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The Development of a Water Level Monitoring System Through The Blynk Application to Reduce Stress among Workers in Monitoring The Waste Water Treatment Sewage Water Level

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Workers often face the challenge of constantly monitoring tank water levels to prevent overflows, especially submersible pumps cannot be controlled automatically. This study aims to develop an automatic water level monitoring and pump control system using the Blynk application, thereby reducing the stress and workload of workers tasked with monitoring wastewater treatment systems. The project employs the Design Thinking model as a structured approach, progressing through five phases: empathy, definition, ideation, prototyping, and testing. This methodology ensures that the system is user-centered and addresses the challenges faced in industrial settings. The findings demonstrate that integrating a water level monitoring system with the Blynk application significantly enhances the ease of monitoring. Workers can track water levels remotely through a smart device, eliminating the need for physical inspections. This approach prevents unnoticed overflows caused by pump failures and improves operational efficiency in wastewater management.
Keywords: Submersible Pumps; Water Level Monitoring System; Waste Water Treatment (WWT); Blynk Application.

1. Introduction

Several factors can cause stress among sanitation workers. Some aspects contributing to this stress are that workers are often exposed to uncomfortable conditions, bad smells, health risks, and critical tasks involving monitoring and maintaining the sewage system [1]. Employee mistakes can cause significant problems, including pollution and public health issues. For example, if workers fail to monitor tank water, it will indirectly pollute the environment because it may flow into the drain [2, 3, 4]. Allows the industry to be subject to legal action through the Environmental Quality Act 1974 (Act 127) [5], which is related to preventing, eliminating, and controlling pollution and repairing the surrounding environment for its purposes. This act has been in effect since April 15, 1975. The problems faced by these workers can add to mental and emotional stress.

Workers must monitor the tank's condition at all times, worrying that the water in the tank will overflow and sanitation workers cannot turn on and off the submersible pump automatically. Therefore, the automatic submersible pump system is designed to solve industry problems related to overflowing tank water. The Automatic Water Level System for Submersible Pump project is designed to make it easier for workers to monitor the volume of water in a temporary tank without going to the tank area [6, 7, 8]. It involves the Internet of Things (IoT). Workers can monitor the volume of water using smart devices such as their mobile phones to find out what percentage (%) of water is in the temporary tank [9, 10, 11]. In addition, this system is designed to turn on (ON) and turn off (OFF) the submersible pump automatically when the water level reaches a predetermined level from 0% to 100%. All the coding for this project's development has been programmed into the Arduino, which acts as a place to store all the controls for this project. In the new era of Industrial Revolution 4.0, this project is designed to improve the existing system to a more sophisticated one.

The submersible pump consists of four main parts: the pump body, motor, water pipe, and float switch. The pump body acts as a protection, cover, or house to protect and support most of the components inside, as shown in Figure 1. It is used to prevent leakage and maintain pressure during the liquid suction process. The pump body on the submersible pump is tightly closed, not allowing liquid to enter it [12].

Figure 1: Pump Body "Yellow" [13]

A motor, as shown in Figure 2, is a device that converts electrical energy into mechanical energy to move [14]. Inside the submersible pump, the motor turns the impeller to draw water to the production channel through the suction grid. The strength of a submersible pump to suck liquid depends on how big the motor is used. The motor used in submersible pumps in the industry is an Alternating Current (AC) motor, either a single-phase AC motor or a three-phase AC motor [15].

Figure 2.9 : Motor Submersible Pump in the Center [13]

Water pipes function to flow water that has been pumped to the surface of the irrigation system. They are usually made of stainless steel or plastic to ensure corrosion resistance. The float switch controls the pump's operation, usually by turning the pump on and off automatically based on the water level. The pump is operating dry, which can damage it. Inside the float switch is a limit switch and an iron ball. When the float switch is at the set liquid height, the iron ball inside the float switch will move to press the limit switch, causing the submersible pump to operate. When the float switch is at a low water level, the iron ball will return to its original position, causing the limit switch not inside the float switch to be pressed, and the submersible pump will not operate or stop operating.

Figure 3: Float Switch [16]

A submersible pump is a pump that sits vertically to suck water [17]. The entire body of this submersible pump is tightly sealed and does not allow water to pass through the wiring, which can cause the pump to be damaged. The device used to start this pump uses a float switch [18]. A floating switch is the simplest automatic system. It operates or moves the system according to the liquid level. The floating switch can only send signals at two levels, namely at low or high levels, to turn on or off some processes, such as a submersible pump. Figure 4 also shows where the iron ball no longer presses the switch handle and puts the switch in the "ON" state, i.e., in the closed contact position (normally close). At this time, the supply passes through the switch to reach the load, causing the load to operate. It usually happens when the liquid is at a high level.

Figure 4: Float Switch In On Condition [19]

Figure 5 shows the inside of the float switch in the "OFF" state, i.e., in the normally open contact position. At this time, the iron ball presses the switch handle, causing the switch to open and the supply not to reach the load. It usually happens when the liquid is still at a low level.

Figure 5: Float Switch In Off Condition [19]

However, some technicians in the industry modify the float switch system with a switch to turn the pump on and off manually. Accordingly, there are several problems related to water level monitoring, namely:

i. Dirt Inside The Tank Overflows Out

Most septic tank users need to pay more attention to emptying the tank because it needs to be maintained at least once every two years. Failure causes dirt in the tank to overflow and pollute the environment [20]. It also occurs due to the failure of the pump system at the sewage plant, preventing the process of treating sewage waste from being completed.

ii. Float Switch Failed to Work

This float switch is very reliable in its industry application but often fails to operate. Among the failures of this float switch to operate is because it is not maintained or cleaned. Among other reasons for the failure of this float switch are:

- The wrong configuration of the float switch.
- Lack of maintenance.
- Using a float switch that is not designed for a specific purpose.
- Using a float switch that is not evaluated correctly for its application, for example, liquids with high heat.

Figure 6 shows an example of a dirty tank from chemical residues that can cause the float switch to stick to the wall surface and the submersible pump system to fail to function.

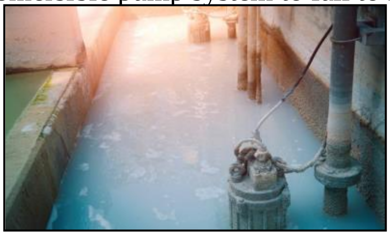


Figure 6: Chemical Waste Liquid Tank [21]

iii. Excrement overflows out of the septic tank

Among the damages that often occur are floating switch failure, damaged impellers, and pumps jammed because water has entered the pump body, causing damaged bearings and other components that result in the pump being unable to operate correctly. As a result of the interview, the respondent, an electrical technician, shared the photos he had taken while maintaining the pump and cleaning the tank. Figure 7 shows a sewage tank overflowing because the float switch failed to work due to getting stuck in a part of the iron pipe that was there. Sometimes, it got stuck in a cable or chain.

Figure 7: Condition of Overflowing Sewage Tanks

Figure 8 shows the condition of the submersible pump, which needs to be maintained after the workers dig out the excrement in the tank to keep the pump.

Figure 8: Condition of Submersible Pump that Needs to be Maintained

Therefore, this study aims to develop a water level monitoring system through the Blynk application to reduce workers' stress when monitoring Waste Water Treatment sewage water levels.

2. Methodology

In the production of this project, the Design Thinking model is used as the main guideline so that the development process can be carried out properly following the five phases: empathy, definition, idea, prototype, and testing. Blynk, as shown in Figure 9, is a platform with applications on Android and IOS that can run various hardware modules such as Arduino Uno, Raspberry Pi, and more. To connect and use this application on a device such as a mobile phone, it needs to be connected using wifi. Bylnk creates many applications and can use them to control hardware that is connected to devices such as Arduino Uno and has internet access that can be controlled using a smartphone [22].

Figure 9: Blynk Application Software

Figure 10 shows a block diagram of an Automatic Water Level System for a Submersible Pump. There are three blocks, namely entry, process, and output. In this design, the researcher used two tank units measuring 20cm in height. One tank is temporary, and the other tank is a transfer tank. The ultrasonic sensor will monitor the water level in the temporary tank from a reading of 0% to 100%. When the water in the tank reaches 85%, the Ultrasonic sensor will send a signal to the Arduino Uno. Arduino Uno will read the signal, activate the relay, and indirectly send the signal to the production process, which is to turn on the submersible pump. The submersible pump will also automatically shut off when the water level drops to 5%. The Arduino Uno will send its signal to the LCD Display LCM1602ICC to monitor the water level, and the LCD Display will show the mode used, either automatically or manually. In addition, this Arduino Uno has been installed with NodeMCU ESP8266, a wifi module programmed for users to monitor the tank's water level using a smart device. Users can see and monitor the water level in the tank to ensure that the water does not exceed the dangerous level that can cause excess water and overflow using their smart device. In addition, users will also receive a notification when the water reaches a predetermined level of danger. Users need to download the Blink application software on their smart devices to monitor the water level in the tank. When the water in the tank reaches 92%, the buzzer will sound, indicating that the water in the tank has reached a dangerous level, and the sound will continue as long as the water level in the tank is not reduced. The product development design of the Automatic Water Level System for Submersible Pump prototype is also equipped with a manual mode switch. When this automatic system fails, a worker can use a manual mode to turn the submersible pump on and off.

3. Results

3.1 Empathy
Based on the interviews conducted by the researcher with three respondents, it was found that there is a problem in the water transfer system in the tank where workers need to regularly monitor the water level to ensure that the submersible pump is working correctly. Among others is the experience of colleagues in the industry who have gone through it, where the float switch failed to work, causing the liquid in the tank to overflow because the submersible pump didn't work. Researchers also found a problem in the water transfer system in the tank, where workers had to monitor the water level regularly to ensure that the submersible pump was working correctly. In addition, the float switch failed to work, causing the liquid in the tank to overflow because the submersible pump did not work.

3.2 Define
From the define phase, the researcher has an idea for developing a prototype Automatic Water Level System for Submersible Pump. In addition, the researchers also performed a cost analysis to create this product, which must be cheaper than the actual product. Therefore, all the materials, equipment, and components are affordable for the researcher to design and develop a product in the form of a prototype to solve the problem, as stated in the background of the problem.

3.3 Idea
Researchers are trying to design their circuits and coding to control the submersible pump. For the components used are: (i) Junction Box, (ii) Arduino Uno, (iii) NodeMCU ESP8266 (wifi Module), (iv) Ultrasonic Sensor (HC-SR04), (v) Relay Module (Single Channel), (vi) LCD Display (LCM1602ICC), (vii) Switch, (viii) Buzzer, (ix) Submersible Pump, (x) Power supply Ac to Dc (230V AC to 12V DC), (xi) Selector Switch, (xii) Push Button, (xiii) Cable Tray, and (xiv) Pilot Lamp.

3.4 Prototype
3.4.1 Hardware Development

The development of this hardware involves 14 main components: a Junction box, Arduino Uno, NodeMCU ESP8266, Ultrasonic Sensor, Relay Module, LCD Display, Switch, Buzzer, Submersible Pump, Power Supply AC-DC, Selector Switch, Push Button, PVC Cable Tray, and Pilot Lamps.

i. The junction box is where all the wiring kit accessories, such as Arduino Uno, NodeMU ESP8266, and LCD Display LCM1602ICC, are placed. It is placed at the bottom of the tank to facilitate the maintenance process. The junction box used is 6" x 8" x 4" (width x length x height). The junction box is tightly closed and does not easily enter water, such as rainwater.
ii. Arduino Uno is where all programs or coding for the operating process of the designed system operate and is the central control for a developed system. This Arduino Uno will be placed in a junction box and covered because it cannot be exposed to water.
iii. NodeMCU ESP8266 is a wifi module that allows Arduino Uno to be accessed using IoT. In developing this product, the ESP8266 is used to enable users to monitor the water level in the tank and receive warning notifications using their smart devices by connecting their wifi to the ESP8266. This component is also placed in the junction box.
iv. This ultrasonic sensor (HC-SR04) detects the tank's water level reading. It is placed in the tank to measure the water level. Next, the Relay module (single channel) is used in the development of this product to turn on the submersible pump motor and the red (pump stop) and green (pump on) pilot lamps. This relay module receives signals from the Arduino Uno to allow the current from the supply source to reach the submersible pump motor.
v. The LCD Display (LCM1602ICC) shows whether the submersible pump is on or off, in either automatic or manual mode, and the percentage of water in the tank. It is placed in front of the junction box cover.
vi. This switch turns the motor on and off, which is the primary circuit. The engine can be turned off if you want to test the water level system. So, when the system is tested, the submersible pump will not turn on. This is also a safety feature when testing the system and repairing it without involving a submersible pump. In addition, a switch is needed to turn the entire automatic water level system on and off.

vii. A buzzer to warn users or workers when the water level has exceeded the appropriate level. It is placed to alert the user to go to the location and turn on the system manually.
viii. A submersible pump is a pump that sucks water for the process of transferring water from one location to another. It has various sizes and types. In this prototype model, the pump used is only small-scale and not specified for actual use because it considers the volume of water, the size of the pipeline, and the transfer distance from the temporary tank to the transfer tank. A submersible pump will be placed in the water tank.
ix. An AC-to-DC power supply converts an alternating current supply source to a direct current. It is used to supply Arduino Uno and other hardware that requires direct current supply.
x. The selector switch is used in the Automatic Submersible Pump project, which functions as a choice of automatic or manual mode. It is placed as a safety feature if the automatic system fails to work or to facilitate the user's tank maintenance to control the submersible pump motor whether they want to turn it on (On) or off (Off). This selector switch will be placed in front of the junction box cover because that is where all the main components and controls are made and stored.
xi. A pushbutton (open state NO) is placed to turn the submersible pump motor on (On) and off (Off). The push button only works in manual mode. This pushbutton is also placed in the junction box to make it easier for the user to control it. In addition, there is a pushbutton (NO open state) placed on the side of the junction box that functions as a reset button for the entire Automatic Water Level System for the Submersible Pump.
xii. A PVC cable tray as a route for each cable to each hardware. A Cable Tray or cable path arranges each cable that passes through it and indirectly protects it from damage. The pilot lamp is an indicator light. When the submersible pump is on, the green indicator light or pilot lamp will light up; when the submersible pump is off, the red indicator light or pilot lamp will light up.

Figure 11: Overall design and development of the prototype

3.4.2 Software Development

To allow the tank's water level to be monitored remotely using a computer and a smart device such as a mobile phone, the settings on Blynk need to be done for both devices. Blynk Settings Steps on Smartphone/Mobile Phone: Table 1.

Table 1: Blynk Settings Steps On Smart Devices

No.	Steps	Description

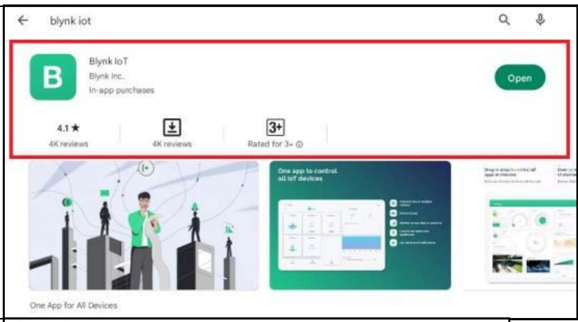
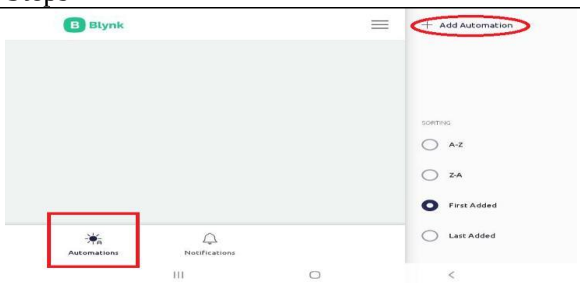
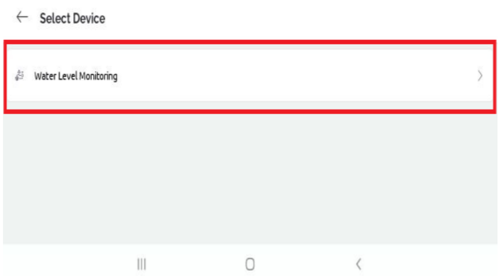
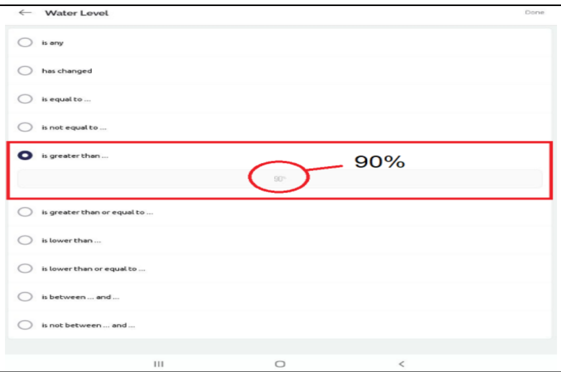
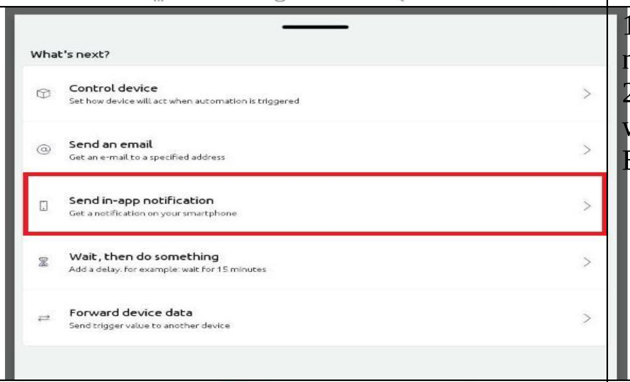
1		1. Open the Play Store app for Android or App Store users for Apple IOS users. 2. Find the Blynk IOT app and load it download the application. 3. Next, open the application.
2		1. Login using email and the same password during the create account at Blynk Cloud.
3		1. Press the circled button as in the picture and press Add New Device. 2. insert the template created while on Blynk Cloud.
4		1. After choosing a template, name it the selected template follows the suitability of the project done. 2. Press the button create.
5		1. Once done. The result display that will appear on the display on the smart device cell phone.

Table 2: Notification Settings Steps on Blynk

No.	Steps	Description
1		1. Open the Blynk IOT app on the device. 2. Select Automations as in the red box in the picture. 3. select Add Automation as in the red circle inside the picture.

2		1. On the Select Device section, select Water Level Monitoring, that is templates that have been created for remote monitoring settings.
3		1. Then, on this option, select "is greater than..." like that shown on the red square in the picture. 2. After that, set the percentage for the water level in the desired tank to be notified if it exceeds the range made, i.e., over 90%. 3. Press the Done button if done.
4		1. Press on add action and then select send in-app notification. 2. This option will send notifications to the users whose devices have downloaded the application Bylnk IoT.
5		1. After completing all settings, Automation will exit the template notifications that have been built. 2. Activate the notification by pressing the button in the red circle, as in the picture. 3. Complete notification settings.

3.4.3 Wiring And Hardware Arrangement On Junction Box

For manufacturing the circuit made on this software, a power circuit that converts 230VAC to 8VDC for the electronic components found in the system created is used. The circuit made using Proteus has been tested for success in the software to ensure it works well. The components used in the production of this circuit are i) 1 unit of transformer 230vac - 12vac, ii) 4 units of the diode, iii) 1 unit of capacitor 1000uf, iv) 1 unit of capacitor 470uf, v) 1 unit of resistor 1k ohm, vi) 2 terminal block two i/o units, vii) ic voltage regulator lm7808 with heatsink, and viii) One led unit (blue).

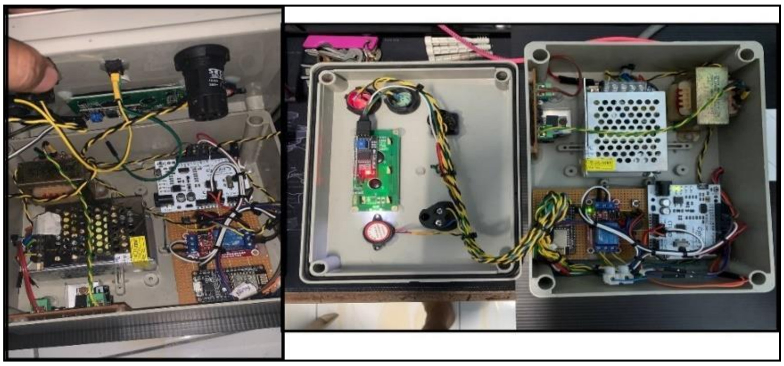


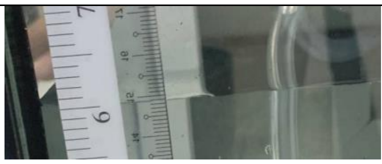
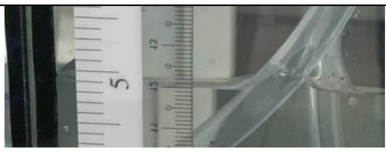
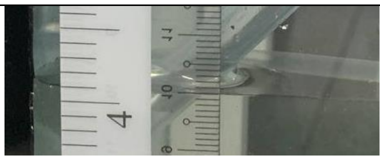
Figure 12: Wiring And Hardware Arrangement At Junction Box

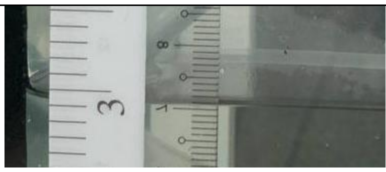
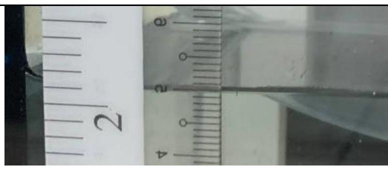
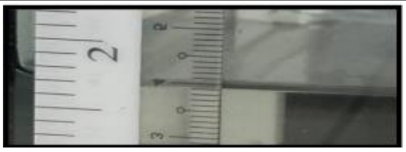
3.5 Test Phase

3.5.1 Water Level Detection Functionality

To identify the functionality of detecting the water level, the researcher measured the distance of the tank from the floor to the top, which is 20cm high. The water has been filled to a height of 16cm according to the amount set in the coding. This analysis is done by reducing the water in the tank from 100% to 0%. The analysis table of the water level in the tank can be seen in Table 3.

Table 2: Notification Settings Steps on Blynk

No.	Water Level Display Reading (%)	Tank Water Level Reading (cm)
1	 99%	 16 cm
2	 92%	 15 cm
3	 71%	 12 cm
4	 57%	 10 cm

5	 35%	 7 cm
6	 14%	 5 cm
7	 0%	 4 cm

The functionality analysis of the water level in Table 2 shows that at a percentage of 0%, there is still 4cm of water in the tank. This is done to allow the submersible pump to always be submerged in water. The coding has also specified that there is excess water in the tank for the submersible pump to remain submerged.

3.5.2 Functionality Receive Alerts And Notifications

Researchers have tested the functionality of the prototype design of the Automatic Water Level System for the Submersible Pump, which will receive warnings (alarms) and notifications on smart devices when the water level reaches the percentage set in the coding. For the analysis, the researcher put water into a 15cm high tank of 92% water. The warning (alarm) will sound at this time, and the smart device will receive a notification, as shown in Figure 13.

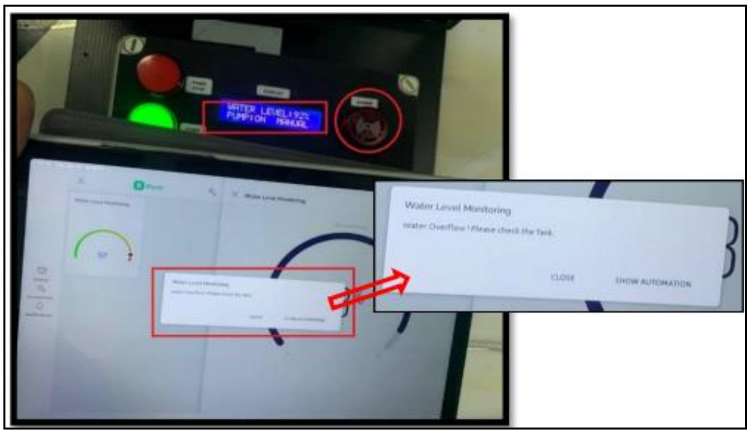


Figure 13: Warning Notification Display On Smart Devices

3.5.3 Analysis of Prototype Improvement Suggestions and Comments from experts

This research involved three experts: a lecturer in electricity and electronics from the Faculty of Technical and Vocational Education (FPTV) at Universiti Tun Hussein Onn Malaysia (UTHM), an assistant engineer in electricity and electronics at FPTV UTHM, and a planner engineer from the industry.

Table 14: Suggested Comments And Improvement Comments

No.	Experts	Suggestions And Comments
1	lecturer in the field of electricity	i. Good idea, have a combination of hardware and software.

	and electronics from the Faculty of Technical and Vocational Education (FPTV) at Universiti Tun Hussein Onn Malaysia (UTHM)	i. The prototype works as the objective of the study. iii. It is recommended to the actual application to see its effectiveness or suitability.
2	assistant engineers in the field of electricity and electronics at FPTV UTHM	i. The prototype works well. i. Replace with a more accurate sensor for reading the water level. iii. Suitable for further development.
3	planners engineer from the industry	i. A good prototype with simple functions that are easy to understand and practice in industrial operations. i. A little improvement can be done on the float switch sensor (Ultrasonic Sensor) to set the temporary tank load rate according to the operation suitability of the float switch sensor (Ultrasonic Sensor) which is easily adjustable and can make it easier for other uses.

4. Conclusions

To design a prototype Automatic Water Level System for a Submersible Pump that can turn on (ON) and turn off (OFF) the submersible pump automatically, the researcher has made a connection with the previous study, which, looking back at the type and system used on the pump before and has thought solutions to improve the existing system. There are several problems throughout the prototype design process; workers can solve them through the selected model. Among the issues found during this process, researchers find it challenging to find information on the internet regarding the issues that often occur, which are related to the problem of submersible pumps failing to work. Something that usually happens in the industry will not be brought to outside news to protect the industry's reputation. However, when the researcher conducted an unstructured interview with a worker in the field of pump maintenance, the researcher obtained information about problems that often occur in the industry, along with a picture of a sewage tank overflowing due to a submersible pump failing to work. This water level monitoring system through smart devices is familiar in the industry because, with the latest technology, users or workers can monitor the water level in their control room by looking at their computer displays. However, developing a water level monitoring system in the tank through the "blink" application on this smart device is more sophisticated. Users or workers can monitor the water level in their tank wherever they are at an unlimited distance. The NodeMCU ESP8266 is connected using Wi-Fi, and it is automatically connected to the Blynk cloud, which allows anyone who uses the "Blynk" application and has obtained access permission to monitor the water level in the tank. In addition, not only can the tank's water level be monitored through this application, but they will also receive a notification when the water in the tank has exceeded the appropriate level. The user or employee will not continuously monitor the water level in the tank, and when the water has reached the proper level due to system failure or the submersible pump fails to function, it will send a notification every second or minute according to the set time so that the user or employee is aware of the warning. This is also an initial step for users or workers to immediately act and go to the tank area to see the situation there. In conclusion, the development of a water level monitoring system in the tank through the Blynk application on a smart device to make it easier for workers to monitor the water level in the tank without having to go to the area was made the number two objective after taking into account the need because often when the submersible pump fails to work the water will overflow out (overflow) without the user or employee realizing.

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