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Development of Teaching Aids Model for Direct Current Motor Based on the Fleming Left Hand Rule

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Abstract: The purpose of this study to development a Teaching Aids Model for Direct Current Motor Based on the Fleming Left Hand Rule to assist instructors in vocational colleges and students. This model focus on topic the basic concept of direct current model construction and the concept of direct current motor movement in AC and DC Motor (DEA 1323). Objective of this study is to design, develop and test the functionality of a teaching aid model. The Engineering Design Process (EDP) development model was chosen to develop this direct current model. This direct current model can convert electrical energy into mechanical energy by having two operating operations, namely in manual mode or in IoT mode with the help of blynk application and main electronic hardware ESP 32, LCD 2004, Relay, Servo Motor S90 180 °, Mini motor and DPDT Switch. A total of three experts were involved in evaluating this model. These experts have confirmed that this direct current motor model has met the objectives and scope of the study. Therefore, this direct current motor model is suitable to be a teaching aid for DC motor subject.

Keywords: Fleming Left Hand Rule, Direct Current Motor Teaching Aids Model, IoT Mode, Manual Mode, Engineering Design Process (EDP)

1. Introduction

According to Japar, (2020) human potential can be developed more sustainably with more effective dissemination of information through systematic and dynamic management, teaching and learning that is able to develop scientific culture, trigger creative ideas, new knowledge and innovative. Based on that, technical and vocational education needs to do some proactive work in implementing teaching and learning with teaching aids based on the latest technology Torres et al., (2008).

Thus, we are aware that the development of teaching aids in teaching and learning can provide many benefits to students and teachers who present a topic clearly and effectively. According to (Abiden, 2010) creative and interesting activities will be generated through the production of teaching aids activities that have a positive impact on students that is easily understood and explained to students.

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Various reforms and ideas have been triggered so that this teaching aid can be used at the primary school level up to the highest level such as in the university. According to Abd Samad et al., (2019) teachers should provide teaching aids in teaching and learning implemented to be more effective by deepening the content to be taught by diversifying teaching methods. Therefore, the teacher is categorized as a quality and good teacher. In addition, the teacher able to know the ability of students to be accepted in teaching and learning sessions, motivate students to be diligent in learning to achieve excellence and balance based on the philosophy of national education in terms of physical, emotional, spiritual, and intellectual students.

If a model of direct current motor teaching aids based on Flemings' Left Hand Law for motor subjects can be produced, it can be used by teachers during the teaching and learning process and it can even attract students with the use of tools. More creative direct teaching and learning will run effectively and smoothly and be able to meet the learning objectives Abdul et al., (2020).

1.1 Background Problems

The invention of Flemings' Left Hand Rule by John Ambrose involves the direction of magnetic force movement (F), the direction of the magnetic field (B) and the direction of the electric current (I) flowing on the motor and electric generator in the conversion of mechanical energy into electrical energy Aidan, (2011).

Mastery and achievement in the topic of AC and DC Motor (DEA 1323) according to the results of a study conducted by study participants from Vocational College lecturers for electrical courses and the results of interviews showed students in the school are not focused during teaching and learning sessions for direct current motor involving explanations related to the theory of the production of motor motion from electrical energy. In addition, student achievement results for the current motor syllabus continue to be less encouraging in the examination. Furthermore, the study participants also showed that the students did not show interest in mastering the subject of direct current motor which involves the theory of direct current motor production which is difficult to understand and does not interest them. Therefore, an appropriate teaching aids need to be created to improve student performance in learning sessions Mohd Bakhir & Zamri, (2016).

2. Methodoolgy

Engineering Design Process (EDP) model was selected to develop the teaching aid because it is an appropriate model for product development. EDP model is a process that identifies problems and develops answers based on multiple methodical and orderly steps in a variety of ways (Winarno et al., 2020) EDP is a method that can be applied in practically any circumstance. It is also a strong and adaptable approach to problem resolution. Six tasks must be completed to construct a model from direct current motor, as shown in Figure 1. The model direct current motor developed by the four's phases below:

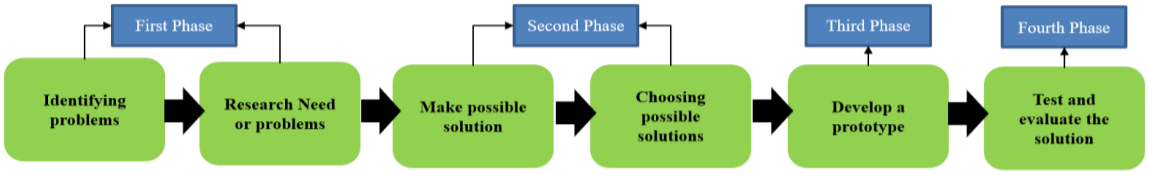


Figure1: EDP models
(Bringing Engineering Design to the Classroom (teachingchannel.com)

Phase 1: Problem identification and problem research

The phase of determining the problem and researching the problem is the initial phase of research studies conducted to identify the problems encountered and the purpose of the product to be developed. The researcher obtained the study participants to find out the problems that exist through the interviews conducted with Vocational College lecturers. In this phase, the objectives and purposes of the study are based on the problems encountered to ensure that the development process carried out continues in accordance with the objectives to be achieved.

Phase 2: Create and select possible solutions

This phase helps make possible solutions in implementing product design where information is obtained through journal reading and review of existing products. The collection of this information leads to the path of appropriate solutions and methods to be applied. There are few of possible solution:

- Model of direct current motor based on Flemings' Left Hand Rule, which is a lightweight and easy to operate design to ensure that students can imagine and relate the theory of direct current motor production based on that Law.

- Blynk application on smart phones can create new teaching aids in vocational colleges to overcome the problems that exist related to teaching aids equipment that is lacking and does not follow the latest technological developments in vocational colleges. according to study participants.

- To attract the interest and focus of students during teaching and learning sessions, teaching aids is equipped with Liquid crystal display (LCD) 2004 which can attract students to learn theories related to direct current production based on Flemings' Left Hand Rule.

Phase 3: Prototype Development

Product development is divided into two main parts namely hardware and software. So this direct current model operates in two modes, namely operating in IoT mode or operating in manual mode. At this phase involved is an overview of the prototype, product cost, operating block diagram, program flow chart and model of the actual direct current motor teaching aids.

- Prototype Overview

  The figure 2 showing the front view of the final model and the figure 2 showing the rear of model of teaching aids for direct current motor based on the Fleming left hand rule.

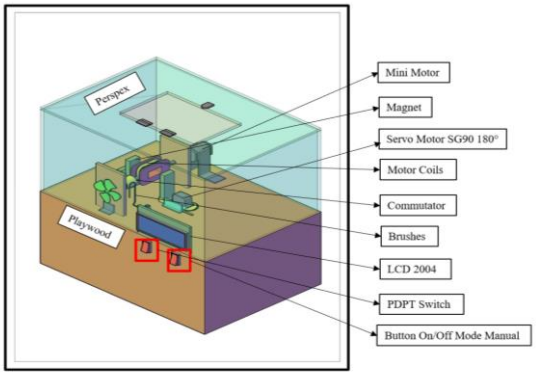


Figure 2: The front view of model

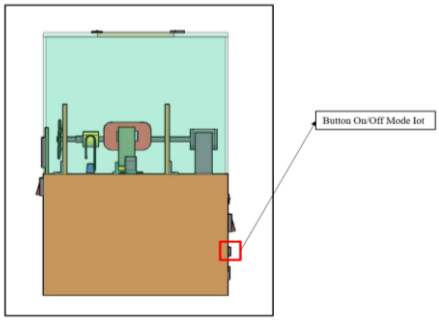


Figure 3: The rear view of model

- Product Costing

Table 1: Overall costing in the development of a direct current motor teaching aid model based on Flemings' Left Hand Rule

Bill	Components	Quantity (Pcs)	Prices (RM)	Total (RM)
1	Play wood	1	20.00	20.00
2	Perspex	5	8.80	44.00
3	ESP 32	2	35.00	70.00
4	Voltage Regulator LM2596	1	15.00	15.00
5	Relay 2 Channel	1	6.00	6.00
6	Mini Motor	1	5.00	5.00
7	Magnet	3	18.00	54.00
8	LCD 2004	1	25.00	25.00
9	Copper Wire	1	30.00	30.00
	Sub Total			269.00

- Operation Block Diagram

Model direct current motor with IoT mode operation has an input device consisting of a 12 V adapter controlled by a smart phone through the Blynk application which involves a step-down voltage regulator set to 5 V for input at the input voltage value on ESP 32. The output on this model is on the display instructions and experiments in Liquid crystal display (LCD) 2004 involving motor speed because of the production of air gap (Air Gap) and motor movement (Rotation Reversal) that is the movement of the motor counterclockwise or clockwise. For manual operation this direct current model can also exhibit all three experiments within the scope of the study with the use of using Double Pole Double Throw (DPDT) Rockers Switch 2 Ways.

Model Direct Current motor in IoT Mode Operation	Model Direct Current motor in Manual Mode Operation

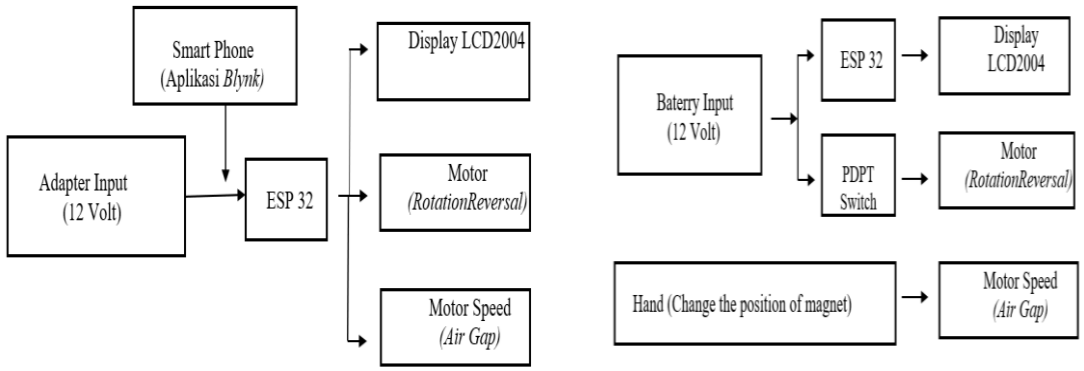
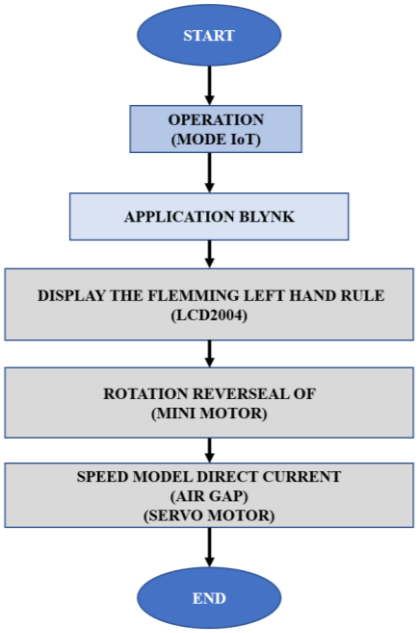


Figure 4: The operation of Model Direct Current based on Fleming Left Hand Rule

- Flow chart program (IoT Mode and Manual Mode operation)

The program flow chart of the teaching aid model direct current motor based on Flemings' Left Hand Rule has two operations namely using internet network (IoT Mode) with Arduino IDE and without internet network (Manual Mode). For operation using internet network Blynk application required in this operation with ESP 32. A 12 V adapter power supply is required in this operation to carry out the scope of this study. For operation without using the internet (Manual Mode). A 12 V battery power supply is required by using Double Pole Double Throw (DPDT) Rockers Switch 2 Ways to control the polarity of the 12 V battery in reverse and the scope of the experiment can be done in this mode as well.

Flow Chart Program (IoT Mode Operation)



Flow Chart Program (Manual Mode Operation)

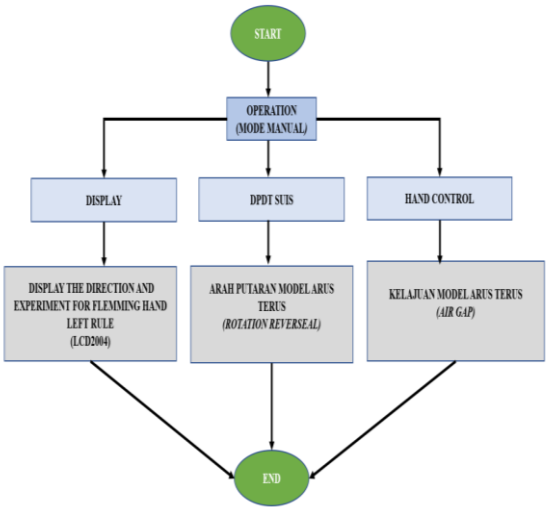


Figure 5: The flow chart operation of Model Direct Current based on Fleming Left Hand Rule

- The model of teaching aids for direct current motor based on Fleming Left Hand Rule. The Figure 6 below showing the final model of DC motor model with the operation of IoT and manual operation.

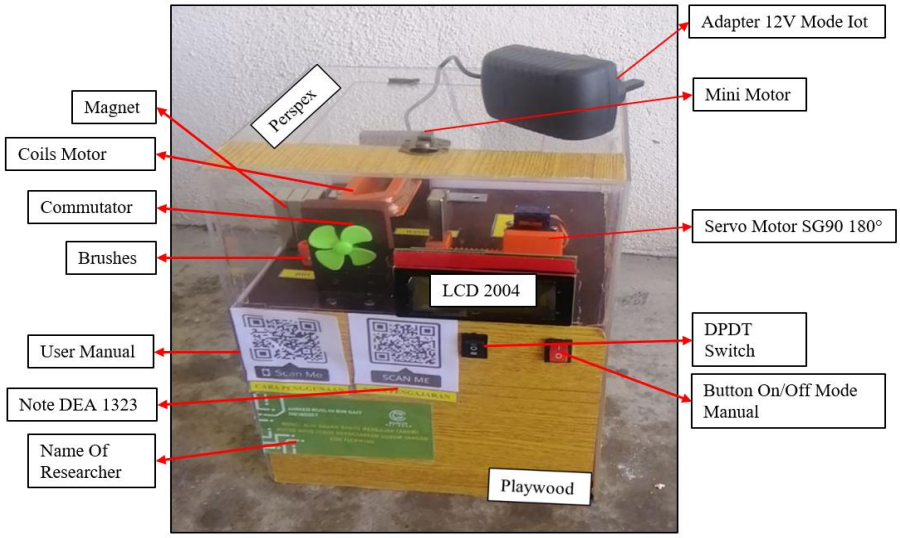


Figure 6: The final model of DC motor model of teaching aids for direct current motor based on Fleming Left Hand Rule

Phase 4: Product Testing

The testing process is a very important phase and will done after the product construction phase. This test is conducted to find out if the product can work well or otherwise. This testing involves an electronic circuit being developed in which testing the suitability of the components used in the circuit. This phases demonstrate the functionality of the product to prove three limited scope outlines. The tests that will be done are such as design testing, electrical testing, and functionality testing.

Table 2: The testing for the functionality of model direct current motor

The Product Functionality		
Bill	Testing Aspect	Result
1	Display and experiments of Fleming's Left Hand Law Theory	Function
2	Rotation Reversal	Function
3	The speed of motor (air gap)	Function

3. Result and Discussion

Engineering analysis is an important element and must be presented in writing to document a project accurately and in detail. This analysis is also conducted according to various methods and instruments appropriate to the developed product. Three analysis is conducted by the researcher namely circuit design analysis, design analysis and functionality analysis. This analysis is also a very important.

3.1 Circuit Design Testing

This model of teaching aid of a direct current motor based on Flemings' Left Hand Law has two circuits for electrical power supply, namely the 12 V Adapter power supply circuit and the 12 V battery

power supply circuit. In this analysis it tests the functionality of the circuit in terms of supply voltage and electric current from the input voltage supply to the desired operating output.

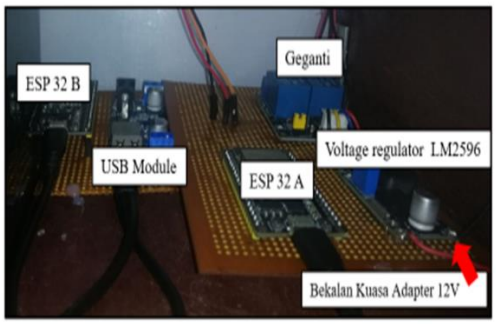
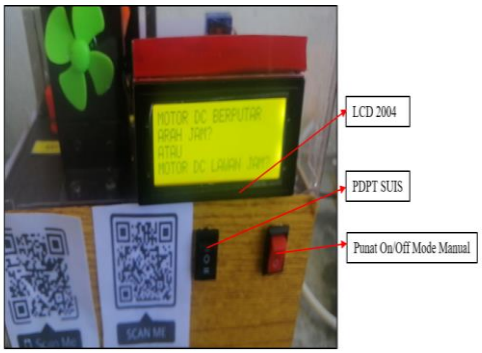
Power Supply Adapter 12 V	Power Supply with battery 12 V
	

Figure 7: The testing for the main circuit in the model direct current motor

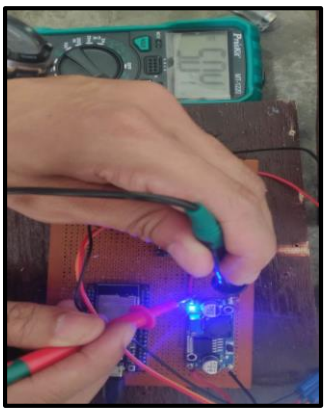
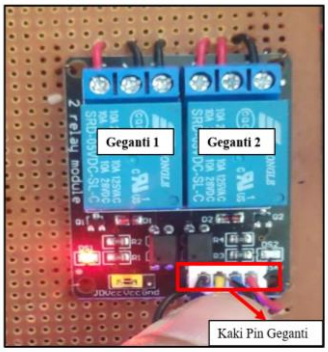
i. Design Analysis

This design analysis is made because the development of the product a begins with the main framework of the model. In this design analyzing involves mode size, model development design and material cost used in developing this direct current motor model. The size of this direct current motor teaching aid model is 22 cm x 22 cm for site space. For height and width size is 29 cm x 22 cm. Before this size was used, analysis was performed by marking, arranging and positioning the direct current model with other electronic hardware parts to fill the available space. This teaching aids model of direct current motor is tested with design durability. During the development process, the wood used is 15 mm thick play wood and has strong durability and is not easily cracked during impact. In addition, this model also uses a 5 mm thick Perspex as a direct current model protection box along with other electronic components. As a result of expert validation, the durability of the design of this teaching aide is built from durable and strong materials.

ii. Component Functionality Testing

This direct current model is developed with several major electronic components to complete the operation of this model in IoT mode or manual model. This analysis is performed to identify each electronic component used can operate properly. There are a few a main component that need to testing the functionality:

Table 3: The main Component Functionality Testing for model direct current

Component	Description
Voltage Regulator LM2596 	Analysis or testing performed on this component is to ensure that the output voltage of this module is 5 V. This voltage value is important to the next input components, namely the relay, mini motor and servo motor SG90 180 ° and LCD204. This can be done with the input voltage is 12 V from the adapter and a multimeter tester is used on the output of this module to see the output value is 5 V after the adjustable output voltage is turned to the right until the multimeter displays the output value of 5 V.
Relay two Channel 	The analysis for relay is to ensure that the relay works well when the electric current is supplied which is 5 V. The method in keeping a relay in good condition is to keep the circuit in a closed state. A voltage of 5 V is routed to the relay. Testing is performed on the first relay by connecting the circuit from the negative source of the terminal to the yellow signal wire. The red light on the first relay will illuminate, indicating that the first relay is working properly. The same goes for the second relay, which connects the circuit from the negative source of the terminal to the blue signal wire. The red light on the second relay will illuminate.
Ardurnio IDE ESP 32 	The analysis for ESP32 is to make observations that is from the upload of programming made into ESP 32 and look at the functionality that has been designed. Examples such as looking at programming that has been designed to work with the operations desired by the researcher. In the researcher's study, the ESP 32 was able to control the movement of the SG90 180 ° mini motor and servo motor. With the help of the Blynk application. Additionally, the second ESP 32 can display commands on the LCD2004.

- Evaluation of product by the expert review analysis

The evaluation of this product was performed by three experts who has confirmed the functionality of the Teaching Aids model of Direct Current Motor based on Flemings' Left Hand Rule. In the review section, all the experts involved agreed on the functionality of this direct current motor model and have met the objectives. Expert suggested that the casing of this model can be improved, and the expert also suggested that the addition of instruments to measure current and voltage to make comparisons between theory and experiment.

Table 4: The evaluation of product from the expert reviews

Bill	Expert Details	Reviews and Suggestions
1	Expert 1 Vocational College Teacher (teaching crusade DEA 1323 direct current motor and alternating current motor).	Good project layout and there are some improvements such as: 1. The speed of the motor is reduced so that the student can see well. 2. Place the footnote sticker related to Fleming's Left Hand Rule.
2	Expert 2 (Faculty Lecturer of Universiti Tun Hussein Onn Malaysia (UTHM))	1. Product packaging needs to be improved (casing). 2. Product can be supplemented with devices that can measure current and voltage to make comparison between theory and experiment.
3	Expert 3 (Faculty Lecturer of Universiti Tun Hussein Onn Malaysia (UTHM))	1. The ABBM produced meets the objectives of the study and can be commercialized.

3.2 Discussion

The production of a Teaching Aids Model requires systematic and careful planning so that the development process of this Teaching Aids Model can be implemented smoothly and well. Discussion based on the objectives of the project developed, namely:

i. Design a direct current motor teaching aid based on Flemings' Left Hand Rule.

Some constraints exist for the direct current model does not rotate well and smoothly. Therefore, the researcher has made an analysis by replacing the direct current model commutator from aluminum sheet to copper sheet because the electrical conduction on copper is higher (Dwigista et al., 2022) and facilitates the movement of direct current model and magnets into this direct current model to facilitate the rotation of this direct current model. At the end of this direct current model design, the researcher has achieved the first objective with all experts agreed in part B of the expert confirmation form related to this direct current model design.

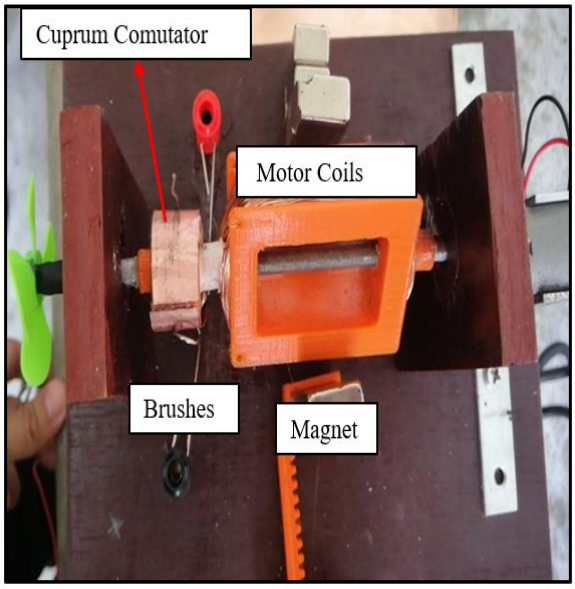


Figure 8: The final design of model direct current with the cuprum commutator

ii. Development of a teaching aids direct current motor based on Flemings' Left Hand Rule

The development of this direct current model involves the development of hardware and the development of electrical and electronic power supply circuits. According to the program flow chart. There are two operations, namely operating without internet network (manual mode) and operating with internet (IoT mode). Both operations could include three experiments within the scope of the study already stated. Hardware development has been completed on the final design of this direct current model which involves activities such as play wood cutting, Perspex assembly, direct current model coil installation and others. Developed a teaching aids direct current motor in electrical and electronic power circuit which involves the programming of Arduino IDE which needs to be uploaded into ESP 32. There are two circuits in this direct current model namely 12V Battery Power Circuit and 12V Adapter Power Circuit. During the development of this direct current model, there was a problem that the 2004 LCD did not work properly or could not display words on the LCD. This is due to the unbalanced voltage distribution, so the researcher has decided to supply a 12V battery power circuit to the LCD2004 in manual model operation. Overall, a direct current model based on a pre-planned sketch was successfully developed and met the second objective.

Figure 9: The model direct current motor based on Fleming Left Hand Rule

iii. Functionality test of teaching aids of direct current motors based on Flemings' Left Hand Rule.

In the testing or analysis phase this is particularly important in the functionality of the developed direct current motor model. This objective can be achieved through the fourth phase EDP model which is the product testing phase. Referring to analysis of functionality (technical) which includes three aspects in the development of this direct current model which is the testing of each electronic component used in this direct current model. Next is the complete circuit analysis of the direct current motor model with two operating conditions namely manual mode and IoT mode. Finally, an analysis of the functionality of the direct current model with the scope of the study to be achieved by the researcher. Next, upon completion of the analysis session conducted by the researcher. This Teaching Aids Model of Direct Current Motor Based on Flemings' Left Hand Rule will be evaluated by three experts to confirm the functionality of this model. With this, the third objective was successfully achieved through the results of expert verification on Testing and Evaluation of Product. The figure below showed the result of the scope study that achieved by the model direct current based on the Fleming left and rule.

Figure 10: The Fleming Left Hand Rule was proved by the experiment follows by the instruction of the LCD2004

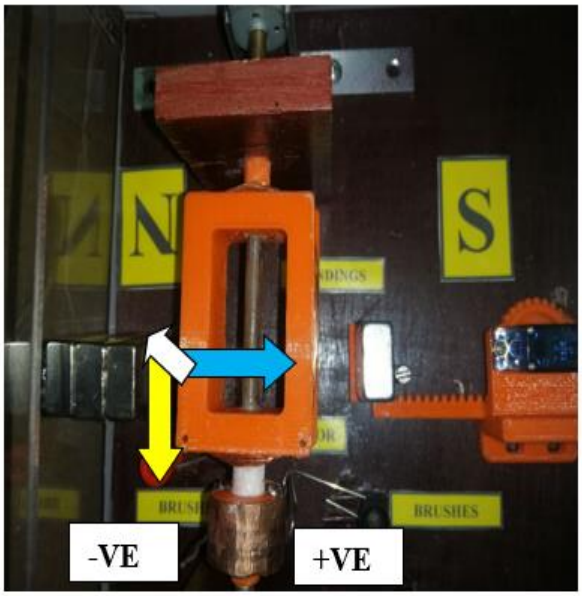


Figure 11: The Rotation reversal proved by the change of the polarity power supply battery

Figure 12: The speed of the motor proved by the tachometer result when the air gap effect by the magnet position

4. Conclusion

The objectives of the model of DC motor based on Fleming Left Hand Rule Model of Teaching Aid study that have been successfully achieved after the process of designing, developing and analyzing the functionality Model of Teaching Aids Direct Current Motor Based on Flemings' Left Hand Rule. The purpose of this product development is to help and facilitate teaching and learning sessions of lecturers in vocational colleges who teach Direct Current Motor and Alternating Motor (DEA 1323) with the lecturers. Finally, the Direct Current Motor Teaching Aids Model Based on Flemings' Left Hand Law has achieved its objective. It is linked to the results of the analysis of the study in achieving the purpose of the development of this direct current model. It is hoped that this study can be extended in the future by other researchers.

Acknowledgement

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