully detects gas leaks and alarms individuals in the vicinity of the device.

3.5 Discussion

The acquirement of gas leak detectors has significantly benefited households' health and safety. Over 73 million residential, industrial, and commercial premises in the United States use natural gas, which is highly flammable, and leakages of this risk the chances of fire and high-end explosions (American Gas Association, n.d.). Even so, installing gas leak detectors has proven to prevent this through the broader spread of gas leaks and large-mass explosions through its early detection of gas leaks in the area.

Furthermore, gas leak detectors can cut unnecessary extra costs and payments, such as medical bills and repairs (TR Miller, 2023). Despite this, many households still do not purchase gas leak detectors because of their costly prices, averaging $1,000 per sensor (GDS Corp, 2019). However, with the use of a metal oxide semiconductor, an affordable and eco-friendly gas leak detector that possesses the same effectiveness as that of other gas leak detectors sold in the industry was created, which was the aim of this study.

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The gas leak detector presented satisfactory results throughout the testing process in Table 1 and Table 2. In Table 1, the researchers were able to determine that the gas leak detector can detect the gas leak up to 2 meters with an interval of half a meter as all the trials that were done resulted in a passing rate. Proper placement of gas leak detectors is essential. These detectors are wired to detect the presence of dangerous gases, so it is vital to install them in the right location and at the correct distance, thus they should be positioned near potential gas leak sources for optimal effectiveness (Gas Safety Certs, 2023).

Table 2 shows adequate speed detection times ranging from 4.62 seconds to 30.81 seconds from 0 to 2-meter distances. However, in a real-life situation, it would be more practical to base on the results obtained from the 0-meter distance, as gas leak detection systems are usually placed right where gas leaks would occur, such as beside the gas tank (RKI Instruments, 2021). Additionally, the recorded average speed detection times are relatively quick, as according to Industrial Scientific in 2021, a gas leak detector should be able to detect a gas leak within 30 seconds.

This research aimed to assess the feasibility of the gas leak detector through its detection time rate. The ability to detect gas leaks from certain distances. Lastly, the feasibility was evaluated based on the quickness of the gas leak detector to activate from certain distances away from the source.

4. CONCLUSION

Based on the results, the farthest distance that the gas leak system can accurately detect a gas leak is within 0-2 meters, which has displayed a quality that can closely live up to the market-standard quality of gas leak detectors available throughout the market.

Moreover, the gas leak system is deemed fast and efficient, with an average of 4.62 seconds before detecting a gas leak within 0.5 meters. Meanwhile, for 1 meter and 1.5 meters, it took an average of 9.39 seconds and 16.35 seconds respectively. The distance of 2 meters garnered an average of 30.81 seconds. The gas leak system works best within a distance of 0 to 4 meters.

This study helps to support the school's vision, which is pro-environment. This study nurtures environmentally friendly learners across the school. In addition, the students and school staff are advised to follow safety protocols and procedures when testing the device, to acquire high-quality materials to ensure proper and better functioning of the device in terms of distance detection and response time and to conduct further investigation to improve the overall capabilities of the gas leak detector.

The Qatar and Philippine communities are encouraged to use readily available materials to create a cost-effective, reliable, consumer-friendly, portable gas leak detection system. Given the catastrophic effects

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of gas leaks on people, the environment, and the community, gas leak detectors are designed to provide early warnings about hazardous gases. Gas leak detector devices enable individuals to take the required precautions to avoid accidents and limit potentially fatal disasters. These systems protect us from invisible hazards and provide a sense of security at home.

Furthermore, investigating the feasibility of utilizing Metal Oxide Semiconductor (MQ2) in creating a gas leak detector has yielded significant knowledge about its potential as a dependable and efficient technology. Through the use of Arduino UNO and MQ2 sensors, a cheap and effective alternative to expensive gas leak detectors was made possible. The study's testing procedure was limited to using both a lighter and a lighter with a blow dryer to simulate a real gas leak scenario wherein there is a much greater gas source. Using lighters was the only safe and possible way for the researchers to test the capabilities of the gas leak detector. It is recommended to future researchers with similar studies to obtain a safe but more powerful gas source for testing. Researchers could also include in their investigation the amount and volume of gas that the device will be able to detect. Lastly, future researchers are also urged to include a Wi-Fi module in the device for easier alerting and notification.

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