

Interactive Solar System Learning Media Using the Raspberry Pi 3B

Mochamad Fajar Wicaksono¹, Myrna Dwi Rahmatya², Syahrul³, Sri Nurhayati⁴

¹ Teknik Komputer, Universitas Komputer Indonesia, Jl. Dipati Ukur No.102-116, Bandung 40132, Indonesia

² Manajemen Informatika, Universitas Komputer Indonesia, Jl. Dipati Ukur No.102-116, Bandung 40132, Indonesia

^{3,4} Sistem Komputer, Universitas Komputer Indonesia, Jl. Dipati Ukur No.102-116, Bandung 40132, Indonesia

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ABSTRACT

The current learning solar system process uses solar system props. This research aimed to create an interactive solar system learning tool for elementary school students. With this tool, students can learn about the planets in the solar system in learning mode. In addition, there is a question mode to test students' knowledge abilities. This research's contribution was to provide an engaging way for sixth-grade elementary school students to learn about and recognize the planets in the solar system. The method used in this research is the experimental method. The primary part of this system is the Raspberry Pi. In this tool, there are two modes: learning mode and question mode. The learning mode involves the input button for eclipse mode and the LDR sensor as a trigger for activating the DC motor and reading solar system material using gTTS. The question mode involves a question bank on the web application, gTTS for reading questions, and speech recognition for processing answers given by students. The teacher can add, change, or delete questions and learning materials through the web application. The test on the learning tool is 100% successful. In learning mode, the device can read input from the LDR sensor and provide sound output, and in question mode, the device will ask questions, receive answers in voice form and then process the response based on program scenarios. On the other side, Based on UAT results from 20 sixth-grade elementary school student, 95.14% of student agreed that solar system learning media and quiz features make the learning process more engaging, easy to use, help students understand solar system material, and can be used as a learning tool.

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Corresponding Author:

Myrna Dwi Rahmatya, Manajemen Informatika, Universitas Komputer Indonesia, Jl. Dipati Ukur No.102-116,
Bandung 40132, Indonesia
Email: myrna@email.unikom.ac.id

1. INTRODUCTION

Learning the solar system is one of the learning themes in the 2013 curriculum for 6th-grade elementary school. The purpose of learning is for students to gather information, observe, ask questions, and have reasoning power. That way, interactive learning is needed to support this. This relates to student learning interests.

The learning process is closely related to what is called interest. The interest is divided into two parts, namely intrinsic and extrinsic interest. Extrinsic interest relates to encouragement from outside. Extrinsic interest is needed to support intrinsic interest. The important thing about this extrinsic interest is that students not only know and identify the value of an activity but also find the core of the given lesson [1]. Based on this, many learning media have been created to support this extrinsic interest, one of which can be achieved by utilizing information technology [2], [3]. Thus, this study aims to create interactive solar system learning media for elementary school students using information technology. The interactive solar system learning media makes learning more engaging and interactive. Learning tools help students achieve learning objectives: gathering information in learning mode, observing, and having reasoning power through question mode.

Research related to solar system learning media has been widely carried out. Research in 2019 created a learning tool using Kinect to introduce the solar system [4]. However, in this study, there was only a learning mode. In addition, the development costs for these media are relatively expensive because they require hardware with high computing power, such as laptops with certain VGA, and the relatively high price of the Kinect sensor.

Another study in 2019 created a solar system learning tool using augmented reality [5]. In this study, it was able to recognize the marker given. However, users have to scan markers precisely, and not all schoolchildren have smartphones.

Research in 2020 created a learning tool about the solar system using a Raspberry Pi [6]. This research has produced interactive learning tools that do not require devices with high specifications and are also easy to use. However, in this study, there was only one mode, namely the learning mode.

In general, it can be concluded that previous research has succeeded in making learning media. However, these learning media do not have question modes that students use independently to test their abilities regarding the solar system. Furthermore, the two previous studies used augmented technology. From an economic view, augmented technology development is costly. There have even been studies that mention the limitations of this technology. Its use is influenced by various factors such as age, gender, and user experience in using the technology [7], [8]. Meanwhile, from a technical point of view, there are obstacles related to the clarity of learning material caused by the limited screen size and brightness level when scanning markers [9].

This study uses Raspberry Pi 3B to process input and output. The created solar system learning media has two modes, namely learning mode and problem mode. Students can choose the mode by changing the mode provided switch. In learning mode, students can bring their hands closer to the LDR sensor on one of the planets in the props. When this happens, the Raspberry Pi will explain the planet using Google Text to Speech (gTTS). Additionally, the Raspberry Pi will activate the DC motor for the selected planet. In the learning mode, there is also the question mode. In threat mode, there is an explanation and visualization of the physical form of lunar and solar storms. Raspberry Pi will activate the servo motor with a predetermined angle so that the moon can move to the position of the moon or solar eclipse.

In question mode, the Raspberry Pi will randomize the available questions in the question bank in the web application. Questions will be delivered in voice form using gTTS. The answer that will be known is in the form of a vote. Answer voices will be processed and recognized using Speech Recognition Python. If the answer given is correct, one point will be added correctly. However, if the answer is wrong, the Raspberry Pi will repeat the question up to three times. If the student answers wrong up to three times, then zero points will be given, then the Raspberry Pi will proceed to the next question. The number of given questions in this mode is ten questions. Questions on this learning media are added, deleted, and edited by the teacher through a web application created using the PHP programming language and MySQL RDBMS.

From the explanation, it can be explained the advantages and disadvantages of learning media in this study. The advantage of this learning media is that it has two modes, namely learning and problem mode. In addition, from an economic point of view, it does not require expensive development costs and devices. The drawbacks of this study are that an internet connection must be available because it uses gTTS and speech recognition that must be done online. Despite these shortcomings, this research contributes to the world of education. The learning media is an alternative in providing an engaging way of learning for elementary school students to get to know the planets in the solar system.

2. METHODS

The system in this study was built using the experimental methodology. Several tests were carried out to put it into practice, according to the fundamental principles that guided this research to achieve the initial objectives [10]. The steps of this procedure are a review of the literature, design, simulation, implementation, and testing to ascertain the reliability of the system [11]. Fig. 1 depicts these steps.

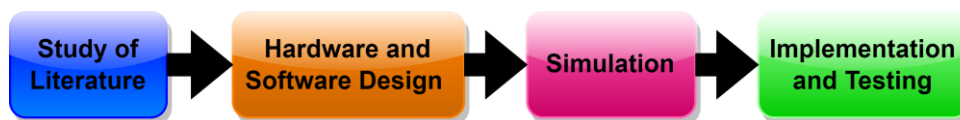


Fig. 1. The Flow of The Experimental Method of The Research

2.1. Study of Literature

At this stage, a study of theory and previous research related to solar system learning media was carried out and a study of the syllabus of solar system learning materials for sixth-grade elementary school according to the 2013 curriculum. In general, previous research requires enormous resources related to system

development and system use, and from a technical point of view, it is limited by environmental light [4], [5]. Then other research does not have a question mode that can be used to test students' abilities independently [6].

2.2. Hardware and Software Design

In this section, hardware and software design are carried out to build solar system learning media. On the software design, the algorithm program design process is carried out. Meanwhile, on the hardware design side, it includes system block diagrams and electronic circuits for this learning media. The solar system learning media block diagram is shown in Fig. 2.

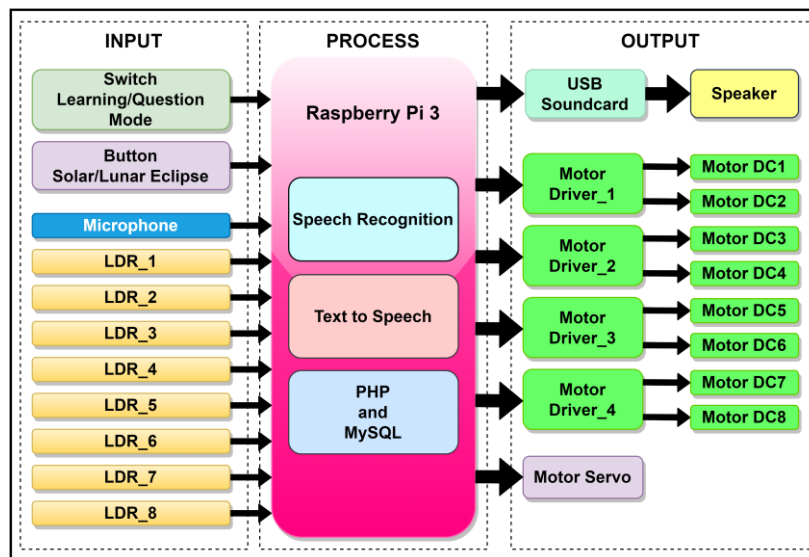


Fig. 2. Solar System Learning Block Diagram

In the block diagram, it can be seen that the primary brain of this system is the Raspberry Pi. The Raspberry Pi used in this study is the Raspberry Pi 3B. Raspberry Pi 3B is a mini-PC equipped with 40 GPIO pins, other peripheral ports such as USB ports, and audio ports used to interact with the outside world [12]–[15]. The Raspberry Pi 3B has 1GB of RAM [16]–[18]. The reason for using the Raspberry Pi is Python environment and IDE are automatically installed when the Raspbian operating system is installed on our SD Card [19], [20]. On the other hand, the Python programming language is open source and has many libraries that support system development [21], [22]. With such specifications, this device is suitable for use in this study.

On the input side, there are four main parts, namely a switch that can be used to select a study mode or question mode, a button to activate and study material related to eclipses, a microphone used to receive answers from students while the question mode is running, and 8 LDR sensors installed on the implementation on every planet in this learning media. The LDR sensor is a sensor that is sensitive to light. The output value of this sensor depends on the lighting conditions [23]–[26]. In this study, the LDR sensor module provides a digital output in the HIGH and LOW values form. Every condition of the input section will affect every running process.

The process section is divided into three main sections, namely speech recognition, text-to-speech, PHP, and MySQL. The programming language used in speech recognition and text-to-speech is Python programming language.

To explain the material and provide questions, this media uses sound output. Raspberry Pi 3B will read out the material text or questions in the database according to the current conditions. gTTS or Google Text To Speech is used to convert text into sound, which uses Deep Learning Neural Networks [27], [28]. This library can be used in Python programming language to convert text into sound [29]–[31]. In this study, gTTS used in both study mode and question mode. The voice recognition block function is a part where the Raspberry Pi will receive input in the form of voice answers from students when they are in question mode. Speech recognition is a science that can convert voice into text [32]. The library used in this study is the Google speech recognition library, which is compatible with the Python programming language [33].

Web application built using PHP programming language and MySQL RDBMS. Teachers can use this web application to create, add or change questions related to the solar system in learning media. PHP is included

in server-side scripting, where the program will be compiled on the server. In addition, PHP is easy to use because it can be directly inserted into HTML lines and be used as a backend system [34]–[36]. Questions created on the front end will be stored in the database using the MySQL command. MySQL is included in the open-source RDBMS category [37], [38].

At the output, there are several blocks, such as speakers that were previously connected to a USB Soundcard, Motor Driver, DC Motor, and Servo Motor. All output in the form of sound on this learning media will be issued via a USB Soundcard and speakers attached via the Raspberry Pi USB port.

Motor Driver and DC Motor are used to rotate each planet on the learning media. This study uses four motor driver modules that could spin 8 DC motors. The driver module used is the L298N module, where this module is a dual H-Bridge module [39], [40]. This module can also be used to adjust the direction of rotation of the motor by providing a voltage of 3.3V to 5V at the input pin [41].

The servo motor in this study is used to move the moon so that it is between the sun and the earth or is in a place after the earth. It is intended to visualize moon attacks and solar explosions. In this study, the SG90 servo motor was used. Servo motors can move as far as 180° [42], [43]. The reason for using this servo motor is that it can proceed with great precision. The servo motor was unique from other motor types in that it could rotate at the precise angles that the microcontroller unit determined from the pulse length. The servo motor is determined by a strong torque and unaffected consistent speed by changes in load [44]. After making a block diagram design for this solar system learning media, the next step is to design the electronic circuit. The circuit design is shown in Fig. 3.

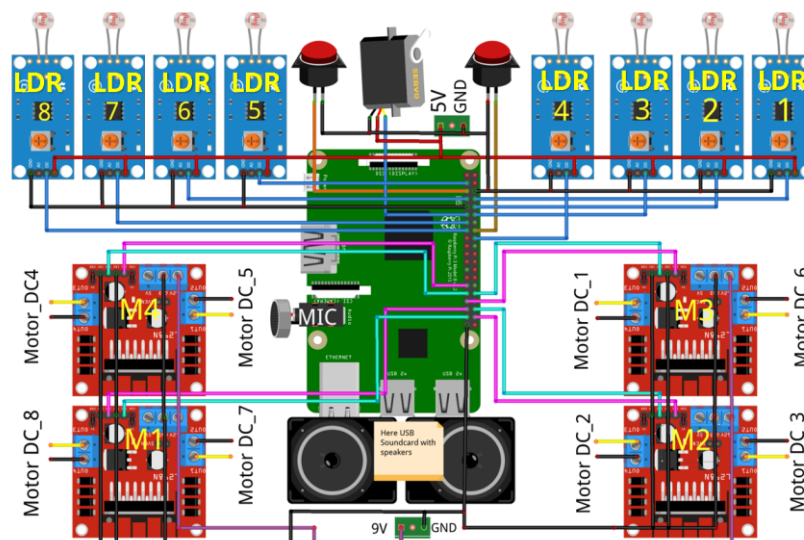


Fig. 3. Solar System Learning Media Circuit Design

From Fig. 3, it can be seen that all the input parts and output parts of this learning media. Switch modes, lunar and solar eclipse buttons, all LDR sensors, all L298N motor drivers, and servo motors use the digital I/O mode. It is given an interrupt mode on the switch mode and the eclipse button. This is intended so that learning media can immediately switch modes and execute the necessary actions. Complete information regarding the use of the GPIO in the Fig. 3 is shown in Table 1.

After completing the hardware design, the following process is to make the software design. The software is designed in a program algorithm form. The following is the design of this algorithm which is presented in the form of a text algorithm.

1. Start
2. Initialize I/O and all variables
3. Enable all DC motors (GPIO36, GPIO38, GPIO31, GPIO33, GPIO37, GPIO35 and GPIO32 are rated HIGH)
4. Play an audio short explanation of the solar system and how to use the tool using gTTS.
5. Read switch mode (GPIO16).
6. Is the learning mode selected (GPIO16 HIGH value)?
7. If yes:
 - a. Play an explanation of how to use learning mode using gTTS.
 - b. GPIO29, GPIO31, GPIO32, GPIO33, GPIO35, GPIO36, GPIO37 and GPIO38 are rated LOW.

- c. Is GPIO08 (LDR1) HIGH?
 - If yes, give a HIGH value to GPIO32 to play the DC motor displaying the planet Mercury, play an audio explanation of the planet Mercury using gTTS, and GPIO29, GPIO31, GPIO33, GPIO35, GPIO36, GPIO37, and GPIO38 are given a LOW value.
 - If not, then go to point d.
 - d. Is GPIO10 (LDR 2) HIGH?
 - If yes, give a HIGH value to GPIO36 to play the DC motor demonstrating planet Venus, play an audio explanation of planet Venus using gTTS, and GPIO29, GPIO31, GPIO32, GPIO33, GPIO35, GPIO37, and GPIO38 are given a LOW value.
 - If not, then go to point e.
 - e. Is GPIO12 (LDR 3) HIGH?
 - If yes, give a HIGH value to GPIO38 to play the DC motor demonstrating planet Earth, play audio explaining planet Earth using gTTS, and GPIO29, GPIO31, GPIO32, GPIO33, GPIO35, GPIO36, and GPIO37 are given a LOW value.
 - If not, then go to point f.
 - f. Is GPIO18 (LDR 4) HIGH?
 - If yes, then give a HIGH value to GPIO31 to play the DC motor of the planet Mars display and play the audio explanation of the planet Mars using gTTS. GPIO29, GPIO32, GPIO33, GPIO35, GPIO36, GPIO37 and GPIO38 are rated LOW.
 - If not, then continue to point g.
 - g. Is GPIO03 (LDR 5) HIGH?
 - If yes, give a HIGH value to GPIO29 to play the DC motor displaying planet Jupiter, play an audio explanation of planet Jupiter using gTTS, and GPIO31, GPIO32, GPIO33, GPIO35, GPIO36, GPIO37, and GPIO38 are given a LOW value.
 - If not, then go to point h.
 - h. Is GPIO07 (LDR 6) HIGH?
 - If yes, give a HIGH value to GPIO33 to play the DC motor of the planet Saturn display, and play the audio explanation of the planet Saturn using gTTS and GPIO29. GPIO31, GPIO32, GPIO35, GPIO36, GPIO37 and GPIO38 are rated LOW.
 - If not, then continue to point i.
 - i. Is GPIO13 (LDR 7) HIGH?
 - If yes, then give a HIGH value to GPIO37 to play the DC motor for displaying the planet Uranus, and play audio explaining the planet Uranus using gTTS and GPIO29. GPIO31, GPIO32, GPIO33, GPIO35, GPIO36 and GPIO38 are rated LOW.
 - If not, then go to point j.
 - j. Is GPIO15 (LDR 8) HIGH?
 - If yes, then give a HIGH value to GPIO35 to play the DC motor demonstrating the planet Neptune, and play audio explaining the planet Neptune using gTTS and GPIO29. GPIO31, GPIO32, GPIO33, GPIO36, GPIO37 and GPIO38 are rated LOW.
 - If not, then go to point k.
 - k. Is there any interruption from the eclipse button (GPIO15)?
 - If yes, read the keypress state
 - If the suppression state = 1, then move the servo to position 0° , play the solar eclipse audio, and increment state.
 - if the suppression state = 2, then move the servo to position 180° , play the lunar eclipse audio, and give the variable state value = 1.
 - If not continue to point l.
 - l. Is there any interruption from the switch mode (GPIO16)?
 - Is there any interruption from the switch mode (GPIO16)?
 - If it remains HIGH then return to point 7.
 - If not, then go to number 8.
8. If not:
- a. Play an explanation of how to use question mode using gTTS.
 - b. Randomize variable value for question number request.
 - c. Request questions to the server and read the questions.
 - d. Wait for an answer.
 - e. Recognizing answers using Python Speech Recognition.

- f. If the answer is wrong, then
 - Repeat this question
 - Wait for an answer
 - If the answer is correct then go to point g.
 - If the answer is wrong, then:
 - Increment question repeat variable.
 - Is the repeated variable equal to 3?
 - If so, then read the correct answer using gTTS then proceed to point h.
 - If not, then return to point f.
 - g. If the answer is correct, then:
 - Increment the correct variable.
 - h. Increment variable number of questions.
 - i. Has the number of questions reached 10?
 - If not, then return to point c.
 - If yes, then state the value of the number of correct answers using gTTS and congratulate the students.
 - j. Back to number 4.
9. End

The following process is the design of the algorithm on the web application. The following algorithm is presented in the form of a text algorithm:

1. Start
2. Is there a question request from the tool using the POST method?
3. If yes, then:
 - Take the question number variable in the request
 - Is the question number in the database?
 - If available, then:
 - Respond by giving the text of the question asked
 - Back to number 2.
 - If not, then:
 - Respond by giving a notification that there is no question with that number
 - Back to number 2.
4. If not, then return to number 2.

Table 1. GPIO pins used in solar system learning media with Board Mode

RPi GPIO	Pin Mode	I/O Direction	Component	Function
16	Board	Input	Switch	Select Learning or Quiz Mode
5	Board	Input	Push Button	Select Lunar or Solar Mode
11	Board	Output	Servo SG90	Actuator for Moon
8	Board	Input	LDR1	Select Mercury
10	Board	Input	LDR2	Select Venus
12	Board	Input	LDR3	Select Earth
18	Board	Input	LDR4	Select Mars
3	Board	Input	LDR5	Select Jupiter
7	Board	Input	LDR6	Select Saturn
13	Board	Input	LDR7	Select Uranus
13	Board	Input	LDR7	Select Neptune
35	Board	Output	Motor Driver1	Rotate Neptune model
37	Board	Output	Motor Driver1	Rotate Uranus model
36	Board	Output	Motor Driver2	Rotate Venus model
38	Board	Output	Motor Driver2	Rotate the Earth model with Motor DC
32	Board	Output	Motor Driver3	Rotate Mercury model
33	Board	Output	Motor Driver3	Rotate Saturn model
29	Board	Output	Motor Driver4	Rotate Jupiter model
31	Board	Output	Motor Driver4	Rotate Mars model

2.3. Simulation

In this section, various experiments are carried out to simulate the program that has been made. This simulation includes hardware program simulation and software program simulation for web applications. Hardware program simulation is carried out by running the Python program in the Raspbian operating system

terminal. The simulations include I/O simulations, text-to-speech simulations, speech recognition simulations, and data requests to the database. Web application simulation is carried out in a browser to simulate the appearance and process of creating, changing, and deleting questions and materials.

2.4. Implementation and testing

At this stage, hardware, Python programs, and web applications are combined to implement solar system learning media. Testing is carried out based on the test scenario and the specified objectives. The test was carried out twice. First, test the functionality of learning media. This functionality test was carried out by researchers. Second, user acceptance testing (UAT) is done to see whether the learning media created meets the user's needs. UAT was carried out by giving questionnaires to users: two science teachers and 20 sixth-grade elementary school students. Tests were carried out on the module for making materials and questions on the web application, followed by testing the selection mode, learning and questions mode, and eclipse mode that included visualization of solar eclipses and lunar eclipses.

3. RESULTS AND DISCUSSION

In the learning media that has been made, all functions can run as they should. Teachers can add material and questions to the web application, and students can study using the learning and question mode features. Meanwhile, in previous research, there could only be a question mode [4], [6]. In addition, previous research used augmented reality [4], [5] which requires additional devices such as smartphones. Meanwhile, not all students have smartphones. From a technical point of view, it is constrained by the size of the screen and the brightness of the light that affects the delivery of the material [9] and the difficulty when changing the material because it depends on the marker that has been determined.

Each function in the learning media can run as it should. It is based on the results of tests carried out on the web application testing, the selection of learning modes and questions testing, the solar eclipse and lunar eclipse modes testing, and the process in the learning and question mode testing. The first test is testing the web application. The web application must be able to store materials and questions created by the teacher.

Fig. 4 shows the teacher's page. There is a drop-down menu containing material menus, quizzes, and FAQs on the left side of the page. On the material menu, the teacher can view material stored in the system shown in Fig. 4. In the material table, the teacher can edit or delete material data. The results of the test are shown in Fig. 4.

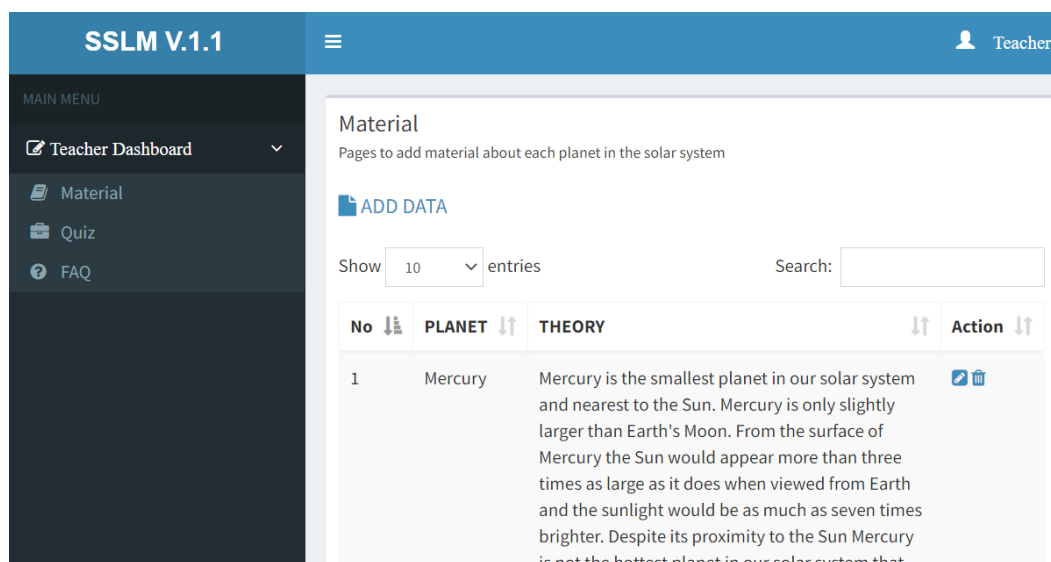


Fig. 4. Teacher Page For Viewing Material That Has Been Added

The teacher can click the Add data menu to add material data that did not previously exist. After clicking Add data, the page for adding material data will appear. The data that needs to be entered includes the name of the planet and the theory related to it. Then click submit to save the material data shown in Fig. 5.

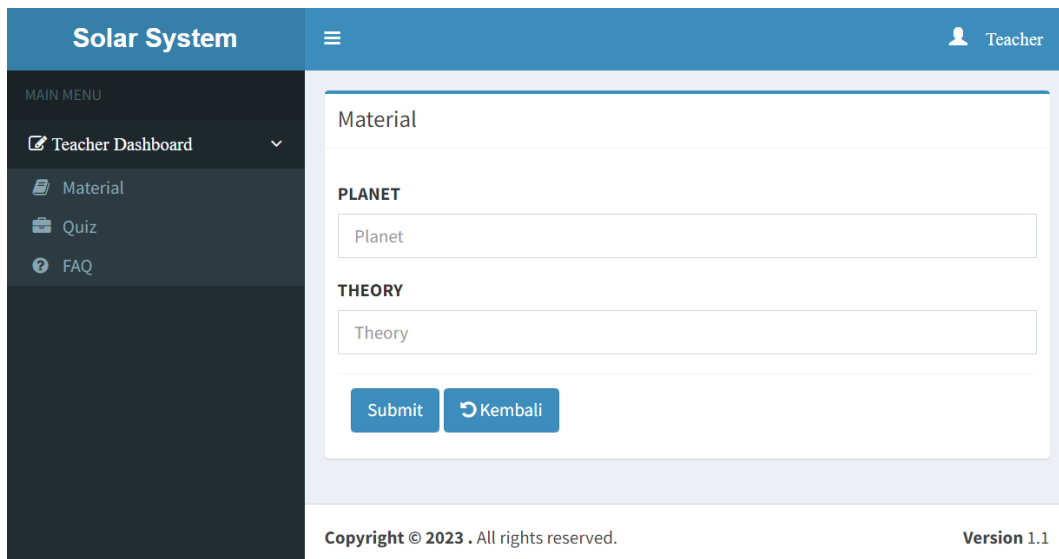


Fig. 5. Teacher Page for Add the Material

Fig. 6 shows the quiz page. On the quiz page, the teacher can see a list of questions that have been made along with the correct answers. The teacher can change the question or answer data and delete existing question data. If the teacher wants to add a new question, the teacher can click Add data on the quiz page. After that, the page for adding questions will appear shown in Fig. 7. The fields that must be filled in are questions and answers. Then click submit to save the question data. The FAQ page contains questions and answers related to learning media applications.

The next section of testing is related to this learning media hardware. The first test is testing the mode switching function. In this section, mode-switching testing is carried out. This testing process is carried out to test whether the learning media can switch modes according to the value read from GPIO16. The results of the switch mode testing process are presented in Table 2.

Based on the results of the mode-switching test, it can be concluded that the mode-switching function in this learning media has been running and succeeded 100%. When GPIO16 is HIGH, the device enters learn mode. When GPIO16 is LOW, it changes into question mode.

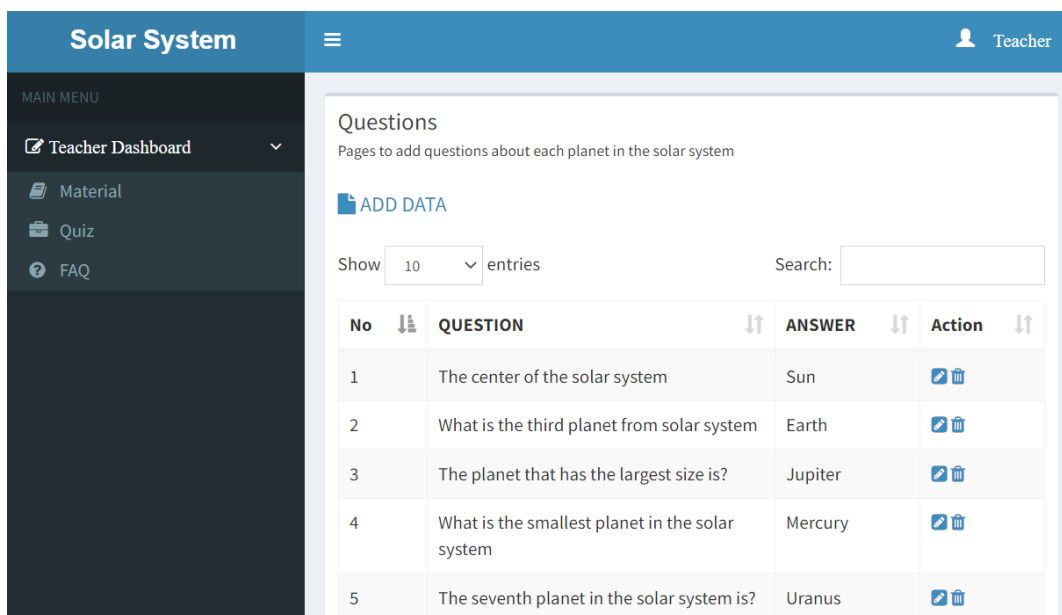


Fig. 6. Teacher Page For Viewing Question That Has Been Added

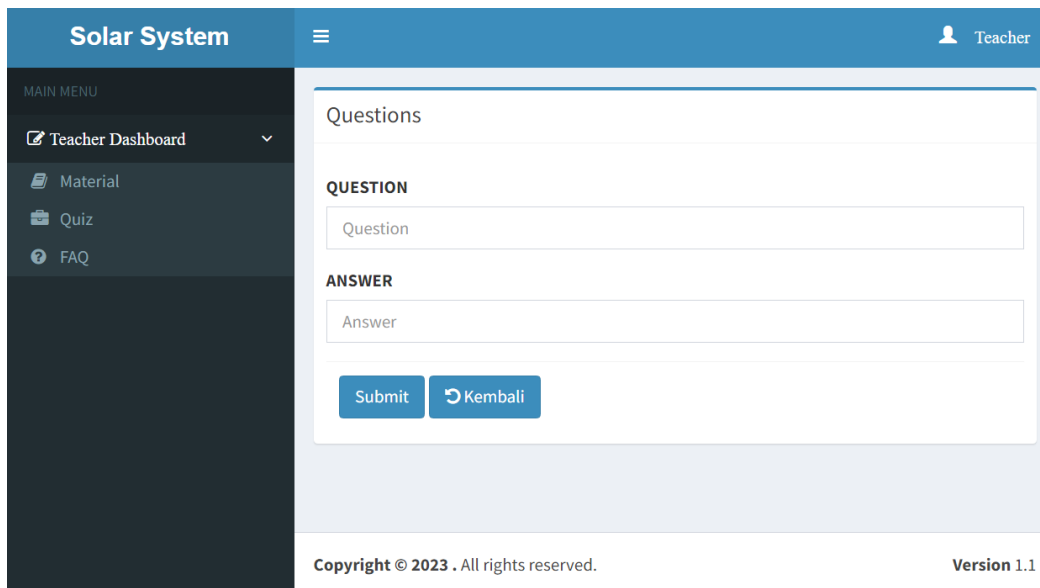


Fig. 7. Teacher Page for Add the Question

Table 2. The Outcome of Testing Mode

GPIO16	Learning Mode	Question Mode	Status
HIGH	√	-	valid
LOW	-	√	valid
HIGH	√	-	valid
LOW	-	√	valid
HIGH	√	-	valid

The next test is testing the eclipse mode on solar system learning media. This test involves testing the servo motor and GPIO05 pin that will determine the moon's position and testing the gTTS function that plays audio explanations about the phenomenon of solar eclipses and lunar eclipses. Both must work according to the GPIO5 pin value and the suppression state. The results of this test are shown in Table 3.

Table 3. The Outcome of the Solar and Lunar Eclipse Test.

No	GPIO5	Keypress State	Servo Motor	Description	Last Action	Status
1	HIGH	-	90 ⁰	-	-	Valid
2	LOW	1 st	0 ⁰	Play Solar Eclipse MP3	inc state and GPIO5 HIGH	Valid
3	LOW	2 nd	180 ⁰	Play Lunar Eclipse MP3	Reset state and GPIO5 HIGH	Valid
4	LOW	1 st	0 ⁰	Play Solar Eclipse MP3	inc state and GPIO5 HIGH	Valid
5	LOW	2 nd	180 ⁰	Play Lunar Eclipse MP3	Reset state and GPIO5 HIGH	Valid
6	LOW	1 st	0 ⁰	Play Solar Eclipse MP3	inc state and GPIO5 HIGH	Valid
7	LOW	2 nd	180 ⁰	Play Lunar Eclipse MP3	Reset state and GPIO5 HIGH	Valid
8	LOW	1 st	0 ⁰	Play Solar Eclipse MP3	inc state and GPIO5 HIGH	Valid
9	LOW	2 nd	180 ⁰	Play Lunar Eclipse MP3	Reset state and GPIO5 HIGH	Valid
10	LOW	1 st	0 ⁰	Play Solar Eclipse MP3	inc state and GPIO5 HIGH	Valid

Based on the test results presented in Table 3, it can be concluded that the eclipse mode function on this learning media has been running 100%. This is proven by the servo motor changing the angle according to the GPIO05 pin value and suppression state. When the first press is pressed, the servo motor moves to an angle of 0⁰, the moon will be between the sun and the earth, and the learning media successfully plays an audio explanation about the solar eclipse. When the second press is pressed, the servo motor moves to an angle of 180⁰, the moon will be behind the earth's position, and the learning media successfully plays an audio explanation about the lunar eclipse.

The following testing process is the learning mode testing process which involves reading each GPIO connected to the LDR sensor, all GPIO pins for DC motor control, and also gTTS to explain each planet in this solar system learning media. The test results in this learning mode are shown in Table 4.

Table 4. The Outcome of Learning Mode Test

LDR No.	GPIO	GPIO State	Motor DC	gTTS	Status
1	All LDR GPIO	LOW	All Motor GPIO HIGH	-	Valid
2	GPIO08	HIGH	Only GPIO32 HIGH	Play Merkurius MP3	Valid
3	GPIO10	HIGH	Only GPIO36 HIGH	Play Venus MP3	Valid
4	GPIO12	HIGH	Only GPIO38 HIGH	Play Earth MP3	Valid
5	GPIO18	HIGH	Only GPIO31 HIGH	Play Mars MP3	Valid
6	GPIO03	HIGH	Only GPIO29 HIGH	Play Jupiter MP3	Valid
7	GPIO07	HIGH	Only GPIO33 HIGH	Play Saturn MP3	Valid
8	GPIO13	HIGH	Only GPIO37 HIGH	Play Uranus MP3	Valid
9	GPIO15	HIGH	Only GPIO35 HIGH	Play Neptune MP3	Valid

From the test results on all functions in the learning mode, it can be concluded that the learning mode can run 100%. The tool can read every input from the LDR sensor and take action according to the program's algorithm flow. Data from Table 2 also shows that when all the LDR sensors are not covered by the student's hand, the GPIO media for DC motor control is given a low value so that all planets will not spin. When one of the LDRs is covered by something, for example, an LDR connected to GPIO12, then the DC motor controlled via GPIO12 is given a HIGH value so that planet Earth will spin. After that, the tool will explain planet earth using gTTS.

The next test is testing the question mode. This test involves gTTS and Speech Recognition. In this process, the learning media provides questions using gTTS then students answer via a microphone. Student voices will be recognized using Python Speech Recognition. The results of testing this question mode are shown in Table 5.

Table 5. The Outcome of Question Mode Test

Question No.	Question (gTTS)	Answer (Speech Recognition)	Feedback (Speaker)	Action	Status
1	What is the center of the solar system?	Sun	The correct answer MP3 active.	Proceed to the next question	Valid
2	What is the third planet from solar system	Earth	The correct answer MP3 active.	Proceed to the next question	Valid
3	What is the name of the planet known as the red planet?	Saturn	The wrong answer MP3 active.	Repeat This Question	Valid
4	What is the name of the planet known as the red planet?	Mars	The correct answer MP3 active.	Proceed to the next question	Valid
5	What is the smallest planet in the solar system	Mercury	The correct answer MP3 active.	Proceed to the next question	Valid
6	The seventh planet in the solar system is?	Uranus	The correct answer MP3 active.	Proceed to the next question	Valid
7	What is the name of the farthest planet in our solar system?	Neptune	The correct answer MP3 active.	Proceed to the next question	Valid
8	The second largest planet in our solar system is?	Venus	The wrong answer MP3 active.	Repeat This Question	Valid
9	The second largest planet in our solar system is?	Uranus	The wrong answer MP3 active.	Repeat This Question	Valid
10	The second largest planet in our solar system is?	Mars	The wrong answer MP3 active.	Proceed to the next question	Valid
11	What is the name of the natural satellite of planet earth?	Moon	The correct answer MP3 active.	Proceed to the next question	Valid
12	What is the name of the hottest planet in the solar system?	Venus	The correct answer MP3 active.	Proceed to the next question	Valid
13	The planet that has the largest size is?	Saturn	The wrong answer MP3 active.	Repeat This Question	Valid
14	The planet that has the largest size is?	Jupiter	The correct answer MP3 active.	Finish	Valid

Based on the results of testing the question modes presented in Table 5, it can be explained that the learning media has been able to request the question text to the server. After that, it provides the question in voice form using gTTS. This learning media can also recognize every answer given through the microphone. Learning media succeeded in responding to correct answers and repeating questions when students answered incorrectly. In addition, the learning media provide correct answers when students answer incorrectly three times. In the final row of table A3, it can be seen that this learning media can deliver the points of the correct answers to students.

After testing the functionality of the learning media, it is followed by user acceptance testing (UAT). UAT was carried out by giving questionnaires to 2 science teachers and 20 sixth-grade elementary school students as learning media users. The table of respondents is shown in Table 6.

Table 6. UAT Respondents

Respondents	Number of respondents
Science teacher	2
Sixth-grade elementary school	20

The list of questions given to the two type respondents is shown in Table 7 and Table 8. A total of 9 questions were given to the teacher and 7 questions were addressed to students.

Table 7. Question Lists for Science Teachers

No.	Question
1	Does this learning media make learning about the solar system more interesting?
2	Is the solar system learning media easy to use?
3	Does every explanation given by the learning media help students understand material about the solar system?
4	Can this learning media be used as a learning tool?
5	Does this learning media help in evaluating students' understanding of solar system material?
6	Are the menus on the learning media website easy to understand?
7	Does this learning media make it easier for students to mention the solar system?
8	Are students able to explain the solar system with this learning media?
9	Do the features of this learning media support the implementation of learning according to the syllabus?

Table 8. Question Lists for Sixth-grade Elementary School Student

No.	Question
1	Does this learning media make learning about the solar system more interesting?
2	Is the solar system learning media easy to use?
3	Does every explanation given by the learning media help to understand the material about the solar system?
4	Does this learning media help students to be able to mention the planets in the solar system?
5	Does this learning media help students be able to explain the solar system?
6	Does the quiz feature make this learning media more engaging?
7	How would you like to use this learning media to support learning about the solar system?

Furthermore, respondents gave answers to the questionnaire based on the terms of the answers shown in Table 9. The weighting of each answer to the questionnaire uses a Likert scale.

Table 9. The Weight of The Answer Value

Answer	Weight
A : Very easy/good/appropriate/clear/want	5
B : Easy/good/appropriate/clear/want	4
C : Neutral	3
D : Quite hard/good/appropriate/clear/want	2
E : Very difficult/bad/inappropriate/unclear/don't want to	1

All respondents answered the questions in the questionnaire by selecting one of the answers ranging from A to E. Then, the teacher and student questionnaires were processed to obtain the percentage weight. Based on the answers from teacher respondents, 94.44% of teacher respondents agreed that solar system learning media makes the learning process more engaging, easy to use, helps students understand the material, can be used as a learning aid, assists in evaluating student understanding, menus in web applications are easy to understand, and supports the implementation of learning according to the syllabus. Meanwhile, 95.14% of student respondents agreed that solar system learning media and quiz features make the learning process more engaging, easy to use, help students understand solar system material, and can be used as learning tool.

It can be said that the learning media meets the needs of the syllabus in terms of students being able to gather information, observe, and have reasoning abilities. Meanwhile, the need to ask questions has not been facilitated in the learning media created. In the learning media that is made, quizzes or questions are given by the tool for students.

4. CONCLUSION

This solar system learning media has been 100% running well. This learning media can run in learning mode and question mode. In learning mode, it can explain the material using gTTS and the motor DC according to the input received. In eclipse mode, this learning media provide explanations and control actuators for physical visualization related to the solar and lunar eclipse processes. In question mode, this learning media send questions ID randomly to the server and then receives questions from the server. It also reads questions and recognizes answers given by students using Python Speech Recognition. Based on UAT results 94.44% of teacher agreed that solar system learning media makes the learning process more engaging, easy to use, helps students understand the material, can be used as a learning aid, assists in evaluating student understanding, menus in web applications are easy to understand, and supports the implementation of learning according to the syllabus. Meanwhile, 95.14% of student agreed that solar system learning media and quiz features make the learning process more engaging, easy to use, help students understand solar system material, and can be used as learning tool. For further development, text-to-speech and offline speech recognition can be used so that the device does not depend on an internet connection. In addition, a feature can be added to complete the syllabus requirements where students can provide questions on the tool about solar systems with specific keywords.

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BIOGRAPHY OF AUTHORS



Mochamad Fajar Wicaksono, Completed master's degree in 2014. Currently active as a professional teacher with a certification issued by DIKTI in the field of computer engineering. The author's area of interest is instrumentation and control, especially IoT and embedded systems. Email: mfajarw@email.unikom.ac.id



Myrna Dwi Rahmatya, Completed master's degree in Information Systems in 2014. Currently active as a professional lecturer based on the certification issued by DIKTI. One of the fields occupied by the author is web programming
Email: myrna@email.unikom.ac.id



Syahrul, Completed undergraduate studies at Hasanuddin University–UNHAS Makassar in 1988 in the field of Electrical Engineering, then in 1999 completed his Masters in Electrical Engineering at the Bandung Institute of Technology–ITB Bandung. Has been a teaching staff since 1991 and is currently a Professional Lecturer in Computer Engineering based on a certification issued by DIKTI, Ministry of National Education. One of the fields occupied by the author is the IoT system. Email: syahrul@email.unikom.ac.id



Sri Nurhayati, Completed his master's education in 2007. Currently active as a professional teacher with a certificate issued by DIKTI in the field of Information Systems. The author's area of interest is Information Systems and Informatics. Email: sri.nurhayati@email.unikom.ac.id