Journal of Applied Multimedia and Networking (JAMN)
Vol.x, No.x, Maret 201x, pp. xx~xx
e-ISSN: 2548-6853

Development of Polibatam P2M Interactive Geovisualization Platform Using AI-Assisted ETL Pipeline and Structured Onboarding Systems

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Article Info

Article history:

Received Jun 12th, 201x
Revised Aug 20th, 201x
Accepted Aug 26th, 201x

Keyword:

Interactive Map
Geovisualization
AI-Assisted ETL
Onboarding
Usability Testing

ABSTRACT

Politeknik Negeri Batam's Pusat Penelitian dan Pengabdian Kepada Masyarakat (P2M) manages community service programs across the Riau Islands, yet program documentation remains confined to text-based listings on static web pages without geographic context. This study integrates AI-assisted data extraction, geospatial visualization, and usability-oriented interface design into a unified platform to address both data scalability and user accessibility challenges. An interactive geovisualization platform was developed to transform unstructured P2M journal articles into an explorable, map-based multimedia experience. An AI-assisted Extract–Transform–Load (ETL) pipeline using GPT-3.5-turbo was implemented to automatically extract, categorize, and geocode 48 community service programs from 49 PDF documents published between 2019–2024, scaling from an initial 5 manually curated entries. The platform was built using Next.js and Leaflet.js with a mobile-first responsive design, featuring marker clustering, category-based filtering, interactive lightbox, and a structured two-tier onboarding system grounded in Cognitive Load Theory. Usability evaluation using Task Completion Rate (TCR) with 5 participants and System Usability Scale (SUS) with 23 respondents yielded a TCR of 95.0% and a SUS score of 67.5, indicating highly effective task completion and acceptable usability at the industry benchmark average. The results demonstrate the feasibility of combining AI-driven data extraction with interactive web mapping to enhance institutional knowledge discovery and geographic awareness of community service impact.

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1. INTRODUCTION

Rapid developments in Information and Communication Technology (ICT) have transformed mapping from static representations into interactive digital ecosystems [1]. Modern interactive cartography is no longer limited to visual communication but is defined as a dialogue between users and maps mediated by computing devices, enabling active “visual thinking” [2]. Studies have shown that interactive maps are more effective than traditional tabular data in supporting spatial understanding and increasing user engagement [3]. In contexts involving large-scale datasets, interactive systems are essential to manage information complexity and maintain data relevance [4].

In institutional environments, data from Community Service (P2M) programs are often stored in unstructured and fragmented PDF documents. This format limits data accessibility, reduces discoverability, and makes it difficult to analyze the spatial distribution of community service activities. Manual extraction is time-consuming and must be repeated for each document, making it impractical as data volume increases. This highlights the need for a more automated and scalable data processing approach.

Recent advances in artificial intelligence enable the use of Extract–Transform–Load (ETL) pipelines enhanced by Large Language Models (LLMs) to process unstructured documents. These models can extract and transform information into structured formats, significantly reducing manual effort [5,6]. With appropriate prompt engineering, LLMs can generate consistent outputs suitable for integration into structured data systems such as JSON [6]. However, while these approaches address data processing challenges, they do not fully address issues related to data accessibility, spatial exploration, and user interaction.

Beyond data processing, the effectiveness of a geovisualization system depends on how well it supports user understanding. According to Cognitive Load Theory, human cognitive capacity is limited; therefore, interface design must minimize unnecessary mental effort [7]. Onboarding mechanisms play a crucial role in guiding first-time users, enabling early comprehension and smoother interaction [8]. Additionally, techniques such as marker clustering are necessary to manage dense spatial data and reduce visual clutter [9].

Previous studies have explored LLM-based ETL for document processing [5,6] and interactive maps for data visualization [3], but these approaches are typically implemented separately. Previous studies have explored LLM-based ETL for document processing and interactive maps for data visualization, but these approaches are typically implemented separately. Few studies integrate automated data extraction, interactive geovisualization, and usability-oriented interface design into a unified system, particularly in the context of higher education community service data.

This study contributes by integrating AI-assisted ETL, interactive geovisualization, and usability-oriented interface design into a unified platform for institutional data exploration. The proposed system demonstrates how unstructured documentation can be transformed into an interactive and spatially contextualized knowledge resource. The system is evaluated using Task Completion Rate (TCR) and System Usability Scale (SUS) to assess both functional effectiveness and perceived usability.

2. RESEARCH METHOD

This study adopts a prototyping-based development approach to design and implement the system. The approach emphasizes iterative refinement of system components, including data processing, geovisualization, and user experience design. Rather than documenting multiple formal prototype versions, the development process reflects progressive improvements based on identified system limitations. The final system represents the outcome of these refinements, integrating AI-assisted data processing, interactive visualization, and usability-oriented design.

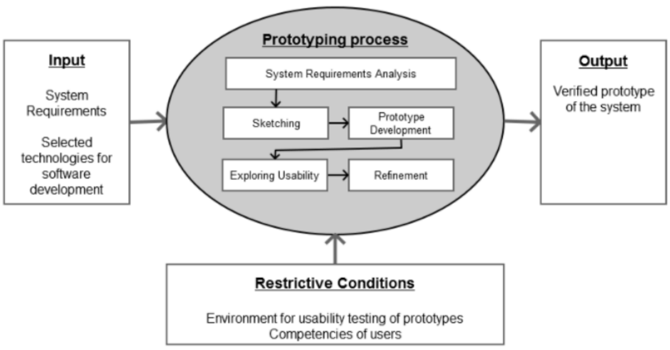

Figure 1. Evolutionary Prototyping based on process approach [11]

Figure 1 illustrates the conceptual prototyping process used as a reference in this study. In this context, the model is applied to describe the logical flow of system development rather than strictly sequential iterations. The refinement process is represented through improvements in system components, including data scalability, visualization features, and onboarding usability. These refinements are further demonstrated through the evolution of system features, which highlight how initial limitations were addressed to achieve the final implementation.

2.1. System Requirements

The system was designed to address the limited accessibility of P2M (Pengabdian kepada Masyarakat) information at Politeknik Negeri Batam. Existing program data is primarily stored in unstructured PDF documents, making it difficult for users to understand the spatial distribution of activities and access relevant information efficiently.

Based on these challenges, a set of functional requirements was defined to support data visualization, usability, and scalable data processing. These requirements were refined iteratively during prototype development, in line with the evolutionary prototyping approach.

Table 1. Mapping of Operational Problems to System Requirements

ID	Functional Requirement	Description	Justification
FR-01	Interactive map visualization	Display P2M program locations as interactive markers on a map.	Improves spatial understanding and data accessibility.
FR-02	AI-assisted ETL pipeline	Automate extraction of structured data from PDF documents.	Reduces manual effort and improves scalability.
FR-03	Marker clustering	Group nearby markers to reduce visual density.	Reduces visual clutter in dense datasets.
FR-04	Guided onboarding system	Provide onboarding guidance for first-time users.	Improves usability and feature discoverability.

The iterative refinement process is reflected in the evolution of system components, where initial limitations were identified and addressed through targeted improvements. This progression demonstrates how the system evolved to better support scalability, usability, and data accessibility.

2.2. Selected Technologies

The system was developed using a modern web-based architecture to support interactive geovisualization and scalable data processing.The frontend was implemented using a React-based framework to enable dynamic user interaction and efficient state management. An interactive mapping library was utilized to render geospatial data, supporting marker visualization, clustering, and user-driven exploration. Responsive interface design was achieved using a utility-first CSS framework to ensure compatibility across desktop and mobile devices.

For data management, structured program data was organized using type-safe modules to ensure consistency and maintainability. P2M program documents in PDF format were used as the primary data source. To address the limitations of manual data extraction, an AI-assisted Extract–Transform–Load (ETL) pipeline was integrated into the system. The extraction process utilizes prompt-based interaction with a Large Language Model (LLM) to convert unstructured documents into structured data. The transformation stage organizes extracted information into predefined attributes such as program name, location, and geographic coordinates.

Following extraction, a geocoding process is applied to convert location descriptions into spatial coordinates for visualization. However, variations in document structure may introduce minor inconsistencies, requiring manual verification to ensure data accuracy and reliability.

2.3. Prototyping Process

The system was developed using an evolutionary prototyping approach, where system components were progressively refined based on identified limitations in functionality, data processing, and user interaction. Rather than producing multiple formal prototype versions, this approach emphasizes continuous improvement of a single system through iterative enhancement.

In this study, the prototyping process focuses on refining key aspects of the system, including data scalability, visualization effectiveness, and usability. Each refinement contributes to the development of the final integrated system, aligning with evolutionary prototyping principles in which system requirements evolve throughout the development process [11].

2.3.1 Sketching

The sketching stage represents the initial design phase of the system, focusing on defining the interface structure and user interaction flow. This stage includes the arrangement of key components such as the interactive map, filtering controls, and information panels to support intuitive navigation.

A mobile-first design approach was applied to ensure accessibility across different devices. Wireframes were developed to visualize the layout structure, while use case diagrams were used to model user interactions and system functionalities.

These design artifacts serve as the foundation for subsequent system development and are presented in Figure 2 and Figure 3.

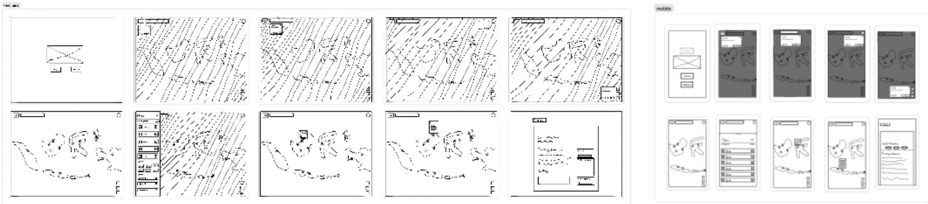

Figure 2. Wireframe

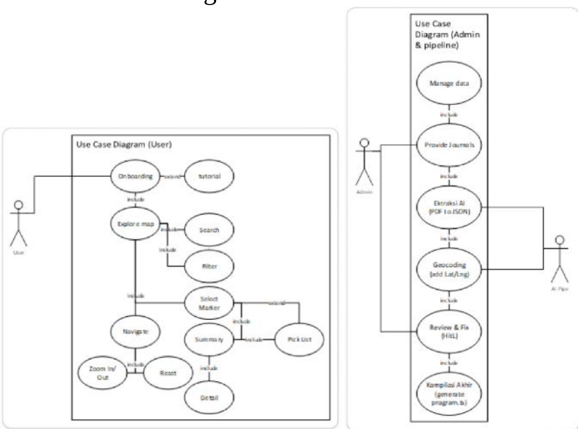

Figure 3. Usecase Diagram

2.3.2 Prototype Development

The prototype development stage represents the implementation of the system through iterative refinement of its components. Rather than producing multiple formally documented prototype versions, the development process involved continuous improvements in data processing, visualization features, and user interaction based on identified limitations during development. The resulting system is a web-based geovisualization platform that enables users to explore P2M program data spatially. Program locations are visualized as interactive map markers, allowing users to access summary information through pop-ups and navigate to more detailed program content.

One key refinement is the integration of an AI-assisted ETL pipeline, which was introduced to address the limitations of manual data extraction. This improvement significantly enhances data scalability by enabling automated processing of multiple documents into structured geospatial data. To support efficient exploration of dense spatial data, marker clustering is implemented to dynamically group nearby data points, reducing visual clutter. Additional navigation features, such as zoom controls and reset view functionality, are provided to improve spatial orientation. Search and filtering features are also integrated, enabling users to locate programs based on keywords, categories, and temporal attributes.

The implementation results of the system are presented in the following figures.

A. Core System Implementation

The prototype was designed as an interactive web-based geovisualization platform to support spatial exploration of P2M program data. The system architecture integrates map-based visualization, filtering mechanisms, and information display components to facilitate user interaction with geospatial data.

To support exploration of dense spatial datasets, the prototype incorporates marker clustering techniques to reduce visual clutter and improve map readability. Navigation mechanisms, including zoom control and reset view functions, were designed to support spatial orientation during interaction. In addition, search and filtering functionalities were implemented to enable users to locate programs based on keywords, categories, and temporal attributes.

These design decisions aim to support efficient data exploration and align with the functional requirements defined in Section 2.1.

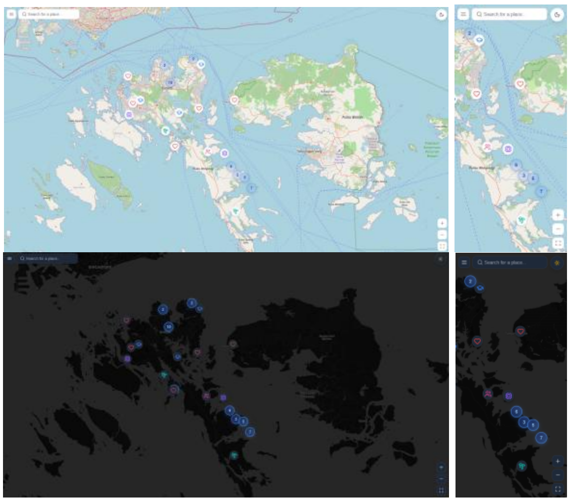

Figure 4. Main Interface of Interactive Map

The main interface displays geocoded P2M program locations on an interactive map. Both desktop and mobile views are presented to demonstrate responsive design and accessibility across devices.

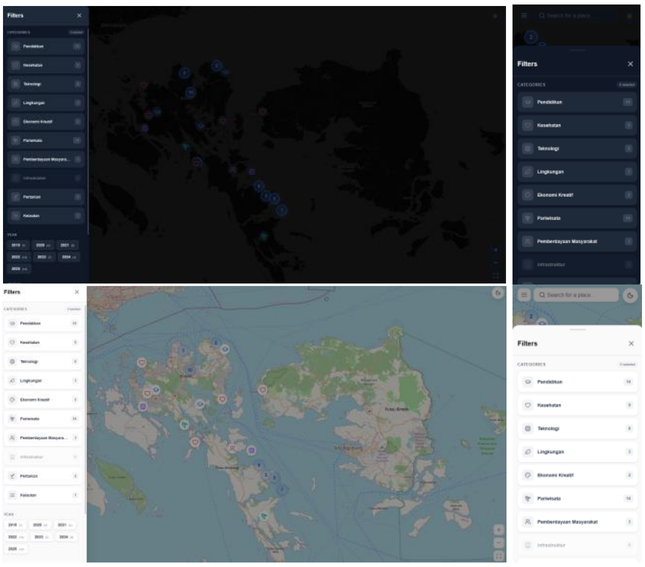

Figure 5. Filtering Feature

The filtering feature allows users to explore P2M programs based on selected categories. This improves data navigation and helps users quickly access relevant information.

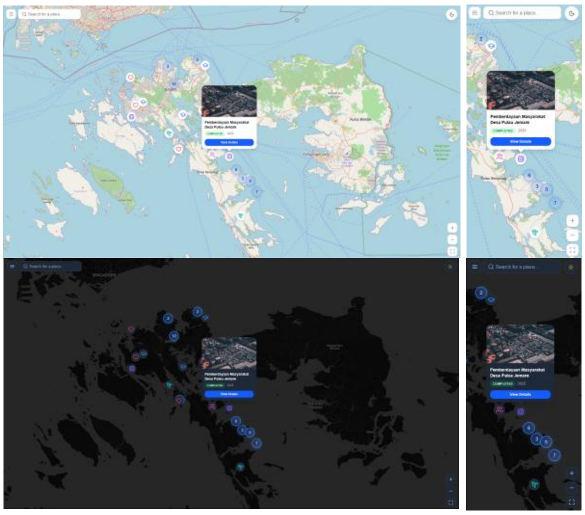

Figure 6. Information Display

The pop-up provides a brief overview of selected programs, including title and key details. This enables quick access to information without leaving the map interface.

B. AI-Assisted ETL Pipeline

To address the challenge of unstructured data, an AI-assisted ETL pipeline was implemented to transform P2M program information from PDF documents into structured geospatial data. A total of 49 P2M articles from 2019–2024 were collected from institutional sources, focusing on the Pengabdian category due to its clear geographic context. The pipeline consists of four main stages: extraction, transformation, geocoding, and loading.

In the extraction stage, relevant text is obtained from PDF documents. The transformation stage utilizes a Large Language Model (LLM) to extract structured information such as program title, category, and location using a predefined prompt format. The geocoding stage converts location descriptions into geographic coordinates, supported by manual correction when needed. Finally, the processed data is compiled into a structured format for integration into the application. This approach reduces manual data processing effort and enables more scalable data preparation compared to traditional manual methods.

C. UX and Multimedia Enhancements

To improve usability and user experience, several interface enhancements were implemented based on usability principles. A two-tier onboarding system was introduced to guide first-time users. The first tier consists of a splash screen that provides a brief overview of the platform's purpose, while the second tier is an interactive guided walkthrough that highlights key features such as filtering, search, and map navigation. This helps users understand the system more quickly and reduces initial confusion.

To enhance information presentation, a multimedia-based detail page was developed, allowing users to access program descriptions, images, and navigation links. An image lightbox feature is also provided to display documentation images in full resolution without leaving the page, improving content accessibility. Additionally, animated visual feedback was implemented using lightweight vector-based animations to indicate system responses during loading states. This improves perceived responsiveness and provides clearer feedback to users.

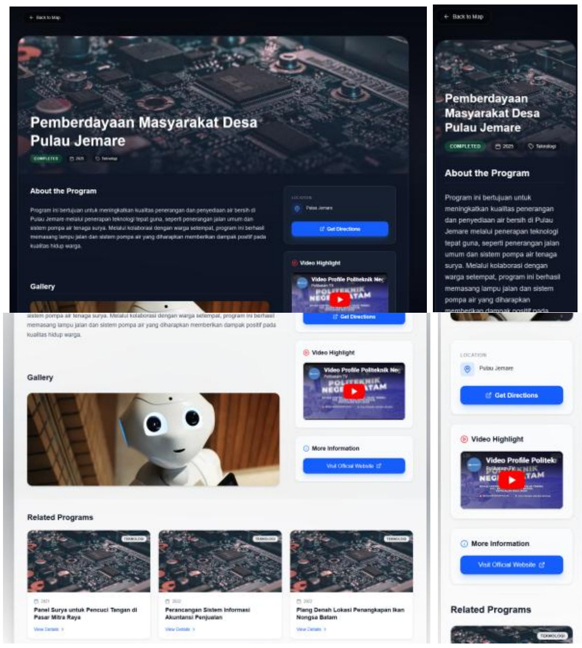

Figure 7. Detail Page

The detail page presents complete program information, including descriptions and multimedia content. This supports deeper exploration of individual P2M activities.

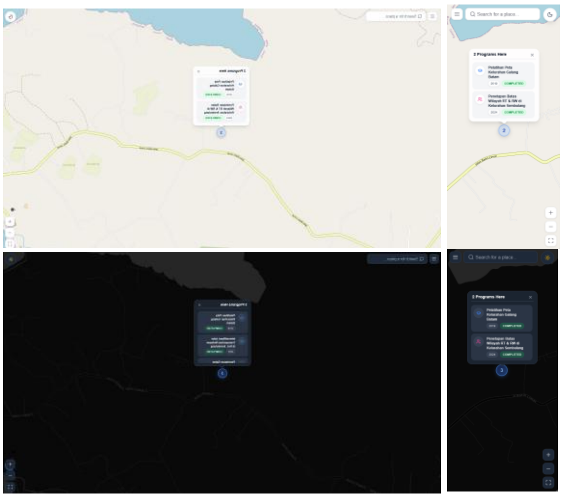

Figure 8. Marker Distribution / Clustering

Marker clustering is implemented to manage high-density data and reduce visual clutter. This improves readability and interaction when exploring densely populated areas.

Figure 9. Onboarding System

The onboarding system guides first-time users through key features of the application. This helps users understand system functionality and improves initial usability.

D. Navigation Enhancement: Related Programs.

The initial prototype supported only linear navigation, where users explored one program at a time and returned to the map to select another. To improve this, a "Related Programs" section was introduced on each detail page.This feature displays up to three programs from the same category, allowing users to discover related community service activities more efficiently. It enables users to navigate between related content without returning to the main map, reducing interaction effort and improving program discoverability.

Table 2 summarizes the full evolution from the initial prototype to the final system.

Table 2. System Evolution

Component	Initial State	Identified Limitation	Final State
Data Source	5 manually created entries (3 real, 2 mock)	Manual process required ~15 minutes per program and was not scalable	AI-assisted ETL pipeline producing 48 programs from 49 PDF articles
User Orientation	No onboarding provided	First-time users were uncertain about how to interact with system features	Two-tier onboarding: glassmorphism splash screen and 4-step guided tutorial
Image Viewing	Static thumbnail grid	No mechanism to view images in higher detail	Interactive lightbox with zoom capability following progressive disclosure principles
System Feedback	Static "Loading..." text	Lacked visual engagement and did not convey system activity effectively	Lottie-based animations for loading states and empty-state feedback
Program Discovery	Linear navigation via map only	Users needed to repeatedly return to the map to explore additional programs	Related Programs section enabling category-based cross-navigation
Splash Screen	Basic overlay interface	Minimal visual context and limited user engagement	Glassmorphism design with backdrop blur and session-based display control

2.3.3 Exploring Usability

This stage represents the evaluation of system usability as part of the development process. Usability evaluation was conducted using a descriptive quantitative approach to measure system effectiveness and user satisfaction. Two evaluation methods were used: Task Completion Rate (TCR) to measure effectiveness, and System Usability Scale (SUS) to measure user satisfaction. TCR measures the proportion of participants who successfully complete predefined tasks without assistance. A total of twelve task scenarios were designed to evaluate key system functionalities, including map interaction, navigation, search and filtering, and multimedia features.

1. Effectiveness: Task Completion Rate (TCR)

Task Completion Rate (TCR) is used to measure system effectiveness by calculating the proportion of participants who successfully complete predefined tasks without assistance. A task is considered successful only if it is completed independently by the participant.

The TCR is calculated as follows:

$$TCR = (\text{Number of participants who completed the task} / \text{Total number of participants}) \times 100\%$$

A total of twelve task scenarios were designed to evaluate key system functionalities, including map interaction, navigation, search and filtering, and multimedia features. The task scenarios used in the evaluation are presented in Table 3.

Table 3. Task Scenarios

TS	Task Scenario (User Reads This)	Success Criteria (Researcher Only)	FR	Tag
Onboarding & Interaction				
TS01	You are using this platform for the first time. Please explore it until you feel ready to use it.	User completes the guided tutorial OR independently opens a program popup and uses at least one control feature (filter or search) without assistance.	FR-04	Onboarding
Map Exploration				
TS02	Try to find one P2M program on the map and view its basic information.	User clicks a marker and opens a program popup.	FR-01	Core
TS03	On the map, some points contain multiple programs. Try to see what programs are available in one of those points.	User expands a cluster (by clicking or zooming) to reveal individual markers or program list.	FR-01, FR-03	Core
TS04	After exploring the map, return it to the initial view that shows the entire Batam area.	User uses the reset view button to return to the default map view.	FR-01	Navigation
Search & Filter				
TS05	Find a P2M program named "Pelatihan Bahasa Asing" using the available features.	User enters the program name in the search bar, selects the correct result, and the map focuses on the corresponding program.	FR-01	Core
TS06	Show only P2M programs related to the Education category.	User applies the "Education" category filter and the map updates accordingly.	FR-01	Core
TS07	Show P2M programs in the Health category from the year 2022, then return the map to show all programs again.	User applies both category and year filters correctly and then resets all filters to default.	FR-01	Core
Detail & Multimedia				
TS08	Select one program from the map and open its detailed information.	User navigates from a popup to the full detail page.	FR-01	Core
TS09	From the program detail page, find how to get directions to the program location.	User clicks the "Get Directions" feature successfully.	FR-01	Navigation
TS10	View one of the program's documentation images in full size.	User opens an image in full-screen (lightbox) view.	FR-01	Core
TS11	From the detail page, try to open another related program.	User clicks a related program item and navigates to another program detail page.	FR-01	Core
TS12	Change the platform appearance to a different mode (light/dark).	User clicks the theme toggle and the interface changes mode.	FR-01	Core

2. Satisfaction: System Usability Scale (SUS)

User satisfaction was measured using the System Usability Scale (SUS), a standardized 10-item questionnaire using a 5-point Likert scale. The questionnaire consists of alternating positive and negative statements to reduce response bias. SUS scores are calculated by converting individual responses into a composite score ranging from 0 to 100. For positive items, the score is calculated as (response − 1), while for negative items, the score is calculated as (5 − response). The total score is then multiplied by 2.5 to obtain the final SUS score. A benchmark score of 68 is commonly used to indicate average usability. Scores above this value suggest acceptable usability, while higher scores indicate better user satisfaction.

The SUS questionnaire used in this study was adapted to the platform context, as presented in Table 5. This evaluation focuses on key usability aspects, including learnability and efficiency, particularly in relation to onboarding and interaction with spatial data.

Table 5. SUS Questionnaire

<table>
<tr><td colspan="5">Scale: 1 (Strongly Disagree) → 5 (Strongly Agree)</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="2">Q1+</td><td colspan="3">I think I would use this P2M Interactive Map platform frequently.</td></tr>
<tr><td colspan="2">Q2−</td><td colspan="3">I found this platform unnecessarily complex.</td></tr>
<tr><td colspan="2">Q3+</td><td colspan="3">I thought the platform was easy to use.</td></tr>
<tr><td colspan="2">Q4−</td><td colspan="3">I think I would need the support of a technical person to use this platform.</td></tr>
</table>

Q5+	I found the various functions in this platform were well integrated.
Q6−	I thought there was too much inconsistency in this platform.
Q7+	I would imagine that most people would learn to use this platform very quickly.
Q8−	I found this platform very cumbersome to use.
Q9+	I felt very confident using this platform.
Q10−	I needed to learn a lot of things before I could get going with this platform.
Positive item: score = response – 1 Negative item: score = 5 – response Total × 2.5 = final SUS score (0–100)	

2.3.4 Refinement

The refinement stage represents the improvement of the system based on usability evaluation and user feedback. This stage aims to enhance system usability, interaction clarity, and overall user experience following the implementation and evaluation phases.

Several refinements were applied to address identified limitations in navigation, interface clarity, and system feedback. These improvements include adjustments to responsive layout, enhancement of interface elements, standardization of language usage, and improvement of search interaction. The refinement process focuses on improving system accessibility and usability across different devices and user scenarios, ensuring that the final system provides a more effective and user-friendly experience.

Table 7 summarizes the key refinements applied to the system.

Table 7. Post-Evaluation Refinements

Issue Identified	Refinement Applied
Zoom controls obscured on tablet viewport	Adjusted CSS positioning with responsive media queries
Icon-only buttons lack text labels	Added hover tooltips to theme toggle and filter buttons
Mixed language in UI elements	Standardized all interface text to English
No search result preview	Added search suggestion dropdown with matching results

3. RESULTS AND ANALYSIS

This section presents the findings from the usability evaluation of the P2M Interactive Map platform, focusing on effectiveness measured by Task Completion Rate (TCR) and user satisfaction measured by the System Usability Scale (SUS).

3.1. Task Completion Rate Analysis

Task Completion Rate (TCR) was evaluated across 12 task scenarios with 5 participants, as summarized in Table 4.

Table 4. Task Completion Rate

	TS	TS01	TS02	TS03	TS04	TS05	TS06	TS07	TS08	TS09	TS10	TS11	TS12	Avarage
User	Success	5	5	5	2	5	5	5	5	5	5	5	5	57/60
	TCR (%)	100	100	100	40	100	100	100	100	100	100	100	100	95.0

The platform achieved an overall TCR of 95.0% (57 out of 60 task attempts), exceeding the 80% threshold categorized as "Highly Effective". This indicates that the system effectively supports user interaction and task completion. Eleven out of twelve tasks achieved a 100% completion rate, demonstrating that the core functionalities of the platform are intuitive and can be operated independently by users. These functionalities include onboarding, map exploration, search, filtering, detail navigation, multimedia interaction, related program navigation, and theme switching.

The only task with reduced completion was TS04 (cluster exploration), which achieved a completion rate of 40%. In this task, 3 out of 5 participants were unable to expand clustered markers on the map. Further investigation revealed that this issue was caused by a responsive layout problem, where zoom and reset controls were partially obscured on tablet-sized viewports, preventing users from performing zoom interactions. This aligns with findings from eye-tracking research demonstrating that visually inaccessible interface controls increase extraneous cognitive load and disrupt spatial reasoning during map interaction [7]. Importantly, this issue was not related to the conceptual design of the clustering mechanism. Participants who were able to access the zoom controls successfully completed the task, indicating that the interaction design itself was understandable. This suggests that the limitation originated from interface implementation rather than usability design.

Overall, the high TCR demonstrates that the platform meets the defined functional requirements and provides effective support for user interaction. The 100% completion rate for onboarding tasks further indicates that the implemented onboarding mechanism successfully assists first-time users in understanding system functionality.

3.2. System Usability Scale Analysis

The System Usability Scale (SUS) questionnaire was administered to 23 respondents. The demographic distribution includes 52% aged 18–25, 39% aged above 25, and 9% under 18. Most respondents were from the general public, with varying levels of prior experience using digital maps.

The individual SUS scores are presented in Table 6.

Table 6. System Usability Scale

ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS
R1	3	2	4	2	4	4	3	2	3	4	57.5
R2	5	5	5	5	5	3	5	1	4	1	72.5
R3	3	2	4	2	4	2	4	2	4	2	72.5
R4	3	1	5	1	4	1	4	2	4	2	82.5
R5	2	4	2	4	3	3	3	3	3	4	37.5
R6	3	2	4	2	5	1	5	1	4	1	85.0
R7	2	2	5	2	4	2	4	2	3	2	70.0
R8	3	1	5	1	4	2	5	1	4	1	87.5
R9	3	3	4	3	3	3	4	3	3	2	57.5
R10	4	1	5	2	4	2	5	2	3	2	80.0
R11	3	2	3	2	4	3	4	2	3	4	60.0
R12	1	1	5	4	4	3	5	2	4	5	60.0
R13	5	5	5	5	5	5	5	5	5	5	50.0
R14	3	2	4	1	4	1	4	1	5	1	85.0
R15	3	1	4	3	3	1	5	1	4	3	75.0
R16	4	2	4	2	4	3	4	2	4	2	72.5
R17	3	2	5	1	3	2	4	3	3	3	67.5
R18	3	3	4	2	3	4	4	3	4	4	55.0
R19	4	3	3	1	5	3	4	3	4	5	62.5
R20	5	1	5	5	5	3	5	1	5	1	85.0
R21	4	3	5	3	5	3	4	1	4	2	75.0
R22	5	2	4	5	3	3	3	3	2	4	50.0
R23	4	3	3	3	3	3	3	3	3	3	52.5

The platform achieved a mean SUS score of 67.5 (SD = 13.7, Median = 70.0), which is close to the standard benchmark of 68. According to established SUS grading scales, scores below 68 fall within the 'OK' or 'Acceptable' range, indicating the system is functional but leaves room for improvement [12, 13]. The obtained score of 67.5 therefore sits at the lower boundary of acceptable usability. users can operate the system but experience friction, particularly during initial interaction. This is consistent with the high TCR of 95.0%, which confirms functional effectiveness while the SUS score reflects residual subjective dissatisfaction.

The distribution of scores ranges from 37.5 to 87.5, showing variability in user experience. A general pattern can be observed where users with higher familiarity with digital maps tend to report higher usability scores, while users with limited experience report lower scores. This suggests that prior experience influences user perception of the system.

An irregular response pattern was observed in one respondent, where all questionnaire items were rated at the maximum value, including both positive and negative statements. This resulted in a neutral SUS score and may indicate inconsistent response behavior. When excluded, the adjusted mean increases slightly to 68.3, placing the system marginally above the benchmark.

To further analyze usability dimensions, a per-question analysis was conducted as shown in Table 8.

Table 8. Per-Question SUS Analysis (N = 23)

Question	Type	Raw Avg	Converted Score (/4)	Interpretation
Q3 — Easy to use	+	4.22	3.22	Strongest
Q7 — Learn quickly	+	4.17	3.17	Strong
Q5 — Well integrated	+	3.96	2.96	Good
Q8 — Not cumbersome	−	2.13	2.87	Good
Q9 — Confident	+	3.70	2.70	Good
Q2 — Not complex	−	2.30	2.70	Good
Q1 — Use frequently	+	3.39	2.39	Moderate
Q6 — Consistent	−	2.61	2.39	Moderate
Q4 — Support needed	−	2.65	2.35	Weak
Q10 — Learning curve	−	2.74	2.26	Weakest

The strongest aspects of the system are ease of use and learnability, indicating that users can effectively understand and operate the platform once familiar with its features. These findings support the effectiveness of the onboarding mechanism implemented in the system. However, lower scores were observed in items related to the learning curve and the need for technical support. This indicates that some users may experience initial difficulty when first interacting with the platform, particularly those without prior experience.

Overall, the SUS results suggest that while the platform provides acceptable usability, improvements are needed to enhance initial user understanding and reduce dependency on prior experience.

3.3 Open-Ended Feedback Analysis

In addition to the SUS questionnaire, open-ended questions were included to capture qualitative insights regarding platform usability.

Most Helpful Features. The filtering functionality was the most frequently cited helpful feature, mentioned by the majority of respondents. Users highlighted that the filtering system was intuitive and effective in narrowing down relevant programs. Other features identified as useful include the category-based organization, map integration, and the detailed program information page.

Most Confusing Aspects. Several usability issues were identified through user feedback. Some respondents reported difficulty in understanding icon-only buttons due to the absence of textual labels. In addition, inconsistencies in language usage within the interface created confusion for certain users. The navigation behavior of the detail page was also noted as a limitation, where opening a program detail replaced the map view, potentially interrupting the exploration flow.

Missing Features. Respondents suggested several improvements, including the addition of a search result list, location-based features, alternative map views, and in-application guidance. Among these, search interaction feedback was prioritized for implementation to improve user experience and reduce uncertainty during search operations.

Overall, the qualitative findings complement the quantitative results by providing deeper insights into user experience, particularly in terms of interface clarity, navigation flow, and feature discoverability.

3.4. Cross-Analysis: TCR and SUS

A notable finding from the usability evaluation is the difference between the high Task Completion Rate (95.0%) and the moderate SUS score (67.5). This indicates that while users are generally able to complete tasks successfully, their overall experience is not perceived as equally satisfactory. This pattern reflects an effectiveness–satisfaction gap, where functional usability is achieved but subjective experience is affected by interaction-related factors. The TCR results demonstrate that the system supports efficient task completion, while the SUS results and qualitative feedback indicate that aspects such as feature discoverability, interface clarity, and initial user understanding require improvement.

These findings suggest that the system is functionally effective but can be further enhanced in terms of user experience. The insights obtained from this analysis form the basis for the system refinements discussed in the next section.

3.5 System Refinement

Based on the findings from the TCR, SUS, and open-ended feedback analysis, several targeted refinements were implemented to improve system usability and user experience. The TCR results identified a critical issue in TS04, where users were unable to interact with clustered map elements due to obscured zoom controls on certain devices. This issue was addressed by adjusting the layout and applying responsive design improvements to ensure that map controls remain accessible across different screen sizes.

Findings from the SUS analysis and qualitative feedback highlighted challenges related to feature discoverability and interface clarity. In response, improvements were made to enhance the visibility and understanding of key interface elements, including the addition of supporting labels and tooltips for icon-based controls. Language inconsistency within the interface was also identified as a source of confusion. To address this, all user interface elements were standardized to use a consistent language, improving clarity and reducing cognitive load.

In addition, improvements were made to the search functionality by introducing a search suggestion mechanism, allowing users to view matching results before map navigation occurs. This enhancement improves interaction feedback and reduces uncertainty during search operations. These refinements collectively address both functional and experiential issues identified during evaluation, contributing to a more accessible, consistent, and user-friendly system.

4. CONCLUSION

This study developed an interactive geovisualization platform to support the documentation and exploration of Pengabdian kepada Masyarakat (P2M) programs at Politeknik Negeri Batam. The system integrates an AI-assisted ETL pipeline with a web-based mapping interface to transform unstructured PDF documents into structured geospatial data, enabling users to explore program information in a spatial and interactive manner.

The usability evaluation shows that the platform is highly effective, achieving a Task Completion Rate (TCR) of 95.0%, indicating that users are able to complete tasks successfully without assistance. The System Usability Scale (SUS) score of 67.5 places the system within the “OK” category, suggesting acceptable usability while highlighting areas for further improvement.

The findings indicate that the integration of AI-driven data processing, interactive geovisualization, and usability-oriented design can significantly enhance the accessibility and exploration of institutional data. However, the results also reveal an effectiveness–satisfaction gap, where users can complete tasks efficiently but still experience limitations in terms of interface clarity and initial interaction.

Future work may focus on enhancing system scalability and user experience, including the integration of a backend-based data management system, expansion of dataset coverage, and improvement of onboarding mechanisms to better support users with varying levels of experience.

ACKNOWLEDGEMENTS

The authors express their gratitude to the academic supervisors for their guidance, as well as all participants who contributed to the usability evaluation.

REFERENCES

[1] Veenendaal B, Brovelli MA, Li S. Review of Web Mapping: Eras, Trends and Directions. ISPRS Int J Geo-Inf. 2017;6(10):317.
[2] Roth RE. Interactive maps: What we know and what we need to know. J Spat Inf Sci. 2013;(6):59–115.
[3] Anindyati L, Utama AW, Arifin KQ, et al. Visualizing Data Palm Oil Plantation in Indonesia: Interactive Map Prototype. J Teknol. 2025;17(1):1–12.
[4] Yu Q, Duan Y, Wu Q, et al. An interactive and iterative method for crop mapping through crowdsourcing optimized field samples. Int J Appl Earth Obs Geoinf. 2023;122:103409.
[5] Li Y, Virtanen I. Unlocking unstructured data: Integrating Large Language Models into AI-Powered ETL. Oamk J. 2025;(78).
[6] Billah MM. A Robust Framework for Data Extraction from Unstructured Sources Using Large Language Models [Master's Thesis]. Västerås: Mälardalen University; 2025.
[7] Rizzo MB, Sato JR. Cartography and Cognitive Neuroscience: Using Eye-Tracking to Investigate How 9 and 10 Year Old Students Read Thematic Maps. Adv Cartogr GIScience ICA. 2025;5:26.

[8] Svanström N, Fredriksson A. User Onboarding Experience: Increasing users' perceived motivation of engaging more with a product [Master's Thesis]. Gothenburg: Chalmers University of Technology; 2023.
[9] Fürhoff L. Rethinking the Usage and Experience of Clustering Markers in Web Mapping. PeerJ Preprints. 2019.
[10] Asri SA, Astawa INGA, Sunaya IGAM, et al. Implementation of Prototyping Method on Smart Village Application. J Phys Conf Ser. 2020;1569(032094).
[11] Nacheva R. Evolutionary Prototyping Model for Software Development. Journal of Universal Excellence. 2023;12(3):43–55.
[12] Lewis JR. The System Usability Scale: Past, Present, and Future. Int J Hum Comput Interact. 2018;34(7):577–590.
[13] Bangor A, Kortum PT, Miller JT. An empirical evaluation of the System Usability Scale. Int J Hum Comput Interact. 2008;24(6):574–594.