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Human Heart Prototype by Using Node MCU for Education

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Abstract: Educators face difficulties when teaching students about theoretical subjects especially in human anatomical and physiological subjects. The same goes for students where it is hard for them to understand about anatomical and physiological of the human system. This project aims to develop a human heart prototype using node MCU for education. The function of this prototype is to show the anatomy and physiology of the heart which will be controlled by an android smartphone. The type of blood that flow will be shown by red and blue watercolour. The red watercolour is oxygenated blood and the blue watercolour is deoxygenated blood. The Blynk application will show the display to the user whether the user will choose the type of heart rate or they will view the ECG signal of themselves by attaching the electrode to the body. The connection between the Blynk application and the project is using Node MCU ESP8266 as the IoT module. The ECG wave is displayed by Arduino IDE software at serial plotter. The signal is obtained from the human body by an ECG sensor. The stepper motor will show the movement of the heart. When the heart rate is at normal condition, the prototype will move at moderate speed. As the result, the heart prototype moves correctly according to the selection of the button in the Blynk application. The movement of blood flow also can be seen clearly from the prototype. Hopefully, this project will bring benefits to people especially educators and students.

Keywords: Heart Model, Arduino, ESP8266, Internet of Things (IoT), Electrocardiogram (ECG)

1.0 INTRODUCTION

In Malaysia, the anatomy of the human heart is traditionally taught by using a 3D plastic model. Those models provide a good representation of true anatomy and also increase the likelihood of retaining knowledge. Unfortunately, most of the students easily get bored and hard to understand because they learned without looking at how it works physically. With the current developing technology, this research aims to develop a human heart prototype by implementing an IoT module that can help educators and students to ease their learning process in the classroom. This prototype has a 3D human heart model where it will display the anatomy and physiology of the human heart and function according to the heart rate which will be controlled by Blynk applications. The blood flow is also shown in the prototype where it will be represented by the water. The main software in this project is Arduino IDE, and Proteus ISIS 7. The ECG wave will be displayed at the serial plotter of the Arduino IDE.

Since Biology is a theory subject, the educators faced difficulties teaching the student about heart anatomy (H. Gulnaz et. all, 2018). Previous research by T. Slominski in 2019 found students' interest was gone while studying the anatomy of the heart. It is because it was tiring to grasp and memorised it. D. Brock was developing the heart's model in 2009 yet it does not show the actual image of the heart. Next, from S. Anjur (2015), the model development was inappropriate caused the LED use was not tally with the heartbeat.

Nowadays, most students prefer to learn through experience where they can feel and touch the prototype. It can help them understand and memorize the anatomical parts rather than reading books and slides. Hence, this study to acquire knowledge of human heart anatomy to become fun because they can experience it while learning. This project proposed to develop a human heart prototype using Node MCU for education and to show how it works. Besides, it can display heart physiology such as circulatory system and ECG waves. Lastly, it is for assisting the student to gain a greater understanding of the human heart. The significance of this project is to enhance the teaching techniques of educators on the difficulties of human heart anatomy physiology. Besides, the students can easily understand and memorize the anatomical and physiological of the human heart because they learn through experience. Hence, experienced is the best teacher in the world.

2.0 MATERIALS AND METHODS

2.1 Block Diagram

Figure 1 shows the block diagram of the human heart prototype using Node MCU. This represented system gives a clear understanding of how this system works.

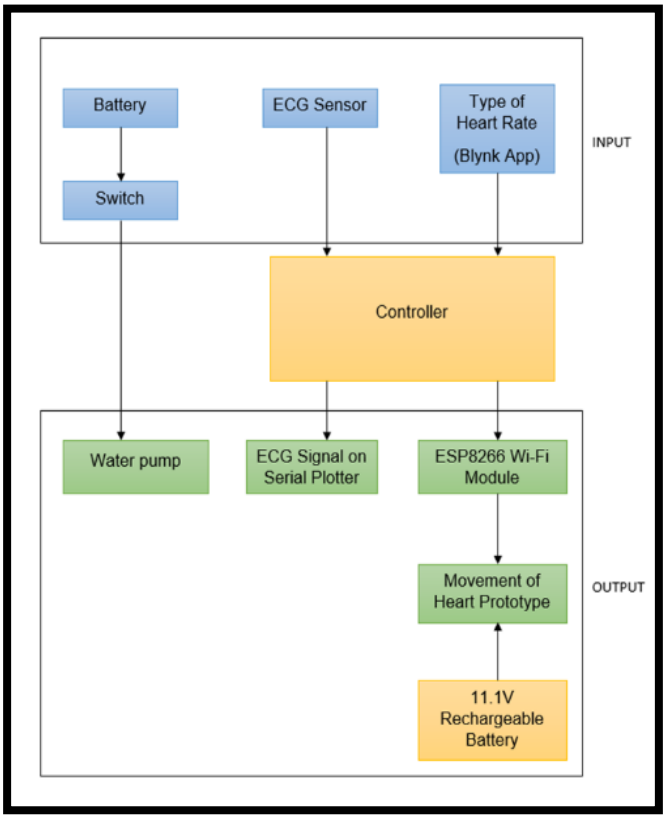


Figure 1: Block diagram of Human Heart Prototype using Node MCU

A flowchart of the system was created to obtain the main procedure of the system. The system will not face any difficulties in the future.

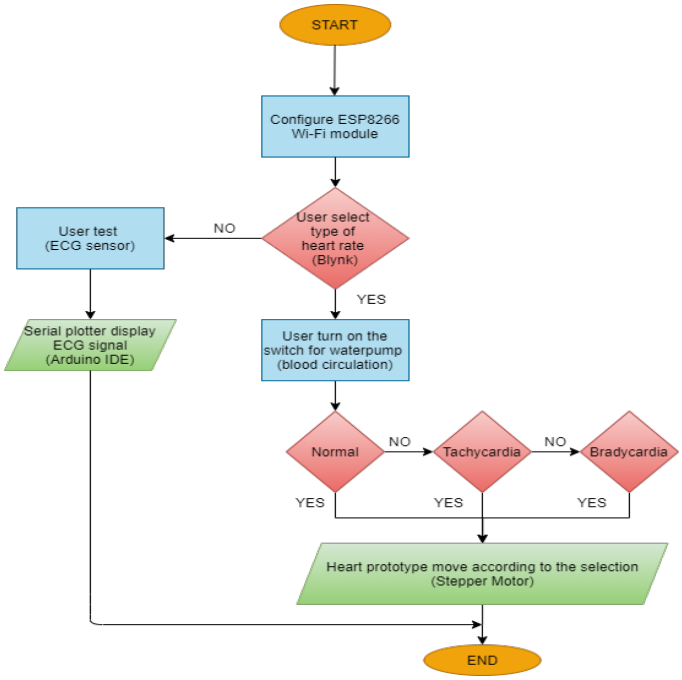


Figure 2: Flowchart of Human Heart Prototype using Node MCU

In this project, the main hardware use is the stepper motor, motor driver, Node MCU ESP8266, ECG sensor, water pump and Arduino Uno. The heart prototype movement will be controlled by the Blynk software. The blood circulatory systems will be controlled by a water pump. The ECG signal is obtained from ECG Sensor that is attached to the subject body. The Arduino IDE software is used to write codes for the project. The proteus software is used to simulate the circuit before compiling the hardware.

3.0 RESULTS

Based on the questionnaire and the survey that has been conducted, the prototype has been developed according to their understanding and lacking about the knowledge in the human heart.

Figure 3: Complete Project Prototype

3.1 Questionnaire in Checking the Students' Understanding Human Heart Anatomy & Physiology

The questionnaire was distributed to secondary school students who took Biology subjects and Bachelor of Electronic Engineering Technology (Medical Electronics) UniKL BMI students. There are 81 respondents to this questionnaire. The questionnaire was conducted using the Survey Monkey platform. While developing the project, several questions were created to check the students' understanding of the human heart and circulatory system. From the questionnaire, the highest score was 97% on question 7. However, only 30% of the respondents answer correctly at question 2 which is "Blood enters into the heart because of muscles of ____". The correct answer is atria relax. From the questionnaire, the prototype can be designed based on the students understanding. The lowest score of the question can be taken as a reference to develop the prototype.

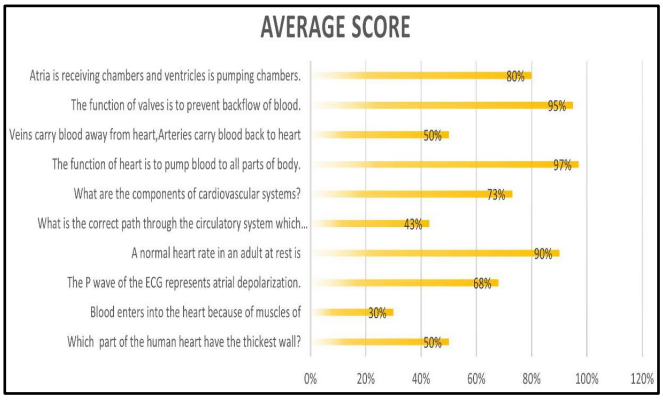


Figure 4: Average Score for Questionnaire

Figure 5 shows the development of the human heart model. The materials used in the making of the model are polystyrene, tissue, PVC, glue and watercolour. First, the polystyrene is carved according to the shape of the heart. As shown in Figure 5a, the model has covered with tissue by using PVC glue. This tissue is to make the surface of the polystyrene easy to colour. The models coloured was using watercolour in Figure 5b. A hole that fit the size of the IV tube has been punch at the entrance and exit of the model's blood shown in Figure 5c after dry. In Figure 5d, the IV tube was inserted into the model. The tube must not fold to ensure the flow of the liquid is smooth.

The system of the project has assembled the hardware, software, and application successfully. Figure 6a shows the blood circulation of the human heart. The blue liquid tube shows the deoxygenated blood while the red liquid tube shows oxygenated blood. Figure 6b shows the complete prototype with the android smartphone to control the movement of the heart prototype.

Figure 5 : The Development of Human Heart Model

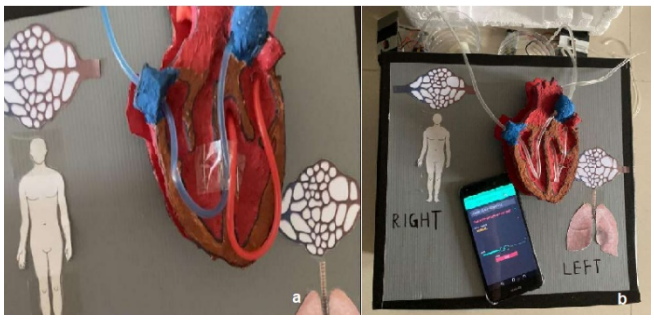


Figure 6 : Complete Project Prototype

3.3 Survey - Working Heart Prototype

Overall, from the survey shown in Figure 7, 75% are agreed the working heart prototype is suitable as a learning tool for anatomy and physiology. 20% of the respondents are neutral and 5% of respondents have disagreed.

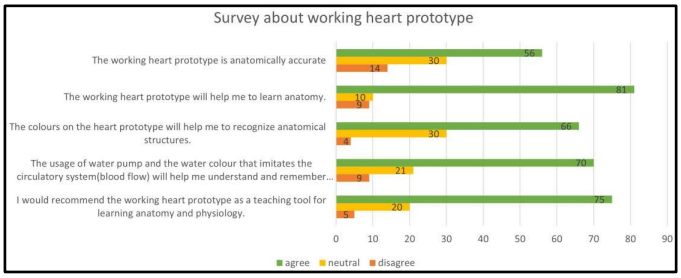
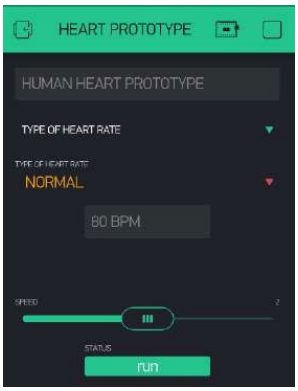
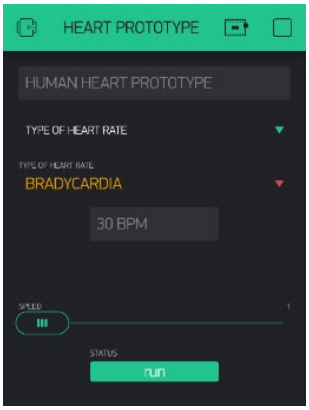
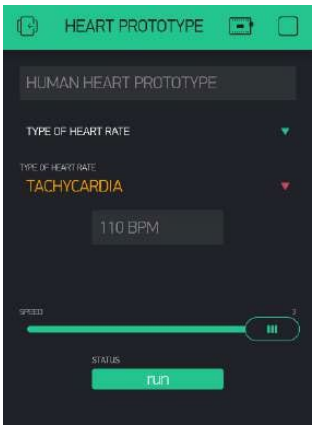


Figure 7: Survey Result

3.4 Results from Blynk Software

Table 1 shows the result of this project. When the user selects bradycardia, the prototype will move slow. It shows how 30 BPM will be moving. The time took also has been recorded. It is to differentiate the speed between different heart rates.

Table 1: Data obtained from the prototype

Type of Heart Rate	Time Taken (s)	Illustrations
Normal	30.97	
Bradycardia	37.49	
Tachycardia	22.75	

4.0 DISCUSSION

4.1 Heart Rate

Formula:

$$\frac{Time\ Taken\ to\ Complete\ 3\ ½\ Rotation}{3\frac{1}{2}\ Rotations}$$

Table 1 shown the time taken for the stepper motor to complete 3 ½ rotations. Each speed has different times taken to complete their one rotation as shown in Table 2.

Table 2: Time Taken to Complete One Rotation

Type of Heart Rate	Time Taken to Complete 3 ½ Rotations	Calculation	Time Taken to Complete 1 Rotation
Normal	30.97s	30.97/ 3.5	8.85s
Bradycardia	37.49s	37.49/ 3.5	10.71s
Tachycardia	22.75s	22.75/ 3.5	6.5s

From the calculation, each speed has a different time taken to complete one rotation. Tachycardia which means fast heart rate has the lesser time taken compared to Bradycardia which means slow heart. From this hypothesis, students can understand the heart is pumping when the heart is not under normal conditions. The students can relate the time it takes to rotate and the beats per minute.

4.2 Subject Testing

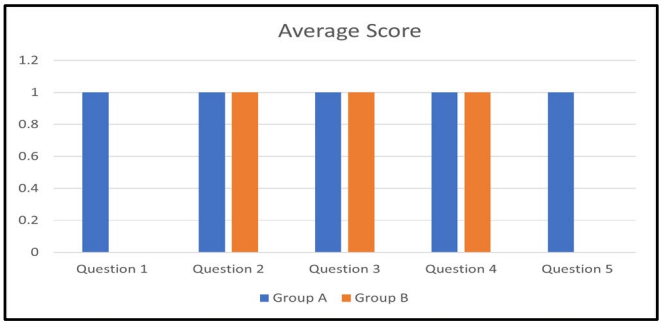


Figure 8: Average Score for Both Group

There are four subjects with the same background where they took Biology subject during secondary school. These subjects were divided into two groups. The heart's model is given to Group A before they answered the questions. They answered all the questions correctly. Besides, they can respond within 6 minutes 11 seconds. However, for Group B, both of them got the wrong answer at questions 1 and 5. Question 1 ask them about part of the heart. The correct answer is Right Atrium. Both of them answer the atrium. For

Question 5, the correct answer is Left Ventricle. One of them answers Right Atrium while the other subject answer Right Ventricle. From the observation, the student that uses the working heart prototype (Group A) score 40% more compared to the students that only learn through slides and videos.

4.3 ECG Signal Results & Discussion

In this section, the ECG signal was obtained from the four subjects. Subject A and B are male while Subject C and D are female. Based on the graph, subject A has lesser noise in the ECG signal compared to others. The time interval was measured in milliseconds. However, the R-R interval does not accurate because the serial plotter does not have small boxes to calculate since 1 square = 0.1mV/0.04 sec. From the signal, the estimated R-R interval is between 0.6s to 1.2s. For normal conditions, R-R intervals are between 0.6s to 1.2s. Subject A is highly active in sports. Subject A has a normal heart rate.

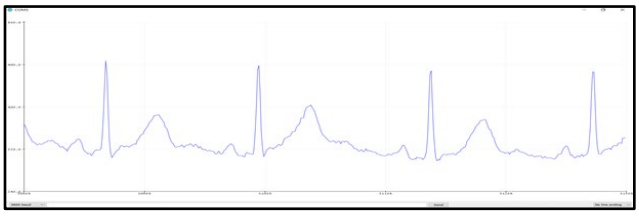


Figure 9: ECG Signal from Subject A

For subject B, only the R-R interval can be shown clearly in the serial plotter. The signal has a lot of noise. From the signal, the estimated R-R interval is between the normal ranges. The subject is active in doing physical activities. From that, subject B has a normal heart rate. Overall, the students can understand how the ECG signal from the human heart looks like.

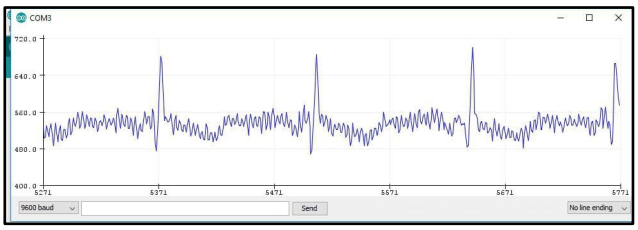


Figure 10: ECG Signal from Subject B

Table 3: Abnormalities of ECG pattern

Type of Heart Rate	Characteristics
Bradycardia	R-R interval > 1.2s
Tachycardia	R-R interval < 0.6s

All subjects have shown the normal ECG wave pattern. Table 3 shows the abnormalities of ECG patterns based on heart rate types.

This prototype has been developed according to the limitation addressed in the literature review where it is not moving and does not use a microcontroller. Apart from that, the questionnaire has been developed to study the understanding of the student's knowledge in the human heart. Most of them didn't score in the circulatory system questions together with the position of part of the heart whether it is left or right. That is why the prototype has been labelled with left and right. Therefore they will easily understand and memorise. Apart from that, a survey has been conducted to ask their opinion about the motion of the heart prototype. The moving of the heart prototype is well when the user can observe the prototype motion and the blood move into and outside from a heart.

The time taken for the prototype according to three different speeds has been taken for testing and results. Tachycardia took the shortest time to rotate while bradycardia took the longest time. This hypothesis can make the user understand more about how the heart will pump if they have the heart abnormalities like tachycardia and bradycardia. Moreover, two groups of students were formed for testing the functionality of the project. Group A are the one who studies using the prototype and Group B are the one who studies using physical notes and videos. Due to Recovery Movement Control Order (RMCO), only four students were tested since they live outside UniKL BMI.

Group A score 100% while Group B score 60%. From the results and observation, the students were confused with the position of the heart's anatomy whether it is left or right. That is why labelling is important to ensure that the user will understand and is easy to memorise.
Lastly, for the ECG sensor testing, the testing was taken at different times and places. This test was done by viewing the ECG signal at the hospital. However, it is not as accurate as an ECG machine at a hospital therefore it is not suitable for medical diagnose [35]. Subject A has lesser noise because before attaching the electrode, the subject was wiped with an alcohol swab. This is due to removing the skin impurities such as dead skin cells and also oil at the surface of the skin [36]. By doing that, the ECG signal noise can be reduced, and the electrode can stick at the skin better. For subject D, the signal has a lot of noise and the R-wave is also inverted. Even using a different sensor, the results is still the same. From the observation, the electrode has broken because it was used so many times.

5.0 CONCLUSION

The first objective stated the development of a human heart motion prototype using Node MCU for education. This project will help educators and students in the anatomy and physiology of human heart classes. Moreover, this project

may display the heart rate and the electrocardiogram waves. By displaying the heart rate, the students precisely understood how the heartbeat of a normal adult, Bradycardia, and Tachycardia types. They also can observe the ECG signal from their body. From these results, the students easy to understand, memorize the process and know how to explain to their teachers. Lastly, this can help the student to gain a greater understanding of the human heart. Students can apply their knowledge because they already have experience in the class. By using the project, 100% of the subjects understand and memorize more about the heart function. The use of the prototype was tested by Group A. They fully understand and even score 100% for the questions that were tested for them. The subject is not tested immediately after the project testing. It proves that they remember and memorize the human hearts. The results have been discussed and shown clearly. Hopefully, this project will bring benefits to people especially for educators and students in Malaysia. Overall, all the objectives in this project have been successfully achieved.

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