XP in Front-End Development of Living Lab Smart City Surabaya to Create User Interaction

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Abstrak − Pengembangan layanan digital dalam ekosistem kota cerdas di Kota Surabaya masih menghadapi tantangan berupa rendahnya tingkat pemanfaatan layanan digital pemerintah. Berdasarkan data Badan Pusat Statistik (BPS), jumlah penduduk Kota Surabaya pada tahun 2024 mencapai 3.018.022 jiwa, namun tingkat penggunaan beberapa layanan digital masih terbatas. Hal ini tercermin dari aplikasi Wargaku, salah satu platform layanan masyarakat Kota Surabaya, yang baru diunduh sekitar 100.000 kali di Google Play Store pada tahun 2025. Kondisi tersebut menunjukkan bahwa pemanfaatan layanan digital pemerintah oleh masyarakat masih belum optimal. Oleh karena itu, diperlukan platform inovasi kolaboratif yang mampu mengintegrasikan berbagai fitur kota cerdas sekaligus menyediakan informasi program pemerintah secara lebih komprehensif kepada masyarakat. Salah satu solusi yang dapat diterapkan adalah pengembangan Living Lab Smart City sebagai media kolaborasi antara warga dan pemerintah. Penelitian ini bertujuan untuk mengembangkan front-end website Living Lab Surabaya Smart City sebagai platform berbagi informasi dan kolaborasi antara warga dan pemerintah kota. Dengan menggunakan pendekatan Extreme Programming (XP), penelitian ini berfokus pada perancangan antarmuka yang mampu mendukung interaksi pengguna secara optimal melalui siklus iteratif yang mencakup tahap perencanaan, perancangan, implementasi, dan pengujian. Pada tahap perencanaan (*planning*), dilakukan penyusunan *mind map* untuk memetakan kebutuhan dan ruang lingkup sistem. Tahap perancangan (*design*) mencakup pengembangan *design system*, *Entity Relationship Diagram* (ERD), *use case diagram*, *activity diagram*, serta pembuatan *prototype* antarmuka. Pada tahap implementasi (*implementation*), rancangan front-end diwujudkan melalui pengkodean menggunakan HTML, CSS, dan JavaScript, serta didukung oleh database MySQL untuk mengelola data reservasi kunjungan dan konten blog secara dinamis. Selanjutnya, tahap pengujian dilakukan melalui *usability testing* menggunakan Maze untuk mengevaluasi aspek *learnability*, *efficiency*, dan *error prevention*. Pengujian melibatkan 30 responden dengan beberapa skenario tugas pada prototype yang dikembangkan. Hasil pengujian menunjukkan bahwa seluruh tugas memiliki success rate sebesar 100% dengan rata-rata waktu penyelesaian antara 2,6 hingga 7,9 detik dan tingkat misclick yang rendah (0–4,8%)**.** Selain itu, setiap skenario memperoleh nilai Single Ease Question (SEQ) sebesar 7, yang menunjukkan bahwa pengguna menilai tugas sangat mudah diselesaikan. Nilai Maze Usability Score (MAUS) sebesar 99 dengan kategori *excellent* menunjukkan bahwa prototype memiliki tingkat *usability* yang sangat baik serta mampu memberikan pengalaman interaksi yang intuitif dan minim hambatan.

Kata Kunci: *Extreme Programming, Front-end Development, User Interaction, Usability Testing, Smart City, Living Lab*

Abstract − The development of digital services within the smart city ecosystem in Surabaya still faces challenges, particularly the low level of utilization of government digital services. According to data from the Central Bureau of Statistics (BPS), the population of Surabaya reached 3,018,022 people in 2024; however, the usage level of several digital services remains limited. This condition is reflected in the Wargaku application, one of the public service platforms provided by the Surabaya City Government, which has only been downloaded approximately 100,000 times on the Google Play Store as of 2025. This indicates that the adoption of government digital services by the community is still not optimal. Therefore, an innovative collaborative platform is required to integrate various smart city features while providing more comprehensive information about government programs to the public. One possible solution is the development of a Smart City Living Lab as a collaborative medium between citizens and the government.This study aims to develop the front-end website of the Surabaya Smart City Living Lab as a platform for information sharing and collaboration between citizens and the city government. Using the Extreme Programming (XP) approach, this research focuses on designing a user interface that supports optimal user interaction through an iterative cycle consisting of planning, design, implementation, and testing stages. In the planning phase, a mind map was developed to identify system requirements and scope. The design phase included the development of a design system, Entity Relationship Diagram (ERD), use case diagram, activity diagram, and interface prototype. During the implementation phase, the front-end design was realized through coding using HTML, CSS, and JavaScript, supported by a MySQL database to dynamically manage visit reservation data and blog content. The testing phase was conducted through usability testing using Maze to evaluate the aspects of learnability, efficiency, and error prevention. The evaluation involved 30 respondents who completed several task scenarios using the developed prototype. The results show that all tasks achieved a success rate of 100%, with an average completion time ranging from 2.6 to 7.9 seconds and a low misclick rate of 0–4.8%. In addition, each scenario obtained a Single Ease Question (SEQ) score of 7, indicating that users perceived the tasks as very easy to complete. Furthermore, the Maze Usability Score (MAUS) reached 99 with an “excellent” category, demonstrating that the prototype achieved a very high level of usability and provides an intuitive user interaction experience with minimal obstacles.

Keywords: Extreme Programming, Front-end Development, User Interaction, Usability Testing, Smart City, Living Lab

1. INTRODUCTION

The development of information and communication technology (ICT) today has had a significant impact on various sectors, one of which is reflected in the implementation of the smart city concept that integrates technology to improve the efficiency of public services and the quality of life of citizens. According to data from the Central Bureau of Statistics (BPS), Indonesia's ICT Development Index (ICT-DI) in 2024 showed a positive trend, reaching a score of 6.02, an increase from 5.90 in 2023. Cumulatively, this rise of nearly one full point (+0.95 points) reflects significant progress in strengthening infrastructure, expanding access to digital services, and enhancing the utilization of ICT among the public [1]. In line with this improvement, the Ministry of Communication and Digital Affairs (Kominfo), through its official press release, stated that between 2017 and 2023, a total of 251 regencies and cities in Indonesia received assistance through the Smart City and Smart Province programs. This fact demonstrates that the development of information and communication technology has become a crucial factor in driving the successful implementation of smart cities across various regions [2].

One of the cities that demonstrates a strong commitment to smart city development is Surabaya. As the second-largest metropolitan city in Indonesia, Surabaya has implemented various application-based digital services, both for government administration and public services. However, among the hundreds of applications developed by the city government, not all are utilized optimally. Challenges such as the low level of digital service integration and the public's limited understanding of how to use these applications remain major obstacles. This can be observed from the download data of *Wargaku*—one of the public service platforms owned by the Surabaya City Government—which has only been downloaded around 100,000+ times (Google Play Store, 2025) out of Surabaya's total population of 3,018,022 people in 2024 [3]. This condition illustrates that the level of utilization and accessibility of government digital services remains relatively low. Many citizens are still unaware of the existence of these applications or face difficulties in using them effectively.

To address these challenges, it is necessary to initiate the development of a collaborative innovation platform capable of integrating various smart city features while providing comprehensive information on government programs to the public. One potential solution that can be implemented is the Living Lab Smart City Surabaya. According to ENoLL (European Network of Living Labs), a *living lab* is described as a functional region where stakeholders establish a Public-Private Partnership (PPP) consisting of companies, public institutions, universities, organizations, and citizens—all collaborating to create, prototype, validate, and test new services, products, and systems in real-life contexts [4]. Through this *living lab* approach, the smart city concept can be implemented in a participatory manner. The *smart city* itself is a concept that integrates advanced information and communication technology (ICT), both hardware and software, into urban planning systems to improve service efficiency and citizens' quality of life. The implementation of smart cities aims to support economic growth, address transportation and environmental issues, and create interactive relationships between citizens and the government through the sustainable use of technology [5].

This study aims to design and implement the front-end of the Living Lab Smart City Surabaya website as an integrative platform that centralizes information on digital services and municipal government programs. The main contributions of this research include the design of the website interface, the development of interactive and responsive user interactions, and the evaluation of system functionality through usability testing. Through this development, the Living Lab Smart City Surabaya website is expected to enhance the integration of digital services, strengthen collaboration among stakeholders, and serve as a model for open innovation–based smart city development that can be adapted by other cities in Indonesia.

a. Extreme Programming (XP)

Extreme Programming (XP) is an Agile software development framework that aims to produce high-quality software while facilitating the work of development teams [6]. The following are the stages in XP:

1. Planning
   The planning stage focuses on identifying system requirements through interviews and observations of research subjects to determine users' functional needs [7].
2. Design
   This stage involves the implementation of the previously completed planning phase through the modeling or design of the system to be developed. In this stage, system modeling or design is carried out for the system that will be developed.
3. Coding
   This stage involves implementing the modeling results into a user interface using a programming language [8].
4. Testing
   This stage involves testing the developed website. The testing process engages system users and focuses on evaluating the overall features and functionality of the website, with the results reviewed based on user feedback[9].

b. Front-End Development

Front-end refers to the part of an application or website that directly interacts with users and displays visual elements such as text, buttons, and images [10]. Its development focuses on creating an intuitive and accessible graphical user interface (GUI). The main technologies used include HTML for page structure, CSS for visual appearance, and JavaScript for interactivity [11].

c. User Interaction

According to Hornbaek & Oulasvirta research about "What is Interaction in 2017, user interaction is part of the concept of interaction as experience, which is described as something shaped by user expectations, momentary experiences, and the retelling of interactions. The immediate, especially evaluative (good–bad), feelings that arise during interaction with a product or service are key factors in how the interaction unfolds. The study also explains that aspects such as aesthetics, emotions, and the fulfillment of needs, as well as feelings of surprise or stimulation, are important elements within the concept of interaction as experience. Although experience can be related to the product's functionality, the main focus lies on non-utilitarian aspects. Thus, it can be concluded that user interaction is an experience formed by user expectations, cognitive processes (appraisal/evaluation), and the feelings that emerge when engaging with an interface. This interaction is not merely about technical use (utility) but also involves emotional, aesthetic, and need-fulfillment aspects, as well as meaning, surprise, and stimulation [12].

d. Usability Testing

Usability testing is a measure of a characteristic that indicates the extent to which a user can learn and use a system or product to achieve their goals while experiencing satisfaction in its use [13]. In this study, the Maze platform was used to conduct usability testing. This platform supports usability evaluation by emphasizing three main aspects: learnability, efficiency, and errors [14]. Maze itself is an online usability testing platform that can be integrated with various interactive design prototypes, such as those created using Figma [15].

2. RESEARCH METHODS

This study employs the Extreme Programming (XP) method as the system development approach, which consists of iterative stages including planning, design, coding, and testing. Prior to the development process, data collection was conducted through observation, literature review, and questionnaires to identify user needs and system requirements. The development process is carried out iteratively, allowing revisions to be made until the system meets the expected outcomes. The overall research workflow based on the XP method is illustrated in Figure 1.

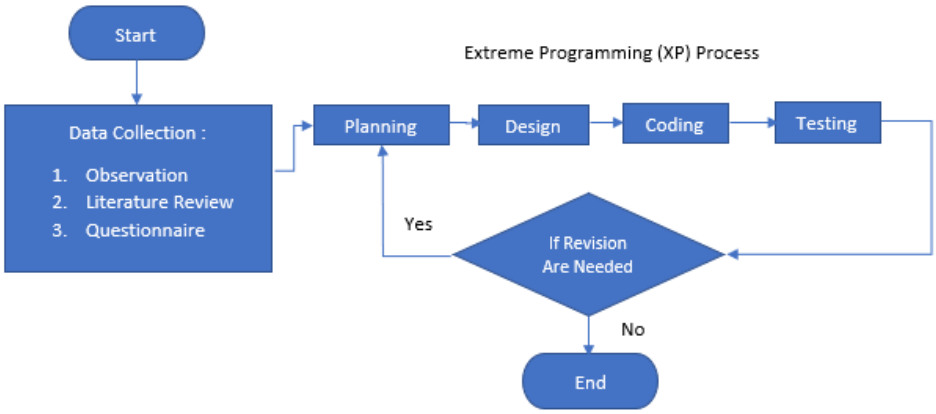

Figure 1. Research Flow with XP Methods

2.1 Data Collection

The research flow in this study follows a series of systematic and iterative stages, as illustrated in Figure 1. The first main phase is data collection, which aims to obtain a comprehensive understanding of user needs, system requirements, and relevant theoretical foundations. Data collection is conducted through three primary methods: observation, literature review, and questionnaire distribution. Observation is carried out to examine existing practices and user interactions related to similar systems. The literature review is used to identify relevant theories, models, and previous studies related to front-end development and usability evaluation. Meanwhile, questionnaires are distributed to gather direct input from users regarding their expectations and requirements for the proposed system.The results obtained from the data collection process are then analyzed to identify user needs and to formulate design requirements that serve as the foundation for the system development process. These

outputs are used to ensure that the proposed system aligns with user expectations and supports the development of an effective and user-centered interface.

2.2 Extreme Programming (XP) Method

Extreme Programming (XP) is an agile software development framework aimed at producing high-quality software while facilitating the work of the development team [6]. The stages in XP consist of planning, design, coding, and testing [8].

a. Planning
The first stage is the planning phase. Planning activities include problem identification, requirements analysis, and the determination of the system development implementation schedule [8] . This study employs a mind map to summarize the planning process. A mind map is a planning support tool used to collect, organize, and present information in a graphical and network-structured form. This tool enables the mapping of scope, objectives, requirements, and ideas from various stakeholders. Mind maps have also been applied across multiple sectors, including smart city design[16].

b. Design
This stage involves the implementation of the previously completed planning phase through the modeling or design of the system to be developed. At this stage, system modeling and design activities are carried out to define the structure and functionality of the proposed system. The design stage involved the creation of a design system and interactive prototypes using Figma, as well as the development of system models. The database design was represented through an Entity Relationship Diagram (ERD) [7], while the system and architecture modeling were illustrated using Unified Modeling Language (UML) through Use Case Diagrams and Activity Diagrams [17].

c. Coding
This stage represents the implementation of the modeling results into a user interface using the selected programming language [8]. This study employs three modern front-end development technologies. JavaScript is used to add interactivity to the website, while CSS is utilized to develop the front-end appearance, including the visual design and core functional elements of the website or software interface. HTML is applied to define the structural framework of the website. Meanwhile, MySQL is used for database management[11].

d. Testing
Finally, in the testing stage, usability testing was conducted to evaluate the extent to which the application can be effectively, efficiently, and satisfactorily utilized by users within its intended context [17]. The testing results are analyzed based on the task completed, time per completed task, error rate, and number of clicks to evaluate the extent to which the product design meets customer needs and expectations [18]. Furthermore the testing results will be evaluated using the Single Ease Question (SEQ) to measure how easy a system is to use based on users' immediate perceptions after completing a task or scenario. SEQ consists of a single question: *"How easy was this task to complete?"* which is answered using a 7-point Likert scale ranging from "very difficult" to "very easy" [19].

3. RESULTS AND DISCUSSION

3.1 Data Collection Result

This section presents the results of data collection conducted through various methods, including observation, literature review, and questionnaires. These findings serve as the foundation for identifying user needs and formulating the design requirements of the proposed system.

3.1.1 User Needs

This subsection describes the identified user needs derived from the data analysis process. These needs reflect the problems, expectations, and preferences of different user groups, which are essential in guiding the development of an appropriate and user-centered solution.

Table 1. User Needs

User Needs	
Resident	Easy and reliable access to essential public services through a centralized platform.
Tourist	Real-time navigation support, attraction details, cultural tips, and language assistance to enhance their travel experience and reduce confusion.

Businesses	Streamlined and transparent processes for licensing, permits, taxes, and other operational needs to promote efficiency and compliance.
Government Officials	Tools and dashboards powered by real-time, data-driven insights to make informed decisions.
Social	Access to educational resources, scholarships, internship listings, and job opportunities.

3.1.2 Design Requirements

This subsection outlines the design requirements formulated based on the identified user needs. These requirements serve as guidelines in developing a system that is effective, efficient, and aligned with user expectations. In this study, the accessibility aspect within the design requirements is specifically limited to multilingual support, focusing only on language-switching features to accommodate users from different language backgrounds.

Table 2. Design Requirements

Design Requirements	
User Centered Interface	Ensure the platform is intuitive, easy to navigate, and tailored to different user groups like residents, tourists, and students.
Accessibility Features	Include multilingual support, screen reader compatibility, and adjustable text sizes to accommodate users with different abilities and needs.
Scalable Infrastructure	Adaptable to growing user demands and service needs.
Secure & Transparent Systems	Protect user data and maintain transparency.

3.2 Implementation of Extreme Programming (XP) in Website Development

3.2.1 Planning

During the Planning stage, user requirements and the basic structure of the Living Lab Smart City Surabaya website were formulated. The identification process indicated that users require centralized access to information related to smart city programs, easy-to-understand navigation, and clear categorization of services such as city hub, smart living, and smart economy. In addition, the need for well-structured and easily accessible information presentation was also considered in determining the essential elements of each page. This stage resulted in a comprehensive overview of the information architecture that serves as the foundation for subsequent design and development processes.

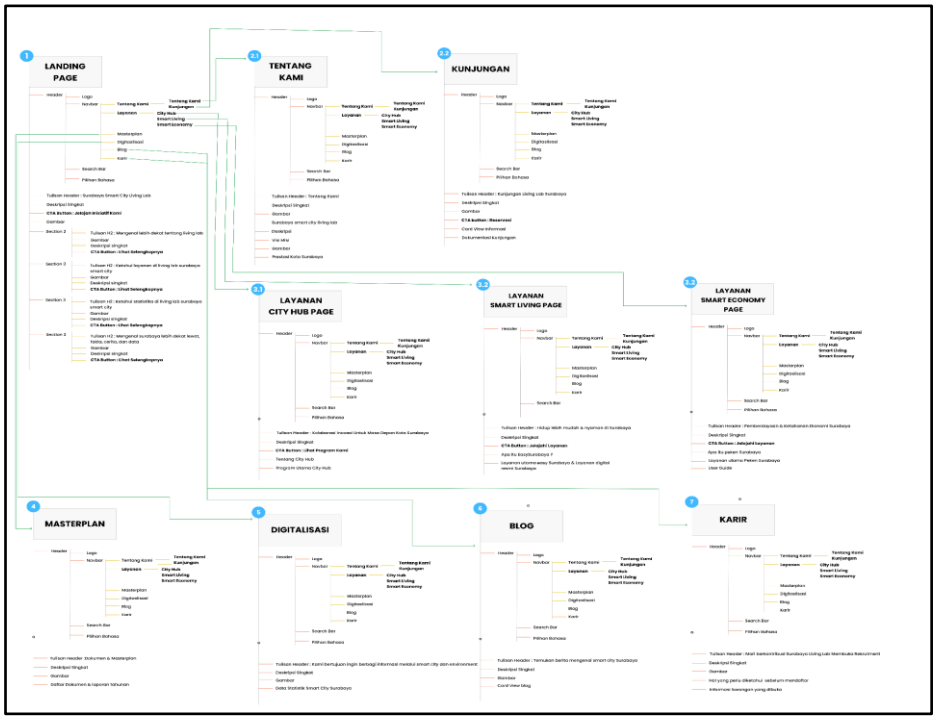

Figure 3. Mind Map Living Lab Surabaya

The mind map developed in figure 3 outlines the core pages, which include the landing page, about us, visit, city hub services, smart living services, smart economy services, masterplan, digitalization, blog, and career. Each page is designed with consistent structural elements, including a header, navigation menu, search bar, and main content section tailored to its informational function. Furthermore, the navigation flow is planned to ensure clear, structured, and user-friendly transitions between pages. The initial development priorities focus on constructing the homepage structure, navigation menu, service categories, and search and filter features, as these components have the greatest impact on the overall quality of user interaction.

3.1.2 Design

a. Design System

In the Design stage, the first step carried out is the development of a design system to ensure visual consistency and to streamline the development process during the coding stage [20]. The design system formulated in this study includes two main components, namely the color palette and typography.

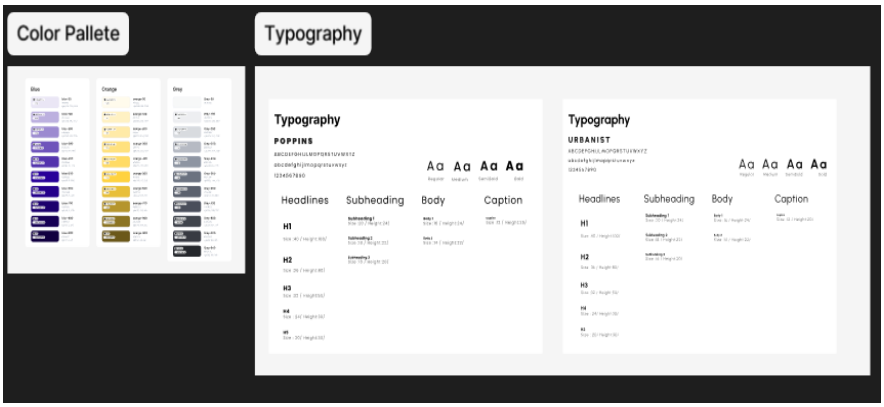

Figure 4. Design System (Color & Typography)

The color palette in figure 4 consists of three color groups. Blue is used as the primary color to convey a modern and professional impression. Orange functions as an accent color that highlights important elements, while greyscale is applied as a neutral color for text, backgrounds, and interface structure. The distribution of color levels from 50 to 900 helps establish visual hierarchy, enhances readability, and maintains consistency across the overall appearance. In terms of typography, this study utilizes two sans-serif fonts, Poppins and Urbanist, which were selected for their high readability on digital interfaces. The text structure is designed comprehensively, ranging from headings (H1–H5), subheadings, body text, to captions, with proportional adjustments to size and line-height to ensure clarity of information.

b. Entity Relationship Diagram (ERD)

1. ERD Model Living Lab Surabaya

The second step is to develop the Entity Relationship Diagram (ERD) model. For the Living Lab Surabaya system, the ERD represents two main functions: the reservation feature and the blog feature.

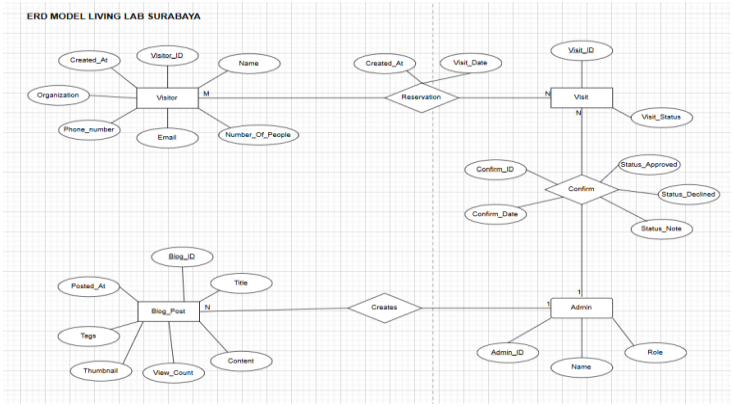

Figure 5. ERD Model Living Lab Surabaya

For the reservation feature, several key entities are involved, including visitor, reservation, visit, confirm, and admin. The visitor entity stores information about visitors, such as name, email, organization, phone number, and registration date. Visitors may submit reservation requests through the reservation entity, which records the visit date and reservation creation time. Each reservation is then connected to the visit entity, which tracks the status of the visit. The validation process is handled through the confirm entity, which contains approval or rejection status, additional notes, and the confirmation date. All confirmation activities are carried out by the admin entity, which represents system administrators and includes attributes such as name, role, and admin identification.

For the blog feature, the ERD includes the blog_post and admin entities, connected through a creates relationship. The blog_post entity stores information related to published articles, including title, content, tags, thumbnail image, visitor count, and upload date. The admin entity is responsible for creating and managing blog articles, allowing one admin to produce multiple posts. Through these relationships and entity structures, the ERD effectively illustrates the data flow necessary to support the reservation process and blog content management within the Living Lab Surabaya system.

2. ERD Table Living Lab Surabaya

The table-based ERD developed for the Living Lab Surabaya system provides a more operational representation compared to the previous conceptual ERD model. At this stage, each entity has been translated into tables with clearly defined primary keys and foreign keys, demonstrating how data are stored and interconnected within the relational database.

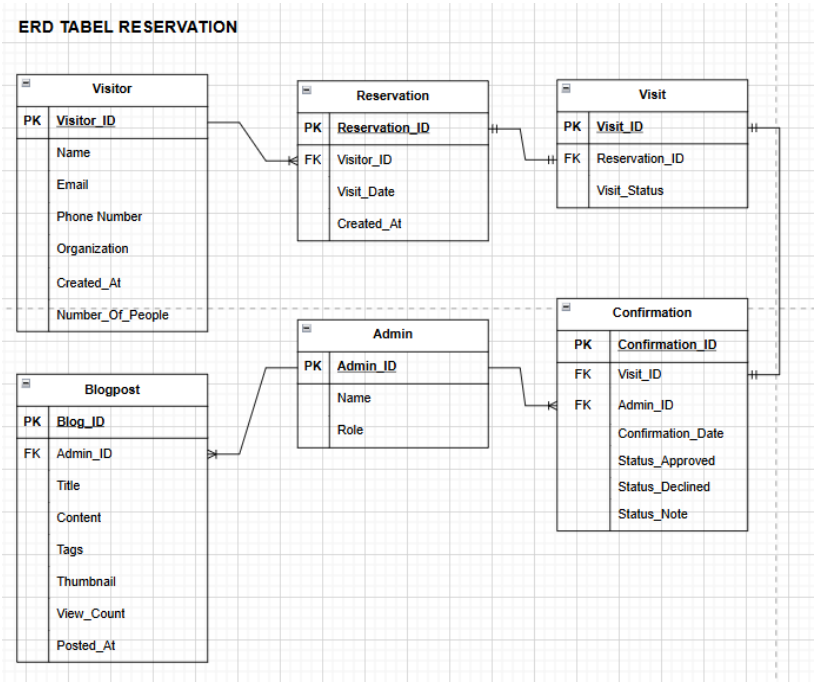

Figure 6. ERD Table Living Lab Surabaya

The visitor table contains structured attributes such as name, email, phone number, organization, and registration date, and includes *Visitor_ID* as the primary key, which serves as a reference for the *Reservation* table. The *Reservation* table records the reservation date, visit date, and references to visitors through a foreign key, ensuring data consistency across tables. Next, the *Visit* table implements the visit process by linking each visit to its corresponding reservation through *Reservation_ID*, while also recording the visit status. Visit validation is represented in the *Confirmation* table, which now has a more detailed structure through *Confirmation_ID* as the primary key and foreign keys referencing both the *Visit* and *Admin* tables. This table stores the approval status, confirmation date, and additional notes, offering a more concrete representation of the administrative process compared to the conceptual ERD model. In the blog component, the *Blogpost* table demonstrates the actual implementation of

content management by including attributes such as title, content, tags, thumbnail, view count, and upload date. Its relationship with the *Admin* table is defined through *Admin_ID* as a foreign key, indicating that each article is managed by a specific administrator. Thus, this table-based ERD provides a more technical, measurable, and implementation-ready mapping of the database structure, differing from the ERD model, which only illustrates conceptual relationships at the design level.

c. Use Case Diagram Living Lab Surabaya

After developing the ERD tables, the next step is to construct the use case diagram. CRUD (create, read, update, delete) operations are widely recognized as the fundamental actions for managing data persistence in software systems [21]. Accordingly, this study applies the CRUD framework in the development of the use case diagram to ensure that all functional processes support a complete data lifecycle.The system's use cases are organized into two main groups, namely reservation management and blog management. Each group demonstrates how CRUD operations are implemented to maintain structured and consistent data processing.

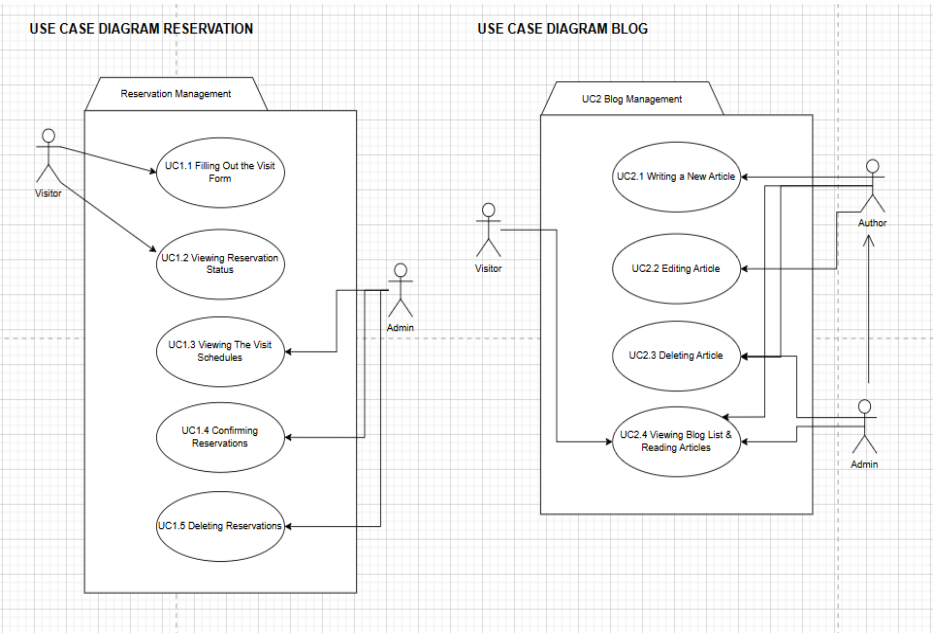

Figure 7. Use Case Diagram Living Lab Surabaya

In the reservation management section, the visitor actor has access to several processes, including filling out the visit form (UC1.1), viewing reservation status (UC1.2), and viewing the visit schedule (UC1.3). Meanwhile, the admin actor performs administrative tasks such as confirming reservations (UC1.4) and deleting reservations (UC1.5), allowing the reservation process to be managed in a centralized and structured manner. In the blog management section, there is a generalization relationship between the author and admin actors. The author actor is a specialization of the admin actor, meaning that the author can perform all use cases available to the admin, while the admin cannot perform use cases specifically assigned to the author. In the system, the author has the authority to manage content through activities such as writing new articles (UC2.1), editing articles (UC2.2), and deleting articles (UC2.3). Meanwhile, the visitor can only view the blog list and read articles (UC2.4), providing public access to available content.

d. Activity Diagram Living Lab Surabaya

After creating the use case diagram, the next step is to develop the activity diagram. In the Living Lab Surabaya system, there are two main processes, namely the reservation process and the blog management process.

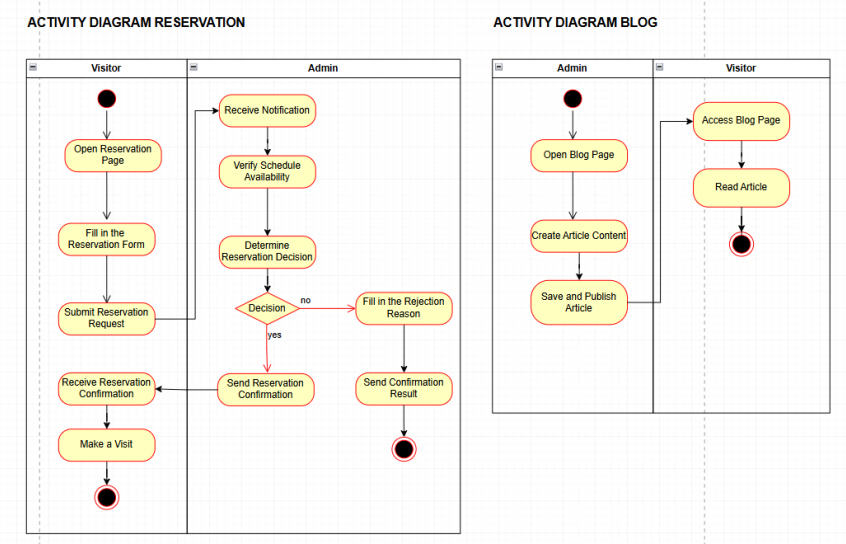

Figure 8. Activity Diagram Living Lab Surabaya

In the Reservation process, the flow begins with the user (Visitor) accessing the reservation page and filling out the reservation form. The submitted request is then received by the Admin, who is responsible for verifying and checking the availability of the schedule. Based on the results of this verification, the Admin determines whether the request is approved or rejected. The confirmation result, either approval or a rejection accompanied by the reason, is then sent back to the Visitor. If approved, the Visitor can carry out the visit according to the scheduled time. This process illustrates a two-way service interaction between the Visitor and the Admin. In the Blog Activity Diagram, the activities focus on content creation and publication. The Admin accesses the dashboard to write, save, and publish articles. The Visitor can then access the blog page and read the available articles. This process is one-way, where the Admin acts as the content provider and the Visitor as the information consumer.

e. Prototype Living Lab Surabaya

The final stage of the design phase involves developing the prototype of the Living Lab Smart City Surabaya website. This prototype was created using Figma as a visual representation of the interface concept and interaction flow that had been formulated during the user needs analysis stage. In this design, the main navigation structure consists of ten pages arranged within a navigation bar at the top of the website. These ten pages include Home, About Us, Profile, Kunjungan (Visit), City Hub, Smart Living, Smart Economy, Masterplan, Digitalization, Blog, and Career, all of which are positioned to ensure that users can access information consistently, clearly, and in a well-structured manner.

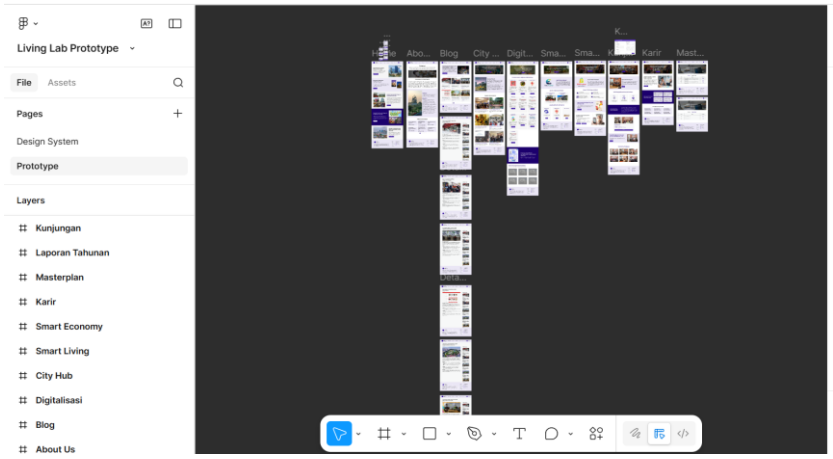

Figure 9. Prototype Living Lab Surabaya

The first page designed is the Home page, which functions as the main orientation point for users when they first access the site. Following this, the About Us page is structured to provide a deeper understanding

of the institution's profile and activities. This menu contains two subsections accessible via a dropdown, namely the Profile page, which presents background information, vision, mission, and the strategic role of the Living Lab in supporting smart city development; and the Kunjungan (Visit) page, which provides procedural information regarding the reservation mechanism for visits to the Living Lab Surabaya. The Services section then serves as one of the key components of the prototype because it encompasses the core categories of Smart City implementation in Surabaya. These service categories are divided into three groups—City Hub, Smart Living, and Smart Economy—all accessible through a dropdown menu. Each category is designed to present a collection of programs and activity documentation that illustrate how technology and innovation are applied across various sectors of urban development. In addition to these pages, the prototype also includes the Masterplan page, which is designed to present Surabaya's Smart City planning documents and annual reports in a more comprehensible format. This page provides structured descriptions of policy directions and city strategies, along with a document download option for users who require deeper access to the planning content. The next page is the Digitalization page, which was developed to display information regarding the implementation of Smart Environment initiatives in Surabaya. The prototype also includes the Blog page as a platform for publishing articles, documenting activities, and sharing the latest updates on Living Lab programs and achievements. This page is arranged in an article-list layout to make it easier for users to select content according to their needs. Additionally, there is a Career page, developed as an information medium related to expert recruitment and collaboration opportunities. On this page, users can directly contact the Living Lab team through an integrated WhatsApp link to facilitate more efficient communication.

3.1.3 Coding

During the coding stage, the front-end development process was carried out using HTML, CSS, and JavaScript, all written within a single main file. This approach was chosen to simplify design iteration, as any changes made to the structure, visual styling, or interactions can be tested quickly without needing to separate the code into multiple components.

Figure 10. Coding Phase in Living Lab Surabaya

The image above shows an example of the code snippets used to build the page structure, configure the layout, and handle basic navigation interactions. HTML is used to construct the page framework based on the previously created prototype, while CSS manages visual aspects such as colors, typography, and element positioning to ensure that the final appearance aligns with the interface design. JavaScript is added to manage interactive functions, such as handling navbar elements, dynamic visual changes, and manipulating specific page content.For data storage, the system utilizes MySQL as the main database. This database is used to manage information related to visit reservations and blog content, which can then be displayed on the website as needed. Integration between the front-end and the database is performed through a basic connection that enables data to be processed, stored, and loaded dynamically.

3.1.4 Testing

At the testing stage, this study conducted a usability testing process to ensure that the prototype of the Living Lab Smart City Surabaya website meets usability standards and is capable of supporting user needs effectively[22]. The usability testing was carried out using the Maze platform and engaged 30 participants selected based on criteria relevant to the system usage context[23]. This sample size aligns with similar studies in usability research, where approximately 30 participants are often used to gather reliable user feedback on interface usability and

satisfaction [24]. Their responses provided valuable insights into the performance and user experience of the system.. The following are the participant criteria used as the basis for conducting the evaluation.

Table 3. Participant Criteria

No	Participant	Criteria
1	General	1. Aged 17–45 years old. 2. Domiciled in or actively engaging in daily activities within Surabaya. 3. Not involved in the prototype design process. 4. Capable of using digital devices such as laptops or smartphones proficiently.

Subsequently, it is necessary to develop a structured plan for the user task scenarios to ensure that the evaluation process accurately reflects real interaction flows. The following are the task scenarios used in the usability testing of the Living Lab Surabaya, conducted through the Maze platform.

Table 4. Task Scenarios

No	Feature	Task
1	Profile	Find Profile Page
2	Reservation Visit	Find Reservation Form Page
3	Service (City Hub)	Find Service (City Hub) Page
4	Service (Smart Living)	Find Service (Smart Living) Page
5	Service (Smart Economy)	Find Service (Smart Economy) Page
6	Masterplan	Find Masterplan Page
7	Digitalization	Find Digitalization Page
8	Blog	Open Article on a Blog
9	Career	Find Career Page

3.1 Testing Result

In the preliminary usability testing stage, initial findings were obtained regarding the misclick rate across several main pages of the prototype. The recorded misclick values include: Profile (21.2%), Visit Reservation (17%), City Hub (51.7%), Smart Living (45.5%), Smart Economy (31.4%), Masterplan (60.8%), Digitalization (50%), Blog (58.9%), and Career (59.1%). The relatively high misclick percentages on several pages indicate inaccuracies in user interaction when attempting to navigate, particularly within the top menu elements.Further inspection of the prototype revealed that the main cause of the elevated misclick rate was the presence of overlapping design components, which hindered optimal interaction within the navigation bar. This issue made it difficult for users to access the intended pages, leading to unintentional clicks on incorrect areas.

Based on these findings, improvements were made to the structure and arrangement of the prototype elements to ensure that each component could be accessed properly.These refinements were then implemented in the second round of testing, which served as the primary basis for analysis, as it represented a more stable version of the prototype without the initial structural errors. The following section presents the results of the second task-based usability testing conducted using Maze.

Table 5. Testing Result

No	Feature	Task	Success Rate	Avg.duration	Misclick rate	SEQ
1	Profile	Find Profile Page	100%	5.4s	3.2%	7
2	Reservation Visit	Find Reservation Form Page	100%	7.9s	2.2%	7
3	Service (City Hub)	Find Service (City Hub) Page	100%	4s	0%	7

4	Service (Smart Living)	Find Service (Smart Living) Page	100%	4.3s	1.5%	7
5	Service (Smart Economy)	Find Service (Smart Economy) Page	100%	4.9s	0%	7
6	Masterplan	Find Masterplan Page	100%	4.7s	0%	7
7	Digitalization	Find Digitalization Page	100%	2.6s	0%	7
8	Blog	Open Article on a Blog	100%	7.4s	4.8%	7
9	Career	Find Career Page	100%	4.7s	0%	7

The results of the second usability testing show that all participants successfully completed every assigned task, achieving a 100% success rate across all scenarios. This indicates that the navigation structure, element layout, and page-finding flow within the prototype had reached a good level of usability following the improvements made based on the findings from the initial testing. In terms of efficiency, the task completion time (average duration) ranged from 2.6 seconds to 7.9 seconds, demonstrating that users were able to locate the intended pages quickly and without significant confusion. The fastest task was locating the Digitalization page (2.6 seconds), while the longest duration occurred in the task of finding the Reservation Visit page (7.9 seconds). Nevertheless, all duration values remain within an acceptable range, reflecting efficient interaction performance. The misclick rate in the second testing also showed significantly lower values compared to the initial test. Most tasks recorded a 0% misclick rate, indicating that users did not encounter unintended clicks while navigating the interface. Only two tasks exhibited minor misclick occurrences—finding the Profile page (3.2%) and opening a Blog article (4.8%). These values remain relatively low and do not hinder task completion, though they may be considered as references for further optimization, particularly regarding layout consistency within the navigation menu. All tasks received a score of 7 on the Single Ease Question (SEQ), representing a “very easy” perception from users after completing each scenario[14]. The consistent SEQ scores indicate that the prototype provides a smooth interaction experience, free from major obstacles, and is easy for users to understand across different categories of pages. To complement the results of each task scenario, the Maze Usability Score (MAUS) is also used as an indicator of the overall usability quality.

Figure 11. Maze Usability Score (MAUS)

Based on the testing results presented in the figure above, the Living Lab Surabaya prototype achieved a Maze Usability Score (MAUS) of 99. This score falls into the *excellent* category, indicating that the overall user experience performed exceptionally well[14]. The evaluation involved 30 respondents and a total of 27 analysis blocks, covering task success, navigation efficiency, and misclick rates. With a MAUS score of 99, it can be concluded that the majority of respondents were able to complete all task scenarios without significant obstacles, following the designed interaction flow effectively. These results indicate that the interface design meets strong usability standards and supports an optimal user experience.

4. CONCLUSION

The findings of this study indicate that the application of the Extreme Programming (XP) method in the front-end design process of the local Living Lab Smart City Surabaya website successfully produced a system with a very high level of usability, while also supporting the development of user interaction quality that aligns with user needs. Each XP phase from planning, interface design, development, to testing—contributed to the creation of a design flow that is easy to understand and responsive to user feedback. The initial testing revealed issues related to navigation, particularly the presence of overlapping elements in the navbar area. This condition resulted in a high misclick rate across several pages, indicating the need for visual restructuring and reorganization of interface components. After improvements were implemented, the second round of testing demonstrated a significant increase in performance. All participants successfully completed every task scenario with a 100% success rate, without encountering major obstacles in locating the intended pages. The misclick rate also decreased drastically to the range of 0%–4.8%, showing that the design revisions enabled users to interact more accurately and consistently.

The Single Ease Question (SEQ) results further reinforced these findings, with each scenario receiving the highest score of 7. This indicates that after completing the tasks, users perceived the system as very easy to use. Additionally, the Maze Usability Score (MAUS) achieved a score of 99, categorized as "excellent." This score demonstrates that the prototype successfully fulfilled the aspects of learnability, efficiency, and error prevention, providing a stable and minimally obstructive user interaction experience. These results are consistent with the concept of user interaction described by Hornbaek & Oulasvirta (2017), which emphasizes that interaction is shaped by user expectations, momentary experiences, cognitive evaluation, and the feelings that arise during engagement with an interface. With clear navigation, predictable usage flows, and consistently high levels of comfort, the prototype not only functions effectively but also delivers a positive overall interaction experience.

In conclusion, this study shows that integrating the XP method into front-end design and utilizing data-driven usability testing can produce a local website with excellent user interaction quality. For future research, it is recommended that usability testing not rely solely on Maze but be complemented with other evaluation methods such as think-aloud protocols, short post-task interviews, or the System Usability Scale (SUS). Combining multiple methods will allow researchers to gain deeper insights into the reasons behind user actions, their perceptions during interaction, and the emotional aspects that may not be captured through statistical testing alone. Such a multi-method approach can lead to a more comprehensive analysis of user interaction and provide richer insights for subsequent design development.

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