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ORIGINAL RESEARCH

USER-CENTERED DESIGN-BASED APPROACH IN SCHEDULING MANAGEMENT APPLICATION DESIGN AND DEVELOPMENT

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Abstract

The process of manually making and setting course schedules using Microsoft Excel is ineffective, time-consuming, and still prone to errors. This research develops a website-based scheduling management application with a case study at SMK Pariwisata Margarana so that it can solve scheduling problems manually. The User-Centered Design (UCD) method is applied in the application prototype design stage. Open interviews, field observations, simulations, and questionnaires were used as research data collection methods. Three iterations were carried out at the prototype design stage to fulfill all user needs. The high-fidelity prototype in the last iteration is then implemented into an application. Application quality is measured using ISO/IEC 25010 with five characteristics. The test results on usability characteristics show that the scheduling management application obtains an average usability score of 91.2%. The appropriateness recognizability sub-characteristic obtained the highest usability score of 93.53%. UCD can help produce an application that can meet all the user's needs when implemented in the application design phase.

KEYWORDS:

ISO/IEC 25010, Recognizability Sub-Characteristic, User-Centered Design, Usability Testing, Scheduling Management Application, Web design

1 | INTRODUCTION

Technological developments have been implemented in the field of education. Online distance learning using e-learning has taken advantage of the role of technology during the COVID-19 pandemic [1, 2]. However, not all aspects of education have taken advantage of technological developments. One of them is the process of mapping class (course) schedules which is still carried out conventionally. This can be overcome by developing a scheduling management application. In fact, by utilizing technological developments such as scheduling management applications, the process of mapping class schedules can be carried out effectively

and efficiently. Many methods have been used in scheduling management applications for course scheduling[3–13], job shop scheduling[14, 15], cloud environments scheduling[16, 17], and healthcare scheduling[18]. Scheduling management applications have become increasingly important in our fast-paced world. From work schedules to personal appointments, these apps help us keep track of our daily tasks and manage our time effectively. However, these applications' usability and user experience can vary widely, and many users may need help to use them. This is where user-centered design (UCD) comes in. By focusing on the needs and preferences of the end-users, UCD can help create scheduling management applications that are intuitive, efficient, and satisfying to use. This is still true in several educational institutions like SMK Pariwisata Margarana. The development of a user-friendly scheduling management application is required at the institution.

SMK Pariwisata Margarana is a vocational high school in Tabanan Regency, Bali Province. This school is under the Yayasan Pendidikan Margarana. The process of mapping the lesson schedule is carried out before the new semester starts. The Microsoft Excel application records all teachers, subjects, rooms, class participants, and subject hours worked by one of the academic staff. Users still must type in each teacher code, subject, class participants, and subject hours when they do manual schedule mapping. This process can take a relatively long time. Human errors are prone to occur at this stage, such as duplicate data, scheduling errors, schedules that exceed the specified subject hours, and mapping teachers for each subject taught. In addition, lesson schedules mapped with Microsoft Excel are impractical to use together and difficult to share among teaching staff. Therefore, it is necessary to develop a special application for scheduling management so that it is expected to be able to overcome the shortcomings of conventional processes and increase productivity. Users need to interact with the application to get solutions to the problems they want to solve. Human and computer interaction can occur through an interface, and the interaction between the two can work well if the user can easily use the application. Applications developed without paying attention to user aspects will make it difficult for users to interact with the resulting application. Software developers focus more on technology development and have yet to fully consider other important aspects, such as usability and user convenience of the software. Therefore, the development of an application that is oriented to user needs is required.

User-Centered Design (UCD) is a methodology for designing software that emerges from human and computer interactions[19]. Users are the focus of every existing process[20, 21]. By involving users, UCD aims to design an interface that can increase user satisfaction through alignment between user expectations and the goals to be achieved[20]. Effective and efficient application development can be achieved by involving users in each process[22]. Moreover, user involvement is important in any software development[23].

Developed software needs to be tested for quality according to standards to obtain valid and reliable results. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) have specified a system standard: ISO/IEC 25010. This standard replaces the previous standard, namely ISO/IEC 9126. There are eight characteristics to assess software quality, and each character consists of several sub-characteristics in ISO/IEC 25010. ISO/IEC 25010 can be used as a basis for software testing because its quality factors refer to several previously issued standards, namely the McCall model, Boehm model, and ISO/IEC 9126-1[24]. The ISO/IEC 25010 model is the newest software quality testing model[25]. This research focuses on developing scheduling management applications using the UCD method. Users are involved in the application development process so that all user needs and user convenience can be realized in the application being developed. In addition, the UCD method is used to provide a scheduling management application that can answer the problems at SMK Pariwisata Margrana that have been previously described. The quality of the applications that have been developed is then evaluated using the ISO/IEC 25010 standard.

2 | PREVIOUS RESEARCHES

Dzulfiqar et al.[19] uses UCD in developing university websites. The case study raised in this research is the website of the State Islamic University (UIN) Syarif Hidayatullah. In the early stages, researchers distributed questionnaires (Likert scale) with the ISO 9126 standard, used as a reference at the website design stage. Four assessment aspects are used to evaluate websites: understandability, learnability, operability, and attractiveness. The results show that the usability of the UIN Syarif Hidayatullah website is 56.6% which indicates an ordinary scale. The UCD processes carried out in this study are planned, analyzed, designed, and test, and refine. The website-based application that has been developed is then evaluated using the same questionnaire as before the 80 respondents who have been assigned for usability testing. The results showed that the developed university website

got a usability value of 81.9%, indicating an interesting scale. This study still uses the ISO 9126 testing standard and only tests software using one characteristic, namely usability.

Kim et al.[26] uses UCD to design Gastroesophageal Reflux Disease (GERD) applications. This research focuses on designing mobile-based health applications (mHealth) with the UCD approach used by people with GERD so that they can monitor and manage their conditions. There are two phases used in application development, namely, the design and evaluation phases. The design phase is divided into four stages following the five structural components: empathize, define, ideate, prototype, and test. Some methods applied in the design phase are creating personas, conducting competitor analysis, completing heuristic evaluations, making prototypes, conducting interviews, completing two stages of user testing (thinks-aloud and semi-structured interviews), and consulting experts after completing the final prototype.

This study used several formative methods to evaluate the resulting applications, namely evaluations based on reviews from competition judges, input from GERD experts, and personal reviews of previous studies. The results obtained in the design phase include a low-fidelity prototype and medium-fidelity prototype at stage 1. Several user reviews and improvements were made at stages 2 and 3, and the final prototype at stage 4 refers to all user reviews. The evaluation carried out in this study has yet to be carried out according to the standards in software testing. The evaluation conducted by the researcher focused on formative reviews.

Hasani et al.[20] surveyed several literatures that apply UCD to the user interface display of e-learning applications. This study emphasizes the various definitions of UCD used by other researchers in developing user interfaces for e-learning applications, so there is a need to define the phases that exist in UCD. This study defines UCD into three general stages, namely the requirements gathering phase, the design phase, and the evaluation phase. This study collects several literatures related to the application of UCD in designing user interfaces in e-learning applications from various indexed sources, namely IEEEXplore, ACM Digital Library, Springer Link, ProQuest, and Science Direct.

There were 17 articles that were successfully filtered using several criteria through two screening stages. The requirements gathering stage refers to the pre-design phase; the software developer collects user needs and user expectations for the application and focuses on existing user needs as a guide in software design. The two methods most frequently used at this stage are surveys and interviews. In the design phase, the software developer develops a prototype from all the information obtained in the previous stage. High-fidelity prototyping is the most popular method used at this stage. In the evaluation phase, the prototype that has been developed is then evaluated by soliciting input from users who use it. Usability testing and questionnaires are the two most popular evaluation methods or tools used. The results of this study indicate that using UCD in designing e-learning application interface designs can lead to better usability and user experience (UX) results. 1].

3 | MATERIAL AND METHOD

This section provides guidelines for the author on writing elements and illustrations when preparing the manuscript.

3.1 | UCD Approach in Scheduling Management Application Design and Development

The UCD method designs a scheduling management application at SMK Pariwisata Margrana based on user needs. The stages of UCD and the research flow used by the researcher are explained in Fing 1 . The UCD stages used in this study specify the context of use, specify user and organizational requirements, produce design solutions, and evaluate designs against user requirements research[27–29]. The stages of producing design solutions and evaluating designs against user requirements are carried out iteratively until all user needs are met. Three iteration processes are carried out in the design phase to adjust the prototype application design that has been produced according to user needs.

Researchers first collect information using open interview methods to find out the problems and needs of users. Users, in this case, leaders, teaching staff, students, and one administrator, are involved in the application development process according to the institution's needs. In addition to open interviews, researchers also conducted field observations to find out what was directly related to the scheduling management process implemented in the institution. This stage implements the human-centered process plan stage as the initial stage of the UCD process.

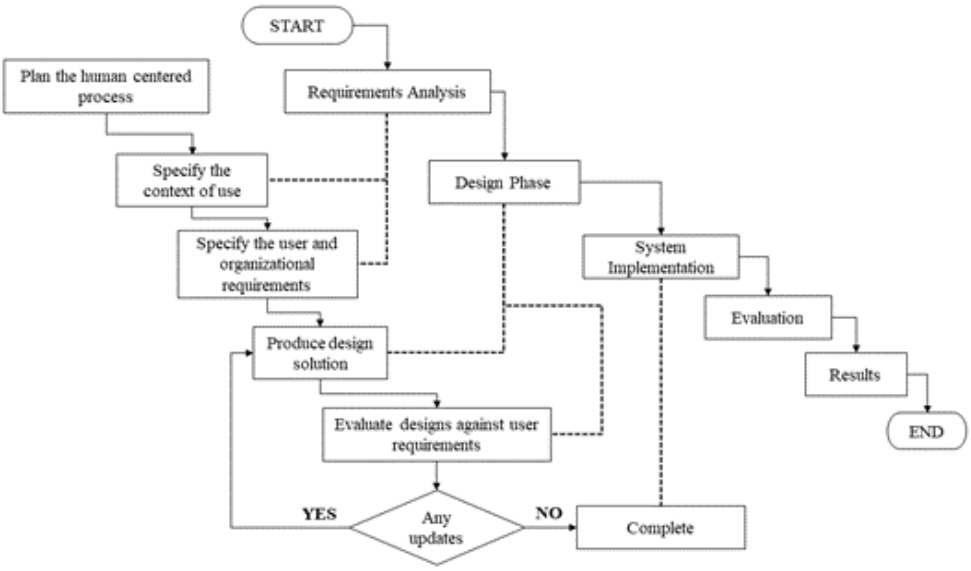

FIGURE 1 The scheduling management application development flowchart based on the UCD method.

The next stage is to specify the context of use. This stage explains the usability context of developing an application. There are several things to do at this stage, namely understanding the context desired by the user, identifying actors who use the application, understanding the characteristics of the user, understanding the things that the user does and likes in the application, and understanding the right environment to use the system or application to be made. Researchers used open interview methods and direct field observations at this stage to obtain information related to user identification and specification of the usability context of the application to be developed.

The next stage is specifying user and organizational requirements. At this stage, a software requirements analysis is carried out to obtain information about user and organizational needs for an application developed by all users. The functional and non-functional requirements of the application to be developed are the outputs at this stage. Functional requirements describe the features that must exist in the application being developed, while non-functional requirements describe the behavioral properties of the application regarding service limitations, time constraints, or other standardization. The next stage is to produce a design and solution. Product design and development are carried out at this stage based on predefined user needs. Prototype and simulation are the two methods commonly used at this stage to produce initial products that users can use[20]. This stage aims to get user feedback based on prototypes or simulations that users have used. This process is carried out iteratively several times until the purpose of the application design is in accordance with the user's needs. Researchers use medium-fidelity and high-fidelity prototype methods to build application designs based on predetermined user needs. High-fidelity prototypes produced in the 3rd iteration were developed into a real application after completing the system architecture design, database design, and use case design stages.

The next stage is to evaluate the design against user requirements. The user evaluates the application design that has been developed at this stage. The medium-fidelity prototype design developed in the previous stage is evaluated at this stage. Users can provide feedback regarding whether efforts to improve features are needed for the next development process. If the user provides input, the prototype design that has been produced is revised until the user's needs are met. However, if there is no improvement in the design, then the medium-fidelity prototype is developed into a high-fidelity prototype. This high-fidelity prototype is then tested again on the user. Interviews and questionnaires are used at this stage to determine the suitability of the prototype design that has been produced to the user's needs.

3.2 | ISO/IEC 25010

ISO/IEC 25010 – Systems and Software Quality Requirements and Evaluation (SQuaRE) is a standard method used to measure and evaluate the quality of a software product or computer system. The product of an application can be described with eight

TABLE 1 The user identification of Scheduling Management Application.

User's Code	Actor/User	Descriptions
P1	Leaders	Leaders are system users consisting of leaders of the Margarana Tourism Vocational School. For example, the principal, vice principal for academic affairs, or someone assigned by the principal to fill this position.
P2	IT Administrator (Superuser)	IT Administrator is a system user with full access rights to the system to manage all data and entities to be scheduled. This position is appointed directly by the leadership.
P3	Teaching staffs	The teaching staff is system users consisting of teachers, academic staff, and other teaching staff who work at the Margarana Tourism Vocational School. The teaching staff at the Margarana Tourism Vocational School consists of two categories, namely Permanent Teaching Staff (TPT) and Non-Permanent Teaching Staff (TPTT).
P4	Students	Students in SMK Pariwisata Margarana

FIGURE 2 The results of field observations to understand the right environment to implement the application to be developed.

characteristics, then divided back into sub-characteristics. In total, there are 31 sub-characteristics out of the eight characteristics in ISO/IEC 25010. The eight characteristics are functional suitability, performance efficiency, compatibility, usability, reliability, portability, security, and maintainability.

3.3 | Determining Participant

The participants used in this study were school internal application users, including leaders, administrators, teaching staff, and students. This is because the application developed is needed only for the internal purposes of the agency and is not accessible to public users. Participants are involved in the design phase of application design and application evaluation after the application design phase is complete. A total of 2 P1 users, 2 P2 users, 20 P3 users, and 10 P4 users were involved as participants in the application design, which was divided into three iterations according to Table 1 . The participants in the evaluation phase were all participants in the 3rd iteration application design stage, with a total of 34 participants.

3.4 | Data Collection

Several methods or instruments were used to collect data and information needed in this study, such as open interviews, field observations, and questionnaires. Open interviews and field observations are used to obtain information related to application development needs (Fig. 2 . Questionnaires are used at the application design stage to record all user input in each iteration. In addition, the questionnaire is used at the application evaluation stage during usability testing.

Questionnaires were distributed to predetermined participants using Google Form[30]. Questionnaires with a Likert scale are used in usability testing for users. Value 1 indicates strongly disagree, value 2 indicates disagree, value 3 states neutral, value 4 states agree, and value 5 states strongly agree[27, 31].

Validity and reliability tests were carried out to measure the research instruments used. The validity test was carried out to determine whether the questions in the research instrument were valid[24] and could collect information effectively[25]. The

standard value of the correlation coefficient is 0.3 [32]. If the value of the correlation coefficient calculated is more than 0.3, then the questions in the questionnaire are valid, and vice versa.

The reliability test can determine the reliability level of the research instrument (r). The value of r is declared "Very low" if it is 0 - 0.2. The value of r is declared "Low" if it is in the range of 0.21 – 0.40. The value of r is declared "Enough" if it is 0.401 – 0.60. The value of r is declared "High" if it is 0.601 – 0.80. The value of r is declared "Very high" if it is in the range 0.801 – 1 [24].

3.5 | Experimental Design

The experimental design is divided into two things: the experimental design at the design stage and the experimental design at the evaluation stage. At the design stage, the research team presented the resulting prototype design to the participants, who had been determined in each iteration. The research team installed the prototype in each iteration locally on several of the school's internal computer devices so that participants could simulate it. Participants then provided feedback to the research team either directly verbally or through a questionnaire provided by the research team. At the evaluation stage, participants are asked to access and use the application via the link provided. After the participants finished using the application, the participants filled out the usability testing questionnaire sent by the research team. The results of the usability testing questionnaire were then analyzed

4 | CONTEXT OF USE AND USER REQUIREMENTS

The results on identifying actors and user characteristics were obtained from open interviews with the Deputy Principal for Academic Affairs and several teaching staff at SMK Pariwisata Margrana. In addition, field observations were made to understand the right environment to use the scheduling management application.

The scheduling process that took place at the school was initially carried out manually using the Microsoft Excel application. The application records all scheduled entities, such as teachers, subjects, class participants, and course hours. Every teacher must manually type in every code from each entity when scheduling. This process is considered ineffective, inefficient, and prone to human error.

Class schedules mapped with Microsoft Excel could be more practical to use and access together. In addition, the existence of teachers with non-permanent status at the school must be prioritized when making schedules is also a necessity related to the need for an effective and efficient scheduling management process. The manual scheduling process is difficult to handle the needs of these teachers who have a non-permanent status when they must be prioritized in determining the schedule because they must take turns coming to the school to map out the schedule. Therefore, it is necessary to develop a special application for scheduling management so that it is expected to be able to overcome the shortcomings of manual processes and increase productivity.

Table 2 presents the results of identifying users who use the application. Based on the results of field observations, as shown in Fig. 2 , it can be observed that there is a special room containing computer devices with the Windows operating system, which are usually used by teaching staff when they are in the school environment. In addition, most users also have smartphone devices to support their daily activities. Based on this, a scheduling management application was developed based on a website (Fig. 6 , so that users can access and use this application more flexibly with a computer or smartphone device.

Researchers have conducted open interviews with the Vice Principal for Academic Affairs at SMK Pariwisata Margrana to list the features of the scheduling management application to be developed. Based on the results of the interviews, the resulting application must be made in accordance with the existing curriculum at the institution. In addition, the resulting application must also be accessible with some of the institution's existing hardware, either via a computer or smartphone. In more detail, Table 3 describes the application's functional requirements, while Table 4 displays the non-functional requirements of the application.

5 | DESIGN AND DEVELOPMENT OF SCHEDULING MANAGEMENT APPLICATION

The design produced at this stage is divided into three iterations (Fig. 3). The designs produced in the three iterations were made in the form of a prototype. Simulation is used as a test method of the prototype design produced in each iteration to get

TABLE 2 The functional requirements of the application.

Code	Function Name	Description
KF-01	Registration	P2 can register an account (username and password) from a new user on the administrator page.
KF-02	Login	Users can enter the application by entering data (username and password) that have been registered along with their respective access rights.
KF-03	Login Administrator Page	P2 can enter the administrator page using a unique username and password provided by the application development team.
KF-04	View account	P1, P2, and P3 can see the details of their personal account profiles.
KF-05	Update account	P1, P2, dan P3 dapat melakukan pembaruan data akun pribadi masing-masing
KF-06	Schedule validation	P1 can validate (lock) the lesson schedule that each P3 has entered
KF-07	Cancel schedule validation	P1 can cancel the validation on a previously locked schedule so that P3 can update the lesson schedule again.
KF-08	Schedule revision	P1 can provide a revision of the schedule made by P3 by marking the schedule with the status "Revise."
KF-09	View Schedule	P1, P2, and P3 can see the schedule entered by each P3 and the final schedule that P1 has validated.
KF-010	CRUD Data by Admin	P2 has full access rights to manage teacher data, subjects, classes, lesson times, rooms, and schedules through the administrator page.
KF-011	Data reset	P2 can reset schedules and other data
KF-012	View schedule revised	P3 can view and correct schedule revisions provided by P1
KF-013	Schedule manage	P3 can manage (create, read, update, and delete) subject schedules
KF-014	View Schedule	P4 can see the final schedule that P1 has validated

TABLE 3 The non-Functional requirements of the application.

Code	Description
KNF-AP-01	The application can be accessed and used through several web browsers (Google Chrome, Microsoft Edge, Safari, Mozilla Firefox) inside or outside the school.
KNF-AP-02	Applications can be accessed and used via smartphone devices
KNF-AP-03	The application can run when the user is outside the school environment through several web browsers on each mobile device.
KNF-AP-04	The application can fulfill all the features or tasks previously set on the system's functional requirements according to the existing school curriculum.
KNF-AP-05	The application has a display that is easy to learn, understand and use
KNF-AP-06	The application must be able to ensure that it can only be accessed by users who have registered and have access rights.
KNF-AP-07	The application must be able to ensure that each authorized user can only access the stored data.
KNF-AP-08	The application can provide an error message on the interface if the user makes an error while interacting with the application.

TABLE 4 The user feedback on the prototype design resulted from the 1st iteration.

Code	Description
KU-01	The logo icon on the logo bar is changed and adjusted.
KU-02	Interface design for entering subject data and subject mapping to be made separate into two interface designs.
KU-03	There is no need to display class data and study interest path data on the class page interface design.
KU-04	The use of the icon on the button that functions to "add" data needs to be changed.
KU-05	The use of icons on the sidebar needs to be readjusted. Users find it difficult to understand the usefulness of the features of the logo icon used.
KU-06	The login feature and user access rights can be developed immediately so that users can better understand the full and intact flow of the application.
KU-07	Interface design for the needs of P1 users so that it can be developed immediately.
KU-08	The interface design for the needs of P3 users is to view and improve the revision of the subject schedule provided by P1 so that it can be developed immediately.

user input. The application development team then discusses user inputs to improve the prototype design in the next iteration of the results obtained in the previous iteration.

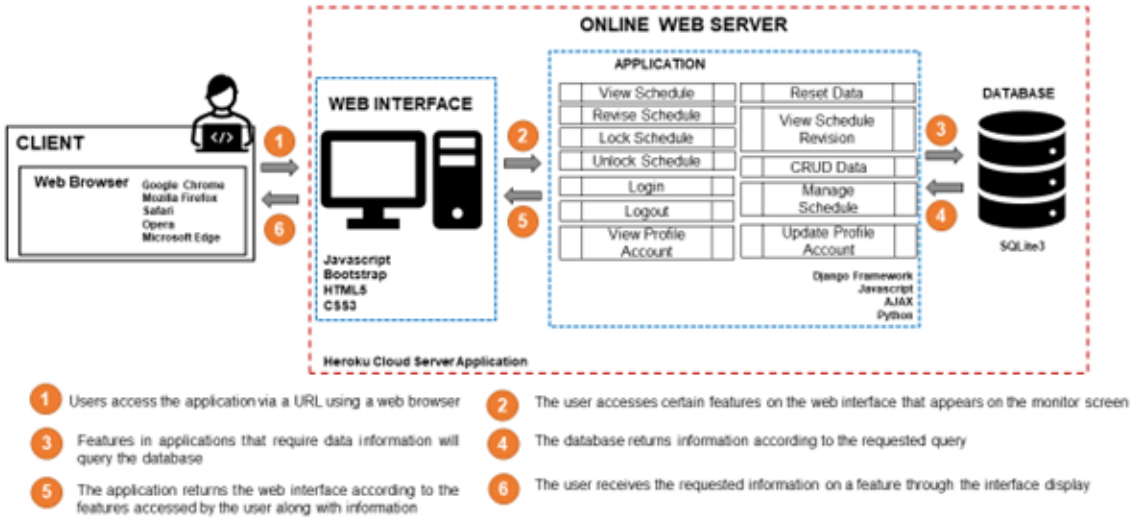

FIGURE 3 The user interaction design with Scheduling Management Applications at SMK Pariwisata Margarana

5.1 | Design Results in 1st iteration

As a first step, a medium-fidelity prototype is used in the 1st iteration to produce a design according to user requirements obtained previously. At this stage, a total of 19 interface designs were produced as a representation of several functional requirements that have been implemented. The functional requirements that have been implemented become a medium-fidelity prototype in the 1st iteration, namely KF-03, KF-09, KF-010, and KF-013. Fig. 4 is several interface designs from the medium-fidelity prototype produced in the 1st iteration.

Several features have been produced from the prototype in the 1st iteration. The administrator page feature is implemented in the application so that users (P2) can manage data that will be scheduled later (see Fig. 4 (a)). Only users with access rights as administrators can access this page with an account registered when the developer developed the application for the first time. Furthermore, the account and password from P2 that logs in on this page can be changed on this page the first time you log in. This feature is an implementation of KF-03 and KF-010.

This medium-fidelity prototype also has features to manage and view class schedules. This feature is an implementation of KF-09 and KF-013. This feature allows P3 users to schedule lessons from each teacher. In this feature, P2 can map between each subject, the class of participants taking that subject, and the total hours of subjects according to the existing curriculum (see Fig. 4 (b)). After the mapping process is complete, a new schedule can be made by P3 by pairing the subjects from the mapping, the teacher, the range of subject hours, and the room where teaching and learning activities take place. By scheduling using this feature, users do not need to manually enter subject codes, participant classes, teachers, subject hours, and rooms. The schedule that P3 has made is then displayed in tabular form grouped by day and participant class (see Fig. 4 (c)).

The prototype results at this stage were then simulated for 17 users to get feedback from users. Users are asked to try all the features that have been produced at this stage, then users provide direct feedback or send feedback via a questionnaire on the Google Form provided by the team. After hearing and analyzing all user feedback on the questionnaires obtained, the researcher summarizes all user feedback in the 1st iteration.

5.2 | Design Results in 2nd Iteration

The design in the 2nd iteration focuses on updating and developing prototypes based on all input from users. in the 1st iteration (Table 5). At this stage, 14 interface designs were produced in addition to the previous iteration. The functional requirements that have been implemented become a medium-fidelity prototype in the 2nd iteration, namely KF-01, KF-02, KF-06, KF-07, KF-08, KF-12, and KF-014. Fig. 4 and Fig. 5 are some of the interface designs of the medium-fidelity prototype produced in the 2nd iteration.

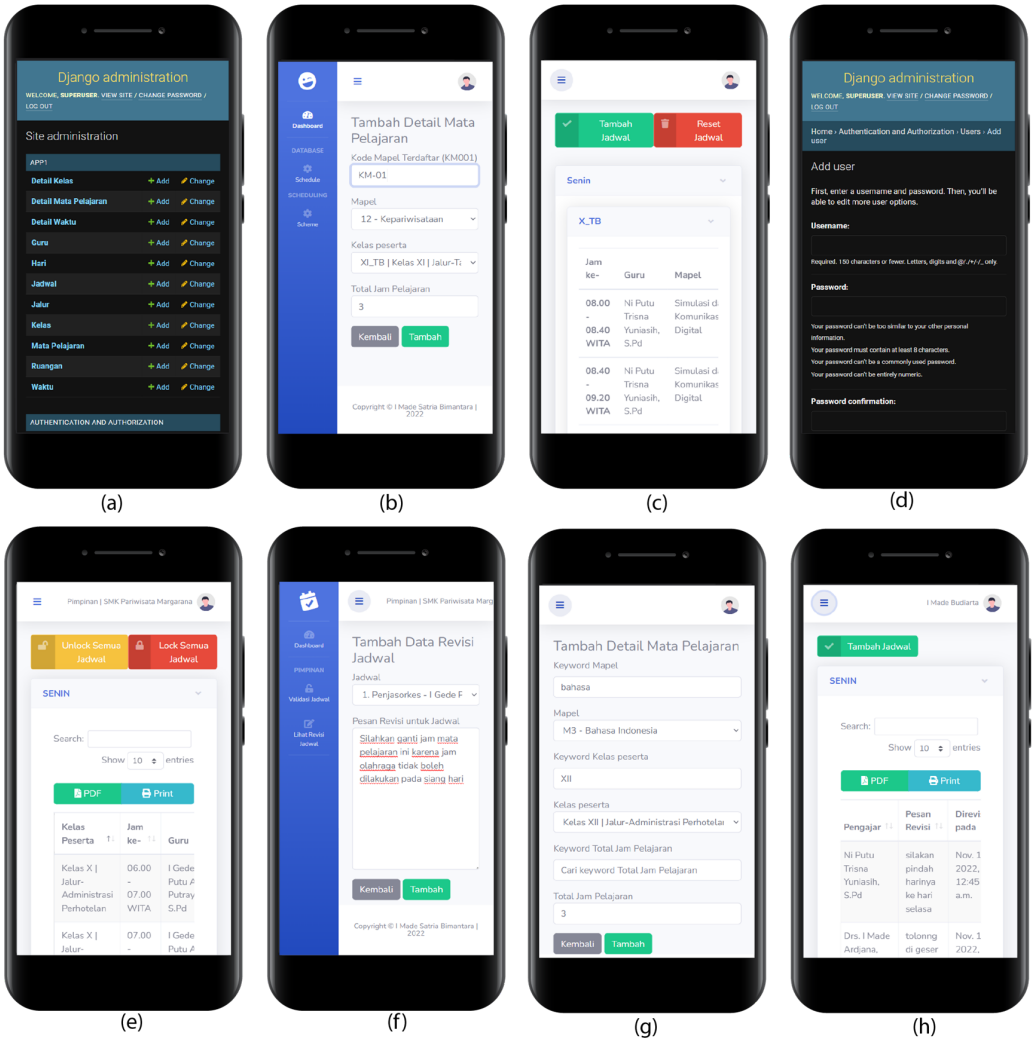

FIGURE 4 several interface designs from the medium-fidelity prototype produced in the 1st iteration.

TABLE 5 The user feedback on the prototype design resulted from the 2nd Iteration.

Code	Description
KU-013	The feature for viewing and changing user account information that the administrator has registered can be developed soon.
KU-014	When scheduling subjects, there must be a search column for subject mapping data, teachers, range of study hours, and rooms. P3 users feel more efficient and comfortable scheduling subjects from the resulting designs.
KU-015	Reset teacher data, subjects, participant classes, rooms, class hours, subject mapping results, and subject schedules by the admin due to efficiency needs so users can keep all correctly inputted data individually.

Several additional features have been produced from the prototype in the 2nd iteration. User registration and login features have been implemented so that users can enter the application with access rights (P1, P2, P3, or P4). This feature is an implementation of KF-01 and KF-02. Administrators can only register new users on the administrator page, considering that this scheduling management application is only used for internal school purposes and is not accessible to the public (see Fig. 4 (d)). Users can enter the application via the login page after getting the username and password registered by the administrator.

The resulting medium-fidelity prototype also finds features for the needs of P1 users (KF-06, KF-07, and KF-08). This feature allows P1 users to provide revisions of the subject schedule that P3 has entered. Revisions in the form of messages can be

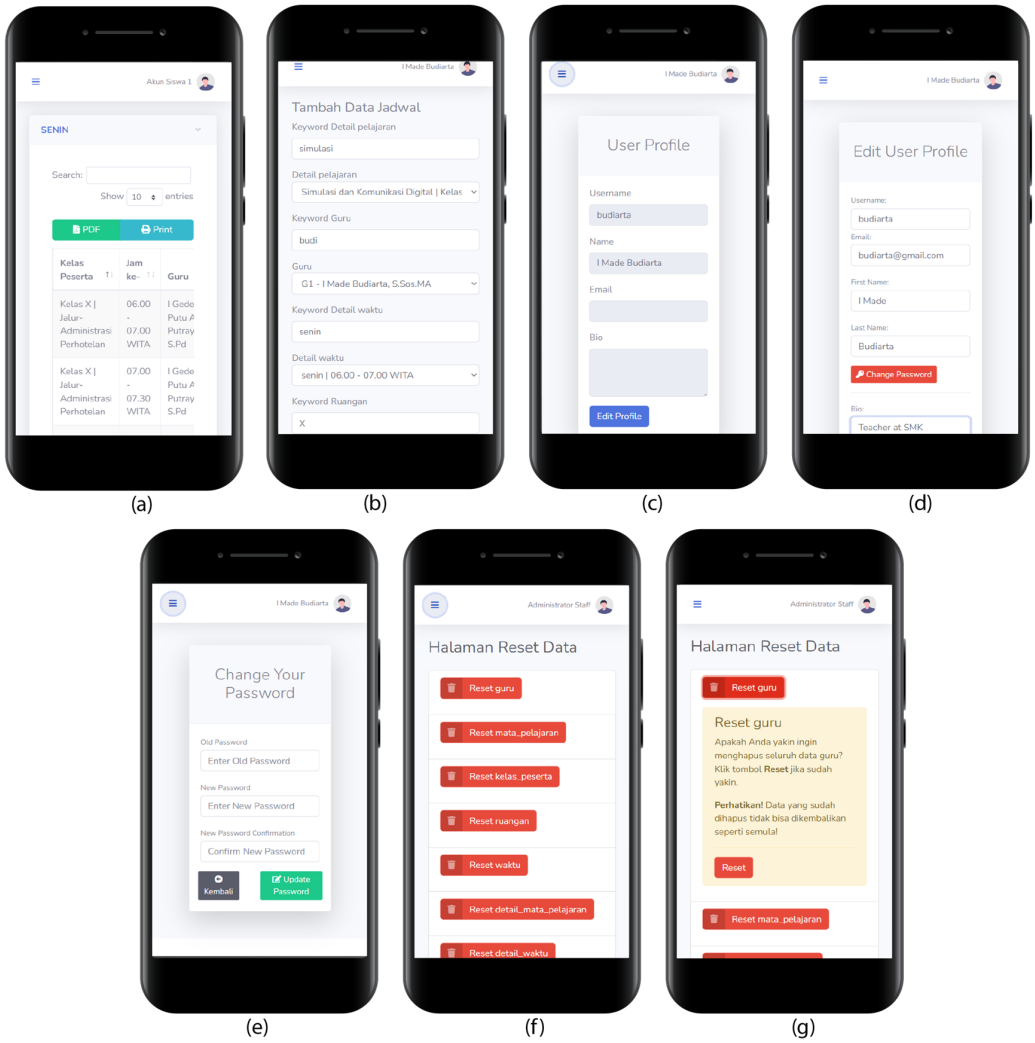

FIGURE 5 The results of the medium-fidelity prototype design in the 2nd iteration: (a) Feature improvements according to KU-010. The results of the high-fidelity prototype design in the 3rd iteration: (b) Feature improvements according to KU-014; (c) Profile view feature for all users; (d) Profile edit feature for P1, P2, and P3 users according to KU-013; (e) User password change feature for user account security; (f) Page to access the data reset feature; and (g) Validation display from P2 users before resetting data.

given by P1 to the subject schedule, which still needs to be corrected by related P3 (see Fig. 4 (e)). In addition, P1 users can lock the subject schedule that has been produced by P3 if there is no need for revision of the related schedule (see Fig. 4 (e)). If the subject schedule is locked, then P3 can not edit and delete the schedule, and all users, including P4 (KF-014), can not access the final subject schedule that has been produced. P1 users can cancel locked subject schedules by clicking the yellow button in the top left corner (see Fig. 4 (e)). Unlocked schedules are still editable by P3 and are not final schedules accessible to all users. According to Table 5 , all user feedback has also been implemented into a medium-fidelity prototype at this stage. For example, KU-011 and KU-012 have been implemented as features to make it easier for P2 users to map between subject schedules, participating classes, and total lesson hours (see Fig. 4 (g)). P2 users no longer need to enter the code "Registered Folder Code (KM001)," as shown in Fig. 4 (b). The new prototype design provides code automatically when P2 users do the mapping process. In addition, KU-08 has been implemented as a feature in the resulting prototype so that P3 users can view and improve the revision of the subject schedule given by P1 (see Fig. 4 (f)). When a P3 user fixes a subject schedule according to the revision message given, the revision of the relevant subject schedule will automatically be deleted from either the interface for P1 or P3 users. The prototype results at this stage were then simulated for 29 users to get feedback from users. Users are asked to try all the features that have been produced at this stage, then users provide feedback directly or send feedback via the

TABLE 6 The validity test results.

Variables	r	Sig. (2-tailed)	Samples	Variables	r	Sig. (2-tailed)	Samples
X1	648**	0,000	34	X9	.607**	0,000	34
X2	648**	0,000	34	X10	.577**	0,000	34
X3	.705**	0,000	34	X11	-.648**	0,000	34
X4	.675**	0,000	34	X12	.682**	0,000	34
X5	.682**	0,000	34	X13	.705**	0,000	34
X6	.648**	0,000	34	X14	.648**	0,000	34
X7	.648**	0,000	34	X15	-.690**	0,000	34
X8	.562**	0,001	34	X16	.626**	0,000	34

Google Form provided by the team. After hearing and analyzing all user feedback on the questionnaires obtained, the researcher summarizes all user feedback in the 2nd iteration, as shown in Table 6 .

5.3 | Design Results in 3rd iteration

The design in the 3rd iteration focuses on updating and developing a medium-fidelity prototype based on all input from users in the 2nd iteration (Table 6). The functional requirements that have been implemented become a medium-fidelity prototype in the 3rd iteration, namely KF-04, KF-05, and KF-011. At this stage, the medium-fidelity prototype design is developed into a high-fidelity prototype. This was done because most of the features that are the main needs of users have been implemented in the 2nd and 3rd iterations so that user testing can be more comprehensive at the end of the 3rd iteration. At this stage, six interface designs were produced in addition to the previous iteration. Fig. 5 is several interface designs from the high-fidelity prototype produced in the 3rd iteration.

One additional feature has been produced from the prototype in the 3rd iteration based on input from the user (KU-014). P3 users who have simulated the prototype produced in the 2nd iteration suggest adding a search column to the subject schedule page, making it easier to make a lesson schedule. The prototype design for this feature is presented in Fig. 5 (b). P3 users only need to type keywords for certain fields and press the "tab" button on the keyboard or "enter" on the smartphone screen, then automatically, the data line containing the entered keywords will appear in the option fields provided without having to search for the data manually one by one. For example, a P3 user wants to find a teacher with the name "I Made Satria," so in the search field, the user only needs to type the keyword "satria" and then press "tab" (on the desktop) or "enter" (on a smartphone), so a teacher with the name "I Made Satria" will appear in the "Teacher" field option.

The view and edit registered user profile feature has been implemented so that each user can view and edit their respective user profile information (see Fig. 5 (c) and Fig. 5 (d)). Each feature is an implementation of KF-04 and KF-05 and is based on user input in the 2nd iteration (KU-013). All users can access this feature (P1, P2, and P3). However, P4 users cannot access these two features. This is based on the results of interviews obtained with P1 users that all P4 users can access the application using only one registered account, so they are not allowed to access these two features. In addition, the use of the application for P4 users is only to access and download the final schedule that P1 users have locked.

The resulting prototype design has also implemented the data reset feature (see Fig. 5 (f)). This feature is an implementation of KF-011 and KU-015. This feature is only for P2 users. This feature allows the user to delete all incorrectly related data without deleting each row of data individually. Based on the results of interviews with 2 P2 users, this feature needs to be made to make it easier for them to delete data during the adaptation phase of using the application later. Several red buttons make it easier for users to delete the data entity they want to reset. This design adds validation before the user performs a data reset (see Fig. 5 (g)). A yellow dialog box containing a data reset confirmation message will appear if the user presses one of the red buttons in Fig. 5 (g) design.

The prototype results in this iteration are then simulated for 34 users to get feedback from users. Users are asked to try all the features that have been produced at this stage, then users provide feedback directly or send feedback via the Google Form provided by the team. After hearing and analyzing all user feedback from the questionnaires obtained, users are satisfied with the prototype design. There is no need to add a new feature or improve the features implemented so far. Based on this, the production design solutions and evaluation designs against user requirements stages can be completed in three iterations. The

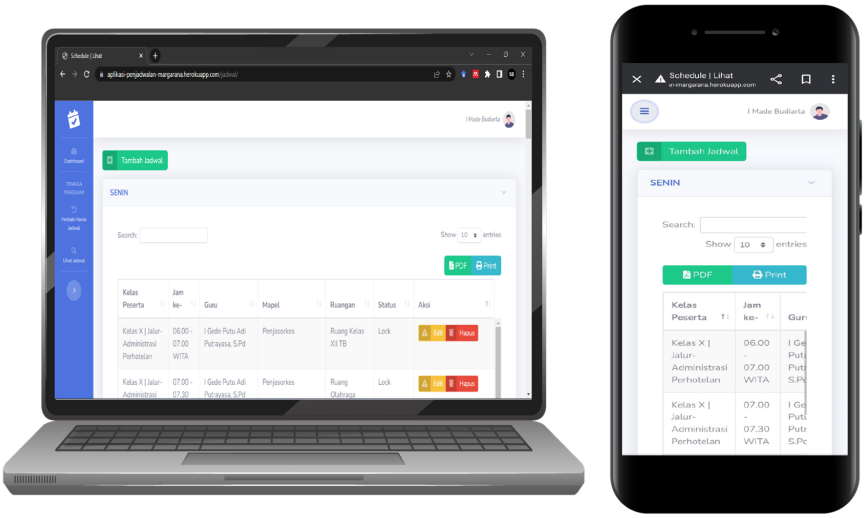

FIGURE 6 The results of the scheduling management application that can be accessed online using the website address provided via laptop (Left) and smartphone (Right) devices

next stage is implementing the high-fidelity prototype design that has been produced into a real application so that users from related institutions can use it.

6 | SYSTEM IMPLEMENTATION

This stage implements a high-fidelity prototype design into an application that users in the affiliated institution can directly use. The stages of designing the application architecture and database design used in the application are carried out before the application is implemented.

The results of the application architecture design are shown in Fig. 6 . The developed application is website-based and can be accessed via the user's computer or smartphone. Several supporting technologies are used to develop this application. From the user side, some web browsers, such as Google Chrome and Mozilla Firefox, can access applications via a URL. Interfaces that allow user interaction with applications utilizing technology, such as Javascript, Bootstrap, HTML5, and CSS3. Every feature that has been produced in the high-fidelity prototype is implemented into an application using the Django framework with Python. This application acts as a link between the user interface and the data stored in the database. The database design that has been generated is then implemented using SQLite3 so that the application can later access all information or data needed in the scheduling process. Heroku is a web server to upload web interfaces, applications, and databases that have been implemented so that users can access these applications online.

7 | RESULT AND ANALYSIS

Testing the software quality produced in this study focuses on four characteristics: functional suitability, usability, portability, and security. These four characteristics were selected based on the system's non-functional requirements that have been obtained according to Table 4 .

Functional suitability characteristics are checked using black-box testing. Portability characteristics are checked by running the application on several web browser software (Google Chrome, Microsoft Edge, Mozilla Firefox) and hardware (laptops and smartphones). Security characteristics are checked using The Sucuri Sitecheck web software (https://sitecheck.sucuri.net/). Usability characteristics are checked by analyzing the results of the questionnaires that have been distributed to users. The questionnaire consists of 16 statements related to six sub-characteristics: appropriateness recognition, learnability, operability, user error protection, user interface aesthetics, and accessibility. IBM SPSS version 26 software is used to test the validity and

TABLE 7 The total scores of each usability sub-characteristic from the questionnaires data obtained.

Usability Sub-Characteristics	Likert Scale 1	2	3	4	5	Sum
Appropriateness recognizability	0 x 1	0 x 2	0 x 3	22 x 4	46 x 5	318
Learnability	0 x 1	0 x 2	11 x 3	57 x 4	102 x 5	771
Operability	0 x 1	0 x 2	0 x 3	32 x 4	36 x 5	308
User error protection	0 x 1	0 x 2	3 x 3	32 x 4	33 x 5	302
User interface aesthetics	0 x 1	0 x 2	0 x 3	52 x 4	84 x 5	628
Accessibility	0 x 1	0 x 2	3 x 3	9 x 4	22 x 5	155

TABLE 8 The percentage of usability score for each usability sub-characteristic.

Usability Sub Characteristics	Sum	Maximum Score	Usability Score
Appropriateness recognizability	318	340	93.52941
Learnability	771	850	90.70588
Operability	308	340	90.58824
User error protection	302	340	88.82353
User interface aesthetics	628	680	92.35294
Accessibility	155	170	91.17647
Average Score			**91.19608**

reliability of the questionnaires used (Fig. 7 . This research focuses on user involvement in application design so that usability characteristics become important. Usability testing is used at the evaluation stage to verify that the resulting application design can properly interact with users[27].

Testing on the characteristics of functional suitability has been carried out by testing all the features produced in the application based on the functional requirements in Table 3 using black box testing. The test results show that all the system's functional requirements have been implemented in the application and function normally.

Usability testing is done by calculating the usability score from a questionnaire tested for validity and reliability. The validity test results are said to be valid if the r value obtained from the Pearson Correlation (r) calculation exceeds the r value in the table with samples (N) = 34 at a predetermined significance level. Based on the results of the validity test in Table 7 , all questions (Var) in the questionnaire are valid at a significance level of 1% (sig. (2-tailed)).

The calculation of the usability score is then carried out after the questionnaire used is declared reliable from the results of the reliability test. Table 8 shows the process of calculating the usability score according to research[27]. Based on the results of the usability score calculation that has been done, the scheduling management application that has been produced in this study has an average usability score of 91.2%. Five of the six sub-characteristics obtained a usability score above 90%, but the user error protection sub-characteristic still needs to achieve a usability score above 90%. Appropriateness recognizability obtained the highest usability score among the other five sub-characteristics, 93.53%. This shows that the 34 participants have recognized the product or application's suitability for their needs. Based on this, the UCD method applied in the application design phase can help produce an application that can meet all users' needs, and users can interact well with the resulting application.

After all the questions contained in the questionnaire are declared valid, the next step is reliability testing. Based on the reliability test results in Fig. 7 , the Cronbach Alpha value obtained was 0.770, with 16 question items. Based on the reliability index criteria in the study[24], the reliability test results in this study were included in the "High" criteria. Based on this, all question items filled in by participants are reliable.

Tests on portability characteristics have been carried out by running a scheduling management application using several hardware and software. The application can be accessed using laptops and smartphones (using the built-in web browser). In addition, the application was also successfully run using several web browser applications, as shown in Fig. 8 . Based on the results of this test, the resulting application has successfully fulfilled the characteristics of portability.

The test results on security characteristics using the Sucuri Sitehack application are shown in Fig. 9 (a). Application security testing was conducted on October 24, 2022, at 01.30 a.m. Based on the results of application security testing, no malware or

Case Processing Summary			
		N	%
Cases	Valid	34	100.0
	Excluded[a]	0	0.
	Total	34	100.0
a. Listwise deletion based on all variables in the procedure.			

(a)

Reliabillity Statistics	
Cronbach's Alpha	N of items
.770	16

(b)

FIGURE 7 Reliability test results from the usability testing questionnaire used.

viruses were found in the application, and it was not stated as an application affected by the blacklist. Therefore, the resulting scheduling management application is safe for users because it meets security characteristics.

In addition, researchers tested the application on performance efficiency characteristics using third-party software, namely GTMetrix (https:/gtmetrix.com/). The test results are shown in Fig. 9 (b). This test was conducted on October 23, 2022, at 11.24 a.m. Based on the overall test results, the application gets a grade A with a performance score of 98% and a time to interact of 1.4 seconds. This indicates that users can access the application interface quickly and don't have to wait long.

8 | CONCLUSION

This research focuses on designing and developing scheduling management applications at SMK Pariwisata Margarana. The four stages in the User-Centered Design (UCD) method, namely specifying the context of use, specifying user and organizational requirements, producing design solutions, and evaluating designs against user requirements, are used in the design phase so that users can be directly involved in the application to be developed. The application design process is carried out at the product design solution stage and evaluates the design against user requirements. This process involves the user going through three iterations. Users involved in this process are leaders, administrators, teaching staff, and students, with 34 participants. There are three features generated from the application that assist users in managing scheduling at the school compared to doing it manually with the Microsoft Excel application: data management features by administrators, schedule management features by teaching staff, and schedule validation and revision features by leaders.

The quality of the resulting application has been tested according to ISO/IEC 25010 standards for functional suitability, usability, portability, security, and performance efficiency characteristics. The application has met the characteristics of functionality suitability based on black-box testing. The application has fulfilled the characteristics of portability after testing the application on several hardware and software. Based on the test results on the Sucuri Sitehack application, the scheduling management application did not find malware or viruses in the application, so it meets security characteristics. The usability test results involving 34 participants showed an average usability score of 91.2%. The highest usability score was achieved in the appropriateness recognizability sub-characteristic of 93.53%. The scheduling management application gets a performance score of 98% and a time to interactive of 1.4 seconds based on the results of testing performance efficiency using GTMetrix.

CREDIT

Darlis Herumurti: Methodology, Project administration, Writing – review and editing, Supervision. **I Made Satria Bimantara:** Conceptualization, Methodology, Writing – original draft preparation, Writing – editing, Software, and Formal Analysis. **I Wayan Supriana:** Conceptualization, Data Collection, and Investigation. All authors read and approved the final manuscript.

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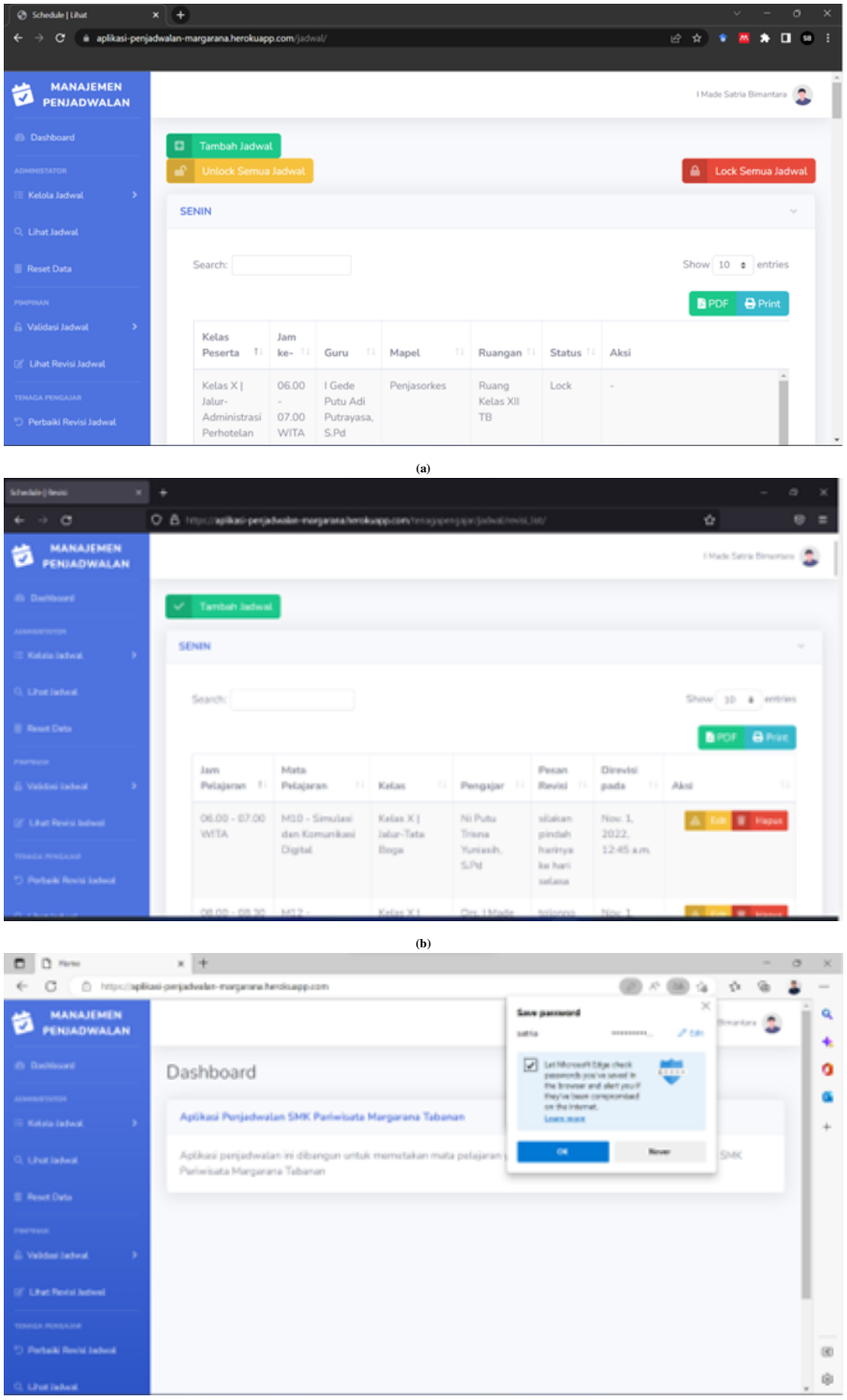

FIGURE 8 The results of testing the portability characteristics of the scheduling management application by running on several web browser applications: (a) test results on Google Chrome; (b) test results on Mozilla Firefox; and (c) test results on Microsoft Edge.

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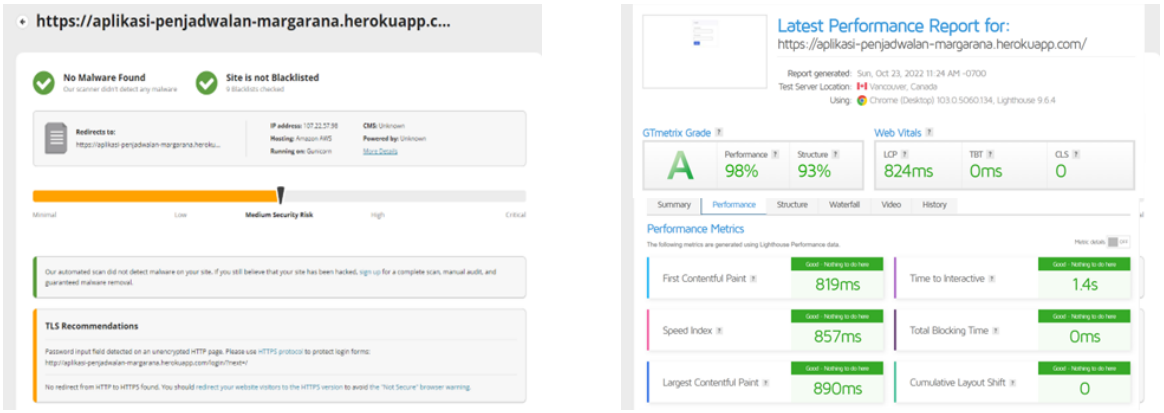

(a) (b)

FIGURE 9 The results of (a) application security testing and (b) application performance efficiency testing.

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