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Looping Board: Development of an Electronic Educational Quiz Board That Test Student Knowledge on Laplace Transform for Electrical Circuit Modelling

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Abstract — *The application of electronics and internet technology in the current education system is increased tremendously to enhance the students learning activities. One example is an electronic educational kit or simulator which adopted in the classroom to supplement the formal teaching and learning methodology. The educational kit offers attractive and fun learning experiences that possibly enhance the student's interest and knowledge as compared to ineffective and boring traditional lectures. The objective of this works is to design and develop a prototype of an educational quiz board (named Looping Board) that is automatic, cost-effective, portable, and interactive. This prototype comprises of quiz assessment module that is used to evaluate the students' knowledge of translating the transfer function of an electrical circuit to its equivalent electrical circuit. Looping Board is developed using Arduino Mega 2560 as the microcontroller, resistors, and female header pin as the inputs, LEDs as the output, and Bluetooth HC-05 module used as a communication device to connect between Arduino and the smartphone. MIT apps inventor is applied to develop smartphone application which consisting of questions and answers of Laplace Transform. To measure and evaluate the effectiveness of the prototype, a survey has been carried out among 50 respondents at the Faculty of Electrical & Electronics Engineering Technology in Universiti Teknikal Malaysia Melaka. Based on the result, more than 60% of students have agreed the Looping Board is useful in enhancing student's interest and knowledge.*

Keywords — *educational kit; educational quiz board; quiz board; control system; Laplace transform; teaching and learning; assessment*

I. INTRODUCTION

Laplace transform generally is one of the topics covered in the Advanced Electronic Circuit and Control System subjects. Mathematically, the Laplace transform is an integral transformation of a function $f(t)$ converted from the time domain into the complex frequency domain, $F(s)$. The Laplace transform has many applications in science and engineering, especially in electrical circuit analysis, where Laplace techniques were converting circuits with voltage and current signals that change with time to the s-domain. Therefore, the student can analyze the electrical circuit's behavior just using algebraic techniques.

Most of the assessments done to evaluate student understanding of translating electrical circuits to their equivalent transfer function are paper-based exercises. This medium is deemed interactive and does not provide feedback on the essential feedback to the teaching personal. Therefore, introducing an educational quiz board as a supplement to formal classroom education has many advantages. Besides attracting the student interest due to its interactive nature, the educational kits can also provide feedback on the student's level of understanding of the subject matter. The educational kit's success use, especially the educational quiz board, has been recorded in several kinds of literature [1-14]. Besides Laplace Transform, the educational quiz board has been developed for other sub-topics in electrical and electronics subjects such as mnemonic codes in the programmable logic controller (PLC) [2], second-order transient response in Control System [5], flowchart command in C programming [6], mathematical transformation [7] and logic gate combinational circuit in digital electronics [14]. R.F. Mustapa [1] has embedded the CDIO framework element into undergraduate final year project to help the student understanding, visualize, and relate real application with theoretical concepts. Arduino microcontroller is selected to use in developing the educational quiz board due to it is an open-source electronics platform based on easy to use hardware and software [1– 14]. Meanwhile, [3], [4], [9], and [10] have developed the educational quiz board interactively using the Arduino microcontroller communicated together with smartphone apps which are created using MIT Apps inventor. Another example of educational kits related to Laplace Transform is developed by M.S. Karis et al. [15], where this kit will help the students obtain the transfer function of the system from the circuit using a tactile-based educational kit named Laplace Circuit Solver.

This work proposes developing an educational quiz board to evaluate the student knowledge on the Laplace transform topic covered in Advance Electronic Circuit and Control System subjects. This work aims to build a cost-effective (which is defined as less than USD100), portable (a product that can carry a single hand effortlessly), interactive (provide instant feedback to the user and teaching personal), and user-friendly (defined as require no supervision or assistance during user operating the product).

This project has its limitation. The first limitation comes from the educational kit itself. Looping Board is only a proof of concept built to test the concept of having an automatic quiz board to test student knowledge on a specific topic in the Control System. The word specific earlier suggests that the quiz board only covers converting the transfer function to electrical circuit equivalent, which is a single topic in Control System. The number of questions is only limited to 11 questions. This is seen as adequate to show the concept rather than to prove the effectiveness of the product.

The second limitation comes from the methodology employed to measure the respondents' feedback, rather than employing a complex quantitative methodology in designing the survey questions and analyzing the data obtained. This study keeps the question simple and focuses on the product's functionality rather than its effectiveness in improving students' marks.

II. METHODOLOGY

This looping board's development can be divided into two main parts, namely hardware and software. As depicted in the system block diagram in Fig. 1, the hardware development is categorized by three main parts: inputs, the microcontroller, and the outputs. The input components being used were resistors and female headers, where resistors are applied as input for the student to construct the circuit according to a given question. Those resistors will be constructed using the female header. Each of female header contains the different value of resistors such as 1kΩ, 2kΩ, 3kΩ, 4.7kΩ, and 6.8kΩ. This different value corresponds to the electrical circuit's different components (such as a resistor, capacitor, and inductor). Meanwhile, the two pairs of red and green LEDs are used as the outputs of the board. These LEDs were purposely used as an indicator of the answer to the question, either correct or wrong.

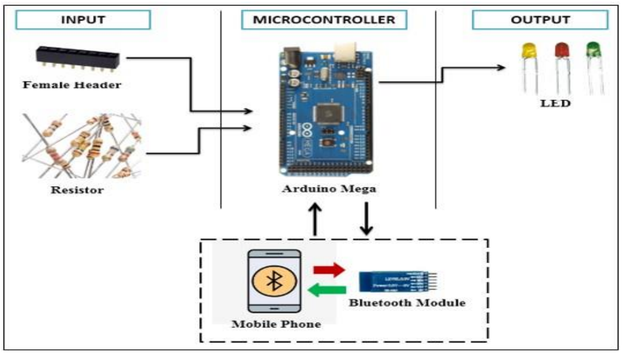


Fig. 1. Block Diagram of the project

Green LED represents the correct answer, while the red LED showing the wrong answer. The smartphone has been introduced to make this board more interactive. The communication between the quiz boards with the smartphone is using Bluetooth communication. The smartphone will display the questions and solutions through a custom application developed using MIT Apps Inventor. Arduino Mega 2560 used as a microcontroller responsible for controlling and processing all information from the input, output, and communication with the smartphone app. Fig. 2 shows the actual prototype of the Looping Board.

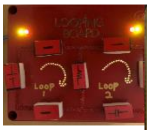
Fig. 2. Looping actual board prototype

For the software development section, Arduino Integrated Development Environment (IDE) was used to program Arduino Mega 2560 microcontroller, and MIT Apps Inventor used to program the mobile phone custom application. In this project, MIT apps inventor is used to create questions and answers for the looping board in the form of a graphical user interface (GUI) which later can be displayed on the smartphone. The proof of concept development cost is around USD35, while the proof of concept's weight is slightly above 700 grams with the size of 30cm X 22cm X 15cm. Thus, fit the objective of the project to have a low-cost and portable educational kit.

III. RESULT AND DISCUSSION

Table 1 shows the possible scenarios of a general flow of users using the product. The table shows the project prototype responds to MIT Apps and LED indicators for correct or wrong answers. MIT Apps will display the final total mark at the end of the questions. Thus, from the scenario, it can be seen that the proof of concept is interactive and require no supervision.

TABLE 1
LOOPING BOARD PROJECT FLOW SCENARIOS, PROTOTYPE AND MIT DISPLAY

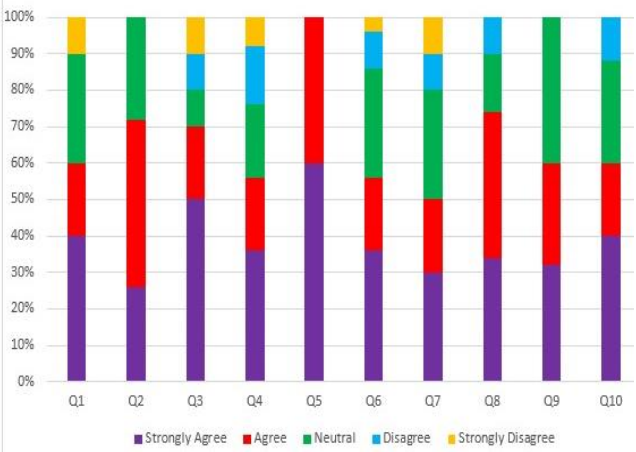
No	Scenario	Project Prototype	MIT Display
1.	When the power supply is connected to the board, a student needs to connect with Bluetooth from the handphone to access the Looping Board as the main screen will display the Bluetooth button.		
2.	After clicking the Bluetooth, there will be a list of other's Bluetooth will show up. The student needs to click at 98:D3:36:F5:9E:47 HC05 to connect with the application. If successful, it will show "You are connected," and otherwise, the screen will show "Blank screen."		
3.	After successfully connected, then click the "Next question" button, and the first question will be showing up, which is the "Construct circuit with the following equation." 11 questions have appeared on the screen that needs to be answered from easy to hard questions level. The student is required to construct the circuit on the educational kit physically.		
4.	After the circuit is constructed on an educational kit, the student needs to click "Check Answer" to check the answer. If it corrects, then the application will show "Congratulation, you are correct," and the green LED will turn on. If the wrong answer, it will show "Sorry you are wrong," and the red LED will turn on.		
5.	If the wrong answer, it will show "Sorry you are wrong," and the red LED will turn on.		
6.	After you finished answering 11 questions, it will show the final mark, which is the total number of questions that you have answered correctly, and later it will be back to the main screen.		

A survey consisting of 10 questions had been conducted among 50 respondents from the Faculty of Electrical & Electronics Engineering Technology (FTKEE) in Universiti Teknikal Malaysia Melaka (UTeM) to evaluate and verify the functionalities and effectiveness of the Looping Board. The procedure of collecting the respondent opinion is as follow: 1) Demonstration of Looping Board is done for at least 10 minutes; 2) Respondent is allowed to try out the Looping Board for at least 15 minutes; 3) The respondent is required to fill up a set of questionnaires. The questionnaires consist of 10 questions. The respondent can respond to each question using a 5-level Linkert scale: 1) Strongly agreed; 2) Agreed; 3) Neutral; 4) Disagreed; 5) Strongly disagreed. These ten questions are listed in Table 2.

TABLE 2
DETAILS OF SURVEY QUESTIONS

No	Questions	Type
1	Is the control principle subject is hard to understand?	5 Likert Scale (LS)
2	Can an educational quiz board give a real answer while we do corrections?	5 LS
3	Educational quiz board saves students time?	5 LS
4	Is an educational quiz board easy to understand?	5 LS
5	How friendly user is an educational quiz board?	5 LS
6	Can the educational quiz board motivate students to study?	5 LS
7	Educational quiz board is provided a series of questions from easy level to hard level?	5 LS
8	Can students operate an educational quiz board without lecture or lab assistance?	5 LS
9	Can educational kits bring change in the classroom environment?	5 LS
10	Do you think this project can marketable in the industry?	5 LS

Fig. 3 represents the analysis data in the form of a bar chart from the survey result distributed to 50 respondents in the faculty. It can be summarized that more than 60% of the students were agreed this Looping Board could help them have a better understanding of Laplace transform topics, save student learning time, motivate the students to study, and the real answer given without any errors. Besides that, the Looping board itself is easy to operate without any supervision, cost-effective with less than USD100 spending for hardware prototyping, portable where it only weight around 700 grams, and the size: 30cm X 22cm X 15cm, and user friendly. Nevertheless, approximately 10% of the students disagree with the survey, where the majority disagreement contributed from question 4 and question 7. Possible factors are that the students who do not sufficiently understand the Laplace transform concept theoretically cannot answer the questions correctly. This is reflected in survey question 1, where 60% of the students have difficulties understanding the Laplace Transform. Furthermore, the students might be having insufficient time to test the Looping Board since only 15 minutes allocated per student make them rush to answer the 11 questions provided. Also, the lack of proper instructions on how to use the Looping Board correctly, another possible factor contributing to the students' disagreement on the survey questions 4 and 7.



Fig, 3: Survey result from 50 respondents FTKEE, UTeM

IV. CONCLUSIONS

This paper explains the development of an educational quiz board that tests student knowledge on a specific topic of Laplace Transform: transfer function conversion to electrical circuit equivalent. The construction costs are less than USD100, stating that the educational kit is low cost. The educational kit also fulfills the claimed to be portable where it only weighs around 700 grams and the size: 30cm X 22cm X 15cm. The educational kit also achieves its objective that it is interactive and requires no supervision. A survey done shows that most of the questions achieve above 60% positive feedback, proving the educational kit's potential on the field test. Further improvement is essential in making the proof-of-concept a reality product, especially in developing proper instructional design and assessment for the educational kit.

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