

Development of Library Management System using Web-Based Approach

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Abstract: A Library management system is a software that is used to manage and run a library. It is important to help the library deliver its core services to the library user. The core services include showing the availability of books in the library, managing the book inventory records, issuing the borrowing record, and issuing punishment to overdue borrow records systematically. However, the library in Sekolah Kebangsaan (Perempuan) Bandar Kluang (INTEG) (SKPBK) is using a manual system to run its library. It is appointing librarians to manage the book inventory records, borrowing records, and issue penalties on overdue borrow records manually. Therefore, a new web-based library management system is needed to replace the current manual system. The proposed system will be applied in the library of the SKPBK. By using this system, the library of SKPBK can be more efficient in doing its daily operations.

Keywords: Library Management System, Web-Based System

1. Introduction

Managing library manually is a common way for many schools, and now, Sekolah Kebangsaan (Perempuan) Bandar Kluang (INTEG), SKPBK is using a manual method to run its library [1]. SKPBK is appointing teachers and students to manage the book information and borrow or return book records. After the students borrow the books, they need to insert a reading record in another system which is iQ-NILAM System. iQ-NILAM System is a system where the students are encouraged to record their reading reports online. The students need to input the book information and reading review in iQ-NILAM System, and the system will record the total number of books read by students based on the number of reading reports made by students. At the same time, the teachers can evaluate the reading reports of the students in iQ-NILAM System too.

The manual and traditional way of running a library is no longer effective and efficient [2]. The main three issues if the implementation of existing manual system does not change to the new system are listed as follows

- By using a manual system to run a library, the library needs a lot of manpower to manage the book inventory record to deliver better service to library users [3].
- The borrow book record tracking process is difficult as the library cannot search for the exact record for a student with handwritten records [4]. Managing late returning books process can be error prone because miscalculation of due date is very likely to happen [5].
- The process of creating a reading report in the iQ-NILAM System might be a burden for the students or their parents as they need to insert their reading report together with book information such as book name, book author, book pages and many more in the iQ-NILAM System.

Therefore, the objectives of this proposed system are to:

- Design a library management system using client-server approach.
- Develop a library management system using a web-based approach.
- Test the developed system in SKPBK library.

The proposed system will be used by the library of SKPBK. All the students and teachers at this school will be the target users for this system. There are four types of system users which are student, teacher, librarian and administrator and each of them will have different permissions to carry out different operations for the library. The system is designed to have six function modules. Table 1 shows the functional modules and their descriptions.

Table 1: Functional modules descriptions

| No | Functional Requirements | Description |
|----|-------------------------------|---|
| 1 | User Management Module | Allow sign up, login and logout functions. Also, will create four types of user groups which are student, teacher, librarian and library administrator. Student, teacher and librarian user groups are managed by administrator user group. |
| 2 | Book Management Module | Allow librarians to manage book categories and book information. This module will display a book catalog at system home page and allow students to search for a particular book. |
| 3 | Borrow and Return Book Module | Allow librarian to carry out borrow or return book operations and allow students to check book availability which contains current book borrower information, borrow date and due date. The students can choose whether to create a reading report or not based on the book borrowed during borrowing book process. |
| 4 | Reading Report Module | Allow students to create reading reports based on books borrowed and allow teachers to evaluate reading report created by the students. |

Table 2: Functional modules descriptions (cont)

| No | Functional Requirements | Description |
|----|-------------------------|---|
| 5 | Penalty Module | Allow the library to charge money as penalty for late returning book based on the due date created by borrow book module |
| 6 | Reporting Module | Allow all types of system users to view the borrowed record, penalty record, total number of books read and reading record summary of students in different ways based on different system user groups. |

The expected outcome from this project is that SKPBK will have a web-based library management system for its library. This library management system can solve the problems stated before by letting the library maintain book information, borrow or return book records systematically. Then, the library can generate a borrow record report and penalty record for the students. The students and teachers at the school can also manage their reading report based on the books borrowed from the library. The system will generate reading report similar to the iQ-NILAM System that shows the book reading count for each student from time to time.

This proposed system is significant for the library of SKPBK because it can help SKPBK run the library smoothly and systematically. By applying this system, the library can increase the effectiveness and productivity by eliminating time consuming and repeating activities in running library operations such as keeping book records, manage borrow or return books, keeping borrow book records and calculate penalty amount for overdue borrow records [6]. Also, the students and teachers at this school will find it easier to create reading report based on the book borrowed by students.

This section is mainly about project background, existing process and issues, proposed solution together with its objective, scope, expected outcome and project significant. Section 2 discussed the related study for library management system. Section 3 discusses the methodology used to develop this project. Section 4 discusses the discussion and implementation of this project and Section 5 discusses the conclusion of this project

2. Related Work

The proposed system is a web-based system and developed using client-server architecture. The proposed system is hosted on Firebase web hosting and running on a Firebase cloud firestore which is a NoSQL database. Firebase is a web application and mobile application development and hosting platform owned by Google and it is used to host single-page application.

A single-page application is a web application that does not reload the entire page when a user requests data from server. However, only a part of the web page is reloaded and changed whenever user requests new data from server [7]. NoSQL database stands for Not only SQL database. It is a non-relational, schemaless database that stores data in key-value format [8]

2.1 Study on similar system

This project reviews three similar library management systems and discovered the features and advantage of each system and compare them with the proposed system. The similar systems are National Library Malaysia System, Library Tunku Tun Aminah System and the Library University Malaya System. Table 3 shows the comparison between 3 related systems and the proposed system.

Table 3: Comparison between 3 related systems and the proposed system

| System Feature | System A | System B | System C | Proposed system |
|--|-------------------|---|-------------------------------|-------------------------------|
| Target User | Malaysia citizens | Students of University Tun Hussein Onn Malaysia | Students of University Malaya | Teacher and students of SKPBK |
| System scale | Big | Big | Big | Small |
| Introduce the library | Yes | Yes | Yes | Yes |
| Provide book catalog | Yes | Yes | Yes | Yes |
| Search for book function | Yes | Yes | Yes | Yes |
| Check for book availability | Yes | Yes | Yes | Yes |
| Borrow and return book | Yes | Yes | Yes | Yes |
| Provide online resources | Yes | Yes | Yes | No |
| Reserve unavailable book | No | Yes | Yes | No |
| Create reading report based on book borrowed | No | No | No | Yes |
| Penalty on late return book | Yes | Yes | Yes | Yes |
| Payment gateway for fine due to late return book | Yes | No | Yes | Yes |
| System A: National Library Malaysia System | | | | |
| System B: Library Tunku Tun Aminah System | | | | |
| System C: Library University Malaya System | | | | |
| Proposed system: Library Management System for SKPBK | | | | |

3. Methodology

The software development lifecycle used to develop this project is agile methodology. This is because agile methodology can let the project react to the changing requirements, target user feedbacks and target user satisfaction based on the system prototype presented to target users (Madan Singh, Naresh Chauhan, Rashmi Popli, 2019). By involving the target users in the project development cycles, the risk of project failures can be significantly reduced.

There are six phases in agile methodology. The phases are requirement phase, design phase, development phase, testing phase, deployment phase and review phase. After the first agile cycle, the design phase, development phase, testing phase, deployment phase and review phase are repeated for two times to modify the system prototype based on target user requirements and comments after they review the system prototype.

In requirement phase, an online interview session is held between the authors of this paper and Mr. Saifulnizam bin Saari who is the teacher of SKPBK. The purpose of the online interview is to elicit user requirements for the proposed system. Then, the requirements gathered in this phase is carried on to design phase. In design phase, the system developer designs the system architecture by analyzing the user requirements. At the end of this phase, the functional requirements for this project, context diagram, data flow diagram, entity relationship diagram and wireframe of the system will be the supporting documents for the system developer to develop the system program code in the next phase.

In development phase, the system developer develops the program code for the proposed system in localhost environment. Then, the system developer carries out an alpha test against the system to confirm that the system process flows that a system user might perform are free of errors. Alpha test is carried out by the system developer, and it is the first testing phase of a system to make sure the system meets functional requirements and work without errors. The developer will proceed to fix all the errors that come out during the testing phase before going into the next phase.

In deployment phase, the system developer deploys the system prototype from the local environment to the live server so that the system prototype is accessible by target users. The system developer will then demonstrate the system prototype to the target users, and the target users are allowed to explore the system on their own to get familiar with the features of this system before next phase. In this phase, the target users' feedback and target users' satisfactory level on the system prototype are collected. The feedback given by the target users will be studied and reviewed to improve and amend the system prototype.

The system development workflow is shown in Table 4.

Table 4 : System development workflow

| Phase | Task | Output |
|-------------------|---|---|
| Requirement phase | <ul style="list-style-type: none"> • Gather requirement • Determine the project schedule, activities and output | <ul style="list-style-type: none"> • Project proposal • Develop Gantt chart |
| Design phase | <ul style="list-style-type: none"> • Design system flow, context diagram, data flow diagram • Design wireframe for user interfaces | <ul style="list-style-type: none"> • Context diagram, • Data flow diagram • Wireframe for user interfaces • Entity relationship diagram |
| | <ul style="list-style-type: none"> • Design entity relationship diagram • Analyse user requirement to get functional requirements • Carry out feasibility study on functional requirements | <ul style="list-style-type: none"> • Functional requirements |

Table 5: System development workflow (cont)

| Phase | Task | Output |
|---------------|--|---|
| Develop phase | <ul style="list-style-type: none"> • Develop program code using HTML, CSS, JavaScript • Launch the system prototype in local environment | • System prototype |
| Testing phase | <ul style="list-style-type: none"> • Alpha test against system prototype • Fix error if any error is found during the alpha test | • System prototype |
| Deploy phase | <ul style="list-style-type: none"> • Deploy the system prototype in live server | • System prototype is available in live server and can be accessed by target user |
| Review phase | <ul style="list-style-type: none"> • Demonstrate the system prototype features to target user • Target user explores and reviews the system prototype • Target user gives feedback and satisfactory level on system prototype | • Feedback and satisfactory level on system prototype |

3.1 Functional testing

Functional test is carried out to make sure the developed system achieves all the functional requirements requested by the users. Functional test is done by the system developer against all of the functional modules of the system. Functional testing is carried out by following the steps which are identify the functional modules to be tested, create input data for the tested function, expect the ideal system output, execute the test case, compare the expected output with the actual system output and lastly, modify the system code if there are errors detected or the ideal system output is different from the expected system output.

Table 6 shows the functional test survey form and its result. The result and feedback are filled in by system developer. The system developer carries out functional test to make sure every requirement requested by the users are completely applied to the developed system and make sure the system is free of errors. If the system does not produce the ideal system output, the system developer will fix the system in this phase until the system can produce the ideal system output

Table 6: Functional testing form and result

| No | Functional Modules | Test cases | Result | Feedback |
|----|------------------------|--|--------|----------|
| 1 | User Management Module | Administrator can view, add edit student, librarian, teacher account. | Pass | None |
| | | Administrator, librarian and teacher can login to their accounts. | Pass | None |
| | | Student can sign up and login to their accounts | Pass | None |
| | | Student can login to their account by scanning barcode on their member cards | Pass | None |

Table 7: : Functional testing form and result (cont)

| No | Functional Modules | Test cases | Result | Feedback |
|----|------------------------------------|--|--------|---|
| 2 | Book Management Module | Administrator can view, create, edit and delete book. | Pass | None |
| | | Barcode can be generated and printed. | Pass | None |
| | | Student can view book catalog and book details. | Pass | None |
| | | Student can search for a particular book by using book name as search keyword. | Pass | Can search book by starting string only |
| 3 | Borrow Book and Return Book Module | Librarian can help students borrow book and return book. | Pass | None |
| | | Librarian can scan the book barcode to capture the book barcode data. | Pass | None |
| | | If the borrowed book is overdue, the students must pay for the penalty before they can return the borrowed book. | Pass | None |
| | | The student can only borrow maximum 2 books at the same time | Pass | None |
| 4 | Reading Report Module | Students can create, edit, view reading report based on the book borrowed by them. | Pass | None |
| | | Students can view the NILAM medal count. | Pass | None |
| | | Teacher can view, evaluate the reading report created by the students. | Pass | None |
| 5 | Penalty Module | The students can pay for his penalty fine if they have overdue book record. | Pass | None |
| | | The system can calculate the penalty fine based on the overdue days. | Pass | None |
| | | The maximum penalty fine for a student is RM10 for 2 overdue borrow book records | Pass | None |
| 6 | Reporting Module | The administrator can view the overall borrow record, penalty report and reading report based on the selected date period. | Pass | None |

3.2 Non-functional testing

Non-functional testing is conducted to check the non-functional aspects of the developed system. In this project, the non-functional testing is carried out to test the readiness of the developed system which is not tested in functional testing. Table 8 shows the aspects of non-functional testing and their results.

Table 8: Non-functional testing and result

| No | Non-functional testing aspects | Result |
|----|--------------------------------|--|
| 1 | Security | The developed system will check for user session when the user wants to access some parts of the system. |
| 2 | Availability | The developed system can be access anytime anywhere as long as the users have internet connection. |
| 3 | Usability | The developed system has instruction text, informative text and modal pop-up box to tell user what to do and the current status of the system. |
| 4 | Reliability | The developed system can execute all the functional modules without failures and errors. |
| 5 | Efficiency | The developed system can response to users' interactions and perform any CRUD actions with maximum 3 seconds waiting time, but the waiting time depends on the users' internet connection speed. |
| 6 | Interoperability | The developed system can be accessed by using any up-to-date browsers in computers, laptops and mobile devices. |
| 7 | Load | The developed system can handle 50000 read requests, 20000 write and delete requests on Firebase Firestore database daily based on the free plan provided by firebase web hosting |

4. Results and Discussion

The result of analysis and design is shown by using system flowchart, data flow diagram and entity relationship diagram, some user interfaces and lastly user acceptance test.

4.1 Context diagram and data flow diagram

Context diagram is also known as level 0 data flow diagram. It is illustrated to define the boundaries of the system. It defines the flow of data and information between the system and the entities. Figure 1 shows the context diagram for the proposed system.

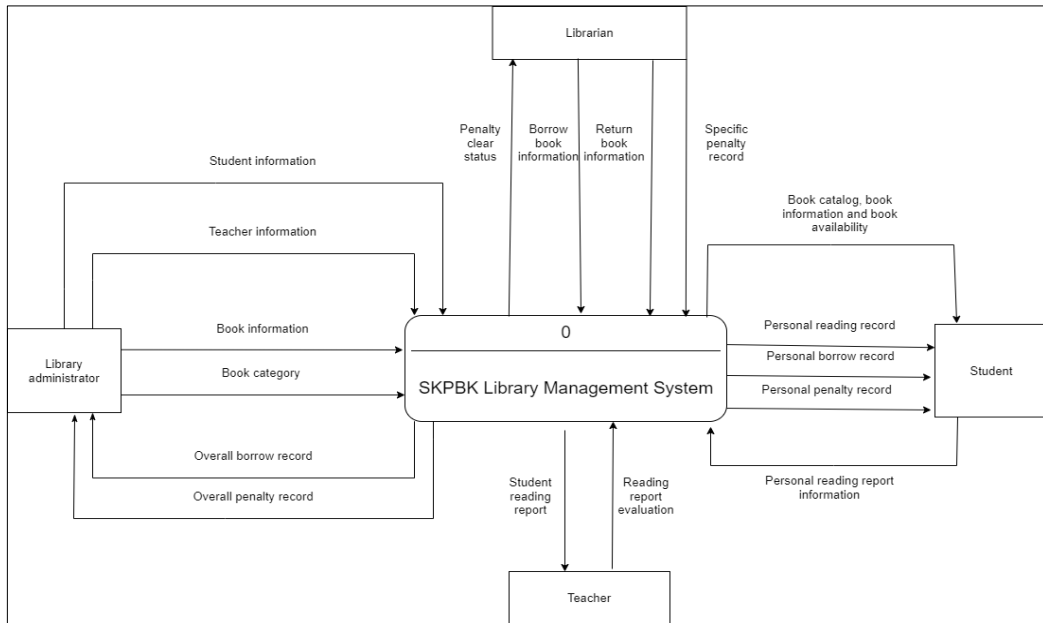


Figure 1: Context diagram of the developed system

Data flow diagram represents the data flow and process in a system. It gives insight on the inputs and outputs for all entities and the system process. Level 1 data flow diagram level 1 further explains the context diagram by illustrating entities, process, data flow and data store to describe the functions of the system. Figure 2 shows the level 1 data flow diagram of this system.

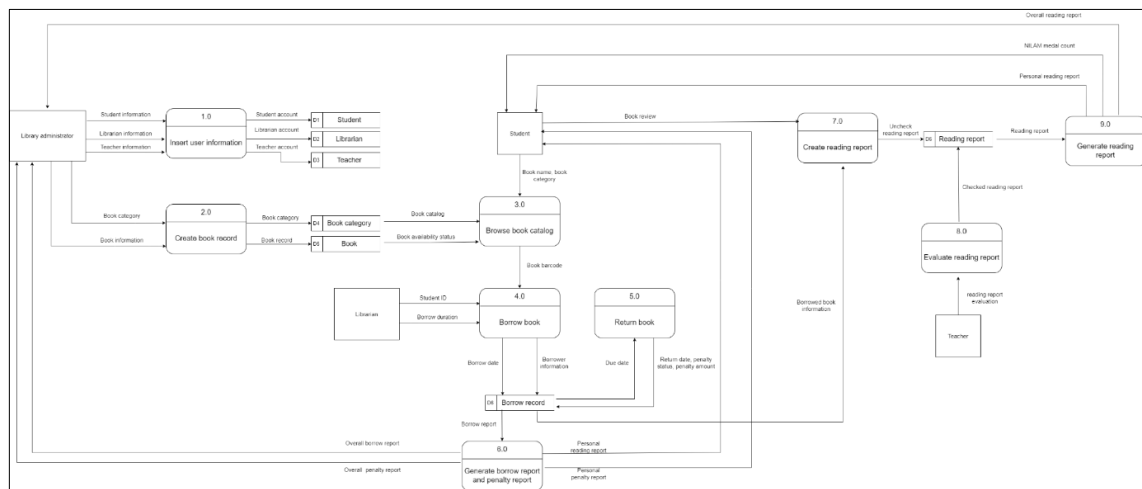


Figure 2: Level 1 diagram for the developed system

4.2 System flowchart

System flowchart is a diagram that describe the system process flow. Figure 3 shows the flowchart of this system. Based on Figure 3, the processes with manage keyword such as "manage reading report", "manage book category and book information", "manage student, librarian and teacher information" include the CRUD action for the respective data.

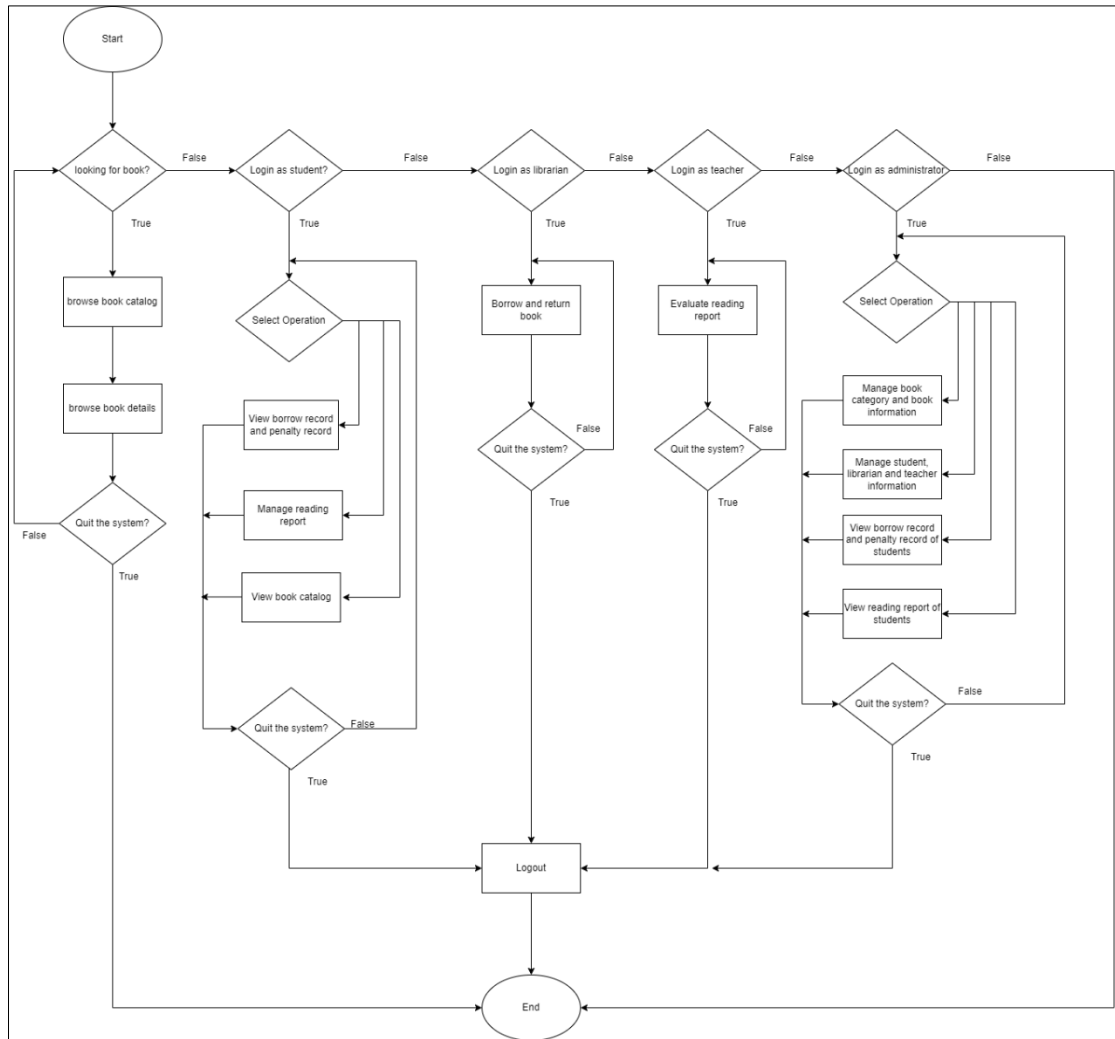


Figure 3: System flowchart for the developed system

4.3 Entity relationship diagram

Entity-relationship diagram is used to define the data or information that are created, stored and used by as system. Figure 4 shows the entity relationship diagram for this system. The Figure 4 only shows the primary key and foreign key for the entity and the relationships between the entities.

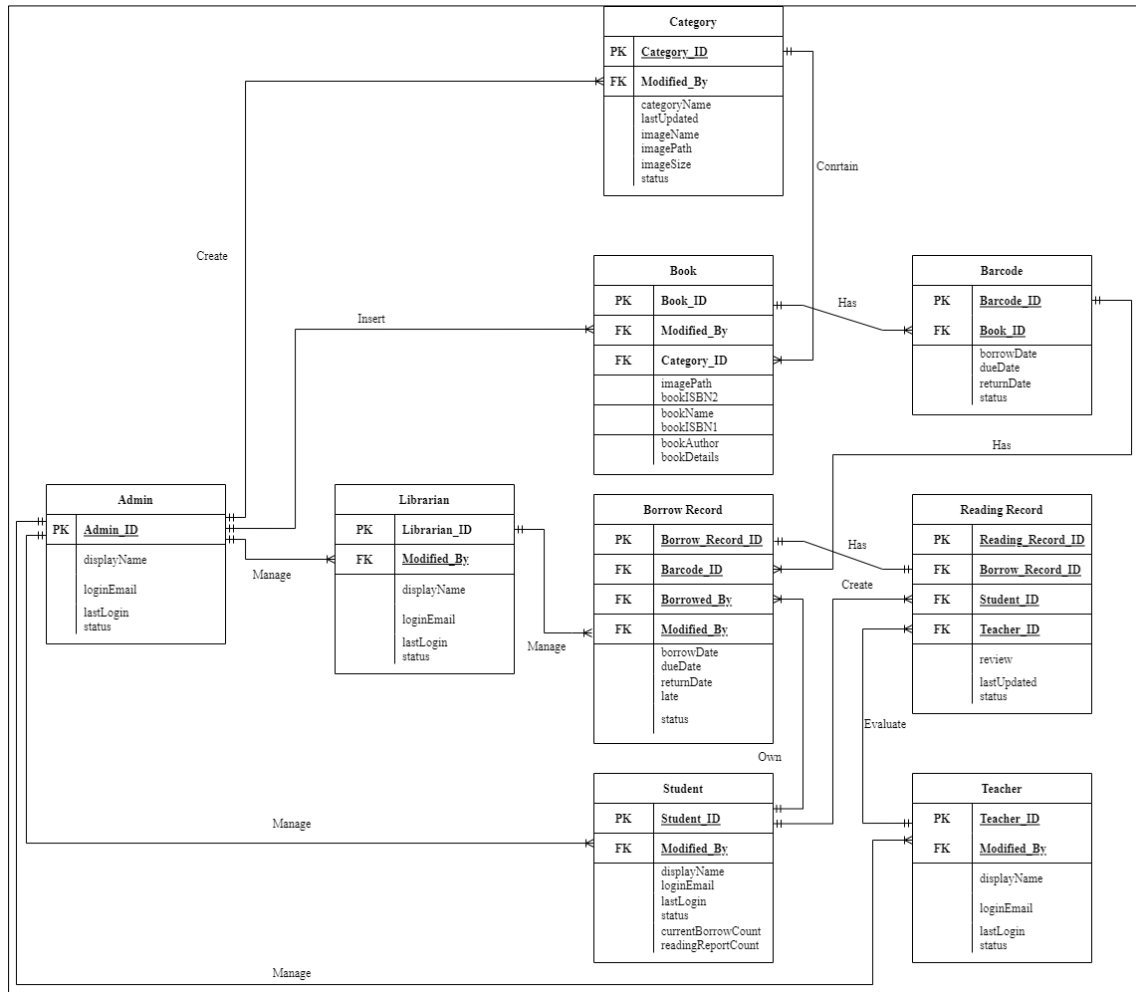


Figure 4: Entity relationship diagram

4.4 User interface

The proposed library management system has been successfully designed and developed. Some of the user interfaces developed system is being discussed by modules in this section.

Figure 5 shows the user interface of student login under user management module. The student needs to input the username and password to login to this system. For librarian, teacher and library administrator, their user interface to login to this system is shown in Figure 6. Based on Figure 6, the librarian, teacher and library administrator need to input their username, password and position in order to login to this system.

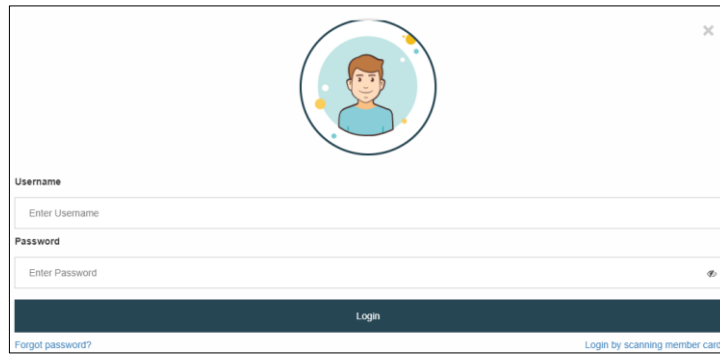


Figure 5: User interface of student login

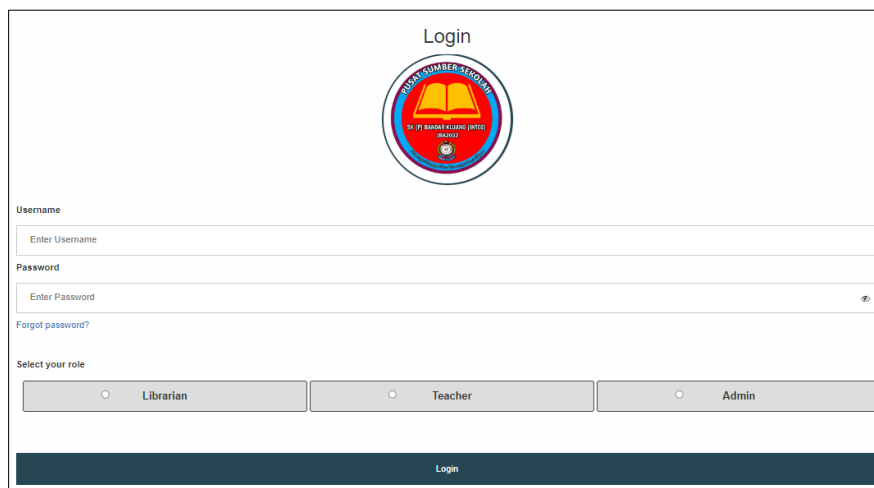


Figure 6: User interface for librarian, teacher and library administrator login

Figure 7 shows the user interface of book catalog under book management module. The system can display book catalog in three ways which are the default way as shown in Figure 7, display book by category and display book by searching with keywords.

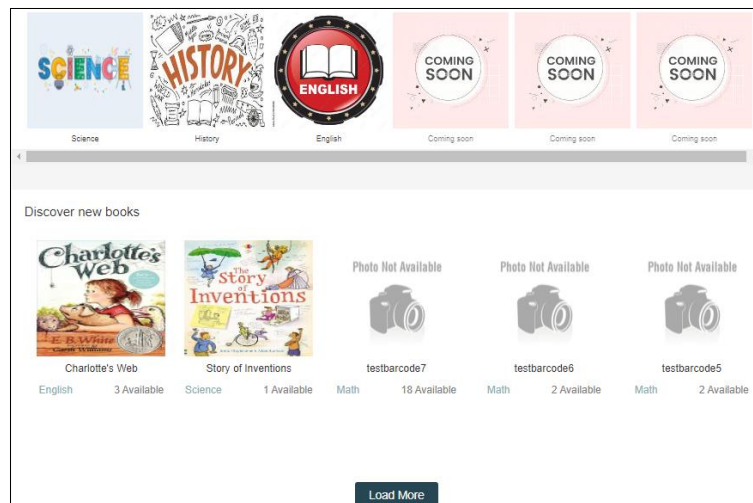


Figure 7: User interface of book catalog

Figure 8 shows the user interface of borrow book under borrow book and return book module. Figure 9 shows the user interface of return book under borrow book and return book module. These two processes require librarian to input different data.

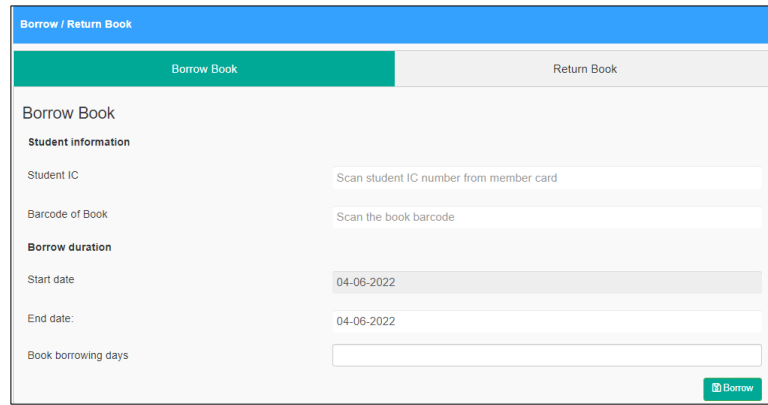


Figure 8: User interface of borrow book

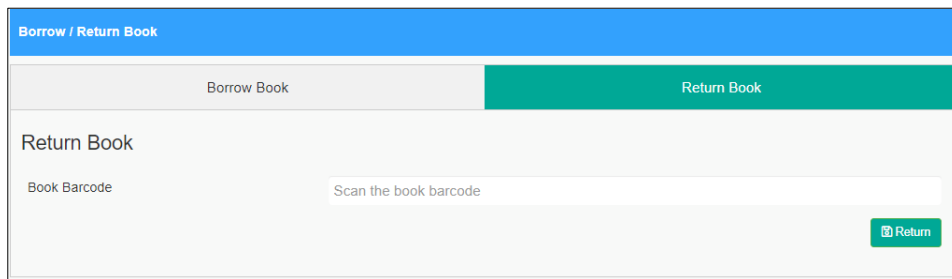


Figure 9: User interface of return book

Figure 10 shows the user interface of displaying the reading report created by students in teacher site meanwhile

Figure 11 shows the user interface to create reading report in student site.

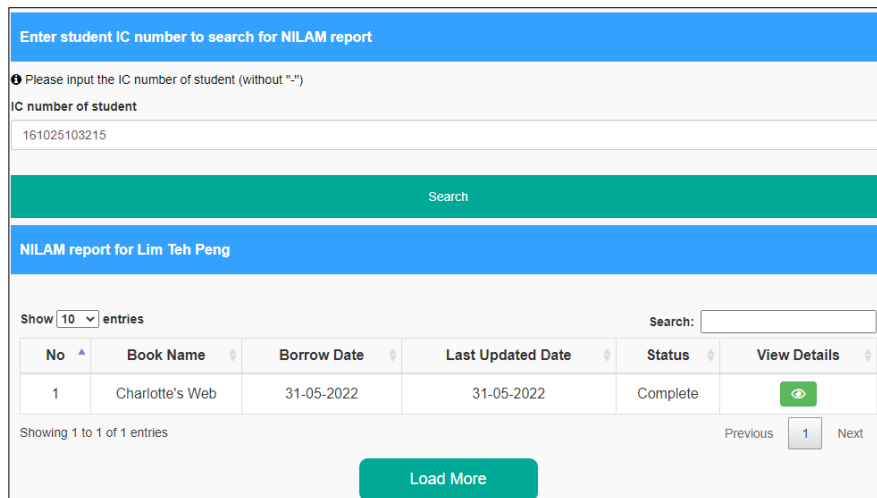


Figure 10: User interface of displaying reading report in teacher site

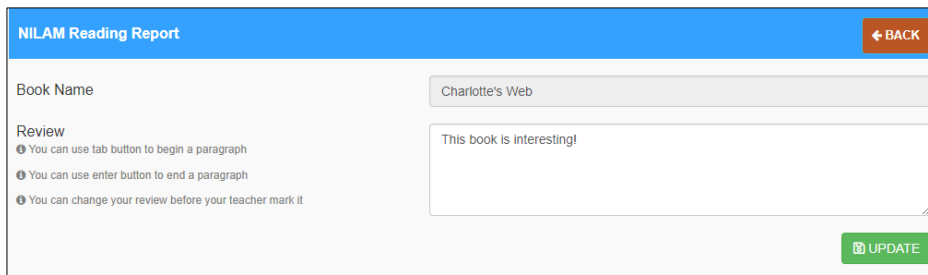


Figure 11: User interface of creating reading report in student site

Figure 12 shows the user interface of displaying overdue borrow book records of a student under penalty module. The librarian can then clear the penalty status of the borrow book records after collect penalty fine from the student.

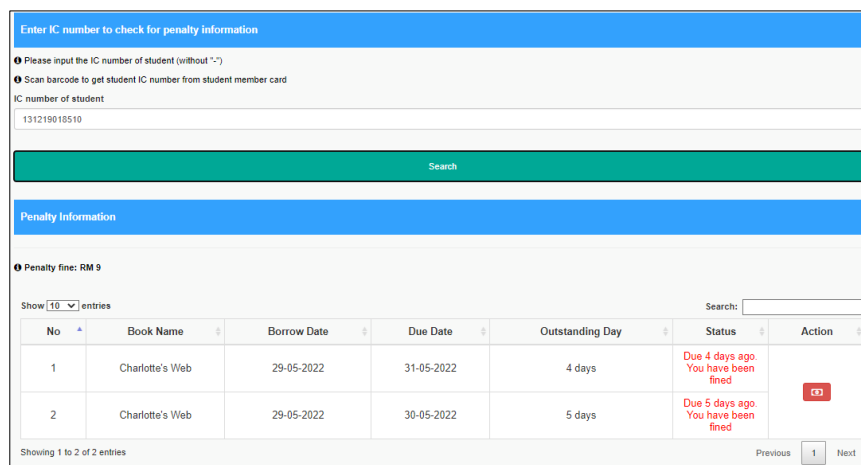


Figure 12: User interface of displaying overdue borrow book records

Figure 13 and

Figure 14 shows the user interface of displaying all borrow records of student using show all method under reporting module. The library administrator needs to select the date range for the system to display the records in show all method while additional IC number of student is required in the search by IC number method. Similar user interfaces are used to view penalty records and reading reports of students under this module.

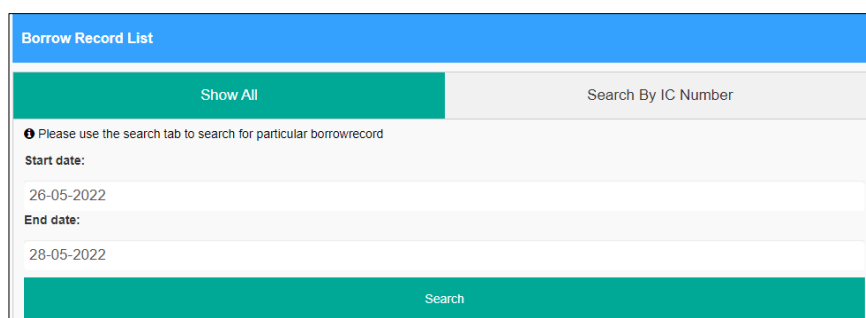


Figure 13: User interface of displaying all borrow records using show all method I

| Borrow Record between 26-05-2022 and 28-05-2022 | | | | | | | |
|---|---------------|---------------------|-------------|----------------|------------|--|-------------------|
| Show 10 entries | | | | | | | |
| No | Student Name | Book Name | Borrow Date | Return Date | Due Date | Status | View NILAM Report |
| 1 | Lim Teh Peng | Charlotte's Web | 27-05-2022 | 27-05-2022 | 29-05-2022 | Returned | |
| 2 | Lim Teh Peng | Charlotte's Web | 27-05-2022 | Deprecated | 28-05-2022 | Deprecated on 29-05-2022 Reason: test deprecate | |
| 3 | Wong Fei Hong | Story of Inventions | 26-05-2022 | Not yet return | 28-05-2022 | This student has paid the fine for return book late. Fine amount: RM 3 | |

Showing 1 to 3 of 3 entries Previous **1** Next

Figure 14: User interface of displaying all borrow records using show all method II

4.5 User acceptance test

The user acceptance test is carried out to determine whether the user can accept the developed system or not. In this project, the user acceptance test is carried out to check whether the user is satisfied with the developed system regarding user-friendliness and ease of use. All user groups which are students, librarians, teachers and library administrator are randomly selected to answer a survey form to evaluate the user acceptability on the developed system.

The user acceptance test is conducted in a rating scale survey that use the rating from 0 to 4 to measure the user acceptance on the developed system. The survey form consists of two sections which are Section A and Section B. All user groups will answer the same Section A, but Section B is specially designed for different user groups because each user groups have different privileges and accessibility to access different web pages for this system. The result obtained are analyzed separately based on different user group.

Table 9 shows the 5 questions that are included in Section A. The users need to answer the survey by giving rating from 0 to 4 which means very unsatisfied or strongly disagree to very satisfied or strongly agree.

Table 9 : Section A of user acceptance test survey form

| No | Questions | Rating (from 0 to 4) |
|----|---|----------------------|
| 1 | Are you satisfied with the user interface? | |
| 2 | Are you satisfied with the website layout? | |
| 3 | Are you satisfied with the instruction, informative text in the system? | |
| 4 | Are you satisfied with the navigation of the system? | |
| 5 | The system is easy to learn and use? | |

Table 10 shows four sets of questions in Section B that are different for all user groups. The different question sets in Section B are designed to investigate the user acceptance of specific tasks involved by the related user group only under each functional module. The users need to answer the survey by giving rating from 0 to 4, which means very unsatisfied or strongly disagree to very satisfied or strongly agree

Table 10 : Section B of user acceptance test survey form

| No | Modules | Specific tasks | Rating (from 0 to 4) |
|---------------------------------------|------------------------------------|--|----------------------|
| Section B (For student) | | | |
| 1 | User management module | Register, login, scan member card to login | |
| 2 | Book management module | Browse book catalog, view book information and availability | |
| 3 | Borrow book and return book module | View borrow book records and check borrow record status | |
| 4 | Reading report module | Create reading report and view number of reading report done | |
| 5 | Penalty module | View penalty records | |
| Section B (For librarian) | | | |
| 1 | User management module | Login | |
| 2 | Borrow book and return book module | Execute borrow book and return book process | |
| 3 | Penalty module | Clear penalty status | |
| Section B (for teacher) | | | |
| 1 | User management module | Login | |
| 2 | Reading report module | View student reading report and evaluate them | |
| Section B (For library administrator) | | | |
| 1 | User management module | Register student, librarian and teacher and manage their record | |
| 2 | Book management module | Manage book category and book information | |
| 3 | Reporting module | View records of borrow report, penalty record and reading report | |

There are 51 respondents who answered the survey of user acceptance test. Among the 51 respondents, 20 of them are students and librarians, 10 of them are teachers and one of them are library administrator. The user acceptance test result of Section A is shown in Figure 15.

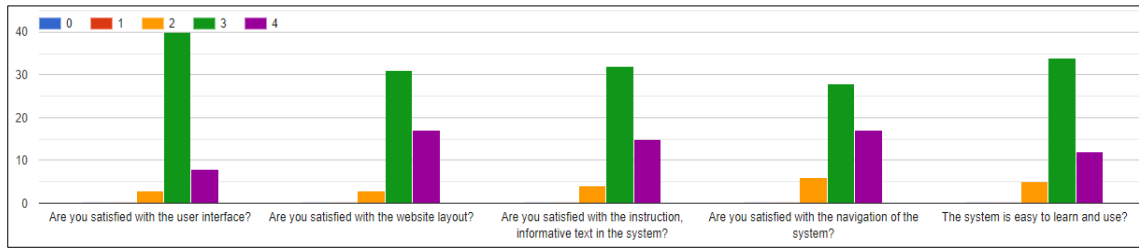


Figure 15: Result of user acceptance test of Section A

The results of user acceptance test for all user groups of Section B are shown below.

Figure 16 shows the user acceptance test result of student.

Figure 17 shows the user acceptance test result of librarian.

Figure 18 shows the user acceptance test result of teacher. Figure 19 is the user acceptance test result of library administrator. Based on the result gathered from the user acceptance test, most of the respondents gave positive reviews (rating 3: satisfied or agree) for all questions. So, a conclusion can be made that the developed system is good in terms of user-friendliness, and it is acceptable and can be used by the users.

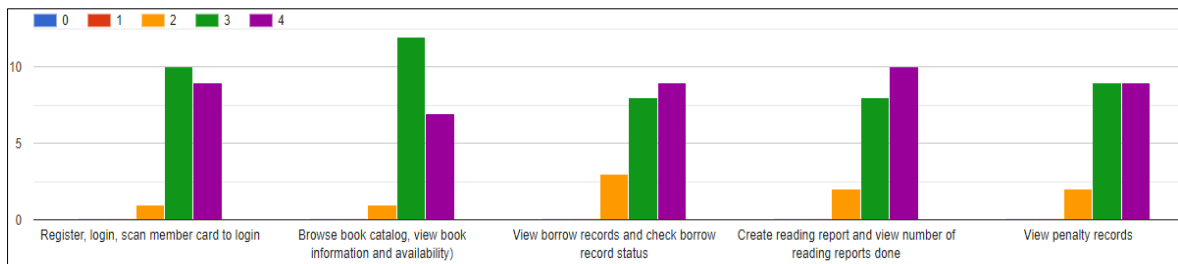


Figure 16: Result of user acceptance test of Section B for student

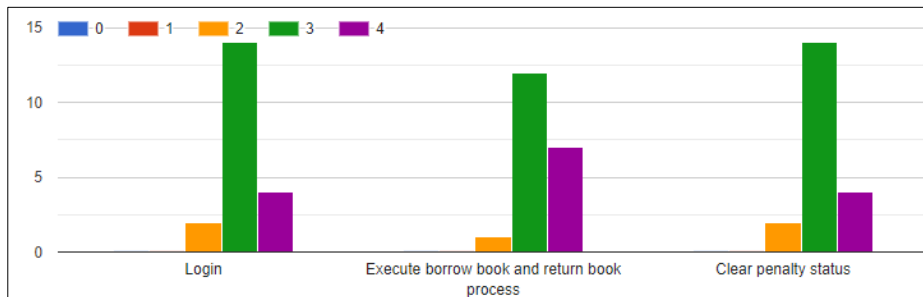


Figure 17: Result of user acceptance test of Section B for librarian

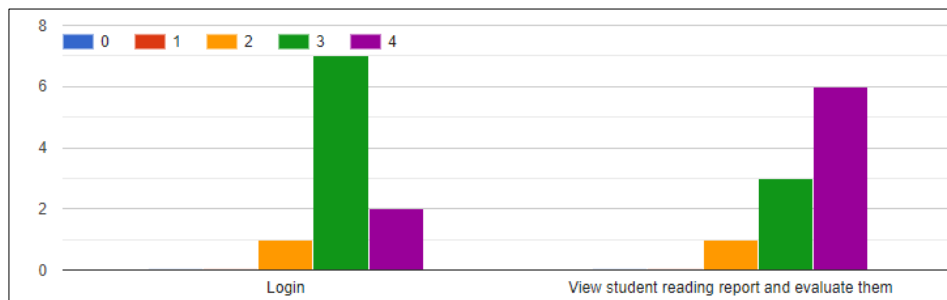


Figure 18: Result of user acceptance test of Section B for teacher

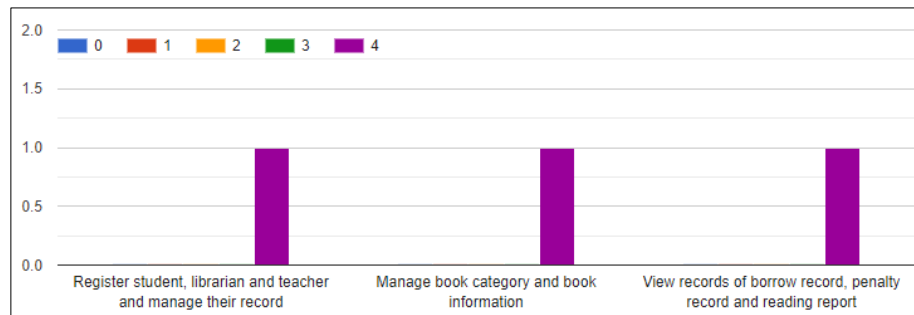


Figure 19: Result of user acceptance test of Section B for library administrator

5. Conclusion

This project is important to let SKPBK run its library more efficiently and systematically by using the developed system to carry out the time-consuming and repeating activities in running a library. These operations include maintaining book inventory records, managing borrow book record, keeping borrow book records and managing the penalty and overdue borrow records. Also, the students and teachers of SKPBK can manage the reading report easily by using the proposed system. The proposed library management system has been successfully designed and developed.

Even the developed system has achieved the project objective and project significance, there are a few improvements that can be made in the future to the current project. First the library management can provide a feature that enable students to book for a borrowed or currently unavailable book. This feature will let the student get notified when the desired book is returned to the library instead of waiting for the due date to come to borrow the desired book again.

Moreover, the library management system can add one more feature to notify the student about the borrow records that are overdue soon. The notifications can be created directly in the system or send to the student mailbox to let the students return the borrow book on time to prevent getting fined for returning book late.

In conclusion, the web-based library management system has been successfully developed by following the requirements stated by the users. All the project objectives are achieved, and the system is currently being used by the library.

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