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PRESIMS: Requirements and Design for Preschool Management System Using Usability Theory

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ABSTRACT

Student Information Management System (SIMS) is a computerized system for education that can be used to manage student information and data. PASTI An-Nur is chosen as a case study in developing the system. Thus, several problems are identified that PASTI An-Nur faces due to the implementation of a manual system in the admission process. The first problem is the paper-based registration form that is prone to lose, misplaced and less secure. As for the payment process, arise a problem in term of higher error rate when checking and calculating the payments. The biggest downfall for PASTI An-Nur is the amount of space used to store all the students' files. These problems bring inefficiency since the world is changing to computerized, where data management become one of the most significant issues nowadays. So, the aim of developing the Preschool Management System (PRESIMS) is for helping the staffs and teachers in managing the students' information. The Adapter Waterfall model was used in developing this system. Additionally, usability heuristics was used also as a theory to guide the development of this system. The system has been tested with the four (4) users and two (2) experts. The testing method is the ISO/IEC 9126-4 approach to measure usability metrics, including efficiency, effectiveness, and satisfaction. Whereas, for the experts, heuristic evaluation is used to bring six (6) usability principles into implementation for testing. The result of the testing is very satisfying, which shows 75.5% of efficiency, 83.33% of effectiveness and three (3) out of four (4) users very satisfied with the system. The result of heuristic evaluation also shows a successful implementation of the system. The details of the result are discussed in this paper and expected to meet the users' specification and it is ready to go live.

Keywords: *Preschool Management System; SIMS, MIS; Usability Theory; Waterfall.*

1. INTRODUCTION

Over the decades, technology has become more prominent in most industries, where it has an overwhelming effect on managing and processing information, especially in education. As the world becomes more technologically advanced, many universities, secondary schools, primary schools and preschools in Malaysia are considering to have their own data management system, especially student information management system (SIMS), that can help them in efficiently managing all the existing students' information systematically. A student information management system (SIMS) is a system that allows the institutions to collect, manage and analyze a student-level data to become more accurate and comprehensive for reporting requirements and programmatic decisions [1].

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Eventually, PASTI An-Nur, a preschool kindergarten located at Pasir Puteh Kelantan, also has acknowledged the evolution of technologies. Therefore, PASTI An-Nur is intended to have a student information management system (SIMS), to replace the existing manual system in handling all of its students' information. To realize the intention, a system called as preschool management system (PRESIMS) will be developed to replace the manual system and solve all the problems facing by PASTI An-Nur when using the manual system. PRESIMS is an online SIMS system developed to improve the management in PASTI An-Nur, which also helps the staff and teachers manage the application of students, students' fees payment process, and students records, performances and events details sharing process. Besides, usability theory is being used in developing this system to make sure that the developed system is easy to learn and used. According to [2], usability theory is applied to a system to fully utilize its ability to function effectively and efficiently, while providing instinctive satisfaction to its users. Accordingly, by implementing the usability theory into the developed system, it can be one of the elements that will enhance the system's functionality and help achieve PASTI An-Nur requirements, needs, and interest.

1.1 Problems & Business Process

As mentioned before, PASTI An-Nur currently is still using a manual process, especially in the data entry processes of the students' information. Based on the interview with PASTI An-Nur owner at the start of the preschool's operation, the manual document filling process is still bearable and easy to conduct for the staff and teachers. However, as the number of students keeps increasing, the manual filling process becomes cumbersome. The current manual system of PASTI An-Nur is depicted in Figure 1 below.

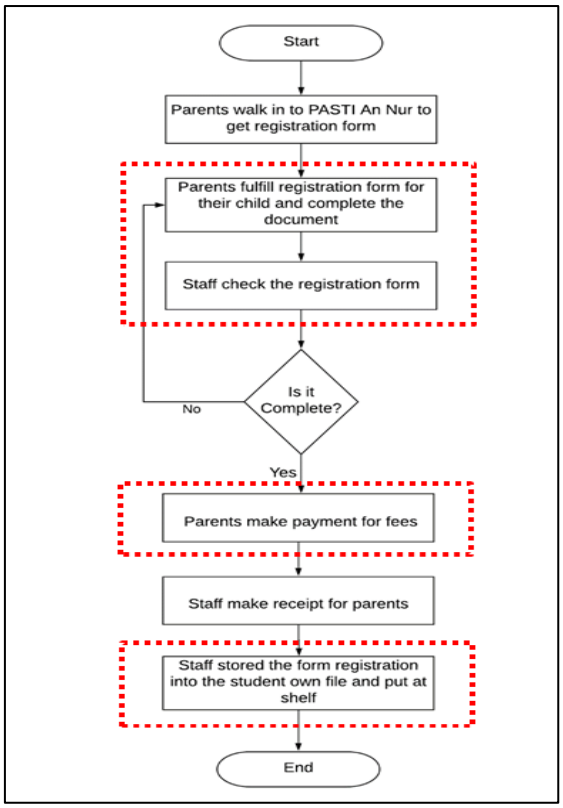

Figure 1: Current Business Process of PASTI An-Nur

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Based on the figure above, students' registration process requires parents to submit a paper-based registration form to the PASTI An-Nur's staff. Moreover,the staff will check whether the form fulfils all the requirements needed. Inevitably, problems may arise where the registration details may prone to lost, misplaced, and less secure. As for the payment process, PASTI An-Nur also uses paper for invoices and a calculator for manual calculation when dealing with the fee payments. Undoubtedly, this process includes pain point on higher error rate when checking and calculating the payments. As mentioned by [3], paper-based documentation means that the organization is placing faith in the people when handling the files. It has been proven that it is impossible to avoid problems as even the most careful employees do make mistakes.

Additionally, this manual system's biggest downfall is the amount of space that it can take up to fit all the students' files at the shelf as the staff need to store all the paper-based registration form and invoices into each of the students' files. This also means that the staff need to go out all the way when searching for a student file, and thus, very time-consuming. Based on the staff's interview, they said that it could take minutes to hours when searching the student file even though those files were already organized based on the students' names in the alphabetical order. Another problem arises is that when working with paper documents, it is tough to make changes when it is needed. Every time the staff want to edit or make changes, they have to make a copy first, so that they will not destroy the original document and distinguish all the changes that have been done.

2. LITERATURE REVIEW

A literature review consists of a censorious analysis and comprehensive summary of past research that depict the critical concepts, research methods, and experimental techniques used in the research [4]. For this research, this paper literature review will focus more on the usability of heuristic theory implementation.

2.1 Usability Heuristic Theory Implementation

When developing a system, human-computer interaction (HCI) has become a crucial activity to evaluate human use in interacting with computing devices. One of the critical evaluation instruments in the HCI area is usability, which is a technique derived by the Nielson Norman group [5]. According to [6],usability ensures that interaction products are practical to use, easy to learn and enjoyable from the user perspective. Another research defined usability as "the capability of the software product to be understood, attractive to the user and easy to for the users where they are put under specified conditions" [7]. In general, usability represents the evaluation of a system's functionality by observing the users' behaviour and reactions to the system.

[8] mentions that there is ten (10) general principles of usability heuristic theory, which are the visibility of system status, match between system and the real world, user control and freedom, consistency and standards, error prevention, recognition rather than call, flexibility and minimalist, help users recognize, diagnose and recover from errors, and the last one is help documentation. The original set of this usability heuristic principles was introduced by Jakob Nielsen and Rolf Molich in 1990 [8]. Table 1 shows the principles of the usability heuristics theory.

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Table 1: Description of the Usability Heuristics Theory.

No	Principles	Explanation	Expected Deliverable
1	Visibility of System	The system shall always keep the user informed of what happening, through appropriate feedback within a reasonable time	The proposed system will be showing the status of the upload documents.
2	User Control and Freedom.	The system shall give the user the control, freedom to navigate and perform actions with proper button	The proposed system will be shown the button so that the user easy to control the system.
3	Match Between System and Real World	The system should speak language, phrases and words. The system uses real-world conventions, logical order and making information appear	The proposed system will be showing the same as what the user thinks in the real world and make the user easy to understand
4	Consistency and Standard	Users do not have to wonder if the difference situation, words, and actions have the same meaning	The proposed system will be using the same word, same font, same color and other to make sure the user is not confused when using the system.
5	Error Prevention	Good error messages is a careful design which in the first place for check and present users with a confirmation option before committing to action	The proposed system will be given a prompt confirmation message to inform users if they have entered the correct information before proceeding to the next step.
6	Aesthetic and Minimalist Design	Dialogues should not contain information that is rarely needed. Every adjunct unit of information in a dialogue competes with the related units of information	The proposed system will keep the information needed short and will minimalist design that can user understand.
7	Help and Documentation	General information should be easy to search, list concrete steps to carry out and focused on user tasks.	The proposed system will be provided with extra information that would be useful to the user.
8	Help Users Diagnose Recognize and Recover From Error	An error message should be manifest in plain language, constructively suggest solving and precisely indicate the problem	If the filled application is entered incorrectly, the input filled will be turned to red.
9	Flexibility and Efficiency Of Use	The system can cater to both experienced and inexperienced users	The system should provide a navigation link
10	Recognition Rather Than Call	Minimize the user's memory load by making actions, options visible and objects.	The user does not have to remember information dialogue from one part to another

In the proposed system, this usability heuristics theory is implemented. However, only six (6) principles are applied. According to [9], the context of usability theory heuristic represents general rules of thumb, however, to attain optimal design, it is suggested to take into consideration between three (3) to five (5) principles of the theory. Supported by [10]this paper found that most of the research uses an informal process to develop usability heuristics because there is no consensus and exact protocol on how they should use these sets of usability heuristics. Thus, when more principles are used, more problems will be identified in turn as these sets of usability heuristics are challenging to understand or use [10].

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3. METHODOLOGY

The methodology that is used to develop this system is based on a waterfall model. Winston W. Royce proposed the first publication on the waterfall model in 1970 [11]. However, this classical model of software engineering has been heavily criticized by other researchers, which results in modifying this model into a different and new model [12]. Despite the criticism raised, the model is still widely used in software engineering, and others also believed that this model would be around for a more extended period. Hence, the methodology chosen for this PRESIMS system is an adapted waterfall model because this model is a suitable methodology that can guide the developers at various stages in the project [13]. This adapted waterfall model consists of six (6) phases: planning, analysis, design, implementation, testing and documentation. Figure 2 shows the adapted waterfall model that has been applied to this research.

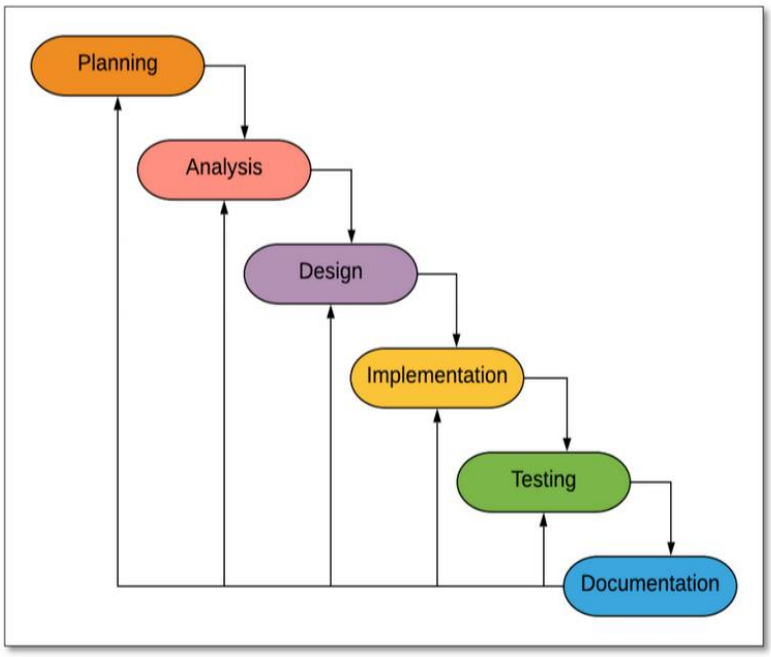

Figure 2: Adapted Waterfall Model

3.1 Planning

The initial phase on this PRESIMS system development is the planning phase, which in this phase, this research goals and objectives are determined and details plan for the intended system development is established. This phase is the most fundamental and critical phase of the research, which it involved three (3) primary activities that are the identification of the system for development, feasibility assessment and creation of the project plan [13]. For the identification of the system for development activity, an interview session is conducted to identify the possible solution for PASTI An-Nur and collect all the possible data that could be gained from the owner, staff, and teachers of PASTI An-Nur. For the feasibility assessment, this research determines whether the proposed system is feasible enough for PASTI An-nur and thus, come out with project scope and significances. As for creating the project plan, this research has come out with a project framework and Gantt chart to kick-start the development of PRESIMS system.

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3.2 Analysis

The second phase of this system development is the analysis phase, where this research considerss the developed system's functional requirements. In this phase, the current business process is analyzed, and the flowchart of the current business process was developed with several problems presented in the form of problem statement metrics. A detailed literature review from past researchis conducted to gain the detailed information regarding the area of interest of this research and the theory implemented in the system development. It is also a phase where a system analysis takes place by analyzing the needs and requirements of the end-users, which are the staff, teachers of PASTI An-Nur, and the parents to ensure that the developed system can meet their expectations. All the required details are gathered and placed into a functional specification and acts as a guideline for developing the system.

3.3 Design

In the design phase of this system development, all of the previous phase's collected requirements are transformed into design models. These design models include process flow diagrams, context diagram, data flow diagram (DFD), entity-relationship diagram (ERD), site map or functional hierarchy diagram (FHD), and also the proposed interface of PRESIMS system.

3.3.1 Site Map / Functional Hierarchy Diagram (FHD)

A site map or functional hierarchy diagram (FHD) is defined as a visual way to organize the system's navigation. The site map also describes the system's overall flow or hierarchy and keeps this system development aligned with the user requirements in mind. Besides, the site map listsd all of the functions that users can do when they access the PRESIMS system. Figure 3 shows the site map for this PRESIMS system.

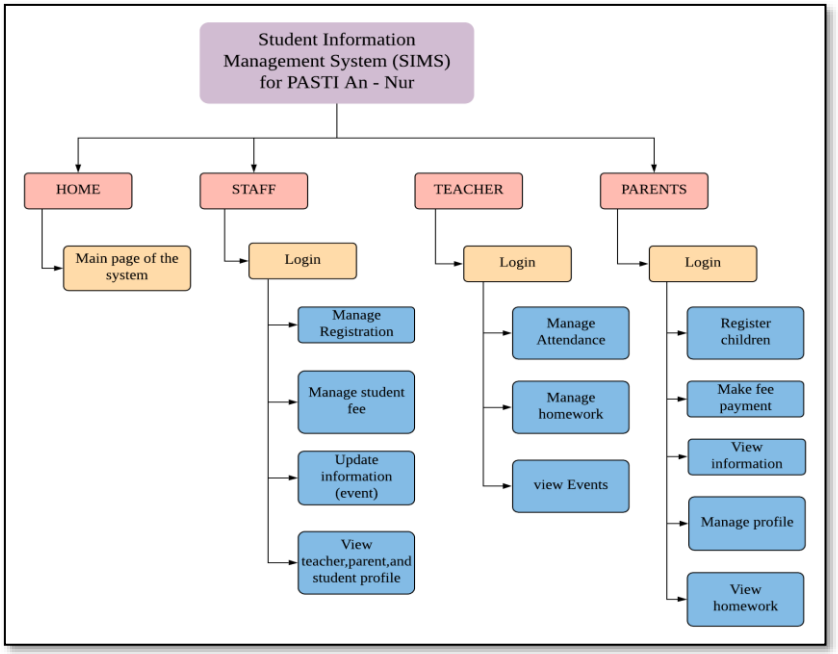

Figure 3: Site Maps of PRESIMS

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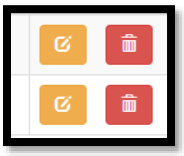
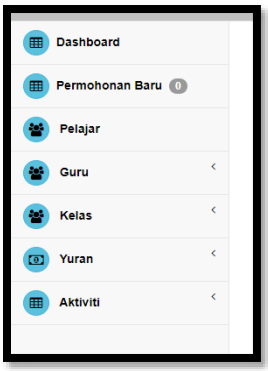
3.4 Implementation

This phase signifies the start of the system development process, where all the documents from the previous phase are transformed into an existing system. There are two (2) primary activities in this implementation phase: the development of the system interface, and the development of database and code [13]. For the development of the system interface, the main goal is to develop the user interface as simple and efficient as possible, while keeping in mind the users' requirements. Additionally, as mentioned before, the six (6) principles of the usability heuristics theory are integrated into the user interface. These six (6) principles are user control and freedom, the match between system, the real world, consistency and standard, error prevention, help and documentation, and aesthetic and minimalist design. Following this, the development of the database and code is started to complete the development of PRESIMS system. Table 2 shows the details of the implementation in the system.

Table 2: Implementation of the Usability Heuristics Theory in System

No	Principles	Explanation	Implemented in Design
1.	User Control and Freedom	The ability staff to click all the student names at the checkbox and send the notification payment to all parents or select only one student and send them the notification.	
2.	Match between System and Real World	The orange button icon notification and the dustbin icon in the proposed system same in the real world.	
3.	Consistency and Standard	Using the same font and size in the system, for example, on the homepage. It uses the same font, size, color and arrangement.	 

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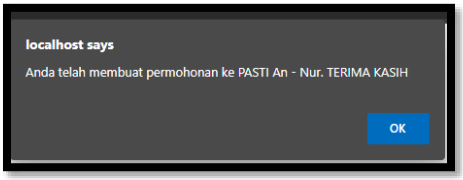
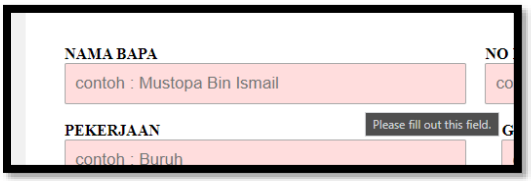
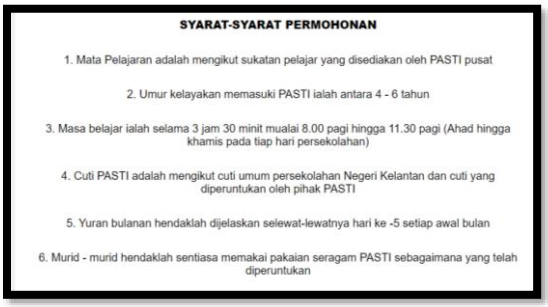
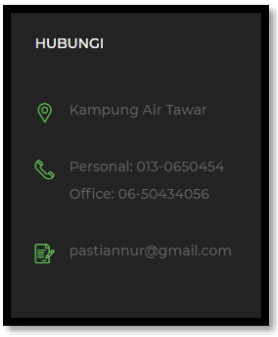
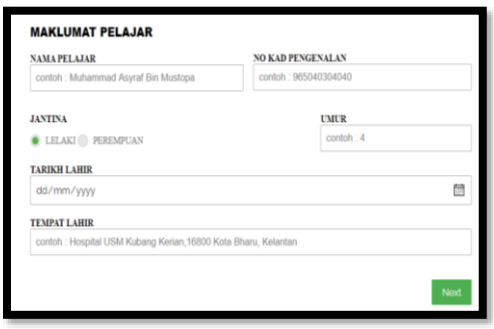
4.	Error Prevention	Pop up the message before proceeding to the next step or highlight field for empty space	 
5.	Help and Documentation	Provide help for parents to input the correct information in the field application form and provide the admission requirement.	  
6.	Aesthetic and Minimalist Design	The form is straightforward with the necessary information to key in, and the design is straightforward with a white background.	

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3.5 Testing

The testing phase is arguably one of the most essential phases in this system development, and it is carried out to determine whether the proposed system meets the initial set of the users' requirements and needs [14]. For this testing phase, user testing and evaluation are carried out by the system's experts and end-users. As the recent rise of ongoing worldwide COVID pandemic, this system's testing also affected, as this research cannot bring in more users to test the system. However, [14] state that a few end-users in range of three (3) to five (5) people are already appropriate to set and test the effectiveness or efficiency of the system and is also validated through expert opinions. Hence, this evaluation involves two (2) experts and four (4) end-users testing the PRESIMS system. The evaluation with the experts is based on the heuristic evaluation, whereas the end-users' evaluation is based on usability testing. This paper chooses different types of evaluations for the testing because due to [15], usability testing is performed by non-professional users with limited experience, which they need to perform and complete specific tasks within the given times. In contrast, heuristic evaluation is more to the professionals with experience testing process with the list of what they need to look for and finds the potential problems [5].

3.5.1 Heuristic Evaluation

To ensure that the PRESIMS system meets the requirements, two (2) experts are involved in the heuristic evaluation to gather their conformity on the six (6) principles usability heuristic theory integrated into the system. This evaluation is carried out based on the open-ended questionnaires with additional status whether they disagree, not sure or agree with the implementation of the usability principles. The experts are free to provide any comments, suggestions and their views about the system. Table 3 below show these experts' qualification and experience.

Table 3: Experts Qualification and Experience

Expert	Level of Education	Experience
Expert 1	PhD	More than five (5) years as a system supervisor
Expert 2	Master	More than five (5) years in system development

3.5.2 Usability Testing

In contrast with the heuristic evaluation carried by experts, this usability testing is performed by the end-users, who are the owner of PASTI An-Nur, two (2) of the staffs and one (1) of the teacher. This usability testing uses three (3) metrics: efficiency, effectiveness, and satisfaction. Efficiency is measured based on the average time the user is taken to complete each of the task given. In contrast, the effectiveness is the success rate or the users' completion rate that also refers to the percentage of the users, who correctly achieve and complete each of the tasks [15]. The satisfaction metric is measured using the closed-ended questionnaires that consist of ten (10) questions with a given Likert scale (from 5-strongly agree to 1-strongly disagree). To determine this metric, System Usability Scale (SUS) is also used to determine the result, as it is a reliable and robust evaluation used by most of the research [16]. Table 4 below show PRESIMS system tasks categorization for this usability testing.

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Table 4: PRESIMS system tasks categorization

Users	Components	Tasks
Staff	Login Manage registration Manage student fees Update event information View teachers, parents and students' information	Task 1
Teacher	Login Manage students' attendance Manage students' homework View events information	Task 2
Parent	Login Registration for children Make fees payment online Manage profiles View children's homework View events information	Task 3

3.6 Documentation

Documentation is the last phase of this research, where all of the data and information gathered is recorded and documented in a report format. The purpose of documentation is to help keep track of all aspects of the development of the system and any changes that have been made into the system and improve the quality of the developed system [11]. Furthermore, it is also crucial and essential to record all the details information in each phase of the development for referral later when any changes are meant to be made or any major rework that needs to be done.

4. RESULT AND DISCUSSION

This section focused on the result and discussion of the PRESIMS system, which is related to the usability testing and heuristic evaluation that have been carried out in the testing phase.

4.1 Usability Testing Using Metrics

The system was tested using three (3) usability metrics: efficiency, effectiveness and satisfaction. Each of the results of the calculation for each of the metrics is discussed below.

4.1.1 Efficiency

Efficiency is measured in terms of task time. The task time means time taken for the user to complete the task. The efficiency can be calculated using two (2) ways: time-based efficiency and overall relative efficiency (17). To calculate this system's efficiency, the formulae of overall relative efficiency are used which is shown in Figure 4.

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$$Overall\ Relative\ Efficiency = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N} n_{ij}t_{ij}}{\sum_{j=1}^{R}\sum_{i=1}^{N} t_{ij}} \times 100\%$$

N = The total number of tasks (goals)
R = The number of users
nij = The result of task i by user j; if the user completes the task, then
Nij = 1, if not, then Nij = 0
Tij = The time spent by user j to complete task i. If the task is not completed, then time is measured until the moment the user quits the tasks.

Figure 4: Formulae for Overall Relative Efficiency [17]

Taking the above equation into implementation, four (4) users have tested and performed the same tasks in this system. Each of the users' result is tabulated in Table 5 below.

Table 5: Result of the Completion Time for All Users

User	**Task 1**	**Task 2**	**Task 3**
User 1	Completed (10 sec)	Completed (5sec)	Completed (8 sec)
User 2	Completed (15 sec)	Completed (6 sec)	Completed (11 sec)
User 3	Uncompleted (18 sec)	Completed (8 sec)	Completed (15 sec)
User 4	Completed (13 sec)	Completed (12 sec)	Uncompleted (24 sec)

Therefore, based on the result of each of the users, the calculation is made by placing the values into the equation as follow:

Task 1 = ((1 x 10) + (1 x 15) + (0 x 18) + (1x13)) = 38
Task 2 = ((1 x 5) + (1 x 6) + (1 x 8) + (1x12)) = 31
Task 3 = ((1 x 8) + (1 x 11) + (1 x 15) + (0x24)) = 58
Overall time taken = 10 + 15 + 18 + 13 + 5 + 6 + 8 + 12 + 8 + 11 + 15 + 24 = 169

Overall Relative Efficiency $= \frac{38 + 31 + 58}{169} \times 100\%$

$= 75.15\%$

From the above calculation, it can be seen that the efficiency of this PRESIMS system is approximately 75.15%. Based on [5], most often, research falls within the average of 70% of the efficiency, which means that it is already considered good enough for the system testing that at least 70% of efficiency is on their first attempt. Based on the result. It shows that the PRESIMS system is efficient and can supports user in achieving the tasks and goals in minimal time, without having to think harder and put more efforts when using the system.

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4.1.2 Effectiveness

Effectiveness can be calculated by measuring the completion rate. The number of tasks completed successfully determines the completion rate, and the total number of tasks undertaken by the user [17]. The formulae for this effectiveness metric is shown in Figure 5.

$$Effectiveness = \frac{\text{Number of tasks completed successfully}}{\text{Total number of tasks undertaken}} \times 100\%$$

Figure 5: Formulae for Effectiveness [17]

Using the above equation and information from Table 5, the overall user effectiveness is calculated as follows:

Task 1 = 3 users completed, 1 uncompleted
Task 2 = 4 users completed
Task 3 = 3 users completed, 1 uncompleted

Effectiveness = $\frac{(3 + 4 + 3)}{(4 + 3)}$ x 100%

= 83.33%

From the above calculation, it can be seen that the effectiveness of this PRESIMS system is approximately 83.33%. Based on [17], the rage of effectiveness between 80% to 100% is considered an exemplary usability implementation of the system, as the success rate (or completion rate) is higher enough. Therefore, this paper can imply that the PRESIMS system effectively allows users to achieve their goals and carry out their tasks.

4.1.3 Satisfaction

For the users' satisfaction level, this paper uses the system usability scale (SUS) method, which provides a reliable tool for measuring user satisfaction. [17] SUS is an easy tool to scale and administer user satisfaction and is suitable for small sample sizes with reliable results. To calculate the satisfaction level, the scale in the questioners is converted into numbers for each of the ten (10) questions and put into the formulae from [17] as below:

- Strongly disagree = 1 points
- Disagree = 2 points
- Neutral = 3 points
- Agree = 4 points
- Strongly agree = 5 points

SUS Score = (X + Y) x 2.5

X = Sum of the points for all odd-numbered questions - 5
Y = 25 - Sum of the points for all even-numbered questions

Using the above equation, the SUS score for each of the user is calculated as follows:

User 1 : (18 + 19) x 2.5 = 92.5
User 2 : (15 + 17) x 2.5 = 80
User 3 : (14 + 17) x 2.5 = 77.5
User 4 : (11 + 13) x 2.5 = 60

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Based on the result, it can be concluded User 1, User 2 and User 3 places this system in an acceptable acceptability score margin. In contrast, User 4 put this system in the marginal category of the acceptability score. Hence, this research can conclude that User 1 think that this system is a best imaginable system that can satisfy users' requirements and needs, while User 2 and User 3 think that this system falls into a sound system that can satisfy users but need to rethink of the better improvement. Lastly, User 3 thinks that this system is still acceptable and can be implemented even though some existing pain points need to be catered.

4.1 Heuristic Evaluation

This section presents the result obtained from the heuristic evaluation that is carried out for the experts. Table 6 below shows the result of this heuristic evaluation.

Table 6: Result of the Heuristic Evaluation for All Experts

No	Usability Principles	Expert 1	Expert 2
1.	User Control and Freedom	Agree	Agree
2.	Match between System and Real World	Agree	Disagree
3.	Consistency and Standard	Disagree	Agree
4.	Error Prevention	Agree	Not sure
5.	Help and Documentation	Agree	Agree
6.	Aesthetic and Minimalist Design	Agree	Agree

Based on the table above, all of the experts agree that this system is fully utilized the usability principles of user control and freedom, help and documentation, and aesthetic and minimalist design. However, for the match between system and the real world, Expert 2 disagrees, as she said that some icon of the buttons that are being used are not suitable for its function and thus, make it difficult for the user to understand the functionality of the button. In terms of consistency and standard, Expert 1 disagreed as she said that some text fields were not consistent in terms of height and width, and the placement of the buttons on the system was not consistent. Expert 2, on the other hand, said that for the error prevention, she is not sure whether to agree or disagree because some of the message boxes stated "localhost" which it should be stating the title of the message instead of the word "localhost". Overall, both experts said that the implementation of the usability principles is successful but need to improve before running in the real environment.

5. CONCLUSION

In conclusion, as for the usability testing result, it shows that in terms of efficiency, this system has a percentage of 75.15%, which means it is efficient enough for the user. This system has a percentage of 83.33% for the effectiveness, which placed this system in the right category of effectiveness. For satisfaction, three (3) out of four (4) users are fully satisfied with the systems. Besides, both experts agreed that this system implemented all of the proposed usability principles for the heuristic evaluation. However, some adjustment needs to be carried out later. There are some limitations when developing this system and the major limitation is this system cannot capture the parent with more than one child who wants to register into the system. Hence, this system is recommended to provide a single login and registration for more than one child

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for the parent. Hopefully, with the result obtained in this research, this system is expected to give enormous advantages to the PASTI An-Nur and provide guidance for future work.

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