Designing for Simplicity: Lessons from a Minimalist EV Charging App

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***Abstract*—This article reflects on the development of a minimalist electric vehicle (EV) charging mobile application created as part of the EV4EU research project. Initially designed with a single core feature, the app aimed to demonstrate a focused experience that emphasized simplicity. However, as development progressed and feedback was gathered from early users, it became clear that minimal functionality was not enough to meet real-world expectations. The application underwent several iterations, eventually incorporating critical features such as real-time charging status updates, user account management, vehicle registration, and smart charging. These additions significantly improved the app's usability without overwhelming its interface. Feedback from users revealed the need for personalization, intuitive flows, and transparency in energy usage. The development process highlighted the value of early user engagement and the importance of balancing minimalism with essential user needs. By reflecting on this journey, we propose a system that aligns with the needs of modern EV drivers and contributes to smarter energy usage and a more sustainable future.**

***Index Terms*—Electric Vehicles, Mobile Apps, User Feedback, User engagement**

I. Introduction

In recent years, Electric Vehicles (EVs) adoption has gained significant traction, with global electric car sales surpassing 17 million in 2024 and projected to exceed 20 million in 2025—representing over a quarter of new car sales worldwide [1]. This shift is not only transforming vehicle markets but also intensifying the demand for accessible charging infrastructure as well as digital tools that help users effectively manage the charging process [2]. Mobile applications, due to their ubiquity and flexibility, have emerged as natural enablers of this transition, providing drivers with enhanced control, status monitoring, and real-time updates [3].

However, conventional charging infrastructure often fails to respond dynamically to user behavior, further underlining the need for user-centered, digitally enabled solutions [4]. Technologies like mobile apps and Internet of Things (IoT) integrations are playing a key role in shaping a more responsive and convenient experience for EV owners, helping to bridge the gap between infrastructure capabilities and daily user needs.

In this context, our mobile application was developed under the Electric Vehicles Management for carbon neutrality in Europe (EV4EU)[1] research project, which promotes large-scale electric mobility through user-centric, bottom-up strategies. Specifically, in the Portuguese pilot, the app addressed a practical challenge: enabling smart charging by collecting minimal but required user input.

This paper outlines the app's evolution, focusing on the design decisions, challenges encountered, and lessons learned. Our aim is to illustrate how a minimalist approach, when shaped by real user needs, can yield intuitive, efficient mobile applications. The paper is organized as follows: Section II reviews the literature on EV charging apps and user-centered design strategies; Section III describes the development timeline and iteration process; Section IV discusses the key features and design trade-offs in both public and home charging contexts; Section V presents insights from user testing and the main challenges faced; and Section VII reflects on the findings and the balance between minimalism and usability in EV app design.

II. Related Work

As EVs adoption rises, researchers and developers have explored a range of design methods and development approaches to support user needs in charging, route planning, and energy

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[1]EV4EU Project, https://ev4eu.eu

optimization [5]. Early research and market analysis provided foundational insight into the fragmented nature of these tools and the challenges involved in creating cohesive, user-centric applications.

Stillwater et al. [3] conducted one of the first comprehensive reviews of the EV mobile application ecosystem. Their study identified six key service categories, ranging from vehicle dashboards to smart grid interaction, highlighting the methodological challenge of standardization across platforms. Despite limited integration across platforms, the authors emphasized the transformative potential of mobile apps to shape driver behavior and promote smarter energy use.

As interest in route planning grew, Bedogni et al. [6] introduced a system that combined real-time traffic data, vehicle parameters, and charging station availability to deliver energy-efficient navigation. Their work exemplifies a data-driven development approach, in which predictive algorithms are informed by environmental inputs. This contribution demonstrates how contextual awareness can directly improve user experience.

Quintal et al. [7] presented *MyTukxi*, a low-cost smart-charging system targeting small electric vehicles such as scooters. Their solution combines off-the-shelf hardware, a mobile application, and a modular backend architecture to implement user-guided smart-charging in scenarios where built-in charging control is absent. A key methodological takeaway from their work is the value of involving end users in the workflow through low-cost interfaces, particularly in scenarios lacking built-in smart charging infrastructure.

Responding to the need for more centralized user experiences, Parkavi et al. [8] developed a web-based aggregator platform that unified data from multiple charging providers. By consolidating information on availability, pricing, and charger type, their system improved accessibility and usability, highlighting the importance of interoperability in reducing user friction.

In parallel, Ferreira et al. [9] proposed the V2Anything App—a highly integrated mobile system incorporating range prediction, energy pricing, and public transport planning. Supporting bidirectional charging (e.g., Vehicle to Grid (V2G)), personalized driver profiles, and infrastructure integration, their work demonstrated the potential of mobile apps as dynamic mobility and energy hubs, though often at the cost of simplicity and ease of use.

More recently, attention has shifted toward improving practicality and accessibility in residential contexts. Panchbhai et al. [10] addressed the limitations of traditional charging setups by proposing a low-cost, IoT-enabled home charging system. Based on a Raspberry Pi controller and mobile interface, their solution emphasized remote control, real-time energy monitoring, and solar power integration—key components for sustainable residential energy management.

Similarly, Hari Krishna et al. [11] developed a Flutter-based application that focuses on reservation of real-time slots, payment processing and QR-based check-ins. Targeted at high-demand public stations, their app prioritizes responsiveness and efficiency, particularly within emerging EV markets.

Collectively, these studies reveal a wide range of approaches, from robust research-driven platforms to lightweight, user-focused implementations. However, many solutions remain either too complex for casual users or too limited in scope to adapt to both real-world and research needs. While each solution reflects a specific technical or contextual priority, they share common challenges in balancing functionality and user experience. These lessons inform the design-oriented methodology adopted in this study, which aims to explore how EV charging interfaces can be developed through an iterative, user-informed process.

III. Development Process

The initial goal of the EV charging app was straightforward, create a simple tool that enabled users to start charging their vehicles in public chargers by submitting basic information. The implementation method was developed considering the approach proposed in [12] and illustrated in the (Figure 1).

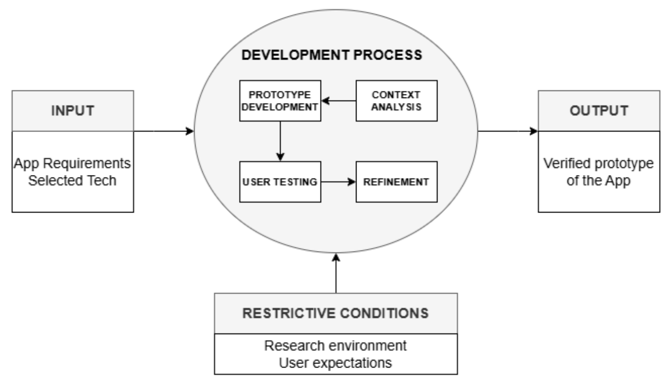
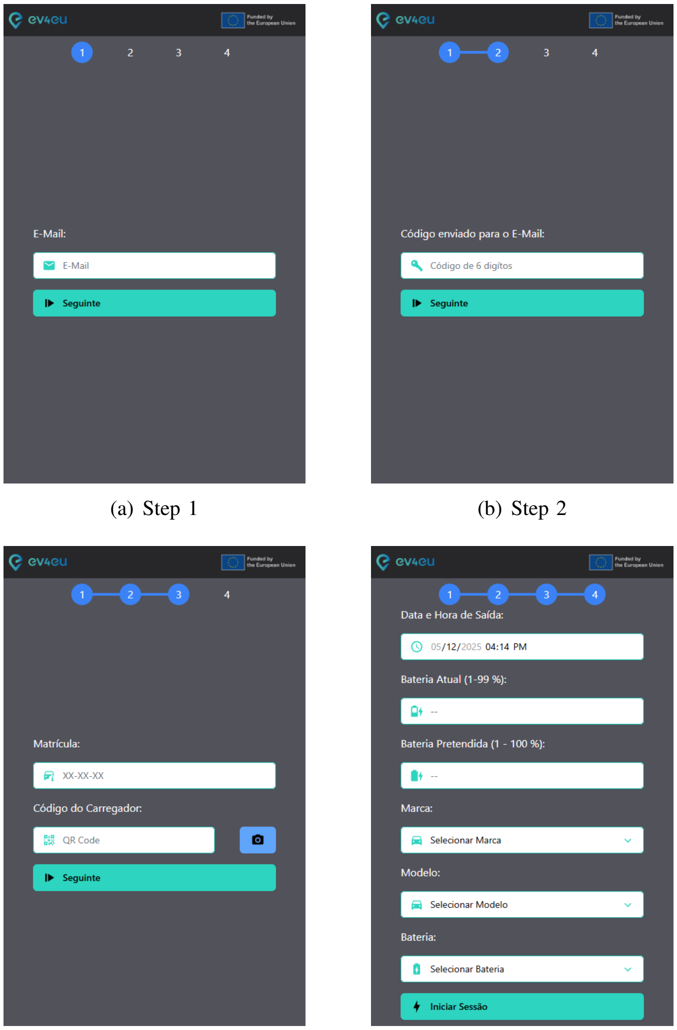


Fig. 1. App Developement Methodology (Adapted from [12])

Guided by predefined requirements and chosen technologies, the initial prototype was developed and subjected to internal testing. These user tests, conducted within the constraints of the research environment and user expectations, revealed several shortcomings. As a result, the development process evolved through iterative refinement, informed by contextual analysis and continuous feedback.

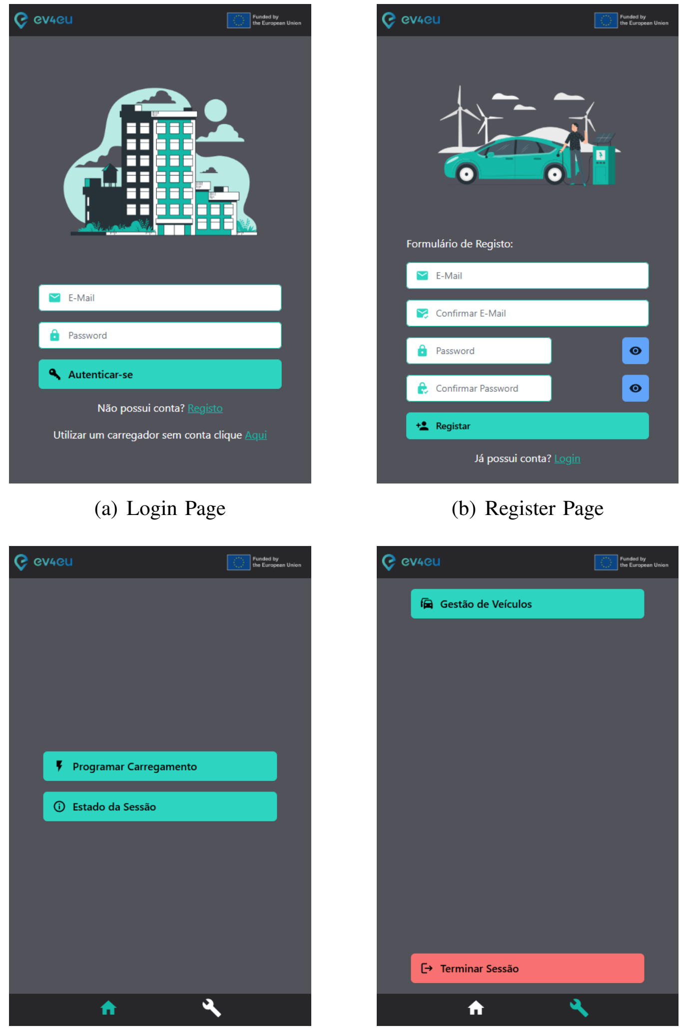
A. First Version

The first iteration of the app followed a linear four-step process (Figure 2) aimed solely at collecting the data necessary to initiate a charging session. Users began by entering their email to receive a login code, followed by providing vehicle's plate number and identifying the charger through either scanning a QR code or manually entering a code. The final step required users to input charging details such as initial and target State of Charge (SoC), departure time, and vehicle specifications. While this flow technically fulfilled the minimum requirements for backend integration and smart charging logic, after some internal tests it quickly became clear that the experience was cumbersome and repetitive.



(a) Step 1 (b) Step 2 (c) Step 3 (d) Step 4

Fig. 2. Application Version 1



(a) Login Page (b) Register Page (c) Dashboard (d) Settings

Fig. 3. Application Version 2

B. Second Version

Following feedback from the first version, the team came together to design a low-fidelity prototype, incorporating user suggestions into a more conventional application, before any development efforts. This Account-Centered Designs (ACDs) approach aimed to streamline the user experience and lay the groundwork for user-specific settings, such as personalized charging preferences. While this version continued to focus on enabling charging, it marked a significant shift toward a more comprehensive and user-friendly platform. The key design decisions and features supported by this architecture are discussed in the following section.

IV. Design Considerations

The second version of the application introduced a range of features aimed at improving usability, functionality, and user satisfaction. This section outlines the key design decisions that shaped the app's evolution, focusing on both the public and home versions. Each feature was developed in response to user feedback or specific requirements.

A. Real Time Session Data

One of the key improvements in the second version of the application was the introduction of real-time session monitoring. As shown in Figure 4 a), users are now presented with a graphical display of both the scheduled and delivered charging power throughout a session. This feature addresses a common concern among users, the need for visibility into ongoing charging activity. Even when users check the app only occasionally, the ability to verify the current session status fosters confidence and a sense of control over the process.

B. Smart Charging

The application also integrates a smart charging interface that enables users to specify their current battery level, desired charge, and expected departure time, as illustrated in Figure 4 b). This input is used by the backend system to dynamically

(a) Status (b) Smart Charge (c) Vehicle Management (d) Add Vehicle

Fig. 4. App Features

optimize the charging schedule across all connected vehicles. The platform ensures that each vehicle receives the maximum possible energy within the available window.

C. Car Management

The vehicle management feature on the settings page allows users to register and store multiple vehicles within the application, as shown in Figure 4 c) and d). This functionality not only simplifies the charging process but significantly reduces user effort by pre-filling essential information such as license plate, make, model, and battery details during the smart charging setup. In addition, users can easily add, select, or delete vehicles from their personal list.

V. Results of Think-Aloud Sessions

This interface was developed as part of a research project, where access to external participants was limited. As a result, only four users were recruited for think-aloud testing sessions. Despite the small sample size, this approach is well-supported by usability research. As noted by Nielsen [13], testing with five users can uncover up to 85% of usability issues, while Rubin and Chisnell [14] similarly highlight the value of early testing with just a few users.

Participants were asked to complete a core task using the app: charging an electric vehicle on-site at our laboratory. During the task, they were encouraged to verbalize their thoughts, ask questions, and share impressions. User A tested both the initial and updated versions of the app, while the remaining participants used only the latest version. Users were also guided through specific features to validate key parts of the app.

In the first session, User A (UA) criticized the app's repetitiveness and limited functionality. After inputting his vehicle details to start a charge, the tester remarked: *"Do I have to fill in this form every time I need to charge my car?"*(UA)

The system fails to acknowledge the persistent relationship between the user, their vehicle, and the service. From the user's perspective, the app is expected to behave like a "smart assistant" rather than a repetitive data-entry form.

Upon testing the second version, User A noted that the inclusion of user accounts and vehicle management significantly improved usability. The user particularly appreciated the ability to store vehicle information, which reduced the number of steps required to initiate a charging session.

Another concern raised by User A was the charging status display. The initial implementation showed raw numerical updates that were hard to interpret and, at times, redundant. For example, User A wondered the necessity to show the amount of energy charged and the battery SOC (%): *"What's the difference between energy charged and battery increment?"*(UA)

Presenting multiple, correlated numerical data points simultaneously increases cognitive load. Users should not have to perform mental calculations or interpretation to understand the fundamental status of a process. This led to a redesign of the session status page, incorporating more relevant metrics and a visual plot to improve clarity.

User B (UB) was confused when trying to schedule a session without a vehicle linked to his account. Although the app redirected correctly to the settings page after a warning, the user found the navigation cumbersome: *"Ah, do I have to press "Add Vehicle"? It should redirect me straight to here."* (UB)

Although the system successfully detected the issue, it did not assist the user in resolving it. To improve the user experience, it was suggested that the app automatically navigate to the vehicle creation form.

Meanwhile, User C (UC) and User D (UD), in addition to the previously mentioned issues, highlighted several minor quality-of-life improvements. These included the need for a password visibility toggle during login or registration, and clearer labels in the settings menu. A particularly relevant concern was the possibility of emails sent from the App being flagged as spam: *"A warning to check email's spam folder would be useful."* (UD)

While individually minor, addressing these concerns is essential for fostering user trust and minimizing avoidable frustrations.

VI. Lessons Learned

Developing this application provided valuable lessons not only about interface design but also about the overall development process within a research context.

One of the most significant insights was the importance of involving users early in the design cycle. In this project, usability testing was postponed in favor of backend development and milestone delivery. As a result, user expectations were not fully understood until late in the process, leading to avoidable rework. Early feedback would have helped identify critical usability issues and shaped the system around actual user needs from the start.

Another lesson was the need to balance simplicity with functionality. While the initial design emphasized minimalism, this sometimes came at the cost of usability. Users expected essential features to be readily available, even in a lightweight interface. This showed that minimalism should not mean withholding functionality, but rather presenting it in a clear and progressive manner.

The project also highlighted the importance of user engagement and continuity. In a research setting, where access to participants is limited, every user is a valuable resource. The concept of sample mortality, in other words losing users over time, proved to be a real risk. Keeping participants engaged requires that their feedback is visibly integrated, their concerns are acknowledged, and their time is respected. Maintaining this connection helps ensure they remain invested in the project and aligned with its evolving goals.

Lastly, the process emphasized the need to continuously align research goals with user value. A system that fulfills technical or scientific objectives is not necessarily successful if it does not deliver a usable, relevant experience to its end users. Research and usability should not be seen as separate concerns but treated as mutually reinforcing throughout the development process.

VII. Conclusion

This paper presented the design, development, and evaluation of a minimalist EV charging application created under the EV4EU project. Through an iterative process informed by early user feedback, the app evolved from a functional prototype into a more complete, user-centered tool capable of managing both public and home charging scenarios.

Four main lessons emerged from this work: the value of early feedback, the need for minimal but complete functionality, the importance of persistent user context, and the risk of user attrition in research environments. These insights are essential for anyone looking to replicate or extend this study in similar contexts.

The results show that while minimalism is a promising design strategy, it must be balanced with core features that reduce friction and enhance trust. Usability testing, even with a small sample, proved invaluable in identifying pain points and guiding design priorities.

However, it must be acknowledged that the small sample size and controlled testing environment limit the generalization of the findings. Hence, future versions should increase transparency and user agency in these smart charging features.

Looking ahead, this line of work points to broader research opportunities. While many EV charging apps already exist, a critical area of investigation remains: how to design systems that keep the user in the loop, particularly as EVs transition from personal transportation tools to active participants in energy services. Emerging use cases like V2G require that apps go beyond passive status updates to actively engage users in energy-aware decision-making.

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