

Web-Based Laboratory Inventory Application Using QR Code and RFID in Telecommunication Engineering Laboratories/Workshops

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Abstract: State Polytechnic of Sriwijaya is one of the universities that organize vocational education in Indonesia, by having a variety of laboratories to support its education. One of them is the Laboratory of Telecommunication Engineering Study Program, which has assets in the form of equipment/instruments used by its students to carry out practical activities based on predetermined courses. However, the current borrowing equipment system in the laboratory still uses a manual system, where students are required to fill out a loan form provided by the laboratory technician. In this case, the use of website-based applications as a medium for stock information and lending activities is expected to be an alternative in the inventory process. The prototype method is used in application development. Web-based applications are designed using the Laravel framework. After testing using a black box, it shows that all the functionality of the application system that has been designed runs properly and well. From the test results, the QR Code and RFID can display the scan results in the application quickly. A web-based inventory application with QR Code and RFID technology can assist in monitoring inventory and the process of borrowing equipment in the Telecommunication Engineering Study Program laboratory.

Keywords: Inventory, QR Code, RFID, Web, Laravel Framework

INTRODUCTION

The development of today's technology is increasingly rapid and can be used in all fields, including the field of inventory and its supporting technology has been widely applied in all institutions, including educational institutions. Based on previous research (Pranoto and Sedyono 2021) a web-based information system that can assist in providing as well as collecting information and data has been created. The development of web applications since the advent of internet technology provides convenience and speed in sending, delivering, distributing, and receiving information for users who need it. Starting from companies, schools, institutions, and including universities have utilized web-based applications for sales, promotions, learning, and other activities as needed.

Polytechnics are universities that carry out vocational education in various science and/or technology groups and if they meet the requirements, a polytechnic can provide professional education (Parenreng and Nas 2019). In the learning process, the polytechnic accounts for 70% of the practicum and 30% of the theory. The high percentage of practical activities affects the number of laboratories in the polytechnic.

A laboratory is a place or room that functions as a place for study and research with a number of necessary equipment or instruments (Aminah, Bhaskoro, and Sunarya 2020). Sriwijaya State Polytechnic has laboratories/workshops in each of its study programs. The Laboratory of the Telecommunications Engineering Study Program at the Sriwijaya State Polytechnic has assets in the form of tools/instruments to support students in the learning process and practicum. In each semester, several practicums will be carried out based on predetermined courses. Students need equipment/instruments to support these practicum activities, therefore assistants or laboratory/workshop technicians play a role in preparing equipment based on the job done.

Currently, the equipment lending system is still using the manual method. Students still have to bring a guidebook and apply for a loan by filling out the loan sheet provided. The obstacle that occurs is that it requires a long time to process the loan and recap inventory data. Accountability report sheets are collected every semester

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and cause an accumulation of hard files. Therefore, a web-based information system was created to help to facilitate technicians and students. This application utilizes QR Code (Quick Response Code) and RFID (Radio Frequency Identification) technology which is integrated with a database and website system that can assist in the process of borrowing tools and inventory in the Telecommunication Engineering study program laboratory.

LITERATURE REVIEW

QR code (Quick Response code) is a type of two-dimensional image, where the QR code displays data in the form of text. The QR code can also be recycled and reused (Putra 2019). QR code is an extension of the barcode. Barcode is an image made of black and white bars thus it can be recognized by the computer (Qr et al. 2016). Barcodes are only able to store data horizontally while QR codes can store more information both horizontally and vertically. QR codes can store data in the form of URLs, phone numbers, addresses, or any text. The purpose of using this QR code is to assist users in accessing information quickly and responsively without having to do it manually.

RFID (radio frequency identification) is an automatic identification technology that utilizes radio frequencies to store and retrieve data remotely. RFID is a method used to identify people, animals, or objects by radio frequency. RFID uses radio frequencies to read information from a small device called a transponder (transmitter and responder) or tag. The RFID tag will be read if it is close to the signal from a compatible device, namely the RFID Reader (Latief 2013).

RFID is used by several companies or agencies for needs of employee identification (Darmanta Sukrianto 2019). There are several types of RFID tags, including tags, cards, and stickers. The workings of RFID are the main components of an RFID tag that contains a chip and an antenna tag (inlay), where the chip stores information and is connected to the tag antenna. Information will be read via radio frequency after the tag receives a signal from the RFID reader, and then the RFID reader will forward the information to the server (Darmanta Sukrianto 2019).

A website or site is a collection of pages used to display information in the form of textual, still or moving images, animation, sound or a combination of all of the above, both statically and dynamically in the form of a series of interconnected buildings. The relationship between one web page and another is called a hyperlink, and the text used as a connection medium is called hypertext (Usnaini, Yasin, and Sianipar 2021).

Laravel is a PHP programming language framework with many features that can help developers to create web-based applications. Laravel is a web development framework designed to improve application quality by reducing development costs, simplifying maintenance processes, and increasing workforce productivity with well-structured program code (Moch Zawaruddin Abdullah et al. 2021). Web application development with the Laravel framework is using the MVC pattern.

In Laravel, there is routing that connects requests from users and controllers. Therefore, the controller does not immediately accept the request (Bin Tahir, Rais, and Apriyadi HS 2019). There are 5 MVC concepts in the Laravel framework that have their respective functions, namely: Routes, as an action provider for requests according to predetermined commands. Controller is a part that connects the model with the view. The controller has commands that handle how to display the data. Model is a collection of data that functions to manage tables in the database. View is a file that contains HTML (HyperText Markup Language) code that is used to display data in the browser. Laravel's display format requires the use of the term Blade, as in `view.blade.php`. Migration is the process of designing a table, in this case, migrations serve as a database blueprint or can be termed as a control system provider for the database schema.

METHOD

The method of software development (application) is the prototype method. A prototype is defined as a version of a potential system that gives developers and potential users an idea of how the system will function in the finished form (Nurajizah 2015). The main purpose of the prototype method is as a tool for providing system designs and menus that need to be included in the prototype to be developed.

At this stage, an interview was conducted with Laboratory/Workshop technicians of the Telecommunication Engineering Study Program. This stage was carried out to find out about the obstacles that exist in the Laboratory/Workshop, and to gain an idea to make the system needed (Elmerillia, Lindawati 2021). Furthermore, design a prototype by making a temporary design according to user needs. Then, determine whether the prototype can be accepted or not. Next, evaluate the system that is in accordance with what is needed, then the next step was to code the system, otherwise, a revision will be made to the system that has been built (Nurajizah 2015). The prototype was completed in the system and the system was ready for use.

The laravel application can also generate a QR code, by installing a library. From this library, the qr code will be formed according to the data we have input. In the process of forming it, after laravel installs the library, it then adds a route and finally that is to run the program with the `php artisan serve` command. QR code tool coding is carried out based on equipment inventory data in the laboratory / workshop of the

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Telecommunication Engineering Study Program. The coding of laboratory / workshop equipment uses a block code in which each digit of the code has a meaning. The block code used consists of the name of the laboratory/workshop, the code of the item or tool, and the sequence number of the tool.

Table 1. Coding Laboratory/Workshop Name

Code	Laboratory/Workshop
01	Microprocessor
02	Antennas and Propagation
03	Basic Telecommunications
04	Signal Processing
05	Multimedia
06	Transmission
07	Data Communication
08	Measuring and Measuring Instruments
09	Electronics and PCB workshops
10	Mechanical Workshop

Table 2. Labeling a QR Code in a laboratory / workshop of a telecommunications engineering study program

No. Digit	Code Meaning
10	Laboratory/Workshop
3080141185	Tool code
001.	Equipment sequence number
10. 3080141185. 001.	Code examples

RFID tag (in the form of a card) has a number code, where the number will be input into the database and linked to the website application as the code of the student's name. The RFID tag will communicate with the RFID reader, when approached, then the data will be displayed on the website application. The RFID Reader is connected to a computer or laptop using a USB cable.

Table 3. Example of RFID code as a student name

No.	Student name	RFID code
1.	Elisa Islami Putri	1239142753
2.	Junio Andika Danda	2867973059
3.	Bayu Sanjaya	2867466243
4.	Selvia Rossa	1239058081
5.	Uzwahnul Azrin	0579279393

RESULT

This web-based application is intended for users (students) and admins (laboratory technicians). The main function of this application is to scan the QR code equipment, and see the activity of scanning the QR code.

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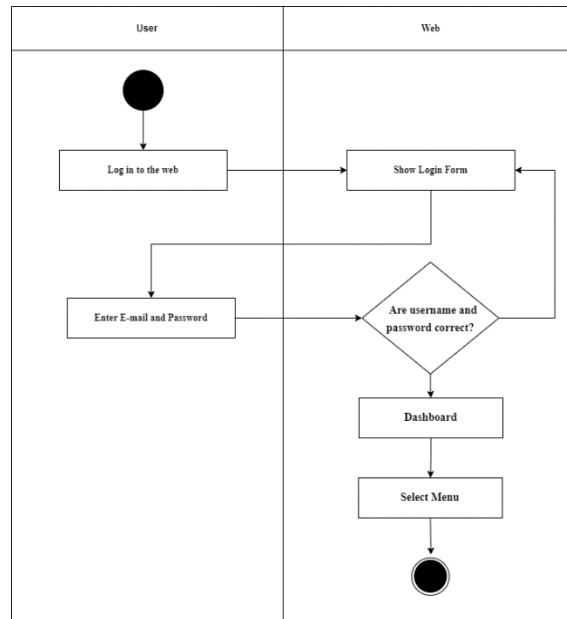
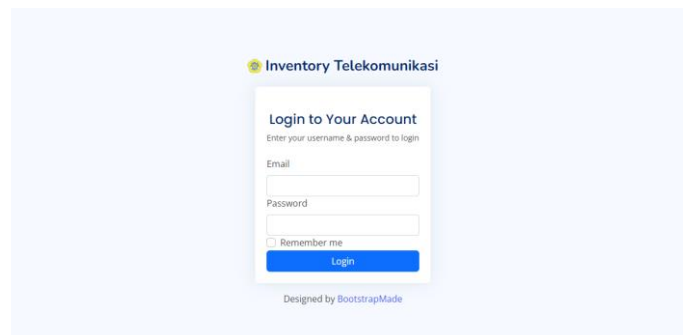


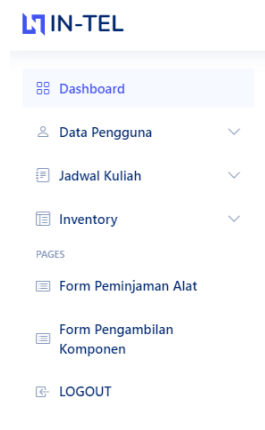
Figure 1. Activity Diagram Log In

Login and Logout

First of all there will be a login page the first time the website is run. To access the application, users must enter their email and password on the login form. In contrast, to maintain data security, the logout menu is also provided.



(a)



(b)

Figure 2. (a) Login menu and (b) logout

Admin Menu and Student Menu

This menu displays user data information from the application, namely admins and students. However, information about admin data can only be accessed by the main admin, and student users cannot. On the student menu, information on active students of the Telecommunication Engineering Study Program at the Sriwijaya State Polytechnic will be displayed.

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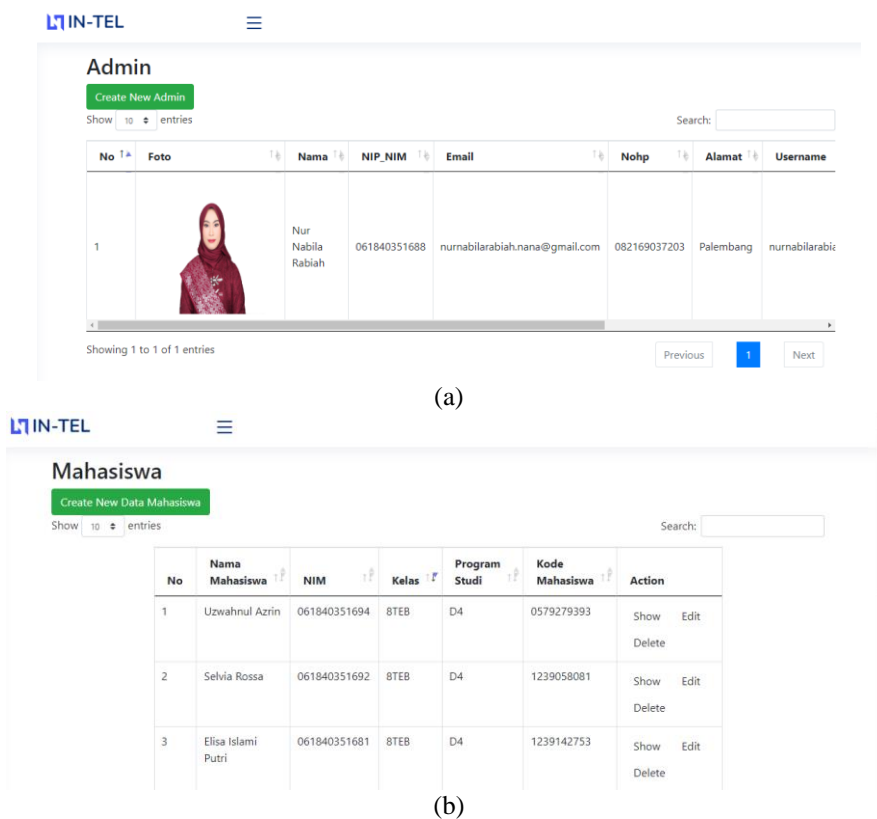


Figure 3. (a) Admin menu and (b) Student menu

Course Menu

This menu displays information about courses for one semester of the Telecommunication Engineering Study Program. This menu contains the name of the course, study program, and semester.

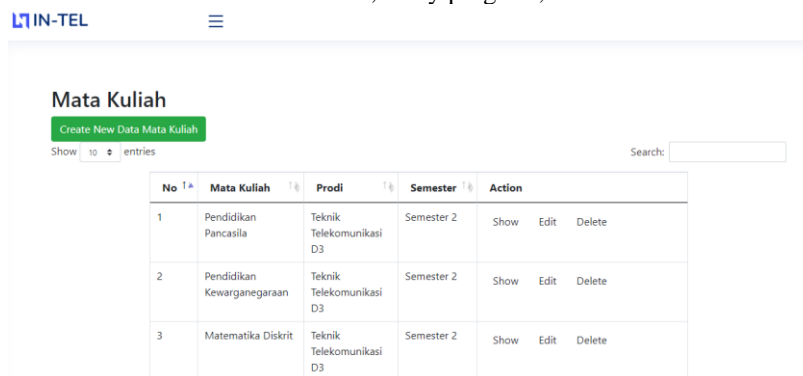
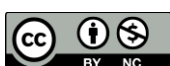


Figure 4. (a) Course menu

Tools Data Menu and Component Data Menu

This menu displays tool data information and the amount of component data available in the laboratory /workshop. In the tool data there is also a QRcode for identification.

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Data Alat

Create New Data Alat Export PDF

Show 10 entries Search:

No	Nama Alat	ID Alat	Merk/Type	Tahun	Laboratorium/Bengkel	QrCode	Action
1	Oscilloscope_01	01.3080141185.001	DIGITAL ULTRA PHOSPOR 100 MHz	2021-12-06	Laboratorium Mikroprosesor		Show Print QR Edit Delete

(a)

Data Komponen

Create New Data Komponen Export PDF

Show 10 entries Search:

No	Nama Komponen	Jumlah	Action
1	ATTENUATOR 0.5 WATT 10 dB 50 OHM	5	Show Edit Delete
2	ATTENUATOR 0.5 WATT 20 dB 50 OHM	7	Show Edit Delete
3	ATTENUATOR 0.5 WATT 10dB 75 ohm	4	Show Edit Delete
4	ATTENUATOR 0.5 WATT 20 dB 75 ohm	4	Show Edit Delete
5	ATTENUATOR 1 WATT 3.dB 50 OHM	2	Show Edit Delete
6	ATTENUATOR 1 WATT 6 dB 50 OHM	3	Show Edit Delete

(b)

Figure 5. (a) Data tools menu and (b) Component data menu

Tool Loan Menu and Component Retrieval Menu

The tool lending menu is a facility for students and technicians in the process of borrowing tools to support practicum activities. On this menu, there are options for student names, job names, and scan qr codes for the tools needed will appear. Students simply submit an identity card (RFID) then the technician will process the loan of the tool. The component collection menu contains a form for students who want to take components based on component details per job. Then the technician will process the retrieval of the component. Every tool lending transaction and automatic component retrieval is recorded and reports will be attached in PDF form.

Peminjaman Alat

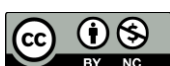
Create New Form Peminjaman Alat Export PDF

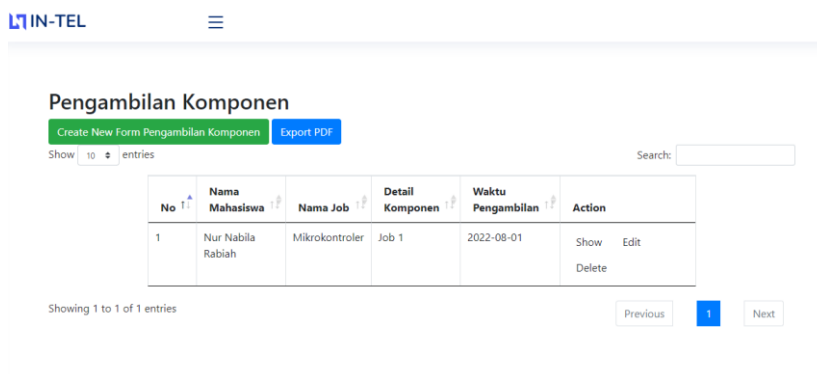
Show 10 entries Search:

No	Nama Mahasiswa	Nama Job	ID Alat	Waktu Peminjaman	Action
1	Selvia Rossa	Mikrokontroler	Power Supply (Peralatan Studio Video Dan Film)_01	2022-07-29	Show Edit Delete
2	Selvia Rossa	Mikrokontroler	Power Supply (Peralatan Studio Video Dan Film)_02	2022-07-29	Show Edit Delete

(a)

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(b)

Figure 6. (a) Tool loan menu and (b) Component retrieval menu

Application Testing

Testing of inventory digitization applications is carried out by testing features according to the needs of the inventory system that has been defined. The procedures in the testing carried out on the software help determine the data that will be used for the needs of software testing. The method used for software testing is the black box testing method. This test method aims to find out the functionality of the application that contradicts the internal structure and work of the application. Test methods can be applied to all levels of software testing, including unit, integration, functionality, system, and acceptance. This usually includes most, if not all, of high-level testing, but can also dominate unit testing.

Table 4. Black box testing

No	Testing Section	Functions tested	Input	Output	Hasil Uji
1.	Login	Login to the web via the login form	Enter the correct email address and password.	The data is recorded to the database and redirected to the admin login page.	Valid
2.	Logout	Log out from web	Click logout menu	The user will exit the application and return to the login page.	Valid
3.	Manage role	Manage role menu	Click role menu	Displays a role page form that serves to set what features can be done by admins.	Valid
4.	Manage user menu	Manage user menu	Click menu user	Display the page form to add an admin account and select the available roles.	Valid
5.	Admin Menu	Admin Menu button	Click the admin menu button	Displays the user admin datapage.	Valid
6.	Student Menu	Student Menu button	Click the student menu button	View the student data page	Valid
7.	Course Menu	Course Menu button	Click the course menu button	Displays the course data page for 1 semester.	Valid
8.	Practicum course menu	Practicum course menu button	Click the practice course menu button	Displaying practicum course pages	Valid
9.	Tools data menu	Tools data menu button	Click the tools data menu button	View the tool's data page in each laboratory	Valid
10.	Component data menu	Component data menu button	Click the component data menu button	View component data pages	Valid
11.	Tool loan form menu	Tool loan form menu button	Click the tool loan form menu button	Displays the loan form page of the tool.	Valid
12.	Component pickup form menu	Component pickup form menu button	Click the component form menu button	Displays the component pickup form page.	Valid

How to Generate QR Code in Laravel

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After designing the application, then the next step is to make a QR code. The QR Code is formed by using the laravel application. In making a QR code, a *simple-qr-code* or *simplesoftwareio/ simple-qr code* library is needed. In the Laravel terminal, run the composer require *simplesoftwareio/simple-qr-code* command (<https://www.simplesoftware.io/#/docs/simple-qr-code>) and Laravel will download the library. After the download process is complete, the next step is to add a route for the QR code. In the QR Code route, there is a generate function, which functions to create a QR Code from the inputted data. In the case of this study, the code to be generated is the tool code, which is contained in the tool data menu. Next to run the program, run the php artisan serve command and a QR code will appear. The QR Code will be displayed in PNG format.

Figure 7. Program for route QR code

```
Route::get('qr-code-g', function () {
    \QrCode::size(100)
        ->format('png')
        ->generate('www.google.com', public_path('images/qr-code.png'));
    return view('qrCode');
});
```

For RFID, make use of the numbers that are already available inside the RFID tag. Those RFID tags will be connected using an RFID scanner. To bring up the RFID reader scan results to the website application, namely by adding coding / attributes to Laravel on the create blade.

Figure 8. Script to call RFID data tags

```
<script>
var data_mahasiswa = <?php echo json_encode($data_mahasiswas) ?>;
console.log(data_mahasiswa);
var e11 = document.getElementById("rfid");
var nama_mahasiswa = document.getElementById("nama_mahasiswa");
var namo = document.getElementById("namo");
e11.addEventListener("keypress", function(event) {
    if (event.key === "Enter") {
        alert(event.key + " " + event.which);

        event.preventDefault();
        var rfid = e11.value;
        console.log(rfid);
        data_mahasiswa.forEach(element => {
            console.log(element);
            if (element.kode_mahasiswa==rfid){
                nama_mahasiswa.value = element.id;
                namo.value = element.nama;
            }
        });
    }
});
```

The getElmenById function is to call elements based on the id attribute, in research the value of the id meaning 'RFID' is the name of the student, so that when the RFID tag number appears then entered, the student's name is automatically displayed on the website application.

QR Code Testing

After designing the system, the next step is to test the functionality of the QR Code. This test aims to ensure that the QR code displayed on the web application matches the tool code that has been inputted into the database.

Table 5. QR Code testing

Initial conditions	The user is on the loan form page of the tool
Test scenario	Device scan QR code
Input	Scan QR code
Predicted results	QR code generator results according to the tool code and successfully recorded in the application
Observation	Results as expected
Conclusion	Succed

The test was carried out by taking data in 3 laboratories, namely signal processing laboratories, telecommunications bases, and measuring and measuring tools.

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Signal Processing Laboratory

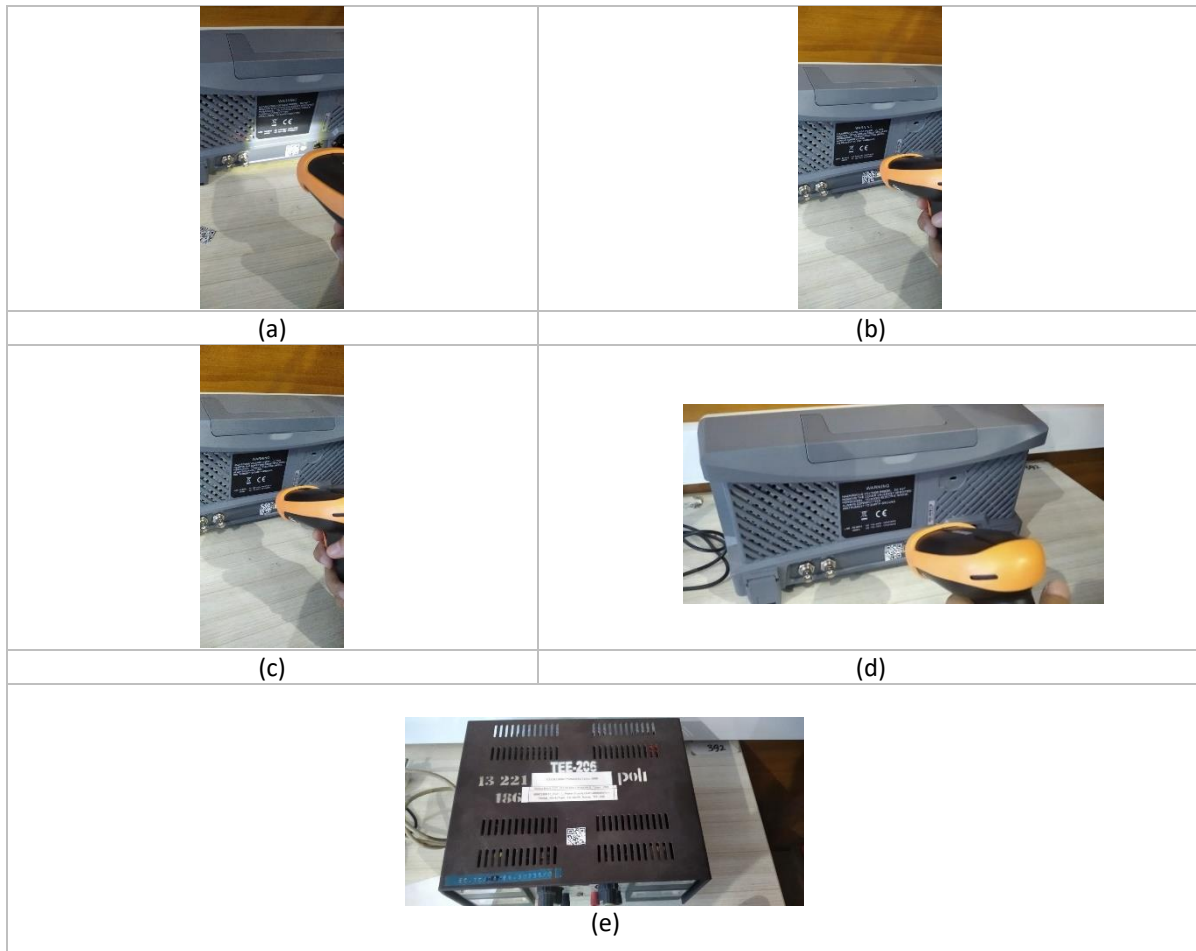


Figure 9. QR Code test at the Signal Processing Laboratory in the form of 4 oscilloscope units and 1 function generator unit

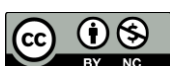
(a)Oscilloscope_04.3080141185.001; (b) Oscilloscope_04.3080141185.002;
(c)Oscilloscope_04.3080141185.003;(d)Oscilloscope_04.3080141185.004
and (e) Power supply 04.3080120017.001

Id	Id_Alrat	Nama_Alrat	Lab	Aksi
299	04.3080141185.001	Oscilloscope_01	Laboratorium Pengolahan Sinyal	Hapus
300	04.3080141185.002	Oscilloscope_02	Laboratorium Pengolahan Sinyal	Hapus
301	04.3080141185.003	Oscilloscope_03	Laboratorium Pengolahan Sinyal	Hapus
302	04.3080141185.004	Oscilloscope_04	Laboratorium Pengolahan Sinyal	Hapus
303	04.3080120017.001	Power Supply (Alat Laboratorium Fisika)_01	Laboratorium Pengolahan Sinyal	Hapus

Figure 8. Data Input Results Of Signal Processing Laboratory Equipment On The Application

Telecommunications Bases Laboratory

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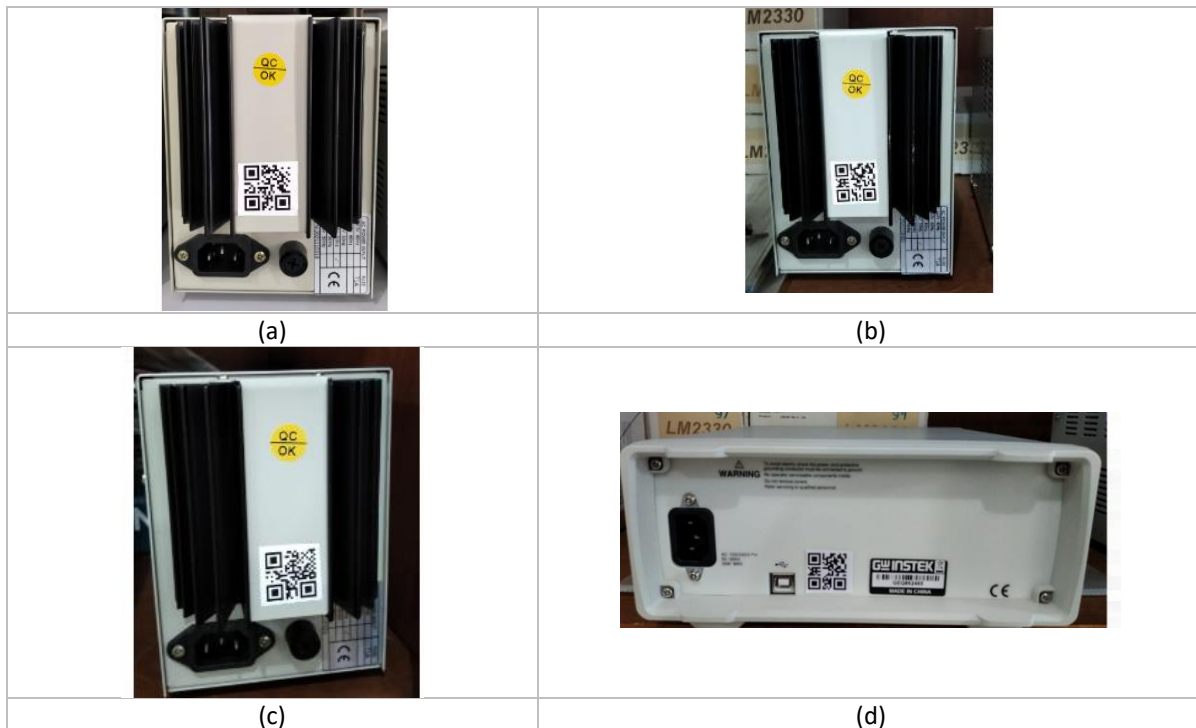


Figure 10. QR Code test at the Telecommunications Bases Laboratory in the form of 3 units DC Power Supply and 1 unit function generator (general laboratory equipment)
(a) DC Power Supply_ 03.3080302044.001, (b) DC Power Supply_ 03.3080302044.002, (c) DC Power Supply_ 03.3080302044.003, and (d) Function generator (general laboratory equipment)_ 03.3080111150.001.

Id	Id_Alat	Nama_Alat	Lab	Aksi
279	03.3080302044.001	DC Power Supply_01	Laboratorium Dasar Telekomunikasi	Hapus
280	03.3080302044.002	DC Power Supply_02	Laboratorium Dasar Telekomunikasi	Hapus
281	03.3080302044.003	DC Power Supply_03	Laboratorium Dasar Telekomunikasi	Hapus
288	03.3080111150.001	Function Generator (Alat Laboratorium Umum)_01	Laboratorium Dasar Telekomunikasi	Hapus

Figure 10. Data Input Results Of Telecommunications Bases Laboratory Equipment On The Application

Measuring And Measuring Tools Laboratory



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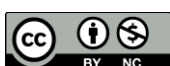




Figure 11. Figure 9. QR Code test at the Measuring And Measuring Tools Laboratory in the form 2 units function generator (general laboratory equipment), 2 units DC Power Supply, and 1 unit Power Supply (Video And Film Studio Equipment)

(a) Function generator (general laboratory equipment)_ 08.3080111150.001, (b) Function generator (general laboratory equipment)_ 08.3080111150.003, (c) DC Power Supply_ 08.3080302044.002, (d) DC Power Supply_ 08.3080302044.003, and (e) Power Supply (Video And Film Studio Equipment)_ 08.3060102038.004

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Id	Id_Alrat	Nama_Alrat	Lab	Aksi
456	08.3080111150.003	Function Generator (Alat Laboratorium Umum)_03	Laboratorium Alat Ukur dan Pengukuran	Hapus
454	08.3080111150.001	Function Generator (Alat Laboratorium Umum)_01	Laboratorium Alat Ukur dan Pengukuran	Hapus
447	08.3080302044.002	DC Power Supply_02	Laboratorium Alat Ukur dan Pengukuran	Hapus
448	08.3080302044.003	DC Power Supply_03	Laboratorium Alat Ukur dan Pengukuran	Hapus
442	08.3060102038.004	Power Supply (Peralatan Studio Video Dan Film)_04	Laboratorium Alat Ukur dan Pengukuran	Hapus

Submit

Figure 12. Figure 10. Data Input Results of Measuring And Measuring Tools Laboratory On The Application

RFID Testing

The RFID tag contains student name information. When students borrow tools and take components, the admin or laboratory technician will scan the RFID card, then the student's name will appear on the application. Testing is carried out to find out if the RFID is legible and the scan results can be displayed in a web-based application.

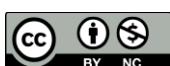
Table 6. RFID card testing

Initial conditions	The user is on the loan form page of the tool
Test scenario	Device scan RFID card
Input	Scan RFID card
Predicted results	the scan results according to the RFID code and the student's name appear in the application
Observation	Results as expected
Conclusion	Succed



Figure 13. RFID reader scan the card

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Add New Formulir Peminjaman Alat

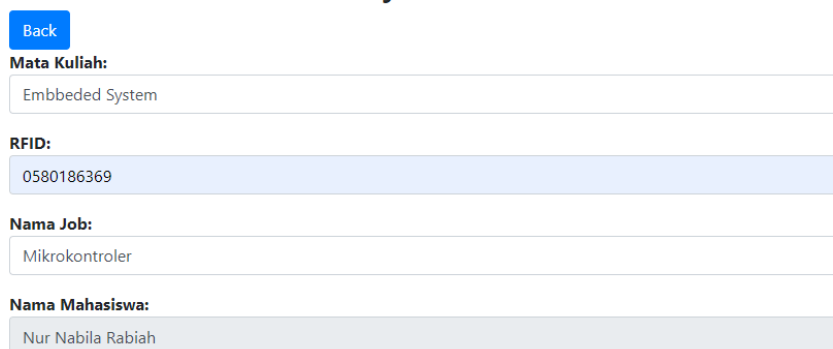


Figure 14. RFID Test results appear on application

DISCUSSIONS

The tests carried out aimed to find out whether the software and hardware are running properly. The result of scanning the QR code was successfully connected to the web application and the code from the tool/instrument appeared in the web application. In the QR code, there is a laboratory code, where this code serves to identify the equipment according to the laboratory designation thus technicians can monitor the borrowing of the equipment.

CONCLUSION

Based on the research that has been conducted, it can be concluded that the application of inventory with QR Code and RFID technology is a solution in the inventory process in the laboratory of the telecommunications engineering study program. Codification using a QR Code provides convenience in automatically collecting data into files. QR Code as tool identification helps technicians in recapping tools/instruments according to their designated laboratory, this is thus the tools are not swapped with each other. After testing with the black box method, it is concluded that the functionality of the web application meets the requirements of the procedure for borrowing laboratory tools/instruments and can provide convenience for students in borrowing equipment in a short time.

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