The Analysis and Improvement of User Interface Design on Climate Information Service Mobile Application Using the Lean UX Method

Muhammad Fauzi[1*], Ni Kadek Ayu Wirdiani[2], Ni Kadek Dwi Rusjayanthi[3]

[1,2,3]Department of Information Technology, Universitas Udayana, Denpasar, Bali, Indonesia
Email: [1*]masfauzi001@student.unud.ac.id, [2]ayuwirdiani@unud.ac.id, [3]dwi.rusjayanthi@unud.ac.id

(Received: 6 Jul 2024, revised: 26 Aug 2024, accepted: 27 Aug 2024)

Abstract

Info BMKG is an iOS and Android app providing weather, temperature, air quality, and earthquake data across Indonesia. Issues related to the usability of the BMKG Info application were identified through observations and feedback found on the Google Play Store, which has a rating of 4.4. The responses identified included an unattractive appearance, limited features, increasing complexity, and a need for more innovation, necessitating usability evaluation and UI design improvements to enhance user experience. The analysis and redesign follow the Lean UX approach and Heuristic Evaluation method. Usability testing, specifically the Post-Study System Usability Questionnaire, is used to assess user satisfaction. The study finds that implementing Lean UX significantly improves the system's quality and user experience. UI design enhancements, based on usability testing, improve navigation, information clarity, and ease of use. Recommendations result in better outcomes, with Heuristic Evaluation yielding scores of H1 = 1 (System status visibility), H2 = 1 (Match between the system and the real world), H4 = 1 (Consistency and standards), H5 = 1 (Error prevention), H7 = 1 (Flexibility and efficiency of use), H8 = 1 (Aesthetic and minimalist design), and H9 = 1 (Help users recognize, diagnose, and recover from errors). The Post-Study System Usability Questionnaire method shows an improvement from high to a better category.

Keywords: User Interface, User Experience, Lean UX, Heuristic Evaluation, Post-Study System Usability Questionnaire.

I. INTRODUCTION

The world is perpetually changing and dynamic, continuously presenting different phenomena over time; as time progresses humans are confronted with change and evolution, particularly in mindsets or paradigms that continuously evolve, especially concerning human-computer interaction. User's mindsets in interacting with computers also change, influencing their comprehension of the information received. The field of human-computer interaction is a discipline that examines the impact of computer technology on human work and activities. Human-computer interaction entails the relationship between humans and computers in the pursuit of specific objectives [1]. UI and UX are short for User Interface and User Experience, respectively. These terms refer to the visual appearance and overall interaction experience of an application or digital marketing tool, such as a website. Effective UI and UX design have the potential to enhance the brand image of a business or company [2].

BMKG Info is a mobile application accessible on Android and iOS devices. It provides various information about weather conditions, climate, air quality, and earthquake events across different regions in Indonesia. Usability problems in the BMKG Info application were identified based on observations and user feedback on the Google Play Store, where the app has a rating of 4.4. The issues reported include an unattractive appearance, minimal features, increasing complexity, and a lack of innovation. These problems can negatively impact the user experience. To mitigate these issues, it is recommended to improve the design of the user interface to enhance user interest, comfort, effectiveness, and efficiency when using the application. This research employs the Lean UX approach, which aims to achieve product success more rapidly through collaboration between functional teams focused on concrete product development. This approach de-emphasizes the creation of redundant documentation and instead emphasizes an increased understanding of the product experience being designed [3].

Improving User Interface design using the Lean UX method has previously been done in a study by [4]. This research designs the User Interface/User Experience design of the dictionary information service website at Pamulang University. In experimental testing involving a number of

application users, around 30 users were involved in the study; in the study users underwent a series of small tests which later combined the results. Improvement of User Interface design in the BMKG Info application has previously been carried out in a study by [5]. The research was conducted using UEQ (User Experience Questionnaire) to measure the user experience level of the application and HE (Heuristic Evaluation) to find deeper problems found by the evaluator.

The main difference between this research and previous research [5], lies in the methodology adopted. While the previous study used Heuristic Evaluation and User Experience Questionnaire to assess the application, this study adopted Lean UX and PSSUQ approaches. Lean UX focuses on team collaboration and rapid feedback cycles to develop products that meet user needs. At the same time, PSSUQ provides a structured assessment of system usability post-study, which includes satisfaction, efficiency, and ease of use. The objectives of this research are to provide more precise recommendations for improvements to application design user interface and functionality, which is based on data obtained from the user's point of view.

II. LITERATURE REVIEW

A literature review is a section that provides a critical review and summary of research, theories, and findings relevant to the study's topic.

A. State Of The Art

In previous research [6], the author outlines how to apply lean UX to the UI/UX analysis and prototype design development of Less-ON, a digital startup. Although statistics on startup success rates show a paradox, the number of businesses in Indonesia is still growing rapidly. Statistics show that about 90% of startups fail. 75% of unicorn startups stated that a well-designed UI/UX could attract investors and help raise startup funds. The result of this research is the final prototype, which has been validated by comments and suggestions from the participants obtained through questionnaires. It also helps Less-On with its branding strategy. The creation of this private tutor booking software required careful consideration to improve utility and create a good user experience (UX). In addition, it has been proven that users benefit a lot from the user interface SUS score of 85.53 is above average and considered satisfactory.

Research conducted by Fatah [7], focuses on the application of usability testing and human-centered design (HCD) methodologies. The smartphone application of the Meteorology, Climatology, and Geophysics Agency (BMKG) serves as an early warning system for meteorological situations. However, the information display of this application is still not user-friendly, and the level of comfort and convenience is still below expectations. The BMKG mobile app should be modified in terms of design as early warning information can be accessed at the provincial and sub-district levels. This can be done by revisiting the Golden Eight Rules on interface design principles and testing the application with the ten questions in the SUS (System Usability Scale) Usability Questionnaire. Interviews with users of the application are also required. The test results based on the principles of the Golden Eight Rules show that three areas need improvement: "Dialog design to generate closure," "Support internal locus of control," and "Support internal locus of control." Subsequently, two SUS tests were conducted. The average score of 60 in the first round of testing for the BMKG mobile app design indicated low user acceptance. Based on these results, design improvements were made in response to respondents' comments. A good level of acceptance can be inferred from the second test's average score of 80.25, which was determined using the SUS approach. The product scored a B on the scoring system and was rated "Excellent" in terms of wording. Thus, customers will find the new look of the proposed BMKG mobile app easier to use and less confusing.

Lean UX methods used in research by [3], to create a User Interface for the Indonesian Patient Room Foundation Information System. Current patient data management has proven to be a problem for the Indonesian Patient Room Foundation. The foundation's mission is that the handling of patient data carried out by the current system is felt to be less structured. In this situation, the internal administrator, Dharmaadi, found it difficult to record and manage patient data thoroughly. This problem also led to a less efficient reporting process, greater data security risks, and more complexity in decision-making. To solve these problems, an organized and easy-to-use system is needed that can help internal administrators manage patient data efficiently. Lean UX is one strategy that can be applied to assist in designing an application user interface prototype that meets the required needs. Once the system is developed, Lean UX makes it easy to get the necessary feedback for the desired system development. The User Experience Questionnaire (UEQ) analysis tool was used to scale each of the two resulting design recommendations. This review resulted in one design recommendation that conformed to the user experience measurement technique.

Research conducted by [8] provides information on redesigning the UI of mobile consulting applications using the Lean UX methodology. The increasing use of smartphones around the world can be attributed to the development of mobile applications that are increasingly diverse both in terms of functionality and type. Application developers are competing to create applications that are very attractive and have potential. User interface (UI) is an important factor in the success of an app as a well-designed UI can enhance the user experience. This research focuses on developing a user interface prototype for a mobile application using Lean UX for online career consultation. Through a survey using UEQ and SUS questionnaires on ten respondents, it was found that there was a significant difference in terms of innovation and website dependability which was the main focus of the research. In response, the author developed a layout prototype for the mobile application "Konsul Aja" with 14 sections that integrate user needs and preferences; although Lean UX offers a good experience in the process, data from the survey is

essential to ensure that the prototype meets the needs of users and does not simply reflect the preferences of testers. Improvements, better colours, font changes, simplification of user flow, and the addition of the TanyaAja system as an in-app customer service.

Research conducted by [9], explains the heuristic evaluation method used in the usability testing of the iBadung app. The iBadung smartphone app serves as a repository for a wide variety of reading books; it can also be thought of as an open-access digital library. The purpose of usability testing is to evaluate the user experience with the iBadung app to measure the level of user comfort, app feasibility, and app interface. Based on the results of the first test, regular users and administrator users get a severity rating scale with one category of cosmetic issues, while lay users get a severity rating scale with two categories of minor usability issues. The application logo, menu icon layout, login menu display, and exit pop-up added to the iBadung application display are areas where problems were found. The display was improved based on suggestions from users, and after the display improvement was completed, a second test was conducted.

B. Lean UX

According to Gothelf in [3], Lean UX is an approach that drives products to achieve success faster by collaborating across functions and de-emphasizing paperwork while focusing more on understanding and developing the experience of the product being designed. There are three activities in the Lean UX method, including [10]:

1. Think
   At this stage is to create ideas related to the problems that have been identified through brainstorming sessions. In this session, the problem is presented to generate ideas and assumptions.
2. Make
   At this stage is to develop the ideas that have been generated into a prototype, to provide an overview of how the User Experience (UX) design will be used. This stage aims to get a design solution concept based on the problems that have been identified in the previous step.
3. Check
   In this step, the developed solution will be evaluated through a series of user experience tests.

C. Heuristic Evaluation

A method for evaluating the usability of user-based computer software is called heuristic evaluation. Ten heuristic concepts are then used to classify the evaluation and input evaluators supply to this system. Ten heuristic principles are listed below, according to Savitri and Ispani in [11]:

1. System status visibility (H1) refers to the availability of data or data obtained from the system about its current state.
2. System-to-world correspondence (H2): The system communicates with users through a language like symbols.
3. User control and freedom (H3): Users can interact with the system in various ways and can control it.
4. Consistency and standards (H4), there is a standard design applied to the system so that the appearance looks consistent.
5. Error control (H5): The system is capable of managing mistakes.
6. Users can readily understand the system's presentation, emphasizing recognition over memory (H6).
7. Flexibility and ease of use (H7): Novice and experienced users can efficiently operate the system.
8. The system has a simple, aesthetically pleasing design (H8) and presents adequate information.
9. Assist users in identifying, discussing, and recovering from problems (H9): The system helps users identify, discuss, and resolve systemic faults.
10. Assistance and records (H10): The system includes help to support users and documentation explaining how to utilize it.

Research by Nielsen [12], severity ratings will classify the problem findings obtained by the evaluator into several categories. Whether or not an improvement is needed will be seen from the level of error. On a scale from 0 to 4, usability problem severity ratings can be found as follows (Nielsen, 1994):

a. Scale 0: There is no problem with the usability.
b. Scale 1: Problem category: cosmetic; if there is still time in the project, there is no need to solve the issue.
c. Scale 2: Classified as a minor usability issue, this issue's resolution needs to be given higher priority.
d. Scale 3: Fixing this major usability problem area is of utmost importance.
e. Scale 4: Categorization usability disaster: something that needs to be addressed.

The calculation of the heuristic evaluation uses the Equation 1.

$$\sum Hx = (0 * x) + (1 * x) + (2 * x) + (3 * x) + (4 * x) \quad (1)$$

$\sum Hx$ = the sum of the rating scores of the usability sub-aspects in each usability aspect (H1,H2,.....,H10)
x = *point usability*, value 1/0

Generate a severity rating value from each usability aspect using the Equation 2:

$$sv = \sum Hx\, n \quad (2)$$

sv = Severity rating result in one usability aspect
n = The number of usability sub-aspects in each usability aspect

D. Usability Testing

Usability testing is a method of testing products in which users complete several typical tasks or activities to improve the interface's quality, depending on the findings. To produce positive business outcomes, organizations and IT specialists now place a great deal of emphasis on user acceptability testing and system testing [13], the quality component in usability has five attributes [14] including the following:

1. Learnability

Learnability is the degree of ease with which users may finish tasks when using an application for the first time.
2. Efficiency
   Efficiency is the level of how quickly users can complete tasks in an application.
3. Memorability
   Memorability refers to the extent to which it is easy for users to remember and repeat how they complete the tasks they have done in an application.
4. Error
   Errors are a measure of how often errors occur and are encountered by users in using an application.
5. Satisfaction
   When we talk about satisfaction, we're talking about how happy the user is with the application and how well it fulfills their needs and expectations.

The research variable that becomes the measurement reference in this study is that three important components must be fulfilled so that a product reaches the ideal usability level. ISO 9241-11 (1998) as the basis for measuring usability, namely measuring effectiveness, efficiency, and satisfaction.

E. PSSUQ

A method for measuring end-user satisfaction with a system or application is the Post-Study System Usability Questionnaire (PSSUQ), which consists of 16 predefined questions [15]. Table 1 below displays the assessment norms for the PSSUQ version 3.

Table 1. Rating Table of PSSUQ Version 3

Sub-Scale	*Lower Limit*	*Mean*	*Upper Limit*
Sysuse	2.79	3.02	3.24
Infoqual	2.28	2.49	2.71
Interqual	2.62	2.82	3.02
Overall	2.57	2.80	3.02

Table 1 shows the assessment norms from PSSUQ version 3. The table below displays the mean, upper, and lower limits for each subscale on the PSSUQ version 3 assessment standard.

F. Validity and Reliability Test

According to Scanria B. Anderson in the statistics module [16], "A test is valid if it measures what it aims to measure." "A test (measuring instrument/instrument) is said to be valid if the test can measure what is intended to be measured," is how it is generally understood.

Validity is a parameter that shows the extent to which a measurement instrument can measure exactly what is being measured. The higher the validity of the instrument, the more accurate the measurement tool is in measuring data [17]. This validity check is very important to ensure that the questions asked do not produce data that comes out of the intended variable description. The validity test formula can be seen in Equation 3:

$$r\ count = \frac{n\sum xy-(\sum x.\sum y)}{\sqrt{\{\sum x^2-(\sum x^2)\}\{n\sum y^2-(\sum y)^2\}}} \quad (3)$$

Description:
r xy : Coefficient of correlation
n : Quantity of samples
Σ XY : Total of the variables' multiplication by x and y
Σ X : Values of x variables in number
Σ Y : Total of the values of the y variable
Σ X2 : Total of the powers of the values of the x variable
Σ Y2 : The values of the y variable added up to their powers

The following criteria were used to conduct this validity test using the SPSS 26 program:
1. The statement is accepted if r count > r table.
2. The statement is considered invalid if the r count is less than the r table.
3. The corrected item-total correlation column displays the computed r-value.

The research instrument's reliability test is used to evaluate the validity of the questionnaire used to gather research data [18], Reliability calculations can only be done after validity has been tested, so if the questions in the questionnaire are invalid, then reliability testing does not need to be continued. Variables can be declared reliable with the following criteria [19]:
1. The assertion is deemed credible if the r-alpha value is positive and exceeds the r-table value.
2. The statement is unreliable if the r-alpha is negative and less than the r-table.
3. Reliable if the Cronbach's Alpha value is more significant than 0.6.
4. It is not dependable if the Cronbach's Alpha value is less than 0.6.

The variable is said to be good if it has a Cronbach's Alpha value > 0.6.

III. RESEARCH METHOD

Research steps are stages that have been applied before conducting research. This research step is adjusted to the stages in the Analysis and Improvement of User Interface Design in the BMKG Info Mobile Application Using the Lean UX Method. The following is the flow of the research stages for redesigning the UI/UX of the BMKG application using the Lean UX method.

Figure 1 shows the flow of research conducted in evaluating and improving the user interface design of the BMKG Info application using the Lean UX Approach Method and Usability Testing using the Heuristic Evaluation and Post Study System Usability Questionnaire (PSSUQ) methods.

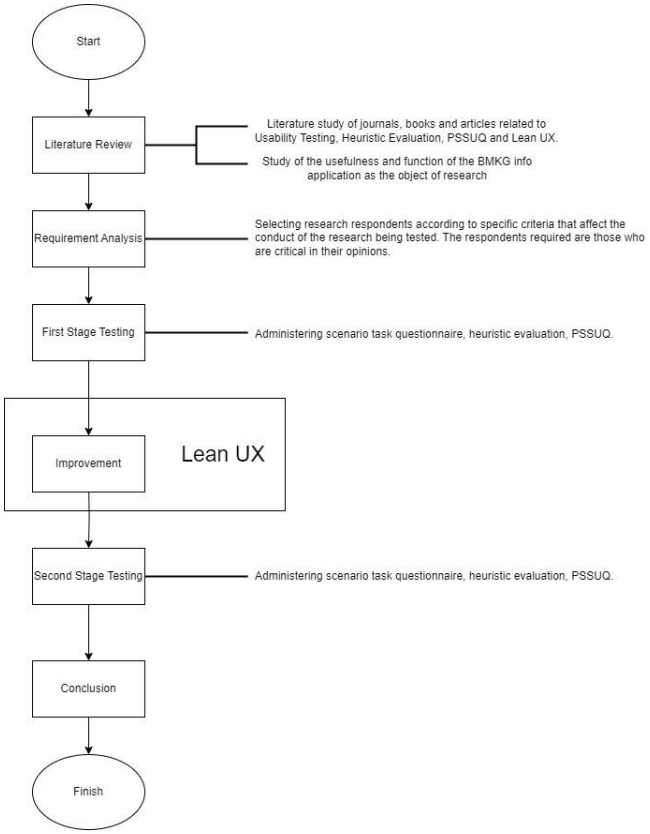


Figure 1. Research Method

A. Literature Review

This stage is a very useful stage for the author to support problem-solving in the research conducted. Some of the theoretical foundations discussed are User Interface, User Experience, Usability Evaluation, Lean UX, Heuristic Evaluation, and Post Study System Usability Questionnaire (PSSUQ). Sources are obtained from several books, journals, official websites, and national and international official papers.

B. Analysis of Needs

Research respondents were selected according to specific criteria that affect the conduct of the research being tested. The respondents needed are respondents who are critical in their opinion. This research involved 80 respondents who were divided into two categories, namely, 40 respondents in the first test and 40 user respondents in the second test. The criteria for respondents included various groups and occupations, considering that the BMKG Info application is used by everyone who has a gadget.

C. Stage 1 and Stage 2 Testing

Distribute a questionnaire that includes various important elements, such as task scenarios, heuristic evaluation, and PSSUQ (Post-Study System Usability Questionnaire). Task scenarios are designed to understand how users complete a particular task in a realistic context, while heuristic evaluation is used to identify usability issues based on recognized usability principles. In addition, the PSSUQ helps in evaluating overall user satisfaction with the tested system. Stage 2 testing was conducted after the improvements were implemented.

D. Lean UX

Improving the user interface design of the BMKG Info application was carried out using the Lean UX approach. User interface design focuses on user needs and involves the user from the beginning of the design to the end. The lean ux stages consist of think, make, and check.

The reason for using Lean UX methods in this research is because Lean UX offers an effective and iterative approach to improving user interface design with a focus on collaboration, user feedback, and rapid validation. In addition, Lean UX enables continuous testing of the resulting prototypes so that each design iteration can be based on real data and user feedback, increasing efficiency and effectiveness in achieving the goal of improving user experience.

IV. RESULTS AND DISCUSSION

The first stage of testing was carried out to find out how far the BMKG Info application is good to use. The purpose of the first stage of testing was to find out how much the BMKG Info application needs to be improved so that users feel comfortable using the BMKG Info application. In the first test, respondents worked on the task scenario that had been given and then continued by filling in the heuristic evaluation questionnaire and the Post Study System Usability Questionnaire (PSSUQ) (Table 2-5).

Table 2. First Stage SysUse Recap Results

Respondent	Question						SysUse
	1	2	3	4	5	6	
R1	4	3	4	4	3	4	3.6
R2	3	3	3	3	3	3	3
R3	3	3	3	3	3	3	3
R4	3	3	3	3	3	3	3
R5	3	4	3	3	4	3	3.33
R6	3	3	3	3	3	3	3
R7	3	3	3	4	4	3	3.33
R8	4	3	3	4	4	3	3.5
R9	3	3	4	4	4	3	3.5
R10	3	3	3	3	3	3	3
R11	3	3	3	4	4	4	3.5
R12	3	3	3	4	3	3	3.16
R13	3	3	3	3	4	4	3.33
R14	3	3	3	3	3	3	3
R15	4	4	4	4	4	4	4
R16	3	3	3	4	4	4	3.5
R17	3	4	3	4	3	4	3.5
R18	4	4	4	4	4	4	4
R19	3	4	3	3	3	4	3.33
R20	4	4	4	3	3	3	3.5
R21	3	3	4	4	4	4	3.66
R22	4	4	4	4	4	4	4
R23	3	4	3	3	3	3	4.16

Respondent	Question						SysUse
	1	2	3	4	5	6	
R24	3	4	3	4	3	3	3.33
R25	3	3	3	4	4	3	3.33
R26	4	4	5	5	3	4	4.16
R27	4	3	3	3	3	3	3.16
R28	4	4	3	4	4	4	3.83
R29	3	4	4	3	3	3	3.33
R30	3	4	3	4	3	4	3.5
R31	4	3	4	3	4	3	3.5
R32	4	4	5	4	3	3	3.83
R33	4	4	3	3	3	3	3.33
R34	3	3	4	4	4	3	3.5
R35	4	3	3	3	3	3	3.16
R36	4	3	4	3	4	3	3.5
R37	4	4	4	3	4	4	3.83
R38	4	4	4	4	4	4	4
R39	3	3	3	3	3	4	3.16
R40	3	3	3	3	3	3	3
ARD	3.45						

Table 3. First Stage InfoQual Recap Results

Respondent	Question						InfoQual
	7	8	9	10	11	12	
R1	4	4	4	4	4	4	4
R2	3	3	3	3	3	3	3
R3	4	3	3	3	4	4	3.5
R4	3	3	3	3	3	3	3
R5	3	4	4	4	4	3	3.66
R6	3	3	3	3	3	3	3
R7	3	4	4	3	3	3	3.33
R8	4	4	3	3	4	3	3.5
R9	3	3	3	3	4	4	3.33
R10	3	3	3	3	3	3	3
R11	4	3	3	3	3	3	3.16
R12	3	3	3	3	3	4	3.16
R13	4	4	4	4	4	4	4
R14	3	3	3	3	3	3	3
R15	4	4	4	3	3	3	3.5
R16	4	3	3	3	3	4	3.33
R17	3	4	3	4	3	3	3.33
R18	4	4	4	4	4	3	3.83
R19	4	4	3	3	3	3	3.33
R20	3	3	3	3	3	3	3
R21	4	4	3	3	3	3	3.33
R22	4	4	4	4	4	4	4
R23	3	3	3	3	3	3	3
R24	3	4	4	4	4	3	3.66
R25	4	3	4	3	3	3	3.33
R26	5	4	4	4	4	4	4.16
R27	3	3	3	3	3	3	3
R28	4	3	3	3	4	4	3.5
R29	3	3	3	3	4	4	3.33
R30	3	3	3	4	3	4	3.33
R31	4	3	3	3	3	3	3.16
R32	3	3	3	4	4	3	3.33
R33	3	4	4	4	4	4	3.83
R34	3	4	3	4	4	4	3.66
R35	4	4	3	3	3	3	3.33
R36	4	4	4	4	4	4	4
R37	4	4	4	3	3	4	3.66
R38	4	4	4	4	4	4	4
R39	4	4	4	4	4	3	3.83
R40	3	3	3	3	3	3	3
ARD	3.43						

Table 4. First Stage IntQuaL Recap Results

Respondent	Question			IntQual
	13	14	15	
R1	3	3	3	3
R2	3	3	3	3
R3	3	3	3	3
R4	3	3	3	3
R5	3	3	3	3
R6	3	3	3	3
R7	3	3	3	3
R8	4	3	3	3.33
R9	4	4	3	3.66
R10	3	3	3	3
R11	3	3	3	3
R12	4	4	4	4
R13	4	4	4	4
R14	3	3	3	3
R15	3	3	3	3
R16	3	3	4	3.33
R17	3	3	3	3
R18	3	3	3	3
R19	4	3	3	3.33
R20	3	4	4	3.66
R21	3	3	3	3
R22	4	4	4	4
R23	3	4	4	3.66
R24	3	3	3	3
R25	3	3	4	3.44
R26	3	3	3	3
R27	3	3	3	3
R28	4	4	3	3.66
R29	4	4	3	3.66
R30	3	3	3	3
R31	3	4	3	3.33
R32	4	4	4	4
R33	4	4	4	4
R34	3	3	4	3.33
R35	3	4	4	3.66
R36	3	4	4	3.66
R37	3	4	3	3.33
R38	4	4	4	4
R39	3	3	3	3

Respondent	Question			IntQual
	13	14	15	
R40	3	3	3	3
ARD		3.32		

Table 5. First-stage PSSUQ Results

SS	S	LL	M	UL	ARD
SysUse	1-6	2.79	3.02	3.24	3.45
InfoQual	7-12	2.28	2.49	2.71	3.43
InterQual	13-15	2.62	2.82	3.02	3.32
Overall	1-16	2.57	2.80	3.02	3.40

SS : Subscale
S : Scale
LL : Lower Limit
M : Mean
UL : Upper Limit
ARD : Average Respondent Data

Table 5 shows the average scores obtained from using the Post Study System Usability Questionnaire (PSSUQ) version 3. The average scores for the System Usefulness (*SysUse*), Information Quality (*InfoQual*), and Interface Quality (*InterQual*) scales are 3.45, 3.43, and 3.40, respectively. These results indicate that the BMKG Info application exceeds the expected upper limit, so improvements are needed so that the PSSUQ value can reach a more optimal lower limit.

Table 6. Results of Severity Ratings Heuristic Evaluation First Stage

NO	SR					NOSR	SRV
	0	1	2	3	4		
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1. Visibilty of System Status							
1.1	23	17	0	0	0	17	0.42
1.2	25	15	0	0	0	15	2.6
1.3	29	10	1	0	0	12	0.3
1.4	3	8	22	7	0	73	1.82
	70	50	23	7	0		5.14
	0	50	46	21	0		1.285
2. Match Between Sistem and The Real World							
1.1	9	31	1	0	0	33	0.82
1.2	8	32	1	0	0	34	0.85
1.3	7	31	3	0	0	37	0.92
1.4	3	25	11	1	0	50	1.25
1.5	15	21	4	0	0	29	0.72
	42	140	20	1	0		4.56
	0	140	40	3	0		0.912
3. User Control and Freedom							
1.1	35	4	1	0	0	6	0.15
1.2	35	3	2	0	0	7	0.17
1.3	6	8	25	1	0	61	1.52
1.4	33	5	2	0	0	9	0.22
1.5	35	5	0	0	0	5	0.12
	138	25	30	1	0		2.18
	0	25	60	3	0		0.436
4. Consistency and Standards							
1.1	12	27	1	0	0	29	0.72
1.2	22	17	1	0	0	19	0.47
1.3	18	19	3	0	0	25	0.62
1.4	28	12	0	0	0	12	0.3
1.5	22	16	2	0	0	20	0.5
1.6	20	20	0	0	0	20	0.5
1.7	3	8	26	3	0	69	1.72
	125	119	33	3	0		4.83
	0	119	66	9	0		0.69
5. Error Prevention							
1.1	31	9	0	0	0	9	0.22
1.2	29	10	1	0	0	12	0.3
1.3	29	10	1	0	0	12	0.3
1.4	6	29	5	0	0	39	0.97
1.5	2	9	28	0	0	65	1.62
	97	67	35	0	0		3.41
	0	67	70	0	0		0.682
6. Recognition Rather Than Recall							
1.1	28	10	2	0	0	14	0.35
1.2	27	12	1	0	0	14	0.35
	56	22	3	0	0	28	0.7
	0	44	9	0	0		0.35
7. Flexibility and Efficiency of Use							
1.1	10	26	4	0	0	34	0.85
1.2	12	27	1	0	0	29	0.72
	12	53	5	0	0	63	1.57
	0	53	10	0	0		0.78
8. Aesthetic and Minimalist Design							
1.1	9	22	9	0	0	40	1
1.2	4	10	25	1	0	63	1.57
1.3	14	23	3	0	0	29	0.72
	27	55	37	1	0		3.29
	0	55	74	3	0		1.096
9. Help Users Recognize, Diagnose, and Recover From Errors							
1.1	24	15	1	0	0	17	0.42
1.2	7	28	5	0	0	38	0.95
1.3	17	23	0	0	0	23	0.57
	48	66	6	0	0		1.94
	0	132	12	0	0		0.646
10. Help and Documentation							
1.1	22	17	1	0	0	19	0.47
1.2	29	10	1	0	0	12	0.3
1.3	33	7	0	0	0	7	0.17
	84	34	2	0	0		0.94
	0	34	4	0	0		0.313

VOEA : Value of Each Aspect
RV : Rounding Value
NOSR : Number of Severity Ratings
SRV : Severity Ratings Value

Table 7. Recap of Severity Ratings Heuristic Evaluation Results First Stage

Aspect	VOEA	RV
Visibility of system status	1.285	1
Match between system and the real world	0.912	1
User control and freedom	0.436	0
Consistency and standards	0.69	1
Error prevention	0.682	1
Recognition rather than recall	0.35	0
Flexibility and efficient of use	0.78	1
Aesthetic and minimalist design	1.096	1
Help users recognize, dialogue, and recover from errors	0.646	1
Help and documentation	0.313	0

VOEA : Value Of Each Aspect
RV : Rounding Value

The findings of usability testing with the heuristic evaluation approach and the severity ratings obtained from each aspect are summarized in Table 6 and 7. H1 Visibility of system status, H2 Match between the system and the real world, H4 Consistency and standards, H5 Error prevention, H7 Flexibility and efficient of use, H8 Aesthetic and minimalist design, and H9 Help users recognize, dialogue, and recover from errors are the severity ratings that need improvement in the first test. These ratings are rounded up to a single cosmetic problem category, meaning that the issue needs to be fixed only if there is still time in the project.

A. Lean UX Think

This stage is the stage of identifying user needs and organizational needs with the needs of the user environment. This stage can be done by distributing questionnaires to find out user needs.

1. Assumptions

Declaring assumptions is the first step in the development process. It is necessary to determine the issues that users are facing. The results of prior interviews are cited when making assumptions [20]. The following Table 8 is a table of assumptions obtained through the distribution of respondents at the stage before improvement.

Table 8. Assumptions About User Needs

No	Assumptions
1	Users want a more organized weather forecast display.
2	Users want dark mode feature.
3	Users want a map-shaped wind forecast.
4	Users want rain and thunder forecast in the form of a map.
5	Users want to speed up searching for regions on the air quality page.
6	User wants to see tides on surrounding beaches.
7	Users want daily/weekly/monthly reports on earthquake data in the vicinity.

2. Ideate

The term "ideate" refers to the act of generating new and original ideas that can address people's needs or solve their problems [21]. The ideation process incorporates a number of teamwork and brainstorming strategies. Table 9 is a table of ideas resulting from brainstorming

Table 9. Ideas

No	Ideas
1	Creating a Darkmode Feature.
2	Create a map-shaped wind forecast feature.
3	Create a rain and thunder forecast feature in the form of a map.
4	Create a daily/weekly/monthly report menu related to earthquake events.
5	Create a search feature on the air quality page.
6	Create a feature to see the tides around the beach.

3. Mental Models

Mental models are people's internal conceptions of how the real world operates [22]. Users use mental models to understand and anticipate how they engage with a system or product based on their expectations, knowledge, and past experiences.

4. Sketch

Sketches used to visualize initial design concepts are referred to as sketches [23]. These images are a quick and effective way to communicate ideas developed during ideation and brainstorming sessions.

B. Lean UX Make

In Lean UX, the "Make" stage is when the team starts working on the solution with the goal of producing a prototype that can be used for testing [24].

1. Wireframe

A wireframe is a straightforward visual depiction of the structure and layout of a page or application [25]. The basic structure is created using wireframes, visual design elements such as colors and graphics are not prioritized. The following are wireframes from the development of ideas and sketches.

Figure 2 is a wireframe of the proposed improvement, which is obtained from the results of distributing questionnaires in the pre-improvement stage. In the wireframe above there are seven letters, namely a to g. Wireframe a is a satellite image display of a map-shaped wind forecast and a Thunder rain forecast. Wireframe b is a display of a report of an area related to the occurrence of an earthquake. Wireframe c is a display of satellite imagery, where this display has an area search column. Wireframe d is a view of the weather page, on this page it will be clearer in the prototype section. Wireframe e is a view of the settings page where there is a night mode feature. Wireframe f and g are pages of beach weather that can see related tide data and others.

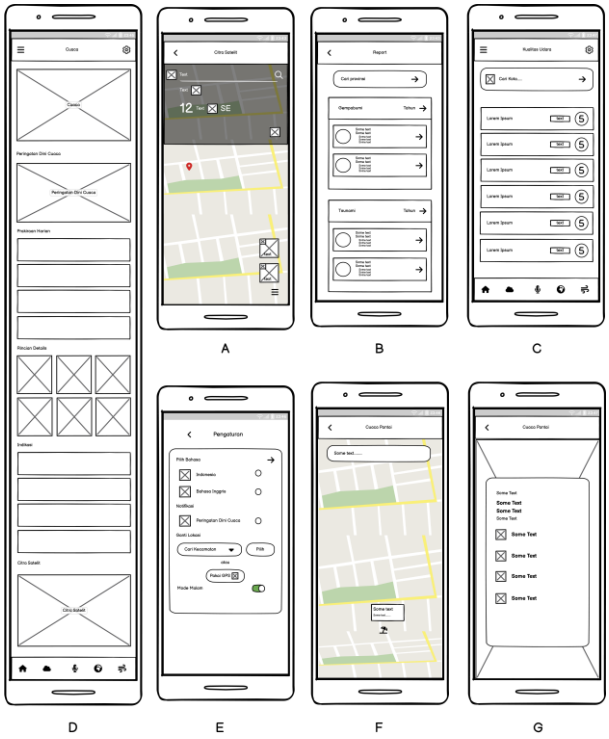
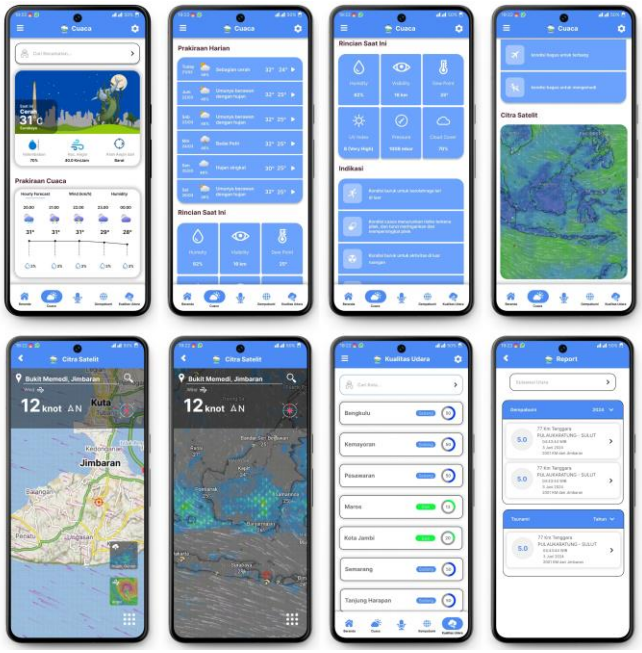


Figure 2. Improvement Wireframe

2. Prototype

A prototype is an early version of a product that is more interactive and more detailed than a wireframe [26]. Before proceeding to the full development stage, prototypes are used to test ideas, interactions, and user flows in the real world and get more precise feedback.



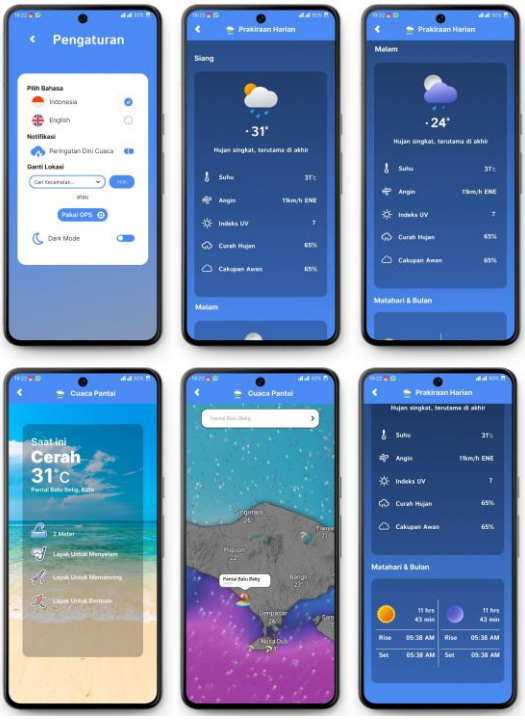


Figure 3. Prototype of Proposed Improvements

Figure 3 is the second stage of the proposed improvement prototype. This image has been adapted to the wireframe stage generated prior to prototype development, ensuring all design elements have been improved and adjusted based on feedback from the first stage of testing.

3. Value Propositions

Value propositions are the special features and advantages that a product or feature provides to customers [27]. The product value proposition outlines the benefits to customers and how the product can fulfill their demands. By formulating a clear and compelling value proposition, a product can be more effective in attracting attention.

4. Hypoteses

The term "hypotheses" refers to the team's preconceived notions about the users, the problems they face, and the suggested improvements [28]. The team can concentrate on what really matters and relates to the users by using these hypotheses as the basis for additional development and testing.

Table 10. Hypothesis Table

No	Assumption statements	Hypotheses	S/F
1	Users Want a More Organized Weather Forecast Display	Adding more features like Hourly weather forecast, wind speed, humidity, daily forecast, current details and indications will increase user satisfaction.	S

2	Users Want Dark Mode Feature	Adding Darkmode feature to the settings will increase user satisfaction	S
3	Users want a map-shaped wind forecast	Creating a map-shaped wind forecast feature will increase user satisfaction	S
4	Users want rain and thunder forecasts in the form of a map	Creating a map-shaped rain and thunder forecast feature will increase user satisfaction	S
5	Users want to speed up searching for regions on the air quality page	Creating a search feature on the air quality page will increase user satisfaction	S
6	Users want to see the tides on the surrounding beaches	Creating a feature to view tides on surrounding beaches will increase user satisfaction	S
7	Users want reports on earthquake data in the vicinity	Creating a report menu related to earthquake events will increase user satisfaction	S

S : Succes
TB : Failure

Table 10 is a hypothesis table that has been made, there are 7 assumptions and 7 hypotheses that have been tested, the following is a description of the table above.

C. Lean UX Check

The "Check" stage in Lean UX is one of the key phases in the Build-Measure-Learn cycle that focuses on evaluating the results of experiments and iterations that have been carried out [29]. At this stage, the main objective is to collect and analyze data to test the hypothesis that has been made.

The objective of the second testing phase is to evaluate how far the BMKG Info application has been improved and whether the improvements make users feel more comfortable when using it (Table 11-13). The objective of the second testing phase was to assess whether the improvements implemented in response to the findings of the first testing phase were practical and met user demands.

Table 11. Second Stage SysUse Recap Results

Respondent	Question						SysUse
	1	2	3	4	5	6	
R1	2	2	2	2	2	2	2
R2	1	2	1	2	1	2	1.5
R3	1	1	1	1	1	2	1.16
R4	1	2	1	2	1	2	1.5
R5	2	2	2	2	2	1	1.83
R6	3	1	1	2	2	2	1.83
R7	2	1	2	1	1	1	1.33
R8	2	2	2	2	1	1	1.66
R9	2	1	1	1	1	1	1.16
R10	1	1	1	2	1	1	1.16
R11	2	2	2	2	2	2	2
R12	2	1	2	2	2	2	1.83
R13	2	1	1	2	2	2	1.66
R14	1	2	2	2	2	2	1.83
R15	2	2	2	3	1	1	1.83
R16	2	2	3	2	2	2	2.16
R17	1	2	1	1	1	2	1.33
R18	2	1	2	1	1	2	1.5
R19	2	2	2	3	3	2	2.33
R20	2	2	2	3	2	2	2.16
R21	2	3	3	3	3	2	2.66
R22	2	2	2	3	3	2	2.33
R23	2	2	2	1	1	1	1.5
R24	2	1	2	2	2	2	1.83
R25	2	3	3	2	2	2	2.33
R26	2	2	2	2	1	2	1.83
R27	2	3	2	3	2	3	2.5
R28	2	3	3	2	2	2	2.33
R29	3	2	3	2	2	2	2.33
R30	2	2	2	2	2	2	2
R31	2	3	2	3	2	2	2.33
R32	2	2	3	2	2	2	2.16
R33	2	2	2	2	2	2	2
R34	2	2	2	2	3	3	2.33
R35	2	3	2	3	2	3	2.5
R36	3	3	3	3	3	3	3
R37	2	3	3	2	3	3	2.66
R38	3	2	3	3	2	3	2.66
R39	3	3	3	3	3	3	3
R40	3	3	3	3	3	3	3
ARD				2.02			

Table 12. Second Stage InfoQual Recap Results

Respondent	Question						InfoQual
	7	8	9	10	11	12	
R1	2	2	2	2	2	2	2
R2	1	2	1	2	2	2	1.66
R3	2	1	1	1	1	1	1.16
R4	1	1	2	2	1	2	1.5
R5	1	1	2	2	2	2	1.66
R6	2	1	2	2	1	2	1.66
R7	1	2	2	1	1	1	1.33
R8	2	2	2	2	2	1	1.83
R9	1	1	1	1	1	1	1
R10	2	2	1	1	2	1	1.5
R11	2	2	3	2	2	2	2.16
R12	2	1	2	1	1	1	1.33
R13	2	2	2	2	2	1	1.83
R14	2	2	2	2	2	2	2
R15	1	1	2	3	2	2	1.83
R16	2	2	2	1	2	2	1.83
R17	2	1	1	1	2	1	1.33
R18	2	2	2	2	1	2	1.83

Respondent	Question						InfoQual
	7	8	9	10	11	12	
R19	2	2	2	2	3	2	2.16
R20	2	2	2	2	2	2	2
R21	3	3	2	3	2	2	2.5
R22	2	2	2	2	3	2	2.16
R23	2	1	2	1	1	2	1.5
R24	2	2	1	2	1	2	1.66
R25	2	2	2	2	2	3	2.16
R26	2	2	2	1	2	2	1.83
R27	2	3	3	2	3	2	2.5
R28	3	3	2	3	2	3	2.66
R29	3	2	2	2	2	2	2.16
R30	2	2	2	2	2	2	2
R31	2	3	3	2	2	2	2.33
R32	2	2	2	2	2	2	2
R33	2	2	2	2	2	2	2
R34	3	3	2	2	3	3	2.66
R35	3	3	2	3	3	3	2.83
R36	3	3	3	3	3	3	3
R37	2	3	2	3	3	2	2.5
R38	3	2	3	2	3	2	2.5
R39	3	3	2	3	3	3	2.83
R40	3	3	2	3	3	3	2.83
ARD	2.00						

Table 13. Second Stage IntQual Recap Results

Respondent	Question			IntQual
	13	14	15	
R1	2	2	2	2
R2	1	2	2	1.66
R3	2	1	1	1.33
R4	1	2	2	1.66
R5	2	1	1	1.33
R6	1	2	2	1.66
R7	1	2	1	1.33
R8	2	1	2	1.66
R9	1	2	1	1.33
R10	2	2	2	2
R11	2	2	1	1.66
R12	1	2	1	1.33
R13	1	2	2	1.66
R14	2	2	2	2
R15	1	2	2	1.66
R16	2	1	2	1.66
R17	1	1	1	1
R18	2	1	2	1.66
R19	2	3	2	2.33
R20	2	2	2	2
R21	2	2	2	2
R22	2	2	2	2
R23	1	1	1	1
R24	2	2	2	2
R25	2	2	2	2
R26	1	2	2	1.66
R27	3	2	3	2.66
R28	2	2	2	2
R29	2	2	2	2
R30	3	2	2	2.33
R31	2	2	2	2
R32	2	2	2	2
R33	2	2	2	2
R34	2	2	3	2.33
R35	2	3	2	2.33
R36	3	3	3	3
R37	3	2	3	2.66
R38	3	2	3	2.66
R39	3	2	3	2.66
R40	3	3	3	3
ARD	1.93			

Table 14. PSSUQ Second Stage

SS	S	LL	M	UL	ARD
SysUse	1-6	2.79	3.02	3.24	2.02
InfoQual	7-12	2.28	2.49	2.71	2.00
InterQual	13-15	2.62	2.82	3.02	1.93
Overall	1-16	2.57	2.80	3.02	1.99

SS : Subscale
S : Scale
LL : Lower Limit
M : Mean
UL : Upper Limit
ARD : Average Respondent Data

Table 14 displays the average scores obtained from using the Post Study System Usability Questionnaire (PSSUQ) version 3. In the second stage of testing, the average scores for System Usefulness (*SysUse*), Information Quality (*InfoQual*), and Interface Quality (*InterQual*) were 2.02, 2.00, and 1.93, respectively. These scores showed an improvement from the first test, indicating better results in the overall evaluation of the system.

Table 15. Results of Severity Ratings Heuristic Evaluation Second Stage

NO	SR					NOSR	SRV
	0	1	2	3	4		
A	B	C	D	E	F	G	H
1. Visibilty of System Status							
1.1	39	1	0	0	0	1	0.02
1.2	36	4	0	0	0	4	0.1
1.3	39	1	0	0	0	1	0.02
1.4	35	5	0	0	0	5	0.12
	149	21	0	0	0		0.26
	0	21	0	0	0		0.065
2. Match Between Sistem and The Real World							
1.1	26	14	0	0	0	14	0.35
1.2	31	9	0	0	0	9	0.22
1.3	36	4	0	0	0	4	0.1
1.4	33	7	0	0	0	7	0.17
1.5	36	4	0	0	0	4	0.1

NO	SR					NOSR	SRV
	0	1	2	3	4		
A	B	C	D	E	F	G	H
	162	38	0	0	0		0.94
	0	38	0	0	0		0.188
3. Consistency and Standards							
1.1	20	19	1	0	0	21	0.52
1.2	39	1	0	0	0	1	0.02
1.3	33	7	0	0	0	7	0.17
1.4	37	3	0	0	0	3	0.07
1.5	36	4	0	0	0	4	0.1
1.6	36	4	0	0	0	4	0.1
1.7	22	18	0	0	0	18	0.45
	223	56	2	0	0		1.43
	0	56	4	0	0		0.204
4. Error Prevention							
1.1	37	3	0	0	0	3	0.07
1.2	32	8	0	0	0	8	0.2
1.3	38	2	0	0	0	2	0.05
1.4	37	3	0	0	0	3	0.07
1.5	32	8	0	0	0	8	0.2
	176	24	0	0	0		1.04
	0	24	0	0	0		0.208
5. Flexibility and Efficiency of Use							
1.1	36	4	0	0	0	4	0.1
1.2	34	6	0	0	0	6	0.15
	70	10	0	0	0		0.25
	0	10	0	0	0		0.125
6. Aesthetic and Minimalist Design							
1.1	24	16	0	0	0	16	0.4
1.2	30	10	0	0	0	10	0.25
1.3	39	1	0	0	0	1	0.02
	93	27	0	0	0		0.67
	0	27	0	0	0		0.223
7. Help Users Recognize, Diagnose, and Recover From Errors							
1.1	33	7	0	0	0	7	0.17
1.2	36	4	0	0	0	4	0.1
1.3	39	1	0	0	0	1	0.02
	108	12	0	0	0		0.29
	0	12	0	0	0		0.096

Table 16. Recap of Severity Ratings Results of Heuristic Evaluation Stage 2

Aspect	VOEA	RV
Visibility of system status	0.065	0
Match between system and the real world	0.188	0
Consistency and standards	0.204	0
Error prevention	0.208	0
Flexibility and efficient of use	0.125	0
Aesthetic and minimalist design	0.223	0
Help users recognize, dialogue, and recovers from errors	0.096	0

Table 15 and 16 summarizes the findings from the second iteration of the usability testing process, which employed the heuristic evaluation method to assign severity levels to each aspect. The results displayed in this table show severity ratings rounded to 0, which indicates that no usability-related problems were found.

Table 17. Comparison of Heuristic Stages 1 and 2

Aspect	VOEA1	RV1	VOEA2	RV2
Visibility of system status	1.285	1	0.065	0
Match between system and the real world	0.912	1	0.188	0
Consistency and standards	0.69	1	0.204	0
Error prevention	0.682	1	0.208	0
Flexibility and efficient of use	0.78	1	0.125	0
Aesthetic and minimalist design	1.096	1	0.223	0
Help users recognize, dialogue, and recovers from errors	0.646	1	0.096	0

VOEA1 : Value of Each Aspect of Stage 1 Testing
RV1 : Rounding Value of Stage 1 Testing
VOEA2 : Value of Each Aspect of Stage 2 Testing
RV2 : Rounding Value of Stage 2 Testing
NOSR : Number of Severity Ratings
SRV : Severity Ratings Value

The comparison of the first and second-stage heuristic evaluation scores, which yield severity ratings for each aspect, is summarized in Table 17. The results displayed in table 17 show the severity ratings rounded to 0 in the second testing stage, which indicates that no usability-related problems were found.

Table 18. PSSUQ Stage 1 and 2 Results

SS	S	LL	M	UL	S1	S2
SysUse	1-6	2.79	3.02	3.24	3.45	2.02
InfoQual	7-12	2.28	2.49	2.71	3.43	2.00
InterQual	13-15	2.62	2.82	3.02	3.32	1.93
Overall	1-16	2.57	2.80	3.02	3.40	1.99

SS : Subscale
S : Scale
LL : Lower Limit
M : Mean
UL : Upper Limit
S1 : Stage 1 testing
S2 : Stage 2 testing

Based on Table 18, in the first stage, the score for Sysuse was 3.45, InfoQual was 3.43, InterQual was 3.32, and Overall was 3.40. Meanwhile, in the second stage, there was a decrease in scores with Sysuse reaching 2.02, InfoQual 2.00, InterQual 1.93, and Overall 1.99. Despite the decrease in scores in the second stage, this actually shows a significant improvement in

system evaluation, as lower results indicate better improvement in meeting user needs and expectations.

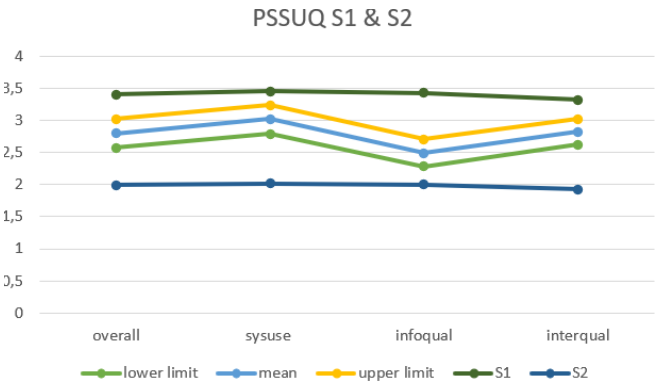


Figure 4. Comparison Chart of PSSUQ Stage 1 and 2

Figure 4 shows a comparison chart between PSSUQ in the first and second tests, with five charts included. It shows the upper, mean, and lower bounds, and contains visualizations of the results from stage 1 and stage 2 testing.

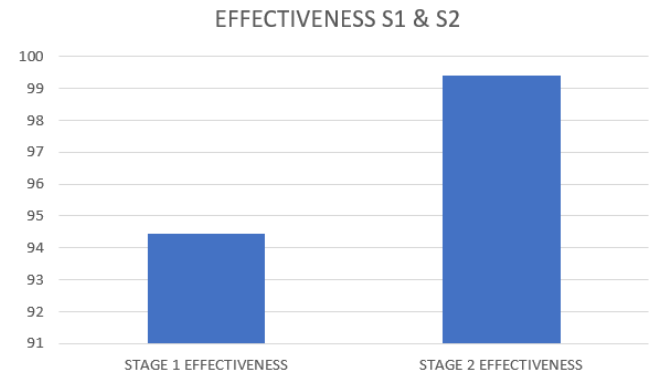


Figure 5. Comparison of Effectiveness of Stages 1 and 2

Figure 5 is a comparison chart between the first and second stage of effectiveness testing. The effectiveness of testing in the first stage reached 94.44%, while in the second stage it increased to 99.4%, although the difference is not too far, this increase shows that the improvements implemented significantly managed to improve the test results between the two stages.

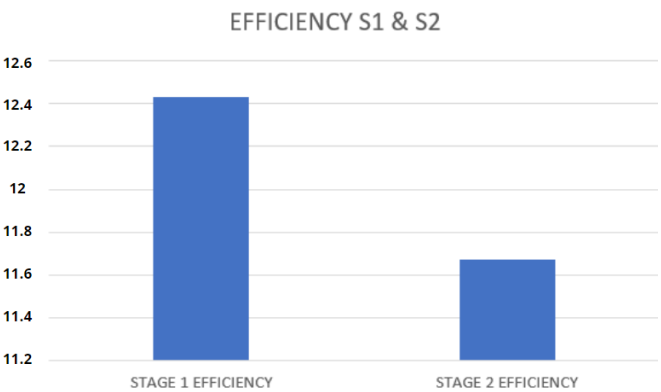


Figure 6. Comparison Chart of Efficiency Testing

Figure 6 is a comparison chart between the first and second stage of efficiency testing. The test efficiency in the first stage was 12.43 seconds, while in the second stage it increased to 11.67 seconds. Although the difference is not too great, this improvement can be influenced by factors such as a more stable internet connection quality and other technical process optimizations. These measures contributed to improving the overall efficiency of the test between the two different stages.

V. CONCLUSION

A comparison of the test results between phase one and phase two showed consistent improvements in the user interface design of the BMKG Info application, with Post-Study System Usability Questionnaire scores increasing from phase one to phase two. The System Usefulness (SysUse) graph shows a decrease in score from 3.45 in stage one to 2.02 in stage two, indicating an improvement in system usability. The Information Quality (InfoQual) graph shows a decrease in score from 3.43 in the first stage to 2.00 in the second stage, indicating an improvement in the quality of information provided. The Interface Quality (InterQual) graph shows a decrease in score from 3.32 in the first stage to 1.93 in the second stage, reflecting an improvement in the quality of the user interface. The Overall Satisfaction graph shows a decrease in the score from 3.40 in the first stage to 1.99 in the second stage, indicating an improvement in the overall satisfaction of the users. It can be seen that the improvement measures implemented successfully responded to the feedback from the previous tests, resulting in an overall better user experience. The test efficiency in the first stage was 12.43 seconds, while in the second stage, it increased to 11.67 seconds. Although the difference is not too great, this improvement could be influenced by factors such as a more stable internet connection quality and other technical process optimizations. The test effectiveness in the first stage reached 94.44%, while in the second stage, it increased to 99.4%. Although the difference is not too great, this increase shows that the implemented improvements significantly managed to improve the test results between the two stages.

REFERENCES

[1] I. Hamidah, I. Nugroho, And S. Surorejo, “Penerapan Interaksi Manusia Dan Komputer Pada Antarmuka Sistem Informasi Akademik,” 2023.

[2] M. Agus Muhyidin, M. A. Sulhan, And A. Sevtiana, “Perancangan Ui/Ux Aplikasi My Cic Layanan Informasi Akademik Mahasiswa Menggunakan Aplikasi Figma,” 2020. [Online]. Available: Https://My.Cic.Ac.Id/.

[3] A. Ingratubun And D. F. Suyatno, “Perancangan Desain User Interface Sistem Informasi Yayasan Ruang Pasien Indonesia Menggunakan Metode Lean Ux,” Oct. 2023.

[4] E. W. Sulistyo And S. Sofiana, “Perancangan Desain User Interface/User Experience Web Layanan Informasi Kamus Dengan Metode Lean User

Experience (Lean Ux) Pada Universitas Pamulang," *Bullet : Jurnal Multidisiplin Ilmu*, Vol. 1, No. 03, 2022.

[5] A. B. Kurniawan, I. Aknuranda, And A. R. Perdanakusuma, "Evaluasi Dan Perbaikan Pengalaman Pengguna Menggunakan User Experience Questionnaire (Ueq) Dan Heuristic Evaluation (He) Pada Aplikasi Mobile Info Bmkg," 2019. [Online]. Available: Http://J-Ptiik.Ub.Ac.Id

[6] R. A. Malik And M. R. Frimadani, "Lean Ux: Applied Pssuq To Evaluate Less-On Ui/Ux Analysis And Design," *International Journal Of Advances In Data And Information Systems*, Vol. 4, No. 1, Pp. 73–85, Apr. 2023, Doi: 10.25008/Ijadis.V4i1.1263.

[7] D. A. Fatah, "Evaluasi Usability Dan Perbaikan Desain Aplikasi Mobile Menggunakan Usability Testing Dengan Pendekatan Human-Centered Design (Hcd)," *Rekayasa*, Vol. 13, No. 2, Pp. 130–143, Aug. 2020, Doi: 10.21107/Rekayasa.V13i2.6584.

[8] O. A. Pradipta, I. M. Sukarsa, And I. P. Arya Dharmaadi, "Pengembangan Ui Aplikasi Mobile Konsultasi Karir," *Jitter- Jurnal Ilmiah Teknologi Dan Komputer*, Vol. 3, 2022.

[9] I. Gusti *Et Al.*, "Analisis Usability Aplikasi Ibadung Menggunakan Heuristic Evaluation Method Analisis Usability Aplikasi Ibadung Menggunakan Heuristic Evaluation Method (I Gusti Ayu Agung Diah Indrayani)," *Journal Ilmiah Merpati*, Vol. 8, Pp. 89–100, 2020.

[10] K. V. Sibuea And Y. Windarto, "Pengembangan Ui/Ux Pada Fitur Ivt: Loan Calculator Dengan Metode Lean Ux (Studi Kasus: X By Pt.Xyz)," 2023. [Online]. Available: Http://Jurnal.Mdp.Ac.Id

[11] Y. M. Geasela, P. Ranting, And J. Fernandes Andry, "Analisis User Interface Terhadap Website Berbasis E-Learning Dengan Metode Heuristic Evaluation," *Jurnal Informatika*, Vol. 5, No. 2, 2018.

[12] A. Rahmadina, I. Aknuranda, And N. H. Wardani, "Evaluasi Usability Aplikasi E-Tpt Berbasis Mobile Kantor Pelayanan Pajak Pratama Malang Utara Dengan Menggunakan Metode Heuristic Evaluation," 2019. [Online]. Available: Http://J-Ptiik.Ub.Ac.Id

[13] P. Riyaldi, P. Narendra, N. Kadek, And A. Wirdiani, "Website Based Ui/Ux Application Design Of Balinese Traditional Products Using The Design Thinking Method," 2023.

[14] T. F. Hasan, T. Wahyuningrum, And A. Cahya Wardhana, "Usability Testing Pada M-Commercemenggunakan Kuesioner Use (Usefulness, Satisfaction, And Ease Of Use) Dan Performance Test (Studi Kasus : Tokopedia)," *Jurnal Teknologi Informasi Dan Ilmu Komputer (Jtiik)*, Vol. 9, No. 4, Pp. 829–838, 2022, Doi: 10.25126/Jtiik.202294753.

[15] O. Sudana, I. W. W. Ivan M.J, And D. Purnami S.P, "Implementation Of Tree Model In The Development Of E-Mantram Android Application," *Lontar Komputer : Jurnal Ilmiah Teknologi Informasi*, Vol. 13, No. 2, P. 117, Aug. 2022, Doi: 10.24843/Lkjiti.2022.V13.I02.P05.

[16] D. A. Setyawan, "Uji Validitas Dan Reliabilitas Instrumen Penelitian," In *Modul Statistika* , 2014, Pp. 1–14.

[17] L. Amanda, F. Yanuar, And D. Devianto, "Uji Validitas Dan Reliabilitas Tingkat Partisipasi Politik Masyarakat Kota Padang," *Jurnal Matematika Unand*, Vol. 8, No. 1, Pp. 179–188, 2019.

[18] E. Rosita, W. Hidayat, And W. Yuliani, "Uji Validitas Dan Reliabilitas Kuesioner Perilaku Prososial," *Fokus (Kajian Bimbingan & Konseling Dalam Pendidikan)*, Vol. 4, No. 4, P. 279, Jul. 2021, Doi: 10.22460/Fokus.V4i4.7413.

[19] F. D. P. Anggraini, A. Aprianti, V. A. V. Setyawati, And A. A. Hartanto, "Pembelajaran Statistika Menggunakan Software Spss Untuk Uji Validitas Dan Reliabilitas," *Jurnal Basicedu*, Vol. 6, No. 4, Pp. 6491–6504, May 2022, Doi: 10.31004/Basicedu.V6i4.3206.

[20] M. Rifky Gifari And M. Awiet Wiedanto Prasetyo, "Perancangan Website Penjualan Dengan Metode Lean Ux Dan User Experience Questionnaire," *Jurnal Tekno Kompak"*, Vol. 18, No. 2, Pp. 368–379, 2024.

[21] D. A. Rusanty, H. Tolle, And L. Fanani, "Perancangan User Experience Aplikasi Mobile Lelenesia (Marketplace Penjualan Lele) Menggunakan Metode Design Thinking," 2019. [Online]. Available: Http://J-Ptiik.Ub.Ac.Id

[22] N. Sugrah, "Implementasi Teori Belajar Konstruktivisme Dalam Pembelajaran Sains," *Jurnal Humanika*, Vol. 19, No. 2, Pp. 121–138, 2019.

[23] S. Tiara Rahayu Ada, D. I. Safinatunnajah, And Agussalim, "Perancangan Ui/Ux Aplikasi Petpat Berbasis Mobile Menggunakan Metode Leanux," *Jommit "Jurnal Multimedia Dan It,"* Vol. 6, No. 22, Pp. 38` – 45, 2022, Doi: 10.46961/Jommit.V6i2.

[24] M. A. Insani, M. A. Gustalika, And I. Kresna, "Prototype Desain User Interface Aplikasi My School Menggunakan Metode Lean Ux," *Journal Of Information System Research (Josh)*, Vol. 3, No. 4, Pp. 626–635, Jul. 2022, Doi: 10.47065/Josh.V3i4.1806.

[25] M. Stefanus, J. Fernandes Andry, F. Teknologi, D. Desain, And U. Bunda Mulia, "Pengembangan Aplikasi E-Learning Berbasis Web Menggunakan Model Waterfall Pada Smk Strada 2 Jakarta," *Jurnal Fasilkom*, Vol. 10, No. 1, Pp. 1–10, 2020.

[26] Zainil Abidin, Daniel Arsa, And Yolla Noverina, "Analisis Penerapan Metode User-Centered Design Pada Augmented Reality (Ar) Dengan Marker Based Tracking," *Jurnal Processor*, Vol. 19, No. 1, May 2024, Doi: 10.33998/Processor.2024.19.1.1640.

[27] R. Mukti Azhar And A. Evanthi, "Jurnal Mirai Management Value Proposition Design Pada Lokawisata Baturaden," *Jurnal Mirai Management*, Vol. 8, No. 1, Pp. 360–367, 2023.

[28] G. Anuraga, A. Indrasetianingsih, And M. Athoillah, "Pelatihan Pengujian Hipotesis Statistika Dasar Dengan Software R," *Jurnal BUDIMAS*, vol. 3, no. 2, pp. 327–334, 2021.

[29] F. Fedelina Christover, L. Magdalena, R. Fahrudin, and M. Hatta, "Perancangan Web Portal Landing Page Klinik Utama Luthfi Medical Center Dengan Metode Lean UX," May 2023.