IMPROVING THE USER EXPERIENCE OF ELECTRIC VEHICLE CHARGING THROUGH PLN MOBILE: EVIDENCE FROM INDONESIA

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Abstract. As electric vehicle (EV) adoption grows, the usability and accessibility of digital platforms and charging infrastructure become critical for sustainable transportation. In Indonesia, PLN Mobile and its Public Electric Vehicle Charging Stations (PEVCS) play a central role in this ecosystem. Yet, users report issues such as system errors during charging and payment, limited availability, uneven distribution, damaged equipment, and long queues. To systematically identify the underlying interface flaws causing these digital friction points, this study evaluates these challenges through heuristic analysis. Five male evaluators (age 24.2 ± 6.05) applied Nielsen's 10 heuristics and identified 21 problems. The most serious issue (severity score: 3.4) was the mismatch between the system language and user expectations, along with unclear error messages that hindered users' ability to understand and resolve issues. The most common problems (19.04%) are related to the visibility of system status and aesthetic and minimalist design. These findings offer actionable insights to enhance user-centered EV infrastructure and promote sustainable mobility in developing contexts.

Keywords: Heuristic evaluation, cdigital platform, PLN mobile

1. Introduction

The global automotive industry is increasingly prioritizing the reduction of environmental impact and dependency on fossil fuels, driving the widespread adoption of electric vehicles (EVs) (1). Countries such as Norway, Sweden, China, the United Kingdom, and Germany have achieved substantial progress in EV adoption ((2). In Indonesia, EV sales grew by 49% from 2022 to 2023, supported by the state-owned electricity company PLN through the development of the PLN Mobile application and the deployment of Public Electric Vehicle Charging Stations (PEVCS).

Despite these developments, field observations reveal frequent system errors in charging and payment processes, yet research on the usability of PLN Mobile's EV-related features remains limited. To address this gap, this study applies a Heuristic Evaluation (HE) based on Nielsen's ten usability principles to identify usability issues and recommend design improvements (3,4).

Beyond software-related aspects, Indonesia's PEVCS infrastructure also faces challenges, including limited charger availability, uneven geographic distribution, equipment malfunctions, long queues, and inadequate user facilities. Although the government is the leading provider, private actors such as Shell Recharger and Voltron have begun contributing to the charging ecosystem (5,6). These conditions underscore the need to enhance the usability and reliability of digital platforms to improve the overall electric vehicle charging experience in Indonesia.

Heuristic evaluation systematically identifies usability problems in the interaction between users and EV charging infrastructure—including mobile applications and charging stations—by enabling the assessment of the various components and tasks involved in the charging process (7). By integrating user feedback and systematic usability testing, heuristic evaluation fosters a user-centered design of EV charging systems by emphasizing key elements—including interface design, real-time availability, payment options, safety features, and network integration—that are essential to improving the overall user experience (8,9).

2. Methods

Heuristic evaluation by experts provides rapid feedback on a system's interface. These evaluation heuristics can be grouped into four main quality components: ease of learning, ease of remembering, efficiency, and error management (10). According to the number of evaluators required, it is 3-5 people (4). It utilizes Nielsen's 10 principles, including visibility of system status, consistency, and standards, error prevention, and a severity rating scale to prioritize issues (3). Five evaluators independently assessed the PLN Mobile EV feature, identifying and rating usability problems.

3. Results And Discussion

The Heuristic Evaluation (HE) was conducted by five usability experts (mean age = 24.2 ± 6.05 years), the majority of whom were male. All evaluators were certified and experienced in UX design, with a solid understanding of heuristic evaluation and usability principles.

The highest average severity ratings were found in "Match between the system and the real world" and "Help users recognize, diagnose, and recover from errors", both with an average severity score of 3.4, indicating major usability concerns requiring immediate attention. Meanwhile, issues under "Aesthetic and minimalist design" and "Consistency and standards" received lower severity scores, suggesting a relatively minor impact. Table 1 summarizes the percentages of issues and average severity ratings across Nielsen's 10 heuristic principles.

Table 1. Severity rating of the 10 principles

Heuristic evaluation principles	%	Average severity rating
Visibility of system status	19.04	2.75
Match between the system and the real world	9.52	3.4
User control and freedom	-	-
Consistency and standards	4.76	2.2
Error prevention	9.52	3.1
Recognition rather than recall	9.52	2.2
Flexibility and efficiency of use	9.52	3
Aesthetic and minimalist design	19.04	1.9
Help users recognize, diagnose, and recover from errors	9.52	3.4
Help and documentation	9.52	2.8

The most frequently violated principles were visibility of system status and aesthetic and minimalist design, each accounting for 19.04% of total issues. Recommendations prioritized issues with high severity (catastrophic and major).

This study identified 21 usability issues within the Electric Vehicle (EV) feature set of the PLN Mobile application, spanning 9 of Nielsen's 10 usability heuristics. These issues were categorized by five expert evaluators (SR1–SR5) based on severity ratings, as detailed in Table 2. Although the evaluation offered valuable insights, it remains limited by the absence of implemented design revisions—recommendations were derived entirely from heuristic analysis.

The issues were classified by severity as follows: 1 catastrophic, 12 major, and 8 minor (see Table 2). The highest average severity scores (3.4–3.6) were associated with the heuristics match between the system and the real world and help users recognize, diagnose, and recover from errors. These scores reflect unclear terminology, inappropriate system responses, and default system alerts that fail to guide users effectively.

Table 2. Determination of evaluation severity rating

Heuristic	The problem	Fig.	Average	Category
Visibility of system status	Error messages are displayed with a button colour similar to the application's main colour. Hence, the sense of urgency conveyed by the error message is less visible, and users may not immediately realize there is a problem.	1	2.6	Major
	Some notifications still display the standard Android format, without any customization to suit the identity or feature needs.	2	3	Major
	The feature has provided informative feedback during charging via time estimation and a progress bar. However, there is no notification or instruction explaining whether the user is allowed to unplug the charger when stopping charging.	7	2.4	Minor
	There is no further notification regarding refund information after the refund request.	3	3	Major
Match between the system and the real world	The notification "User must have *Charge In*" is less clear to new users because the term *"Charge In"* is still not widely understood.	5	3.2	Major
	There is an alert warning using the system's built-in error (programming language), which has not been adapted to a language that is easy for general users to understand.	1	3.6	Catastrophic
Consistency and standards	The interface has not been optimally implemented in terms of design consistency; for example, error notifications still use the system's default display.	3	2.2	Minor
Error prevention	The email verification and resend process is not working properly, as the output shows the verification token is invalid.	6	3.4	Major
	clear input validation, including maximum and minimum value limits and whether decimal numbers are allowed.	7	2.8	Major
Recognition rather than recall	As a beginner, it is necessary to understand some information or menus that use terms that are difficult to remember.	7	2.2	Minor
	Too much information is presented in a single display, making it difficult for users to remember and understand it effectively.	7	2.2	Minor
Flexibility and efficiency of use	The tutorials in the feature are not detailed or effective enough for new users.	7	2.6	Major
	Some errors make it difficult for new users, especially during the charging process, which requires	5	3.4	Major

Heuristic	The problem	Fig.	Average	Category
	registering a "Charge In" account that is less familiar to them.			
Aesthetic and minimalist design	Overall, the interface looks good, but error notifications still use the default Android format.	3	2	Minor
	There are inconsistencies between menus, including varying use of rounded corners.	7	1.6	Minor
	Presenting too much numerical information can make the display crowded and confuse users.	7	2.2	Minor
	Promotional content is considered less relevant and does not need to be displayed in the main context of the feature.	7	1.8	Minor
Help users recognize, diagnose, and recover from errors	An error in the email verification process lacks a clear solution; it only displays a message that the token is invalid.	6	3.4	Major
	Some errors are not handled properly, such as when the user enters a nominal charge of up to one billion, a message appears that the integer data type cannot accommodate that value, but the message is still a default system notification and program code.	8	3.4	Major
Help and documentation	The application includes a helpdesk and live chat, but the refund document lacks information on the estimated refund time.	7	3	Major
	Support services are only provided via WhatsApp, which tends to be less responsive and can slow down the process of handling user issues.	-	2.6	Major

Figure 1 illustrates a catastrophic issue involving unclear language in critical system alerts. The recommended improvement is the use of adaptive, context-aware warnings in plain, user-friendly language, especially within feature menus.

Figure 2 highlights error messages with low visual contrast, blending into the application's primary colour. It is recommended to use high-contrast colours (e.g., red or orange) to draw user attention to errors.

As shown in Figure 3, some system notifications still use the default Android toast format. These should be customized to match the app's visual and functional design, ensuring better user comprehension.

In Figure 4, the refund process lacks confirmation or follow-up details. Recommendations include providing clear refund status updates and estimated processing times.

The message displayed in Figure 5, which states that users must perform a "Charge In," is ambiguous to first-time users. Suggested improvements include integrating in-app tutorials, user manuals, or a helpdesk link.

Figure 6 shows failures in email verification and token expiration, leading to confusion. The system should offer a resend verification link with a valid token and clear feedback.

The tutorial for EV features, as shown in Figure 7, is limited in content and static in design. The evaluator recommends enhancing the tutorial with dynamic, interactive guidance tailored for novice users.

Figure 8 shows a critical input validation flaw: entering a large value (e.g., 1,000,000,000) triggers a programming syntax error in the backend. The solution is to implement real-time input validation alongside inline validation messages near the input field.

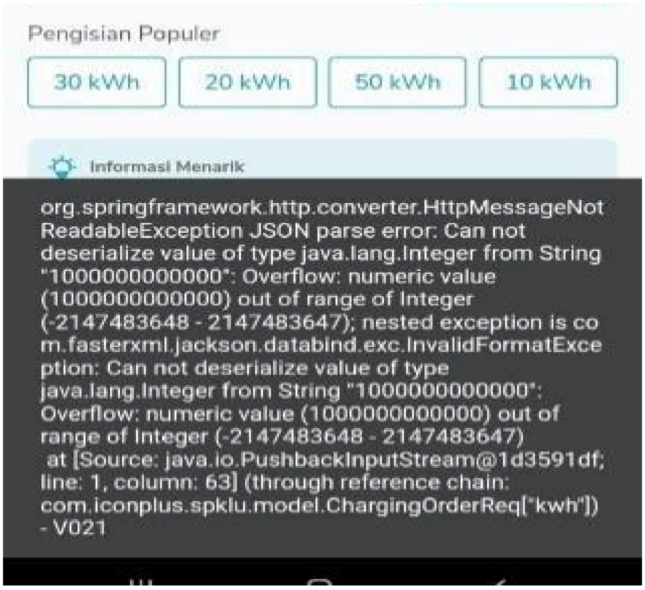

Figure 1. Catastrophic problem

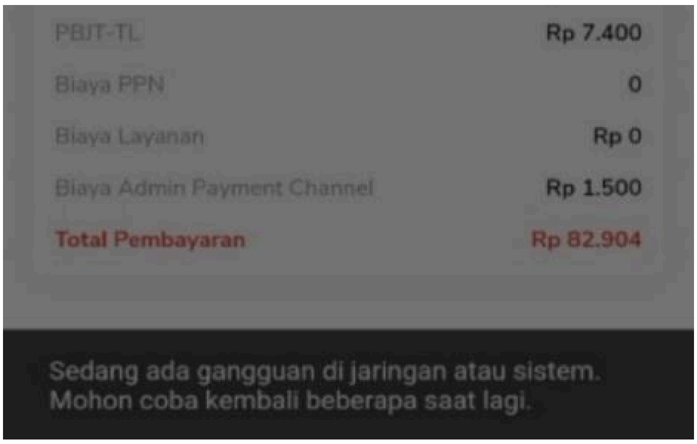

Figure 2. An error message that has a similar color

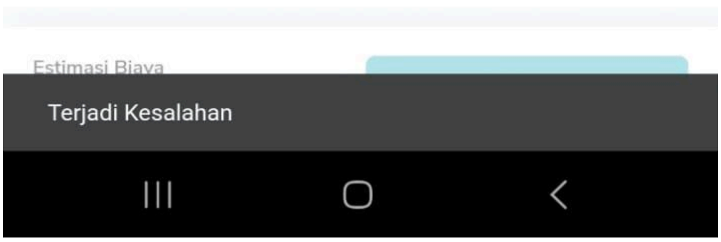

Figure 3. Standard Android notification form

Figure 4. Refund feature display

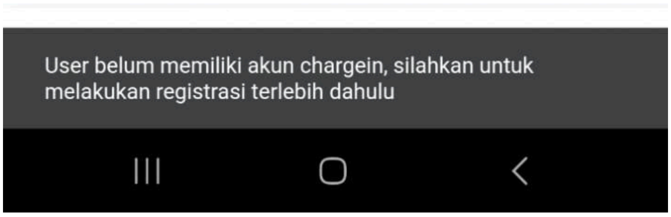

Figure 5. Notification "Charger in"

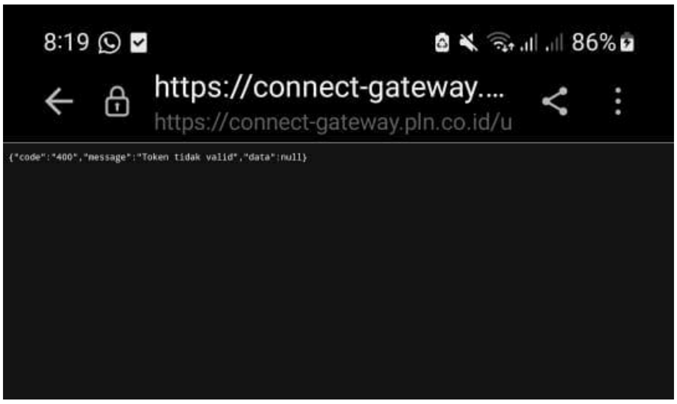

Figure 6. Error on verification link

Figure 7. Electric vehicle feature tutorial

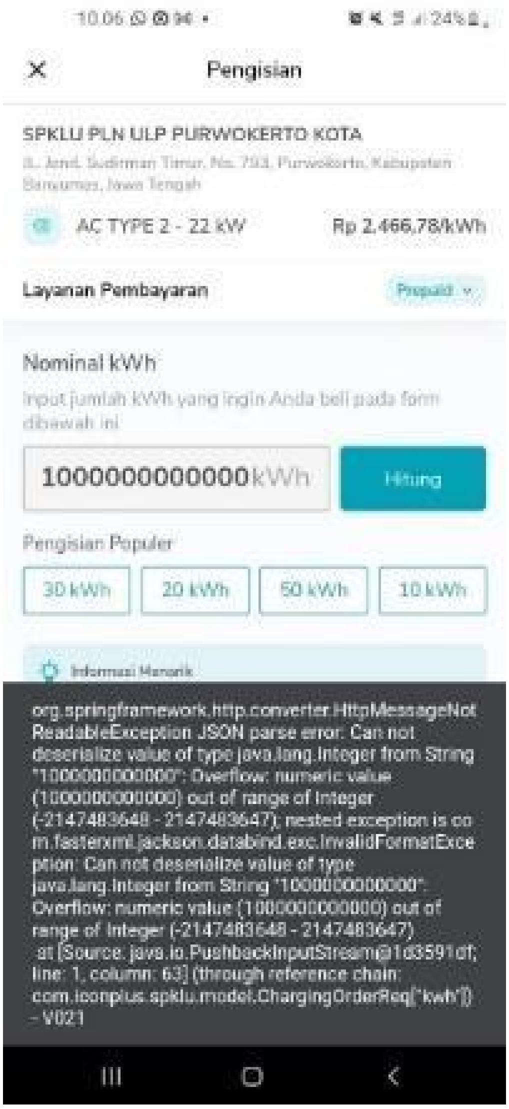

Figure 8. Nominal input error

4. Discussion

Similar findings regarding the importance of interface design have been reported in a recent German study, which compared text-based and map-based web interfaces for managing EV charging locations, revealing that the map-based design improved learning outcomes and provided a better balance between pragmatic and hedonic user experience dimensions (11). Aligns with this present study's findings, emphasizing that interface design and clarity significantly influence user performance and satisfaction in EV-related digital systems.

While this research focuses on software usability, related evidence on the functionality of Public Electric Vehicle Direct Current Fast Chargers indicates that user experience challenges in the EV ecosystem extend beyond digital interfaces (12). Consistent, clear system feedback in mobile applications is crucial for helping users respond effectively to hardware or network-level failures during charging sessions.

Beyond end-user interaction, the broader EV ecosystem also faces usability challenges in infrastructure planning and decision support. For instance, previous work introduced CSLens, a visual analytics system designed to inform charging station deployment decisions by integrating transportation and power network data(13). Interactive visualization and usability are essential not only for user-facing applications like PLN Mobile but also for expert-oriented decision-making tools. Together, these findings highlight that usability and interaction design are critical across multiple layers of the EV ecosystem—from infrastructure management to user engagement.

Finally, beyond usability and interface clarity, trust and data security also play crucial roles in shaping user experience in EV applications. Recent work proposed *SecretCharge*, a blockchain-based privacy-preserving payment system that protects user information in EV payment scenarios (14). While the current study focuses on usability, future research should integrate usability and security perspectives to enhance both functional efficiency and user trust in Indonesia's growing e-mobility ecosystem.

5. Conclusion

The heuristic evaluation of EV-related features in PLN Mobile identified 21 usability issues across nine of Nielsen's ten heuristics, including one catastrophic, 12 major, and 8 minor problems. The most severe issues (mean severity score = 3.4) were associated with System and Real-World Compatibility and Error Recovery Support. The most frequently violated principles were Visibility of System Status and Aesthetic and Minimalist Design, accounting for 19.04% of all identified problems.

These results indicate that PLN Mobile's EV features require stronger alignment between system logic and user expectations, particularly in providing clear feedback, consistent terminology, and effective error recovery mechanisms. Consistent with previous research on e-mobility management systems and EV infrastructure usability, the findings emphasize that interface design quality directly influences user performance and satisfaction. Furthermore, usability challenges in the EV ecosystem extend beyond end-user applications and affect infrastructure planning, decision support, and payment security.

Overall, this study underscores that enhancing usability at every layer of the EV ecosystem—from interface design to data handling—is essential to building a reliable, trustworthy, and user-centered foundation for Indonesia's growing e-mobility infrastructure.

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