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A Secure *Skim Pinjaman Buku Teks* with Two-Factor Authentication for SK Jempol

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Abstract: A secure Skim Pinjaman Buku Teks (SPBT) with two factor authentication for SK Jempol is a web-based system that manage textbook borrowing and returning process. The major purpose for development of this system is to help SK Jempol SPBT management become secure and systematic. Two-factor authentication applied which is strong password and email One Time Password (OTP) can enhance the security of the system. OTP code will be sent to the user's email every time they log into the system. Throughout the system, SPBT coordinator teacher can manage SPBT prefect, student, and textbook. SPBT prefect can scan the QR code on textbook during the borrowing and returning process. QR code help the system become more efficient and systematic. The methodology used in this project is iterative waterfall. For both system interface and functionality testing result, all users were satisfied with the system's interface, and the system functionality successfully met all the requirements. At the end of the project, a secure Skim Pinjaman Buku Teks with two factor authentication will be valuable to SPBT management throughout the whole borrowing and returning process of textbook.

Keywords: Email OTP, QR Code, SPBT, Two Factor Authentication

1.   Introduction

The Ministry of Education has implemented various programs such as The Textbook Loan Scheme which better known as Skim Pinjaman Buku Teks (SPBT). The objective for this program is to ease the financial burden of the parents and to ensure the students from underprivileged families can study with complete textbooks. However, on 1st January 2008, Skim Pinjaman Buku Teks (SPBT) extended to all Malaysian students regardless of their household income in all government schools and government aided schools.

The SPBT management of SK Jempol is handled by Puan Normawati binti Abd Malek, the SPBT coordinator teacher at SK Jempol. Puan Normawati will appoint 10 SPBT prefects to help the textbook borrowing and returning process become more efficient and smoother. Textbook will be distributed to SK Jempol students at beginning of the year, and they will return it at the end of the year. The SPBT process of SK Jempol are still done manually by writing the data of textbooks in SPBT logbook.

Manual method used by SK Jempol SPBT system is not secure. The possibility for the SPBT logbook to be access, modify and dispose by unauthorized party is high because it is in hardcopy form. The second problem is SPBT coordinator teacher finds it is time consuming to write down the details of students during borrowing and returning process. Moreover, SPBT manual system of SK Jempol is unsystematic because it is hard for SPBT coordinator teacher and SPBT prefects to track down the students who damage and lost the textbook. A computerized system has significant advantages over manual system in solving all the problems mentioned.

Therefore, the objective of this system is to design, develop, and evaluate functionality of the secure Skim Pinjaman Buku Teks with two factor authentication for SK Jempol. The purpose of developing a secure Skim Pinjaman Buku Teks system with two-factor authentication is to help SK Jempol SPBT management become secure and systematic. Two factor authentication that will be implement in this system is password and email One Time Password (OTP). Then, the password will be hash and salt to make it more secure. Next, role-based access control (RBAC) will be applied to limit the access of user based on their role. Furthermore, the QR code will be used during textbook borrowing and returning process to overcome the issues faced by SPBT coordinator teacher.

This systematic system has three main users which are SPBT coordinator teacher, SPBT prefect and student. SPBT coordinator teacher can register the new SPBT coordinator teacher, SPBT prefects, students, and textbooks. SPBT coordinator teacher able to manage textbook borrowing and returning process. The second user is SPBT prefect which can manage textbook borrowing and returning process. The third user is student who can only view their textbook record.

2.   Related Work

The important topics that related to the SPBT system such as two factor authentication, password hashing and salting, role-based access control, QR code and existing system are discuss in this section.

2.1   SPBT system

Skim Pinjaman Buku Teks system or also known as SPBT system is basically a textbook management system for primary and secondary school in Malaysia[1]. SPBT program is a Malaysia Ministry of Education action to help all students at school by supplying them with textbooks for educational intention. SPBT coordinator teacher will be appointed by their school to manage SPBT system from the start until the end of the process [2]. SPBT system is beneficial for saving SPBT coordinator and SPBT prefect's time in managing SPBT process with only single mouse click.

2.2   Two Factor Authentication

Two-factor authentication adds an additional level of protection to authentication process by requesting not just email and password but with another factor that the user can provide such as smartphone or fingerprints [3] . However, the factor uses to verify the user must be from different forms. For example, to access the system the user needs to provide both knowledge factor like password and possession factor such as smart card. Moreover, user usually forget password and PIN so two-factor authentication can be applied to help protect the confidential data and prevent unauthorized user from accessing the system. Thus, two-factor authentication is more secure compared to one-factor authentication because even though the attacker knows user password, they still need the second factor for the verification process.

2.2.1   Knowledge Factor

This system applied knowledge factor as one of the two authentication factors. The type of knowledge factor that implemented in this system is password. Passwords are often used as one of the authentication factors in two-factor authentication. This is because they are widely recognized and

convenient way to verify a user's identity. Passwords are good security measure because it can be hard for others to guess. However, it is important to choose strong and unique passwords to keep it secure.

2.2.2 Possessive Factor

The method implement for possession factor is email OTP. Using email OTP as second factor of authentication provides an additional layer of protection by requiring the user to enter both password and email OTP. This makes it hard for the attacker to gain access to the system even if they have user's password. This is because the attacker needs to go through second layer of security which is email OTP to get access to system. Moreover, email OTP are convenient because most individuals have easy access to their email accounts.

2.3 Password Hashing and Salting

Store password in plaintext form or encryption technique is not secure because the attacker can decrypt and steal the password [4]. Password hashing is a process that converts password into a cryptographic representation that cannot be easily reversed [5]. The major goal of hashing a password is to store the password in a secure manner so that it cannot be recovered if the password database is compromised. Each time a user logs in, their password is hashed, and the value is compared to that stored on record [5].

Salting is a process of adding random data to the input of hash function to confuse the real password [6]. During salt generating process, password is combined with random salt key which make the hash password become stronger [5]. The salt guarantees that two users with the same password do not have the same hash value, even if they use the same hashing algorithm. Therefore, password hashing and salting work together to protect against dictionary attacks, which are a type of brute-force attack.

2.4 Role-based Access Controls

Role-based access control (RBAC) technology which first appear in 1990 is an effective and flexible access control technique. RBAC is an efficient method for overcoming the limitation of the previous access control [7]. RBAC require assigning permission and privileges to authorized users. This method secures the confidential information and guarantee that the employees only have access to data and carry out the work based on their position and roles [8].

2.4 QR Code

Nowadays, with the assistance of machinery and the advancement of core technology, QR code has become widely used in all areas of life, popular in all aspects of life, and bringing a great deal of convenience [9]. A Quick Response code which also known as QR code is a two-dimensional barcode that can be read by a smartphone or other device with a camera and a QR code reader [10]. QR codes are used to store and share information, such as URLs, text, or other data. A QR code consists of black and white squares arranged in a grid pattern on a white background as shown in Figure 1. The information is encoded in the pattern of the squares and can be read by a QR code reader by scanning the code with a camera. QR codes can be read quickly and easily, making them useful for a variety of purposes, such as sharing links to websites, displaying product information, or adding contacts to a phone [11]. QR codes can be generated and printed or displayed on screens or devices, and they can be read by any device with a QR code reader app or software. Some smartphones have built-in QR code readers that can be accessed through the camera app.

Figure 1: QR code Figure [11]

2.5 Comparison with Existing Systems

This segment will discuss about the current and existing SPBT system. The existing SPBT system then will be compare with the proposed system which is a secure Skim Pinjaman Buku Teks system with two factor authentication for SK Jempol.

2.5.1 SK Jempol system

SK Jempol currently used manual system for borrowing and returning process of textbook. Since it is done manually, all the record are kept in hardcopy form. SK Jempol system is handled by SPBT coordinator teacher and SPBT prefect. In this manual system, teacher is assigned to manage the textbook record like insert the data of textbook based on the list of the textbook. The list of textbooks is recorded by the standard for example standard 1 and standard 2. In the list of textbooks, it consists of the code, name, and price of textbook as shown in Figure 2(a). The SPBT prefect will help in handling the borrowing and returning process of textbook under supervision of SPBT coordinator teacher. The SPBT prefect will document the record of textbooks of the students by tick the box based on the textbook the student borrows and return as shown in Figure 2(b). Then the prefect needs to make sure the student put their signature and the date on the right column as the proof of the borrowing and returning process. As it is done manually, there is no element security applied.

Figure 2(a): List of textbooks for year 1

Figure 2(b): The record of borrowing and returning process

2.5.2 e-SPBTSKRIP

Another SPBT existing system is e-SPBTSKRIP which is web-based system. This system is made for SPBT management of SK Raub Indah, Pahang. The user for e-SPBTSKRIP are admin, teacher, and parents. This system is developed to make the SPBT management systematic and organize. Users need to fill in their identity card number and password in the box provided to get access to e-SPBTSKRIP system as shown in Figure 3(a). Admin can register teachers by fill in their name, and password as shown Figure 3(b). Moreover, admin can register students by using excel where the admin needs to fill

in students' identity card, birth certificate number and name as shown in Figure 3(c). Furthermore, admin can manage the textbook list by changing the standard of the students, textbook's subject, code, title, record date, and status as shown in Figure 3(d).
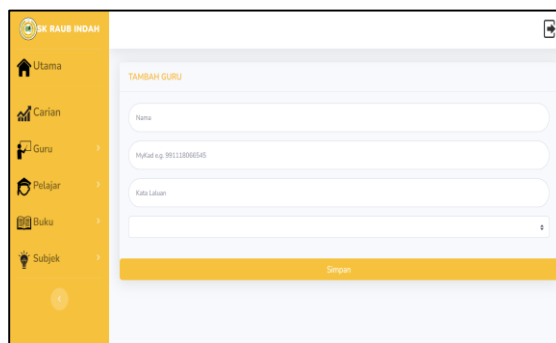

Figure 3(a): Login page

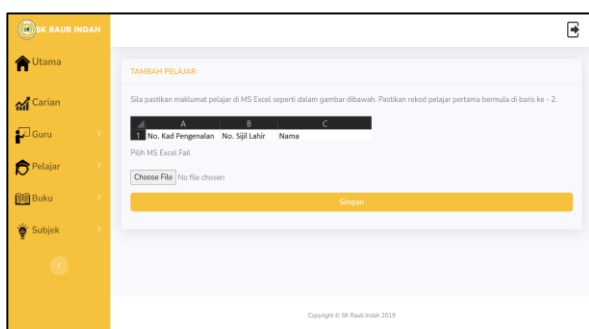

Figure 3(b): Register teacher page

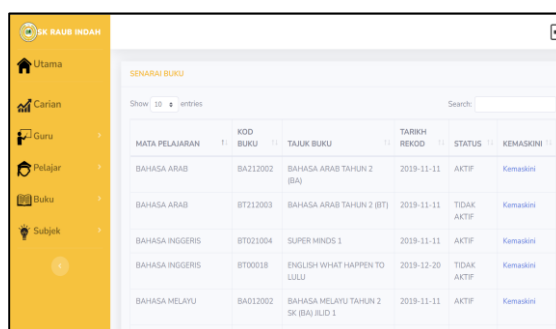**Figure 3(c): Register student page**

Figure 3(d): List of textbook page

2.5.3 Smart Skim Pinjaman Buku Teks School Operation System (SSSOS)

Smart Skim Pinjaman Buku Teks School Operation System (SSSOS) replaces the traditional method of manually recording loan information with a systematic approach utilizing a web-based management system [1]. SSSOS was evaluated at Sekolah Kebangsaan Gambang in Pahang where the SPBT coordinator helps as the tester. Before user can use the application, they must input the right username and password during login as shown in Figure 4(a). The administrator has access to the main menu, can manage users, textbook records, textbook loan, textbook return, and SPBT textbook report as shown in Figure 4(b). Meanwhile, the teacher's interface is only accessible for borrow textbook and textbook return as shown in Figure 4(c).
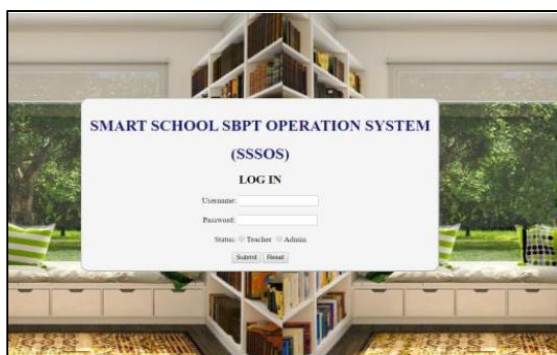

Figure 4(a): Login interface of SSSOS

Figure 4(b): Main Menu interface for Admin

Figure 4(c): Manage textbook record

**Table 1: Comparison between current system and propose system**

	SK Jempol system	e-SPBTSKRIP	SSSOS	Skim Pinjaman Buku Teks System
Type of System	Manual system	Online system	Online system	Online system
Scope of user	SPBT coordinator teacher and SPBT prefect	Admin, teacher, and parents	Admin and teacher	SPBT coordinator teacher, SPBT prefect, student.
Two factor-authentication	No	No	No	Yes, password and email OTP.
Hash and salt password	No	Information not available	No	Yes
ID number for textbook	No	No	Yes	Yes
Way of storing data during borrowing and returning process	Data are recorded in hardcopy logbook.	All data are recorded in excel and upload on system	Fill in the serial of textbook in google form	Scan QR code on textbook by using web camera.
Existence of database	No	Yes	Yes	Yes

Based on comparison between SK Jempol system, e-SPBTSKRIP, SSSOS, and propose system, it can be certainly that SK Jempol system is the only one that still using manual system while others are using online system. Next, only proposed system applied two factor authentication while others are not. Both SK Jempol system and SSSOS does not implement hash and salt password while for e-SPBTSKRIP, it is unknown either it is applied or not because no information provided. Propose system applied hash and salt password to make the system more secure. SK Jempol system and e-SPBTSKRIP does not implement ID number on their textbook while others system applied it. SK Jempol system still use traditional method during textbook borrowing and returning process where all data are recorded in hardcopy logbook. For e-SPBTSKRIP, all data are recorded in excel and upload on system while for SSSOS, the admin will fill in the serial of textbook in google form provided. To insert the data of textbook in database during borrowing and returning process of proposed system, SPBT prefect will scan QR code on the textbook. All the systems have database except SK Jempol system because it still uses traditional method. Based on the comparison, proposed system has more benefits than other systems.

3. Methodology/Framework

The methodology applied to develop a secure Skim Pinjaman Buku Teks with two factor authentication for SK Jempol is iterative waterfall, which will be used during the project. As shown in Figure 5, iterative waterfall model divides the project into smaller sections and phases where each of

its which follows the traditional waterfall model. The system is examined and evaluated at the end of every iteration, and any required modifications are made.
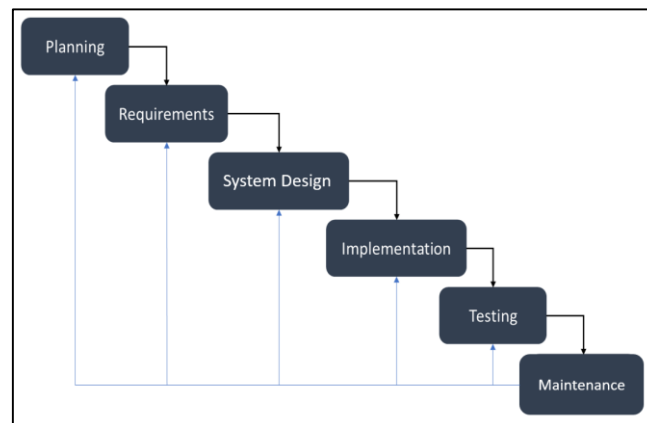
Figure 5: Iterative Waterfall model

3.1   Planning Phase

The planning phase is usually the first process of iterative waterfall model, and it includes several tasks in defining the project's scope and objectives, along with the resources and timeframe required to finish it. The potential risks or challenges that might occur throughout the project need to be identified and then develop an emergency plan to overcome it.

3.2   Requirement Phase

In the requirement analysis phase of an iterative waterfall development process, the objective is to create a precise requirement specification report describing the project's functional and non-functional requirements. The purpose of functional requirements is to explain what the system does and focus on the user requirements. In functional requirements the essentiality is compulsory, and the final product is determined by the system features.

3.3   System Design Phase

In system design phase of an iterative waterfall model, the requirement outlines in requirement analysis phase need to be interpret into a specified design for the system to be develop. System architecture, context diagram, entity relationship diagram and data flow diagram are developed in this phase to produce the detailed plans for the development of the system. Wireframe of the system and interface of database is developed by the end of system design phase.

3.4   Implementation Phase

In the iteration waterfall model, the implementation phase is when the developer begins to build and develop the system based on the plans and designs that were created in the previous phase. This phase typically involves the actual coding and programming of the system based on the requirement of the system. The implementation phase is critical to the development process because it is when the system takes shape and becomes a reality.

3.5   Testing Phase

During the testing phase, several types of testing will be conduct on the system to make sure the system functioning correctly and meets the requirements and specifications. The objectives of the testing phase are to identify any issues or bugs in the system and to ensure that it is of high quality before it is released. In the iteration waterfall model, the testing phase is typically an iterative process where the adjustments and improvements are made for the system based on the result of testing. The first test that will be test

is functionality and security testing of the system. The second test is user test which will be done by SK Jempol SPBT coordinator, SPBT prefect and student. Therefore, from all the stage of testing, the final version of the system will meet the needs and expectation of user.

3.6 Maintenance Phase

The maintenance phase in the iterative waterfall model is the phase that occurs after the testing phase. It involves ongoing support and updates to system. This may include fixing bugs, adding new features, and making performance improvements. The goal of the maintenance phase is to ensure that the system continues to meet the needs of the users and remains in good working order.

4. System Design

In this phase, functional requirement and non-functional requirement is discussed to meet the expectation from SPBT coordinator teacher, SPBT prefect, and student. In design phase, system flow design, entity relationship diagram, context diagram and data flow diagram are design to get a clear plan and visual representation of the SPBT system's structure, relationships, and data flow,

4.1 Functional Requirement

The purpose of functional requirements is to explain what the system does and focus on the user requirements. In functional requirements the essentiality is compulsory, and the final product is determined by the system features.

Table 2: Functional requirement

No	Module	Requirement	User
1	Login	Able to login using email, password, and email OTP	SPBT coordinator teacher SPBT prefect Student
2	Manage SPBT coordinator teacher	Able register, view and remove SPBT coordinator teacher.	SPBT coordinator teacher
3	Manage SPBT prefect	Able register, view, remove, and modify SPBT prefect data.	SPBT coordinator teacher
4	Manage student	Able register, view, remove, and modify student data.	SPBT coordinator teacher
5	Manage textbook	Able register, view and modify textbook data.	SPBT coordinator teacher
6	Borrow and return	Able scan QR code on textbook for borrowing and returning process.	SPBT coordinator teacher SPBT prefect
7	View record	Able view textbook record of each student and record textbook borrows and return.	SPBT coordinator teacher SPBT prefect
8	Change password	Able update and store user's new password in database	SPBT coordinator teacher SPBT prefect Student
9	Log out	Able log out from the system.	SPBT coordinator teacher SPBT prefect Student

4.2 Non-Functional Requirements

The purpose of non-functional requirements is to explain how the system works and focus on the user's expectations. In non-functional requirements the essentiality is not compulsory but advisable and the final product is determined by the system properties.

Table 3: Non-Functional requirement

Requirement	Description
Security	Two factor authentication which is password and email OTP must be implemented during login process. Password hashing and salting, and role-based access control need to be applied as system security features.
Performance	All user able to access to the system based on their role.
Availability	The system can be use when there is internet connection.

4.3 System Flow Design

In system design phase of an iterative waterfall model, the requirement outlines in requirement analysis phase need to be interpret into a specified design for the system to be develop. System architecture, context diagram, entity relationship diagram and data flow diagram are developed in this phase to produce the detailed plans for the development of the system. Wireframe of the system and interface of database is developed by the end of system design phase.

As shown in Figure 6, the user for this system is SPBT coordinator teacher, SPBT prefect and student. Every user has their own role based on their responsibility. SPBT coordinator teacher is responsible to manage SPBT prefect, student, textbook, view record, borrow and return. SPBT prefect role is to help SPBT coordinator teacher manage the textbook borrowing and returning process by scan QR code on textbook. Student can access to the system after registered by SPBT coordinator teacher and then can view their textbook record.
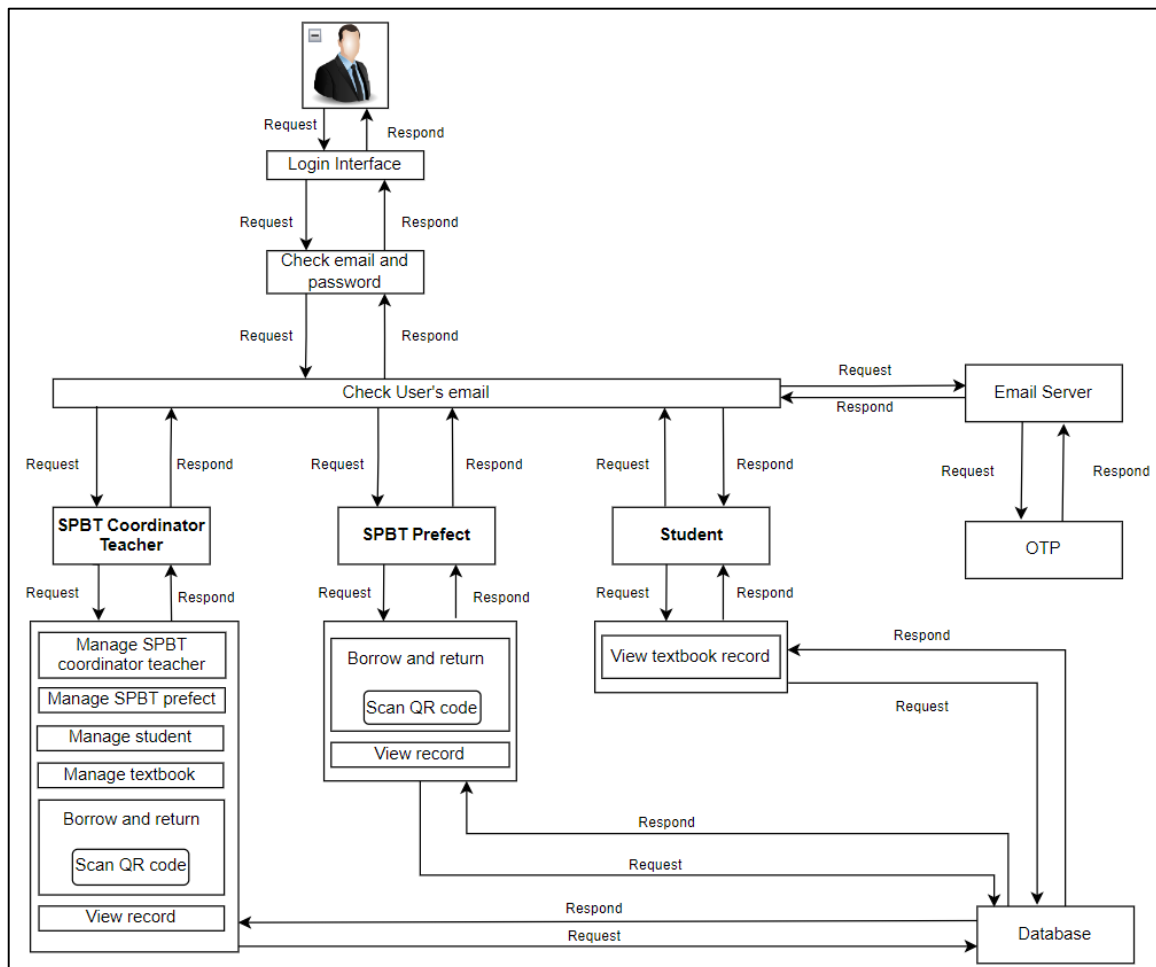
Figure 6: System flow design

4.4   Context Diagram

Figure 7 shown the context diagram of Skim Pinjaman Buku Teks System where at this stage, the full system's procedure is demonstrate including the task conducted by all three entities which are SPBT coordinator teacher, SPBT prefect and student. SPBT coordinator teacher can log in to the system and can manage SPBT coordinator teacher, SPBT prefect, textbook, and student. SPBT coordinator teacher also able to retrieve the data from the system and can manage borrow and return process by scan QR code on textbook. SPBT prefect can log in to the system and manage borrow and return process by scan QR code on textbook. Lastly, student can log in into the system and view their textbook record.
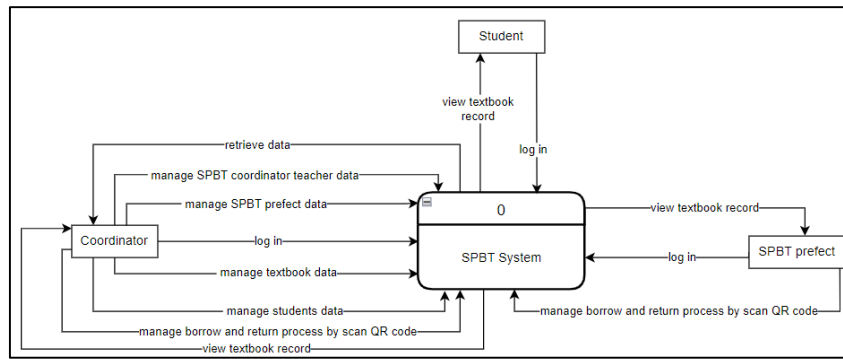

Figure 7: Context Diagram

4.5   Data Flow Diagram

Based on Figure 8, there are six processes involved in this system which are login, manage SPBT coordinator teacher, manage SPBT prefect, manage student, manage textbook and return and borrow. Seven database involves in this system which are users, coordinator, prefect, student, textbook, borrow, and return.
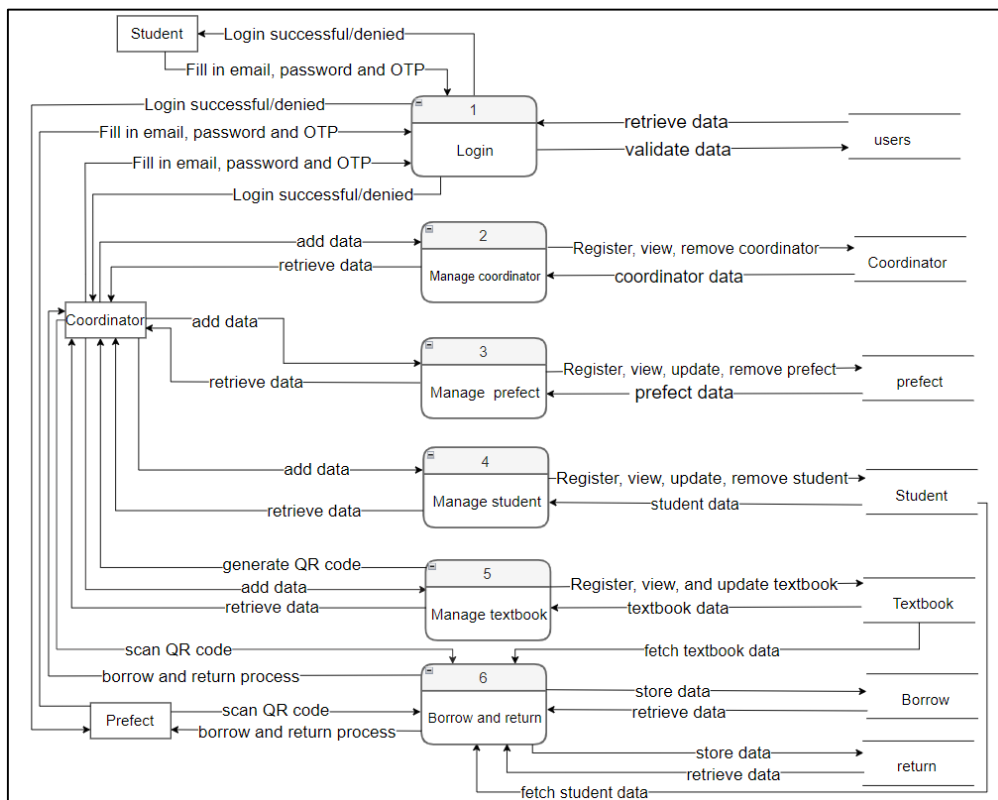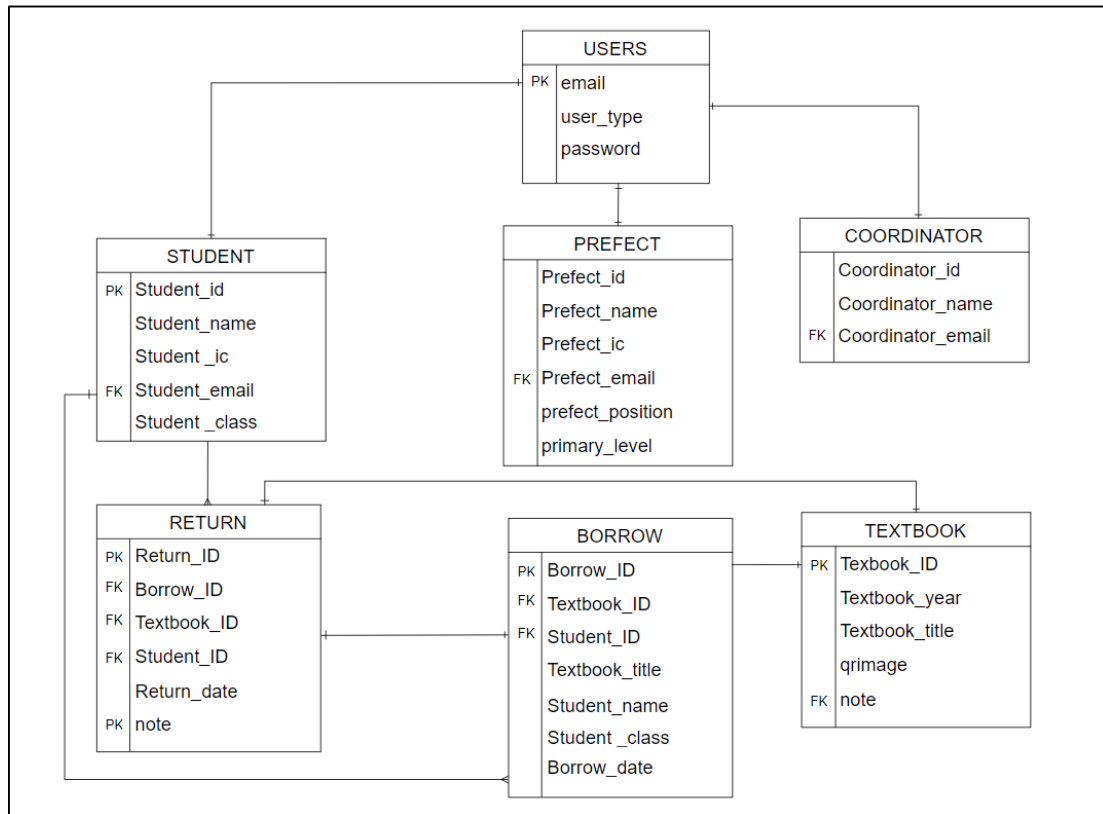

Figure 8: Data Flow Diagram

4.6   Entity relationship diagram

Entity relationship diagram which also known as ERD represent the relationship between entities in database. Figure 9 shows the ERD for Secure Skim Pinjaman Buku Teks system with two-factor authentication for SK Jempol.

Figure 9: Entity relationship diagram

5.   Implementation and testing phase

This section covers the product of system that have been develop based on user requirements. It also discusses feedback from user after user testing done by SPBT coordinator teacher, SPBT prefects and students.

5.1   Implementation

This chapter covers the security features implemented in the SPBT system, including two-factor authentication, password hashing and salting, role-based access control, and strong password validation. It also discusses the module implementation, functional testing, and user testing. The aim is to ensure the system's security, functionality, and usability for different user roles.

5.1.1   Security Module

Two factor authentication is the main security features of the system. Two factor authentication that is applied in this system is password and email OTP. During login, user need to input their email and the correct password as shown in Figure 10 (a). This is the first layer of security to get access to SPBT system. The second layer of security of the system is email OTP. After the user enter the correct email and password, the system will direct the user to the OTP verification page as shown in Figure 10 (b). The SK Jempol email will send six-digit of random code that is generated from the system to the user email as show in Figure 10 (c). The source code to generate six-digit of random code is shown in Figure 10 (d).
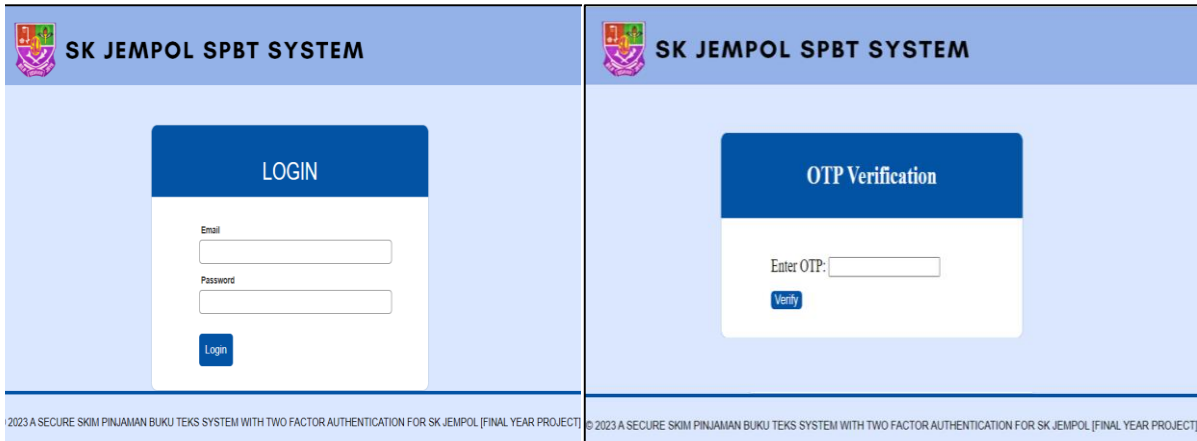
Figure 10(a): Login page   **Figure 10(b): OTP verification page**
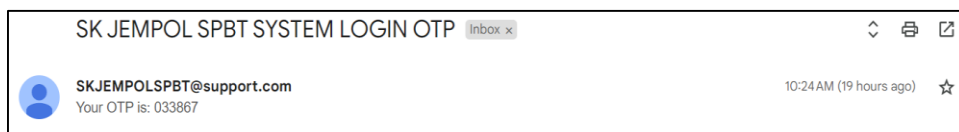

Figure 10(c): Example email that will be received by user

```
// Function to generate OTP using secret key
7 references
function generateOTP($length = 6) {
    // Generate a random secret key
    $secretKey = openssl_random_pseudo_bytes(32);

    // Generate a random OTP based on the secret key
    $otp = '';
    for ($i = 0; $i < $length; $i++) {
        $otp .= random_int(0, 9); // Generate a random digit (0-9)
    }

    return [
        'otp' => $otp,
        'secretKey' => base64_encode($secretKey)
    ];
}
```

Figure 10(d): The source code to generate six-digit of random OTP

Before storing the password in the database, the system will apply salting to password where special security phrase will be added with the password input. After that, the password will be hash and it will be store in database as shown in Figure 11(a). Based on Figure 11(b), password_hash() function is secure because robust hashing algorithm is utilized, and randomly generated salt is added to the process to prevent potential attack like rainbow tables and dictionary attack [5].

email	user_type	password
normawati.skjempol@gmail.com	coordinator	$2y$10$cpmPrwiglYxBT9AJpIPnb.sNKn8VPGD743ttVcFHRdc...
arifdanial.prefect@gmail.com	prefect	$2y$10$dfIxG4sdsfUxW46TDo/8Hufo2MwU7Co2cU2Hbl9bXyU...
prefect2@gmail.com	prefect	$2y$10$Q1hStNqwTHvGOyA25ttKXOfgzxpwa18f1Ftt71hltJZ...
nurmuhammadazib.student@gmail.com	student	$2y$10$gt80ZP82LBvtb7m65qsAFugq2CBxGLxlpCDM4iJ0v8M...

Figure 11(a): Salt and hash password save in database

```
$password = password_hash($password_1, PASSWORD_DEFAULT);
```

Figure 11(b): Password_hash function applied in the system

Role-based access control (RBAC) is one of the major security features that will be implemented in SPBT system. As shown in Figure 12, user role is divided by three which is coordinator, prefect, and student. Once user success to go through security layer of two factor authentication, they will direct to the assign homepage based on their role.

```php
// Perform role-based actions
if ($usertype === 'coordinator') {
    session_start();
    // Redirect to the coordinator dashboard
    $_SESSION['user_type'] = $user;
    $_SESSION['email'] = $email;

    header('Location: coordinator/coordinatorhomepage.php');
    exit();
} elseif ($usertype === 'prefect') {
    session_start();
    // Redirect to the prefect dashboard
    $_SESSION['usertype'] = $user;
    $_SESSION['email'] = $email;

    header('Location: prefect/prefecthomepage.php');
    exit();
} elseif ($usertype === 'student') {
    session_start();
    // Redirect to the student dashboard
    $_SESSION['usertype'] = $user;
    $_SESSION['email'] = $email;

    header('Location: student/studenthomepage.php');
    exit();
}
```

Figure 12: RBAC feature applied in SPBT system

5.1.2   Textbook registration module

Textbook register module is one of the major modules for SPBT system for SK Jempol. During registration coordinator teacher need to fill the registration form as shown if Figure 13(a). The alert message will be pop up after the textbook registration done as shown in Figure 13(b). Textbook QR code will be generate after the registration is completed and the detail about textbook is display as shown in Figure 13 (c).
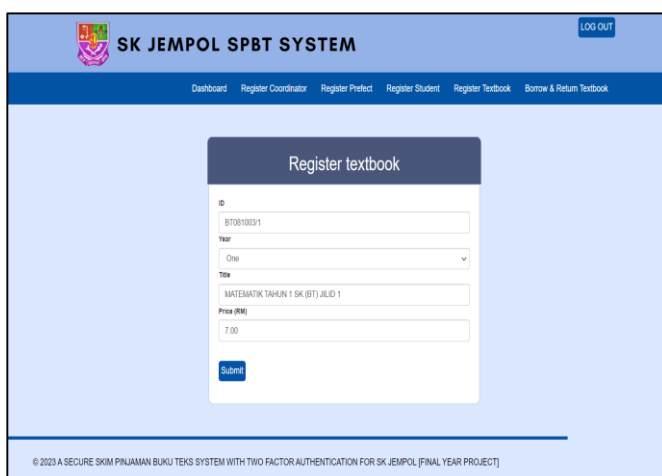
Figure 13(a): Textbook registration interface
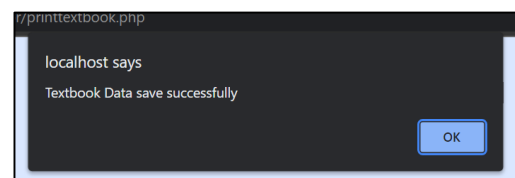
Figure 13(b): Alert message after textbook data successfully save

Figure 13(c): Textbook information interface

5.1.3 User registration module

User registration module is done by SPBT coordinator where she can register another coordinator, prefect, and student. For coordinator registration, name, email, and password need to be input to save the data in database like shown in Figure 14(a). Register information for prefect registration must have name, identity card (IC) number, email, position, primary level, and password as shown Figure 14(b). The position and primary level of prefect is assigned by coordinator teacher. Primary level divided by two which lower primary level and upper primary level. Based on Figure 14(c), the registration of student needs to have student identity (ID), name, IC number, email, class, and password. All the password is fill based on user's name and four last digits of their IC number.

Figure 14(a): Coordinator registration interface

Figure 14(b): Prefect registration interface

Figure 14(c): Student registration interface

5.1.4 Borrow and return module

During borrow process, coordinator or prefect can search and choose student on student list page as shown in Figure 15(a). On student borrow and return record page as shown in Figure 15(b), coordinator or prefect can click button borrow and it will redirect to borrow page. In the borrow page, information of student is automatically fill based on the student chosen. QR code on the textbook will be scan using QR code scanner on top of the page to get the information of the textbook borrow and save it in database as shown in Figure 15(c). During returning process, coordinator or prefect can click the return button based on textbook borrow by the student as shown in Figure 15(b). For return module, the borrow

textbook information will be fetch from database based on borrow id. During returning process, SPBT coordinator teacher and SPBT prefect need to make sure the textbook id of borrow textbook and return textbook is the same after scan the QR code on textbook as shown in Figure 15(d).

Figure 15(a): Student list interface

Figure 15(b): Textbook borrow and return record based on student

Figure 15(c): Borrow interface

Figure 15(d): Return interface

5.2 Testing

A secure Skim Pinjaman Buku Teks with two factor authentication for SK Jempol will be test in every aspect such as security and functionality of the system. There are two testing that is done for this system, which is functionality testing and user testing. Developer and user have both conducted testing for SK Jempol SPBT system. For user testing, it was evaluated by SPBT coordinator teacher, SPBT prefect, and student based on their role. Testing technique is implemented to ensured that the produced system satisfies the client's needs.
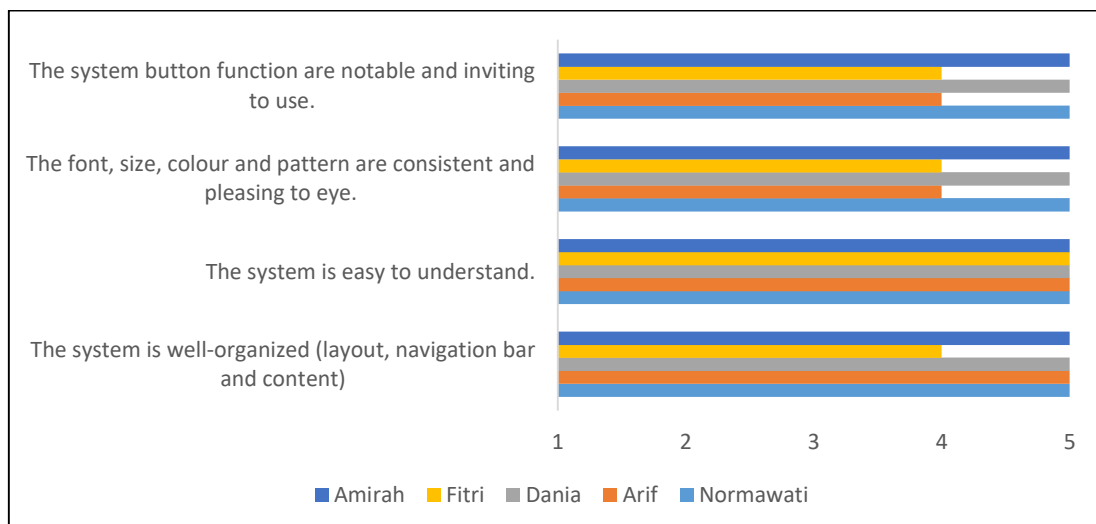
5.2.1 Functional Testing

Functional testing is done by developer to check the SPBT system functionality. From the start until the end of system developing, the goal is meet client requirement and expectation for functionality. Functionality of the system is tested to ensure that the system can run smoothly without any problem. Security testing also is done to ensure that the system is secure from any threat. The functionality testing and security testing result is shown in Appendix A.

5.2.2 User Testing

The user testing is done using Google Form that is evaluate by one SPBT coordinator teacher, two SPBT prefects, two students from SK Jempol. The google form is divided by user role where the user need to evaluate based on their module. Google Form has two section which is section A for system interface section and section B for system functionality section. In section A, user need to rate the requirement for system interface from scale one (very dissatisfied) to five (very satisfied). For section B, user must decide whether the system functionality is working or not by answer pass or fail. The testing was done to guarantee that the SPBT system was designed to meet the client's requirement.

Figure 16 shows the result of user interface testing from Google Form. All the rating given by user are in the range of satisfied to very satisfied. This indicates that SPBT system is user friendly because user is overall satisfied with system's interface.

Figure 16: Result for user interface testing

Based on the result of functional testing, all users indicate that log in, homepage and log out module are passing the requirement. SPBT coordinator teacher evaluate that all the manage module that related to SPBT coordinator, SPBT prefect, student and textbook are working smoothly. SPBT coordinator teacher and two SPBT prefect state that the borrow, return, view, and record module is operated effortlessly without any issue. For view list of textbooks borrow and return module, two students mentioned that they can see their textbook list correctly. However, SPBT coordinator give few

suggestions which is to add print QR code feature during textbook registration and display the student's debt on the textbook borrowing and returning record. Overall, the modules are functioning and working efficiently. The result of functional testing done by coordinator, prefects and students are shown in Appendix A.

6. Conclusion

In conclusion, the objectives of developing the secure Skim Pinjaman Buku Teks System with two factor authentication for SK Jempol have been successfully achieved. The SPBT system provides a secure environment for textbook borrowing and returning process, ensuring only authorized users can access it through a strong password and OTP verification. Based on the user testing results for both the system interface and functionality of the Secure Skim Pinjaman Buku Teks System with two factor authentication, it can be concluded that all users were satisfied with the system's interface, and the system functionality successfully met all the requirements. SPBT system offers several advantages, including enhanced security with two-factor authentication, smooth processes using QR codes for borrowing and returning textbooks, and systematic data management for SPBT. It reduces workload and saves time compared to the previous manual methods. Additionally, it promotes environmental sustainability by reducing paper usage.

However, there are limitations to address where the QR code need to print manually, borrowing multiple textbooks for the same student requires repetitive actions, and there is no resend OTP option during email verification. Future improvements can be made by enabling direct printing of QR codes, developing a feature for borrowing multiple textbooks without repetition, and implementing a resend OTP option. Overall, the Secure Skim Pinjaman Buku Teks System with Two Factor Authentication has successfully achieved its objectives, providing a secure, efficient, and systematic solution for SPBT management at SK Jempol.

Acknowledgment

Appendix A

Table 4: Functional Testing Result

No	Test case	Expected Result	Actual Result
1.	Database connected to the system	NO error message while connecting	Success
2.	The login and logout module can function properly	User can access their homepage by entering the username and password.	Success
3.	SESSION variable can functionally be used	The SESSION variable can be used after the correct username and password are inserted.	Success
4.	The email OTP will be sending each time user enter the system.	User will six-digit random number from the email for OTP verification page.	Success
5.	Coordinator able to register coordinator, prefect, and students	Data of the registered coordinator, prefect, and students is saved in database.	Success
6.	Coordinator able to view and manage coordinator, prefect, and students	Data of the coordinator, prefect, and students that is deleted and edited is saved in database.	Success
7.	The password will be salt and hash before stored into database	The password will be salt and hash after registration and change password module.	Success
8.	Coordinator and prefect can use QR scanners for borrow and return module	The system successfully inserts the scanned QR code details into the database.	Success
9.	Coordinator, prefect, and student can change passwords.	The system successfully updates the users table	Success

Table 5: Security Testing Result

Description	Actual Result
Password must contain alphabet, number, special character and must longer than 8 characters.	Success
System will show message of "wrong credential"	Success
Password must not be shown in the text box in the login page	Success
The email OTP will be sending each time user enter the system	Success

Table 6: User Test for Coordinator

Description	Pass	Fail
System can be executed from start to end	1	0
Coordinator able to login and log out to the system	1	0
Coordinator able to register, view, and delete another coordinator	1	0
Coordinator able to register, view, delete and update prefect	1	0
Coordinator able to register, view delete and update student	1	0
Coordinator able to register and view textbook	1	0
Coordinator able to develop QR code after register textbook	1	0
Coordinator able to view list of borrowing and returning textbook	1	0
Coordinator able to view textbook record for each student	1	0
Coordinator able to scan QR code on textbook for borrow and return module	1	0
Coordinator able to change password	1	0

Table 7: User Test for Prefect

Description	Pass	Fail
System can be executed from start to end	2	0
Prefect able to login and log out to the system	2	0
Prefect able to scan QR code on textbook for borrow and return module	2	0
Prefect able to change password	2	0
Prefect able to view list of students	2	0
Prefect able to view list of borrowing and returning textbook	2	0
Prefect able to view textbook record for each student	2	0

Table 8: User Test for Student

Description	Pass	Fail
System can be executed from start to end	2	0
Student able to login and log out to the system	2	0
Student able to change password	2	0
Student able to view list of textbooks borrow and return	2	0

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