Designing Smart Student Savings Tools Based on Arduino and Web

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Abstract
Fresh In this modern era, everything is done easily, from electronic equipment to electronic transactions is developed increasingly sophisticated. The equipment and sophisticated electronic transactions turned out to have major problems that could result in dissipation, especially students in schools. The purpose of this study is to create and design a smart savings machine tool, where this machine will be controlled via RFID and a sensor with a microcontroller, so that each individual can learn to economize in managing finances. This machine is designed by adding a color sensor for depositing and withdrawing cash with only three nominal banknotes, namely Rp. 10,000, Rp. 5,000 and Rp. 2,000. Furthermore, this device is also able to calculate the financial balance that has been entered. As an input, Arduino Mega 2560 is needed for data processing. Whereas, the color sensor output is used to read the basic colors red, green and blue on the surface of the lower left corner of the rupiah banknotes. This tool works as desired, can read RFID (Radio Frequency Identification) cards that have been determined and the color sensor can respond to colors on a nominal bill of Rp 2,000, Rp.5,000 or Rp. 10,000 and able to detect the time when saving and accumulating the balance. To attract money into the storage area, two DC motors are used. When the TCS230 color sensor detects money, there are several times that the currency is unreadable due to the influence of external light which causes the sensor to be inaccurate in reading the frequency value of the money color.

Keywords: RFID, Color Sensor, Arduino Mega 2560

Introduction
The hallmark of modern times is that everything is made very easy, from electronic equipment to increasingly sophisticated electronic transactions. The sophisticated electronic equipment and transactions turned out to be a major problem that could result in dissipation for someone, especially students at school. There is no other because it is so easy to use two different tools but it is intended as a convenience provider without taking into account the costs incurred. The nature of dissipation like that is what every individual should be able to overcome even avoid it by applying frugality, especially in using money to transact in order to create a planning system in transacting their money properly. One way to save money is done by saving money on a machine that can be accessed by yourself. Hence, we need a tool that can manage income and finance. This tool is needed to save a number of banknotes easily.

Mikrokontroler Arduino Mega 2560
Arduino Mega 2560 is a microcontroller board with a type of chip made by ATMEL with type ATmega2560. The microcontroller has 54 digital input / output pins (15 can be used as PWM outputs), 16 analog inputs, 4 UART (hardware serial port), 16 MHz crystal oscillator, USB connection, power jack, ICSP header, and reset button. The microcontroller is built as well as possible because it contains everything needed to support the microcontroller. it requires low power consumption, just powered by connecting it to the computer with a USB cable or turn it on with an AC-to-DC adapter or a battery to be used.
Arduino Mega 2560 Rev 3 has been equipped with ATmega16U2 chip which has been programmed as a USB to Serial converter. Also equipped with a polyfuse that can be reset to protect the USB port of your computer / laptop from short circuit or overcurrent. The ATmega2560 chip has 256 KB of memory, with 8 KB of that memory already being used for the bootloader. 8 KB SRAM, and 4 KB EEPROM, which can be read and write using the EEPROM library when programming.

**Pin Configuration on AT Mega2560**

The pin configuration on the AT Mega2560 is shown in Figure 2. AT Mega2560 has as many as 54 pins. These pins have their respective functions. Some function as power pins, as digital input and output pins and analog input pins.

**Liquid Crystal Display (LCD)**

LCD or liquid crystal screen is a device for displaying text or numbers. LCD is a popular display device that is used in many ways such as amateur radio, pocket calculators, and mini TVs. Most LCDs are configured as a seven-segment display to allow display of alpha numeric and limited characters. The LCD suppresses reflections or lights in the LCD segment. This results in a dark area in the LCD segment. So, the LCD screen cannot be used in the dark or low light levels.
Radio Frequency Identification
RFID is an identification system that enables data retrieval without having to touch such as barcodes and magnetic cards. RFID is able to transmit identity in the form of certain digits using radio waves and identification systems with radio waves. To operate it requires two devices, namely the so-called Tag and Reader. When scanning data, the Reader reads the signal emitted by the Radio Frequency (RF) signal given by the RFID Tag.

Figure 3: LCD 2x16
(https://www.robotistan.com/2x16-lcd-screen-white-over-blue-tc1602a-2619-11-B.jpg)

Figure 4: LCD Configuration 2x16
(https://www.robotistan.com/2x16-lcd-screen-white-over-blue-tc1602a-2619-11-B.jpg)

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Figure 5: Part of Tag on RFID
(http://3.bp.blogspot.com/-enQcKT5gy10/VP68Ppxj1mI/AAAAAAAATc/zlENUK3ZSsQ/s1600/RFID-chip.png)
Motor DC

DC motors are electric motors that require a direct current voltage supply in the field coil to be converted into mechanical motion energy. The field coil on the dc motor is called the stator (the part that is not rotating) and the anchor coil is called the rotor (the rotating part). Direct current motors, as the name suggests, use direct current that is not direct / direct-unidirectional. The main advantage of a DC motor is that it controls the speed, which does not affect the quality of the power supply.

TCS230 Color Sensor

TCS230 color sensor is a color sensor that is often used in microcontroller applications for the detection of an object or the color of the object being monitored. The TCS230 color sensor can also be used as a motion sensor, where the sensor detects the movement of an object based on the color changes received by the sensor. Basically, the TCS230 color sensor is a series of photodiodes arranged in an 8x8 matrix array with 16 photodiode configurations that function as red filters, 16 photodiodes as blue filters and 16 photodiodes again without color filters. TCS230 color sensor is a sensor that is packaged in an 8 pin DIP chip with a transparent face as a place to receive colored light intensity.
Keypad
Keypad is one type of interface device commonly found on microcontroller systems, it is a 4x4 or 3x4 matrix keypad. As a consequence, as long as no buttons are pressed, the microcontroller will see as logic high "1" on each pin connected to the line.

![Matrix 4x4 keypad (Tri Rahajoeningroem & Wahyudi, 2013)](image)

**Figure 9: Matrix 4x4 keypad (Tri Rahajoeningroem & Wahyudi, 2013)**

NodeMCU ESP8266
NodeMCU is an open source IoT platform and development kit that uses the Lua programming language to assist in making prototypes of IoT products or can be sketched with an arduino IDE. The development of this kit is based on the ESP8266 module, which integrates GPIO, PWM (Pulse Width Modulation), IIC, 1-Wire and ADC (Analog to Digital Converter) all on one board.

![GPIO NodeMCU ESP8266 v3](image)

**Figure 10: GPIO NodeMCU ESP8266 v3**

Research Methodology
Based on the research method used, the initial stage in developing this tool is planning, preparing all the needs in making tools in the form of paper writing material, electronic components and software used in making the program. Then in the next stage is analyzing by observing, researching, collecting and analyzing everything related to research. All tools that have been designed will then be done making the program. Programming is done using the Arduino C programming language, HTML, PHP.
Finding and Discussion

Block diagram analysis
Block diagram analysis presents an overview of how the student savings system works.

In the block diagram above, it can be seen that there is an RC522 RFID as a tap card reader. The RFID Card has been programmed to contain the student's personal identity such as account number, full name, full address, gender after the card is tapped, the student/client enters the password via the keypad when the password entered correctly then the LCD will display the message "Password Match, Access Granted" if you enter the wrong password, then the message "Wrong Card Please try Again" will be displayed and make sure the password is not entered incorrectly. The next step is to place banknotes in Rp.2,000, Rp.5,000, or Rp.10,000 denominations and place them on the TCS230 color sensor that will read the RGB color based on the currency.

In the next step the TCS230 color sensor will read the colors on the money and the LCD will display the message "Nominal Identification" when it has been read by the sensor. The LCD will display the message "Nominal Money" according to the currency placed on the TCS230 color sensor bag, after that the DC motor will withdraw the money into a box with a rotation duration of 3 seconds after the money enters the LCD lunch box will display the message "Finish Thank You", The next step is NodeMCU ESP8266 which integrates the ADC (Analog to Digital Converter) with the serial Wifi feature connected by the laptop that is connected to the laptop. enter the Web which will display the amount of money entered as read by the color sensor. In the web view, identity, money in and the time when students / clients save will appear and students can see the total money that came in by looking at the account code that can be accessed by the admin.

Tool Design
The concept of a smart savings monitoring system based on Arduino students and the web uses two stages, namely the design of the physical form of the tools and the design of the Software.
Based on Figure flowchart can be translated into a program that starts from the initial process or starts to turn the power ON button. The savings system will be active, when the device is on, the device will initialise after that the tool can be used by tapping the card into the RFID reader and then the LCD screen will appear on the user's ID by entering a PIN consisting of 4 letters, if you enter a wrong password then users re-tag the card and make sure the password is not incorrect. If the password is correct, the next step is to enter banknotes between Rp. 2,000, Rp. 5,000 and Rp. 10,000, then the color sensor will read the RGB of each coin, then the LCD display will identify the nominal value of the money after the display will appear on the LCD, total incoming cash that has been read by the sensor, the next ESP8266 will send data to the Web on its display will provide student identity information and the amount of money saved and displays the time when saving. In the web view can be seen in total from students while saving in full.

**Test Results on the RGB Color Sensor**
The sensor used is the TC230 Color Sensor This component can be used to measure RGB color parameters.
Table 1: Testing the measurement of the color parameters of banknotes

| Banknotes | Pembacaan Nilai Warna | Output Sensor |
|-----------|-----------------------|---------------|
| Rp.2000   | Red                   | 50 – 65       |
|           | Green                 | 60 – 70       |
|           | Blue                  | 35 – 50       |
| Rp.5000   | Red                   | 40 – 55       |
|           | Green                 | 60 – 80       |
|           | Blue                  | 50 – 65       |
| Rp.10.000 | Red                   | 70 – 85       |
|           | Green                 | 70 – 85       |
|           | Blue                  | 35 – 45       |

In this experiment the TCS230 color sensor detects the color of the paper currency using a test table displaying measurement parameters on the serial plotter that is available in the Arduino software.

Color Calibration Test Results
The Arduino Mega 2560 microcontroller detects the color sensor it receives from the TCS230 color sensor circuit. Each of the red, green and blue colors gives a calibration value for each object it detects.

Table 2: Testing Banknote Color Calibration Measurement on Rp. 2000

| Percobaan ke- | Uang Kertas | Parameter | Ket.   |
|---------------|-------------|-----------|--------|
|               | Merah (R)   | Hijau (G) | Biru (B) |        |
| 1             | 61          | 67        | 38      | Terbaca|
| 2             | 61          | 67        | 40      | Terbaca|
| 3             | 61          | 69        | 40      | Terbaca|
| 4             | 61          | 65        | 40      | Terbaca|
| 5             | 62          | 67        | 47      | Terbaca|
| 6             | 64          | 67        | 42      | Terbaca|
| 7             | 58          | 66        | 39      | Terbaca|
| 8             | 62          | 64        | 44      | Terbaca|
| 9             | 60          | 62        | 44      | Terbaca|
| 10            | 67          | 62        | 46      | Terbaca|
### Table 3: Testing Banknote Color Calibration Measurement on Rp. 5000

| Percobaan ke- | Uang Kertas | Parameter     | Ket.  |
|--------------|-------------|---------------|-------|
|              |             | Merah (R)     | Hijau (G) | Biru (B) |       |
| 1            | Rp.5000     | 43            | 66       | 54       | Terbaca |
| 2            |             | 43            | 66       | 57       | Terbaca |
| 3            |             | 43            | 72       | 63       | Terbaca |
| 4            |             | 43            | 75       | 63       | Terbaca |
| 5            |             | 50            | 73       | 60       | Terbaca |
| 6            |             | 53            | 69       | 55       | Terbaca |
| 7            |             | 44            | 69       | 58       | Terbaca |
| 8            |             | 45            | 70       | 52       | Terbaca |
| 9            |             | 48            | 72       | 61       | Terbaca |
| 10           |             | 48            | 72       | 64       | Terbaca |

### Table 4: Testing Banknote Color Calibration Measurement on Rp. 10,000

| Percobaan ke- | Uang Kertas | Parameter     | Ket.  |
|--------------|-------------|---------------|-------|
|              |             | Merah (R)     | Hijau (G) | Biru (B) |       |
| 1            | Rp.10,000   | 77            | 71       | 38       | Terbaca |
| 2            |             | 75            | 80       | 38       | Terbaca |
| 3            |             | 75            | 83       | 40       | Terbaca |
| 4            |             | 82            | 77       | 44       | Terbaca |
| 5            |             | 80            | 75       | 42       | Terbaca |
| 6            |             | 75            | 73       | 35       | Terbaca |
| 7            |             | 79            | 79       | 39       | Terbaca |
| 8            |             | 82            | 72       | 41       | Terbaca |
| 9            |             | 80            | 77       | 40       | Terbaca |
| 10           |             | 80            | 73       | 37       | Terbaca |

**Test Results on RFID**

RFID uses a radio wave identification system. For this reason, at least two devices are needed, namely the so-called TAG and READER. When scanning data, READER reads the signal given by RFID TAG.
Table 5: Connector between RFID and Arduino

| PinRFID | Pin Arduino |
|---------|-------------|
| VCC     | VCC 5 Volt  |
| GND     | Ground      |
| RST     | 3           |
| SS (SDA)| 4           |
| MOSI    | ICSP-4      |
| MISO    | ICSP-1      |
| SCK     | ICSP-3      |

Figure 15: Trial Card Readings on RFID Reader

Table 6: RFID test results

| Test | Distance (CM) | Front Look | Backview |
|------|---------------|------------|----------|
| 1    | 0             | Legible    | Legible  |
| 2    | 1             | Legible    | Legible  |
| 3    | 2             | Legible    | Legible  |
| 4    | 3             | Legible    | Legible  |
| 5    | 4             | Legible    | Illegible|
| 6    | 5             | Illegible  | Illegible|
| 7    | 6             | Illegible  | Illegible|
| 8    | 7             | Illegible  | Illegible|
| 9    | 8             | Illegible  | Illegible|
| 10   | 9             | Illegible  | Illegible|

Based on testing of RFID cards those are closer to a certain distance, the results obtained that RFID can read cards or tags around 0 cm to 4 cm.

Tool Testing
This time the test was conducted to find out whether the entire system can run well and function as expected.
In testing this tool is done by providing a voltage so that the tool can be operated. Experiments in this series will produce an output that will be displayed via web media. The output will be generated from the TCS230 sensor which reads the color frequency. Then the data will be sent automatically to the web server and then appear even though it is safe on the web and notifies the amount of money saved and notifies the final balance on the web, thus students who save can see the balance of the balance and the time when saving transactions.

**Overall Device Testing**

Testing is done when students start making savings transactions on the tool and can monitor the amount of balance and currency in the savings and get results on the web in the form of displays on web pages and data stored in the database.

The test is carried out with the following steps:

1. Giving a DC power supply voltage (voltage) to the appliance using an adapter with 12 Volt power.
2. After connecting to a series of devices, the RFID, TC230 color sensor, 4x4 keypad, Arduino Mega, ESP8266, DC motor and LCD will be active and enter into the Web display on the laptop.
3. When all components are active and the web page is ready, the transaction process can be done with students having an RFID Card as an account that is already registered and can make a savings process with paper currency denominations with a nominal Rp.2,000, Rp. 5,000, Rp. 10,000.
2. After having an account, students can make transactions with banknotes, with the first attempt using Rp.10,000 by taping an RFID card and entering the PIN that has been registered, then entering Rp.10,000 in money and placed in the TCS230 color sensor position.
3. Then Arduino will send data to the Web with ESP8266 already connected by the internet.

![Arduino Sends Data to the Web at Rp. 10,000](image)

**Figure 21: Arduino Sends Data to the Web at Rp.10,000**

4. Then enter the Savings Data menu, then students can monitor the results of saving transactions with information in the form of Account No., RFID, Full Name, Amount and Time.

![Display Savings Data with a nominal Rp.10,000](image)

**Figure 22: Display Savings Data with a nominal Rp.10,000**

5. Then with the second experiment using Rp.2,000

![LCD display when the color sensor reads RGB at Rp. 2,000](image)

**Figure 23 LCD display when the color sensor reads RGB at Rp. 2,000**
6. After Arduino sends data to the Web, the main display balance will change to a total nominal of Rp. 12,000 because students save with a currency of Rp. 2,000.

![Figure 24: Increased balance by saving Rp.2,000](image)

7. Then students can monitor savings balances by looking at the Savings Data menu.

![Figure 25: Display Savings With Nominal Rp.2,000](image)

8. Then with the third experiment using money Rp.5,000.

![Figure 26: LCD display when the color sensor reads RGB at Rp. 5,000](image)

9. After Arduino sends data to the Web, the main display balance will change to a total nominal of Rp. 17,000 because students save with a currency of Rp. 5,000, when each student saves then the web
display will automatically change according to the amount of money that goes into the tool smart savings even though all students save in one machine and can monitor savings by entering menu on Account number.

10. Then, students can monitor savings balances by looking at the Savings Data menu

11. If students want to see the total from the beginning of saving by clicking the respective account number listed on the savings data menu.
Conclusion
Based on the results of this study, the authors get several conclusions, namely:

a. This tool works as desired, can read RFID (Radio Frequency Identification) cards that have been determined and the color sensor can respond to colors on a nominal bill of Rp 2,000, Rp.5,000 or Rp. 10,000 and can see the time when saving and accumulating the balance.

b. To attract money into the storage area, two DC motors are used.

c. When the TCS230 color sensor detects money, there are several times that the currency is unreadable due to the influence of external light which causes the sensor to be inaccurate in reading the frequency value of the money color.

Suggestions
There are still shortcomings on this tool. Hence, a few inputs to improve the Smart Savings Tool for Arduino and Web-Based Students in the future better. Some suggestions are proposed including the following points:

a. The development of this tool is expected to reduce the unreadability of currencies by using more effective sensors to be accurate in reading RGB values.

b. This tool can be developed by adding cameras or size sensors and other sensors such as money authenticity sensors. So that this classification process can be more precise in determining the authenticity of money and nominal money according to this tool.

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