

Master's Programme in Human-Computer Interaction and Design - ICT Innovation

Optimizing User Experience of Decentralized Applications for Web2 and Web3 Users

Case Anonymous Decentralized Social Platform

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Abstract

The rapid evolution of decentralized applications (dApps) in the Web3 ecosystem poses unique challenges for user experience (UX), especially as Web2 users meet unfamiliar blockchain technologies. This paper investigates how the UX of dApps may be enhanced to cater to both Web2 and Web3 users, using Unirep Social Taiwan, a decentralized social network, as a case study. The main research issue is: How can the user experience of decentralized applications be adjusted to accommodate both Web2 and Web3 users? The study investigates user demands and obstacles in the transition to decentralized platforms, drawing on ideas such as the Technology Acceptance Model, Nielsen's usability heuristics, and ISO 9241-11 usability standards. The paper situates these issues within the larger framework of blockchain's transparency, data sovereignty, and user control principles.

Employing a mixed-methods approach, the research included two iterative rounds of usability testing involving seven participants per round. Quantitative metrics such as task success rates, completion times, and System Usability Scale (SUS) scores were analyzed alongside qualitative data gathered from think-aloud protocols and interviews. Iterative testing allowed for the evaluation of UX optimizations and their impact on user satisfaction. The results demonstrate a significant improvement in usability metrics between rounds. Task success rates increased from an average of 98% in Round 1 to 100% in Round 2, while SUS scores improved from an average of 62.14 to 70.36, reflecting enhanced user satisfaction. Qualitative insights revealed that simplified onboarding processes and transparent feedback mechanisms reduced cognitive load for Web2 users, while Web3 users appreciated improvements in transaction transparency and system control.

The findings highlight the importance of bridging the gap between Web2 and Web3 user expectations through progressive onboarding, real-time feedback, and design strategies that balance usability with decentralization principles. These insights contribute to the growing field of UX research in Web3 by providing actionable recommendations for dApp developers. Future research should focus on longitudinal studies to measure changing user behaviors and the inclusion of new Web3 technologies, such as zero-knowledge proofs, to improve the UX of decentralized platforms.

Keywords Decentralized Applications (dApps), Web3 User Experience (UX), Web2 and Web3 Usability, Blockchain Technology, Usability Testing, System Usability Scale (SUS), Progressive Onboarding, Transaction Transparency

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Preface and Acknowledgements

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Helsinki, 31st December 2024
Chien-Cheng Hou



1. Introduction

1.1 Research Context and Relevance

Web3 describes the next phase of the internet, moving away from the centralized control of Web2 and toward a decentralized approach that promotes user autonomy, data ownership, and privacy (Murray et al., 2023). Unlike Web2 platforms such as Google and Facebook, which centralize data management and deliver services in return for user information, Web3 uses blockchain and distributed ledger technology to provide people more control over their digital interactions and information (Ray, 2023). This decentralized structure prioritizes user control and transparency, reflecting a vision for a more democratic internet. However, there are significant user experience (UX) problems with the transition from Web2 to Web3, especially for users used to centralized systems who have to deal with the intricacies of decentralized platforms.

Web2's centralized processes promote simplicity and ease. For example, changing a password requires logging in to a central server, which is quick and easy but limits user autonomy (Lacity & Carmel, 2024). Conversely, Web3 applications demand that users take on more responsibility for data management. For instance, recovering access to a blockchain wallet involves handling private keys—an irreversible and technically demanding process. While Web3's self-sovereignty appeals to privacy-conscious users, its steep learning curve can deter those transitioning from Web2's familiar systems (Yu et al., 2024).

Decentralized applications (dApps) are critical components of the Web3 ecosystem because they enable secure, transparent, and resilient interactions across distributed networks (Cai et al. 2018). However, their decentralized nature creates unique UX challenges. Unlike Web2 platforms, which prioritize user-friendly interfaces, dApps frequently require users to navigate complex processes like decentralized identity authentication, wallet connection, and blockchain transaction confirmation. These tasks can create barriers, particularly for users unfamiliar with blockchain technology. These challenges can result in frustration and disengagement, particularly for new Web3 users. Addressing these barriers through thoughtful UX design is critical to lowering the adoption threshold.

Effective UX design can bridge the gap between Web2 and Web3 by simplifying blockchain processes and creating intuitive interfaces. Real-time transaction status indicators reduce user anxiety, while improved onboarding routines and wallet management systems make Web3 applications more accessible (Hiremath & Kenchakkanavar, 2016). As Web3 usage accelerates, with daily unique active wallets (UAWs) rising by 70% in Q3 2024 (DappRadar, 2024), user-friendly dApps are becoming increasingly important for general acceptance.

UniRep Social Taiwan is a decentralized, anonymous social network built on top of the UniRep Protocol, a zero-knowledge (ZK) architecture that uses anonymous identifiers called epoch keys to safely manage user data while maintaining privacy (PSE, 2024). The Ethereum Foundation's Privacy and Scaling Explorations (PSE) team supports UniRep, a proposal by BarryWhiteHat on ethresear.ch that provides trustless interactions so users can engage without depending on a centralized authority to manage or store their data (PSE, 2024). This protocol provides an environment where user privacy and data security are given top priority, supporting Web3's decentralization, user ownership, and data sovereignty principles.

As the UI/UX designer for Unirep Social Taiwan, the researcher was able to observe these issues firsthand, including the operational complexity that Web2 users face and the demands for control and transparency made by Web3 users. This study aims to address these issues by proposing practical UX solutions that enhance user satisfaction and, ultimately, support the broader adoption of Web3 technologies.



Figure 1. Interface Display of UniRep Social Taiwan

1.2 Problem Statement and Focus

Unirep Social Taiwan distinguishes itself from other social media platforms by prioritizing privacy and anonymity as essential values. This study focuses on two main difficulties for improving the user experience: simplifying interactions for Web2 users and meeting the sophisticated expectations of Web3 users. As the number of decentralized apps (dApps) grows, understanding the differences in UX needs between the two categories is crucial for increasing acceptability and engagement (Qasse et al., 2020).

Effective UX design is essential for promoting wider adoption and long-term user retention in light of the frequently steep learning curve connected to decentralized technology (Qasse et al., 2020). Web2 users, accustomed to

centralized and user-friendly services, frequently face challenges with decentralized interactions, such as managing private keys and integrating wallets. On the other hand, Web3 users seek advanced features that fully leverage the potential of decentralized technology, including data ownership, transparency, and customizable privacy controls (Yin et al., 2022).

This study aims to provide workable design enhancements that improve Web3 users' satisfaction while facilitating a more seamless transition for Web2 users by attending to these specific needs. By doing this, the study contributes to a theoretical knowledge of user experience (UX) in decentralized applications and provides practical design suggestions to close the gap between Web2 and Web3 experiences, increasing the accessibility of dApps to a larger audience.

1.3 Research Objective and Questions

This study uses Unirep Social Taiwan as a case study to improve the user experience (UX) of decentralized applications (dApps) for both Web2 and Web3 users. This study's goal is to develop practical design recommendations that meet the changing expectations of Web3 users while also facilitating a more seamless transition for Web2 users by recognizing and addressing their respective UX needs. Finally, the goal of this study is to make decentralized applications more accessible, user-friendly, and satisfying to a larger audience.

- Main Research Question: **How can the user experience of decentralized applications be optimized to support both Web2 and Web3 users?**

The main research question addresses the study's main goal by examining the key UX improvements required to meet the needs of two distinct user groups in a single decentralized application. By focusing on both Web2 and Web3 users, this study aims to identify strategies that not only lower the entry barrier for Web2 users but also improve the experience for Web3 users who are already acquainted with decentralized environments.

- Sub-research Question 1: **What specific challenges do Web2 users face when interacting with decentralized applications, and how does this impact their overall user experience?**

The first sub-research question is to uncover the unique pain problems Web2 users encounter while engaging with dApps, such as a lack of understanding of blockchain ideas, difficulties with private key management, and navigating the decentralized data architecture. Addressing these concerns allows designers to create features and procedures that simplify dApps, making them more accessible and user-friendly for those transferring from Web2 settings.

- Sub-research Question 2: **What UX features and design considerations are prioritized by Web3 users in decentralized applications, and how can these be integrated to enhance their satisfaction?**

The second sub-research topic investigates Web3 users' wants and expectations, such as increased user control on a decentralized network, transparency, and data sovereignty. This study intends to improve Web3 user satisfaction by understanding and incorporating these design criteria, while also ensuring that dApp features adhere to the key decentralization principles.

2. Background Concepts and Theories

This chapter reviews key theoretical foundations and research relevant to optimizing user experience (UX) in decentralized applications (dApps), particularly in the context of Web2 and Web3 users. It explores foundational UX theories and optimization methods that provide a framework for effective design in decentralized environments, introduces the distinctions between Web2 and Web3 technologies and user expectations, and examines the characteristics, behaviors, and experiences of users within decentralized applications. Additionally, this chapter reviews usability evaluation techniques and UX research methodologies essential for assessing and improving the UX of dApps. By establishing a robust theoretical background, this review will guide the study's approach to understanding and enhancing UX for both Web2 and Web3 users within decentralized social platforms.

2.1 User Experience, Acceptance, and Usability

2.1.1 User Experience (UX)

User experience (UX) is defined by the International Standardization Organization (2010) as the reactions and impressions a person has when utilizing or anticipating the usage of a system, product, or service. This expansive definition highlights the holistic aspect of UX, where the efficacy of a design is largely dependent on perceptions, emotions, and behaviors. According to Vermeeren et al. (2010), user experience (UX) goes beyond functional contact to include the emotional reactions, perceived value, and the experienced process.

Morville's (2005) Honeycomb model provides a thorough framework by defining seven key aspects—usefulness, usability, desirability, findability, accessibility, credibility, and value—in light of the complex nature of user experience (UX) (Figure 2). Because they guarantee that users can engage confidently and naturally, these aspects are essential for assessing and creating

great UX. For example, usability and accessibility reduce cognitive load and improve efficiency, while findability and credibility enhance trust and ease of information retrieval.

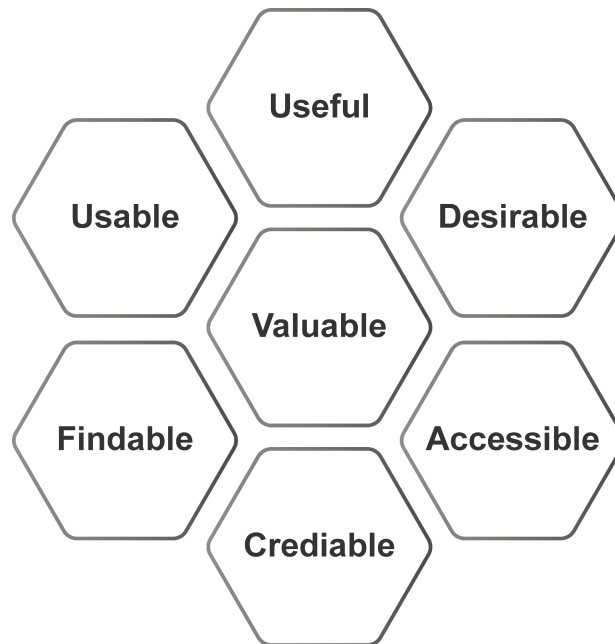


Figure 2. The User Experience Honeycomb (Morville, 2005)

Due to UX's complex and context-dependent nature, effective design must consider various user expectations, emotional responses, and scenarios. Hassenzahl and Tractinsky (2006) argue that UX is shaped by the interplay between the user's internal state (such as expectations and prior experiences), the system's characteristics, and the interaction context. This suggests that design must account for different usage scenarios and users' internal states (such as expectations and emotions) to create effective experiences (Hassenzahl, 2008).

Furthermore, UX is intrinsically subjective, context-dependent, and always changing. This implies that in order to provide a successful experience, design must take into account various usage circumstances as well as the user's internal state (such as expectations and emotions) (Hassenzahl and Tractinsky, 2006). According to Hassenzahl and Tractinsky, UX is ultimately determined by the

interaction of the user's internal state, design system features, and interaction context (as seen in Figure 3).

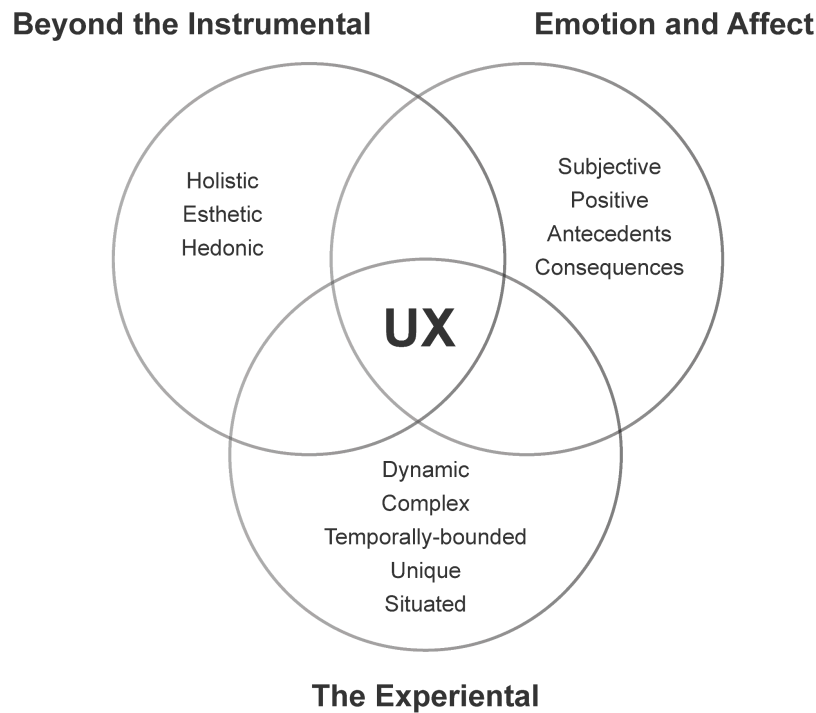


Figure 3. Facets of user experience (UX) (Hassenzahl & Tractinsky, 2006)

2.1.2 Technology Acceptance Model (TAM) and User Adoption

The Technology Acceptance Model (TAM), as illustrated in figure 4, was created by Davis (1989) and adds to these UX foundations by highlighting perceived usefulness and ease of use as important factors in user adoption. According to TAM, users are more likely to adopt a system if they believe it to be helpful and simple to use (Yang et al., 2021). TAM emphasizes the need for efficient and intuitive interfaces that minimize cognitive load and foster user satisfaction.

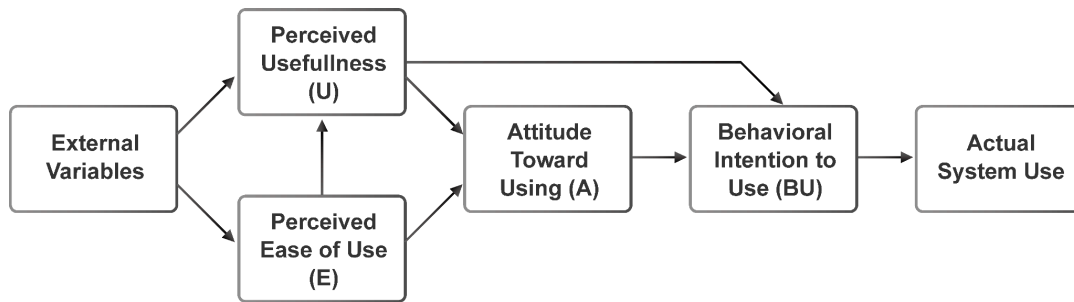


Figure 4. Technology Acceptance Model (TAM) (Davis, 1989)

In UX design, TAM offers a framework for creating systems that satisfy users' needs for both functionality and simplicity. For example, a system that is easy to use and reduces user frustration by simplifying its complexity is more likely to engage users, which will encourage adoption. By focusing on these two primary factors, designers can identify and address the aspects that hinder or encourage user adoption, making the model highly relevant for systems with complex interfaces.

2.1.3 ISO 9241-11 and the Concept of Usability

According to ISO 9241-11 (ISO, 1998), usability is the degree to which a system, product, or service can be utilized by specific users to accomplish specific objectives in a defined context of usage with efficacy, efficiency, and satisfaction. This internationally accepted standard offers a thorough foundation for comprehending and assessing interactive systems' usability.

The ability of users to accomplish activities and get their desired outcomes is referred to as effectiveness. It ensures that the system helps users achieve their goals by taking into account both task performance accuracy and completeness. Efficiency takes into account the resources used to accomplish these objectives, paying particular attention to factors like time, effort, and cognitive load. Lastly, satisfaction addresses the subjective comfort and acceptability of the system, emphasizing the importance of user perceptions, preferences, and overall experience during interaction (as shown in Table 1.) (Bevan & Carter, 2016).

The importance of the context of use—which encompasses the particular people, tasks, tools, and settings involved in system interaction—is also emphasized by ISO 9241-11. By recognizing how these components interact dynamically, the standard promotes a user-centered approach to evaluation and design. This framework, which provides precise standards for evaluating systems and pinpointing areas in need of development, is very helpful in directing usability studies (Bevan & Carter, 2016).

Table 1. Key Components of Usability as Defined by ISO 9241-11 (ISO, 1998; Bevan & Carter, 2016)

Key Component	Definition
Effectiveness	Refers to the accuracy and completeness with which users achieve their goals.
Efficiency	Measures the resources invested in relation to the accuracy and completeness with which goals are achieved, frequently considering the time or effort involved.
Satisfaction	Reflects the system's comfort and acceptance among its users, including subjective feelings and impressions.

2.1.4 Usability Heuristics and Gestalt Principles in Interface Design

To support user-centered design, Nielsen’s 10 Usability Heuristics (shown in Table 2) offer a robust framework for evaluating and enhancing UX. These heuristics—Visibility of system status, match with the real world, user control and freedom, consistency and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, assist users in recognizing, diagnosing, and recovering from errors, and provide help and documentation (Nielsen, 1994)—provide essential guidelines for designing systems that facilitate independent interaction and support users across varying levels of technical familiarity.

Table 2. Nielsen's 10 Usability Heuristics (Nielsen, 1994)

Nielsen's 10 Usability Heuristics	Description
Visibility of System Status	The system should consistently provide users with timely and appropriate feedback to keep them aware of ongoing processes.
Match Between System and the Real World	The system should use language, symbols, and logic that are familiar to the user, aligning with real-world conventions to make it easier to use.
User Control and Freedom	Provide options to undo and redo actions, allowing users to have control and recover easily from mistakes.
Consistency and Standards	Maintain consistent operations and terminology throughout the system, reducing user confusion and enhancing predictability.
Error Prevention	Design the system to prevent errors from occurring in the first place, such as by providing confirmations or alerting users to potential mistakes.
Recognition Rather Than Recall	Reduce memory load by making options, actions, and information visible, so users can recognize items instead of having to remember them.
Flexibility and Efficiency of Use	Cater to both novice and experienced users by offering shortcuts for expert users while maintaining ease of use for beginners.
Aesthetic and Minimalist Design	Keep the design simple and focused, avoiding unnecessary information that could distract or overwhelm the user.
Help Users Recognize, Diagnose, and Recover from Errors	Provide clear error messages and guidance to help users understand the problem and resolve it effectively.
Help and Documentation	Although the ideal design should be intuitive, help and documentation should be available to assist users when needed.

An effective interface should also be visually intuitive, with clearly labeled elements, logical layouts, and accessible menus that allow users to accomplish tasks with minimal friction. Applying Gestalt principles, see table 3, — such as proximity (grouping related items together), similarity (consistent styles for related elements), and continuity (arranging elements to guide the user’s eye) — helps create interfaces that are easily navigable and reduce cognitive load. Gestalt principles enable users to quickly locate and understand key features, enhancing overall usability and satisfaction (Todorovic, 2008).

Table 3. Gestalt principles (Todorovic, 2008)

Gestalt principles	Description
Proximity	Elements that are positioned near each other are seen as belonging to the same group. This helps users quickly recognize related functions or options.
Similarity	Similar elements, such as those with the same color, shape, or size, are perceived as related, aiding in consistency and ease of identification.
Closure	Users naturally perceive incomplete shapes or figures as whole, allowing for simpler designs that are visually intuitive.
Continuity	Elements aligned in a continuous line or pattern are viewed as related, guiding users’ visual flow across the interface.
Figure and Ground	Users differentiate between foreground and background, making it easier to identify key elements by separating them visually from the background.
Symmetry	Symmetrical elements are seen as a cohesive whole, helping users quickly understand visual structures.
Uniform Connectedness	Physically or visually connected elements are perceived as related, enhancing the logical grouping of functions.

2.2 Introduction to Web2, Web3, and Decentralized Applications

2.2.1 Characteristics and Key Considerations of Web2 and Web3

Social networking and e-commerce are examples of Web2's centralized paradigm, in which platforms are run by central authority and servers. Platform providers may manage and enhance the user experience thanks to this centralized architecture's ease and stability (Lacity & Carmel, 2024). Web2 platforms place a strong emphasis on providing a user-friendly, service-oriented experience. These platforms' centralized management over user data allows them to provide consistent assistance, streamlined interactions, and personalized recommendations—all of which improve usability and accessibility for a wide spectrum of users (Hiremath & Kenchakkanavar, 2016). Furthermore, Web2 platforms usually have quick response times and user-friendly interfaces that make it easy for consumers to interact without having to comprehend complex technological intricacies. The broad adoption of Web2 has been facilitated by its usability and accessibility.

Web2 platforms, however, have a number of significant user experience drawbacks. First, because centralized data storage puts consumers at danger of data breaches and misuse, the centralized model limits user control and data privacy. Many Web2 platforms rely on advertising as their main source of income, which restricts users' control over their personal data. Additionally, because Web2 is service-oriented, users become dependent on centralized support; they mostly rely on the platform to help them with problems or offer support. The decentralized, self-managed philosophy of Web3 applications stands in stark contrast to this dependency. Last but not least, Web2's centralized architecture may raise questions about trust, especially in cases of data misuse or breaches (Hiremath & Kenchakkanavar, 2016). These limitations have led to growing interest in Web3, where decentralization and user autonomy address some of the trust-related issues inherent in Web2.

Unlike Web2, Web3 does not require a centralized authority because it is based on decentralized technologies like blockchain and smart contracts. Through peer-to-peer network interaction with programs, this distributed design gives consumers more control and autonomy. Data sovereignty is given top priority in Web3, where users can control and manage their data using private key management and decentralized identifiers (DIDs) (Patel et al., 2022). Some of the privacy and data ownership issues related to centralization are addressed by this control, which provides a degree of privacy and ownership that is generally lacking in Web2.

Web3 also encourages transparency and censorship resistance because transactions and activities are verifiable on a public ledger, and no single entity has the authority to change or censor information. This appeals to users who value privacy, transparency, and the freedom to connect without external influence. However, Web3 also offers new issues in user experience. The intricacy of Web3 technologies, such as private key management and blockchain activities, presents a high learning curve for consumers, especially for those accustomed to Web2's simplicity. UX design in Web3 must focus on streamlining these interactions to lower the entrance barrier for new users.

Furthermore, a significant difficulty in Web3 UX is balancing transparency and privacy. While openness is inherent in decentralized technology, it must be properly controlled to guarantee that users' privacy requirements are met. Finally, while Web3 runs on a trustless basis with no centralized authority, users frequently need to feel confident while completing irreversible activities like transactions. Real-time feedback and intuitive design can make users feel more secure, reducing the anxiety associated with interacting in a decentralized environment.

Table 4. Feature and Aspect Differences between Web2 and Web3 (Patel, et al, 2022)

Features/Aspects	Web2	Web3
Primary Goal	Social interaction, content sharing	Decentralization, user autonomy, data sovereignty
Architecture	Centralized, often client-server	Decentralized, peer-to-peer
User Interaction	Read-write, social media-based	Interaction through smart contracts and dApps
Content Creation	User-generated content, controlled by platforms	User-owned and controlled content, enhanced by AI and blockchain
Main Technology	AJAX, XML, APIs	Blockchain, smart contracts, Semantic Web, AI
Data Ownership	Controlled by platform providers	User-owned, distributed data storage
Focus	User engagement and social collaboration	Data privacy, user autonomy, and security
Limitations	Privacy concerns, centralized control, dependency	Complexity, high learning curve, UX challenges
Examples	Social media platforms, e-commerce, blogs	dApps, decentralized finance (DeFi)

As shown in Table 4, Web3 builds upon Web2's interaction models while addressing its limitations through decentralization, enhanced user autonomy, and data sovereignty. Web2's centralized nature, while convenient, imposes significant limitations in user control and data privacy. In contrast, Web3's decentralized model enables greater user independence, privacy, and security, appealing particularly to users concerned about transparency and ownership of their data (Hiremath & Kenchakkanavar, 2016; Patel et al., 2022). However, these benefits introduce unique challenges in UX design, emphasizing the importance of

accessible and intuitive interfaces to accommodate a broader user base transitioning from Web2 to Web3 platforms.

2.2.3 Decentralized Applications (dApps): Definition and Role in Web3

Decentralized applications (dApps) represent a significant departure from traditional centralized applications, aligning with the foundational principles of Web3. Unlike conventional applications that depend on centralized servers and are managed by central authorities, Decentralized applications (dApps) leverage blockchain technology and distributed networks to improve transparency, security, and give users enhanced control over their data and interactions. According to Cai et al. (2018), dApps are essential to Web3 as they embody decentralization and autonomy, offering a new paradigm for data management and interaction within digital platforms.

One of the defining features of dApps is their open-source nature, which allows the underlying code to be publicly accessible and reviewed. For example, Uniswap, a decentralized exchange (DEX), makes its code publicly available, enabling users and developers to verify its integrity. This transparency builds trust within the community and supports community-driven improvements, reducing reliance on a single entity to control or modify the platform.

Furthermore, many dApps integrate an internal cryptocurrency or token to facilitate transactions and incentivize participation within the application. The presence of these tokens supports a self-sustaining ecosystem, allowing users to be rewarded for contributions and enabling transactions to occur autonomously within the application. Tokens thus reinforce engagement and loyalty among users, which is essential for the growth and stability of dApps.

Additionally, dApps rely on decentralized consensus mechanisms, such as proof of work or proof of stake, which play a crucial role in maintaining security and transparency. Unlike traditional systems that depend on a central authority for

data validation, dApps like Ethereum-based DeFi platforms enable participants across the network to collectively verify transactions, fostering a “trustless” environment that promotes user confidence.

Finally, dApps are designed to operate without a central point of failure, making them inherently resilient against attacks or disruptions. By distributing control across a network of nodes, dApps reduce the risks associated with centralized control, where a single point of failure could compromise the system. This decentralized structure aligns with Web3’s vision, empowering users to interact directly without dependency on centralized intermediaries.

In the context of Web3, dApps play a pivotal role in promoting decentralized control, data sovereignty, and user empowerment. By leveraging blockchain technology and smart contracts, dApps enable users to manage and retain ownership of their data, contrasting sharply with the centralized control prevalent in Web2 applications. This shift addresses the growing demand for privacy, security, and transparency in a digital landscape where data privacy concerns are increasingly significant (Cai et al., 2018; Patel et al., 2022)

2.2.4 Case Study: Unirep Social Taiwan

Unirep Social Taiwan is a fully anonymous, decentralized social platform under development as part of a project initiated by the Ethereum Privacy and Scaling Explorations (PSE) team in June 2023. Although the platform has not been officially launched, it serves as an experimental application of Web3 technologies, aiming to explore the practical challenges and opportunities of integrating Ethereum-based solutions into a social platform. The project’s primary goal is to provide Taiwanese users with a privacy-preserving, decentralized environment for anonymous interaction, while testing the scalability and usability of Ethereum’s Web3 technology stack (PSE, 2024) .

- **Platform Objectives and Features**

The platform is designed to address key issues prevalent in centralized social platforms, such as data privacy, censorship, and lack of user autonomy. Its development focuses on creating a secure, transparent, and user-driven ecosystem by incorporating the UniRep protocol, a cutting-edge zero-knowledge proof (ZKP) framework (PSE, 2024).

Key features of Unirep Social Taiwan exemplify its commitment to user privacy, decentralization, and transparency. The platform enables anonymous interaction through the use of pseudonymous identifiers, known as epoch keys, which protect user privacy without compromising accountability or transparency. To foster a balanced and trustworthy community, it incorporates a decentralized reputation system that incentivizes constructive behavior while discouraging harmful interactions. Additionally, Unirep Social Taiwan employs a community-driven content moderation model, where users collectively report and adjudicate inappropriate content through decentralized voting mechanisms, ensuring fairness and transparency in the moderation process. The platform also includes transaction monitoring features that allow users to track the statuses of their transactions, such as content publication confirmations and reputation updates, providing transparency and user assurance. Collectively, these features demonstrate the platform’s alignment with the core principles of Web3, including user sovereignty, decentralization, and enhanced privacy (PSE, 2024).

Table 5. Key Features of Unirep Social Taiwan and Their Alignment with Web3 Principles

Feature	Description	Alignment with Web3 Principles
Anonymous	Enables users to interact	User privacy and

Interaction	anonymously through pseudonymous identifiers (epoch keys), ensuring privacy without compromising accountability or transparency.	sovereignty
Reputation System	Employs a decentralized mechanism to incentivize constructive behavior and discourage harmful interactions, fostering a balanced and trustworthy community.	Decentralization and community trust
Content Moderation	Facilitates collective governance through decentralized voting, allowing users to report and adjudicate inappropriate content transparently and fairly.	Transparency and decentralized governance
Transaction Monitoring	Provides tools for users to track transaction statuses, such as content publication confirmations or reputation updates, ensuring clarity and user assurance.	Transparency and user empowerment

- **Technical Foundation**

Unirep Social Taiwan leverages the UniRep protocol, a scalable framework built on zero-knowledge proof (ZKP) technology, to enhance the platform's privacy and security features. This protocol incorporates innovative technical mechanisms that align with the principles of decentralization and user autonomy. Zero-knowledge proofs facilitate anonymous yet verifiable interactions, preserving user privacy while supporting trustless engagement. The use of epoch keys enables users to interact without exposing personal data, ensuring anonymity across all activities. Table 6 summarizes these key technical mechanisms, highlighting

how they support privacy, security, and decentralized interoperability (PSE, 2024).

Additionally, the protocol's decentralized interoperability allows users to seamlessly engage across platforms while maintaining consistent anonymous credentials. Furthermore, the non-custodial data management approach ensures that the platform does not store or control user data, significantly reducing risks associated with data breaches. Together, these technical foundations provide a robust and scalable framework for Unirep Social Taiwan, demonstrating the potential of Web3 technologies to deliver secure and privacy-preserving decentralized applications (PSE, 2024).

Table 6. Key Technical Mechanisms of Unirep Social Taiwan (PSE, 2024)

Technical Mechanism	Description	Benefits
Zero-Knowledge Proofs	Enable anonymous yet verifiable interactions, maintaining privacy while supporting trustless engagement.	Ensures user privacy and builds trust in the decentralized system.
Epoch Keys	Provide pseudonymous identifiers that allow users to interact without exposing personal data.	Guarantees anonymity and reduces risks of identity exposure.
Decentralized Interoperability	Allow users to engage seamlessly across platforms while maintaining consistent anonymous credentials.	Facilitates cross-platform interactions and enhances user convenience.
Non-Custodial Data Management	Ensures the platform does not store or control user data, relying on user-managed information instead.	Minimizes risks of data breaches and enhances data sovereignty for users.

2.3 User Characteristics, Behavior, UX, and UX Optimization Methods in Decentralized Applications (dApps)

2.3.1 User Characteristics and Behaviors in Decentralized Applications

Decentralized application users exhibit diverse characteristics, driven by their unique motivations, engagement patterns, and expectations from blockchain technology. Based on large-scale Ethereum data, Yin, Liu, and Gao (2022) identify several key user types, each engaging with dApps for distinct purposes, such as financial speculation, gaming, or decentralized finance (DeFi). Understanding these motivations is essential for designing user experiences that meet the nuanced needs of various dApp users.

- **Motivations and Purpose of Use**

The study categorizes users by their primary motivations, highlighting that a significant portion engages in speculative activities related to cryptocurrency and digital assets. Financially driven users, particularly those involved in DeFi, frequently interact with dApps, seeking transparency and efficiency in managing digital transactions. Conversely, gaming enthusiasts, who represent a growing segment, prioritize immersive and gamified experiences, often valuing ease of use over technical detail (Yin et al., 2022).

- **Interaction Frequency and Behavioral Patterns**

User engagement with dApps varies widely, reflecting different usage patterns. Speculators and DeFi users exhibit high interaction frequency, performing repetitive actions such as asset transfers and contract interactions, while other user segments, such as those interested in social or utility-based dApps, show more sporadic engagement. Recognizing these

interaction patterns helps in designing adaptable interfaces that cater to both high-frequency users and those requiring intermittent access (Yin et al., 2022).

- **Privacy and Anonymity Preferences**

Privacy emerges as a central concern among dApp users, especially those handling sensitive or financial information. Decentralized applications cater to this preference by enabling privacy-focused interactions, often allowing users to remain anonymous while controlling their own data. These privacy-conscious users are drawn to dApps for the data sovereignty and anonymity options offered, distinguishing them from typical Web2 users who engage on centralized platforms where personal information is stored and managed by a central authority (Yin et al., 2022).

- **Trust and Autonomy**

The trustless environment provided by dApps aligns with users' desire for autonomy and control over their assets and personal data. Unlike Web2 users, who may rely on centralized control for data management, dApp users are accustomed to interacting in decentralized environments, where they are responsible for managing their interactions and securing their own data. This preference for autonomy underscores the importance of designing interfaces that provide clear feedback and transparent processes, especially given that dApps often involve irreversible actions, such as financial transactions, that require user confidence (Yin et al., 2022).

2.3.2 UX Challenges in Decentralized Applications

Decentralized applications (dApps), by their very nature, present unique user experience (UX) challenges that distinguish them from traditional, centralized applications. These challenges stem from the inherent complexities of blockchain technology, decentralized data management, and user autonomy. Users are often

required to handle data, security keys, and transaction confirmations independently, which can introduce usability obstacles not present in conventional applications.

One primary challenge is achieving a balance between the need for secure, trustless transactions and user expectations for speed and responsiveness. In contrast to centralized systems, where data is processed on a server and sent back to users almost instantaneously, decentralized systems often involve a delay due to the consensus mechanisms required for validation. This latency can disrupt real-time interactions and deter users accustomed to the immediacy of Web2 interfaces (López et al., 2022). López and colleagues highlight that decentralized networks' distributed nature can also create high latency, negatively affecting user interactions, particularly when users expect immediate feedback from actions such as transactions or data updates.

Furthermore, decentralized systems introduce new complexities around data management and storage. Unlike centralized applications that handle data storage for users, dApps require users to manage their data through external storage systems or tokens. Sambra et al. (2016) propose a solution through the Solid protocol, which allows users to store and control data in Personal Online Datastores (PODs). While this model promotes data sovereignty, it requires users to understand data access permissions and interoperability between applications, adding layers of complexity that can impede ease of use. Without sufficient guidance or simplification, users may find it challenging to manage their data autonomously, impacting overall usability and adoption rates.

In addition, effective UX design in dApps must address security and trust without relying on traditional authentication systems. Althubaiti et al. (2022) introduce the Deferred Authentication mechanism, which enables user actions to be authenticated asynchronously, reducing the cognitive load during the onboarding process. However, even with innovations in authentication, users of dApps must still navigate private key management and interact with irreversible transactions, adding to the perceived complexity. Such challenges highlight the necessity for

clear guidance and user education to instill confidence in users engaging in these irreversible actions.

Lastly, the decentralized structure of dApps emphasizes transparency and autonomy, appealing to Web3 users but often complicating usability for those transitioning from Web2. As decentralized applications gain traction, designing user-centered interfaces that minimize the technical knowledge barrier, address latency issues, and maintain transparency will be essential. Addressing these UX challenges through innovative interface design and user guidance will be crucial for the broader adoption of dApps and the realization of Web3 principles (Althubaiti et al., 2022; López et al., 2022; Sambra et al., 2016). For an overview of the primary UX challenges in decentralized applications, see Table 7.

Table 7. UX Challenges in Decentralized Applications (Althubaiti et al., 2022; López et al., 2022; Sambra et al., 201)

Challenge	Description
Latency and Responsiveness	Decentralized consensus mechanisms can cause delays, impacting real-time interaction and disrupting user expectations for immediate feedback.
Data Management Complexity	Users must handle data independently, often using external storage solutions, requiring an understanding of data permissions and interoperability.
Security and Trust Without Centralized Authentication	Users face challenges with private key management and the risks of irreversible transactions without centralized support.
High Learning Curve for Web2 Users	Users familiar with Web2 interfaces may find dApp autonomy, transparency, and transaction finality challenging to navigate.
Transparency vs. Usability	Balancing transparency with usability is critical, as too much technical detail can overwhelm users and hinder their experience.

2.3.3 UX Optimization Methods in dApps

- **Understanding and Addressing User Barriers**

The decentralized architecture of dApps introduces new complexities that differ significantly from traditional Web2 platforms, posing unique challenges for users unfamiliar with blockchain technology. User education and guidance mechanisms are critical in helping users transition smoothly into the Web3 environment. The literature suggests that providing interactive, context-sensitive tutorials, like those seen in educational dApps, and on-screen prompts can help break down complex tasks, such as setting up wallets, handling private keys, or understanding token functionalities (Cai et al., 2018). Additionally, Qasse et al. (2020) emphasize the importance of incorporating tooltips and modular tutorials that activate based on user behavior, ensuring users do not feel overwhelmed. By guiding users gradually through interactions, dApps can foster a learning environment that supports greater engagement and minimizes the perceived difficulty of interacting with blockchain elements.

- **Designing for Usability and Learnability: Leveraging the Technology Acceptance Model (TAM)**

The Technology Acceptance Model (TAM) (Davis, 1989) has proven to be highly relevant for dApp design, particularly in evaluating the factors influencing user adoption. TAM highlights perceived usefulness and ease of use as key determinants for user acceptance, especially among users transitioning from Web2 to Web3 environments. To enhance usability, designers should focus on interface simplification, which includes restructuring workflows, minimizing redundant steps, and reducing the frequency of user-input actions (Yang et al., 2021). For example, tasks that involve smart contracts or token transactions could be streamlined by consolidating action buttons and using visual metaphors familiar to Web2

users, such as ‘confirm’ or ‘submit’ buttons. This approach minimizes cognitive load and reinforces users' mental models from Web2, allowing them to feel more at ease and confident with the system.

- **Enhancing User Trust and Transparency through Blockchain's Verifiable Nature**

One of the core tenets of blockchain technology is transparency, which can be a powerful tool for building user trust. The use of smart contracts enables decentralized applications to automate and securely execute agreements without relying on a central authority, fostering a trustless environment where users can verify actions independently (Patel et al., 2022). To enhance transparency, dApps should allow users to review transactions and interaction logs through publicly accessible records or transaction histories within the platform. By providing easy access to such verifiable information, users can better understand and trust the operations of the application, which is particularly important in finance- or governance-focused dApps where users seek to ensure data integrity and avoid potential manipulation.

Another effective method for optimizing UX in decentralized applications is by embedding real-time feedback and progress indicators. Visual confirmations, such as transaction status updates (e.g., pending, confirmed, failed), can reassure users about system functionality. This feature is particularly beneficial for Web3 newcomers who may feel uncertain about decentralized processes. Research by Hiremath and Kenchakkanavar (2016) supports this approach, highlighting how feedback loops help reduce user anxiety and build trust by providing immediate, visible system responses.

While transparency is a core feature of decentralized applications, maintaining user privacy is equally critical, especially in Web3

environments where many users value anonymity. The integration of decentralized identifiers (DIDs) and zero-knowledge proofs (ZKPs) has become increasingly popular as a means to enable privacy-preserving interactions without compromising transparency. DIDs allow users to verify their identity and complete transactions without revealing personal information, addressing privacy concerns and enhancing data security (Cai et al., 2018). Effectively incorporating these features into dApps requires thoughtful UX design to ensure that privacy settings are accessible and clear, empowering users to make informed choices about data disclosure.

- **Streamlining Interaction through Minimalist Design: Applying Nielsen's Usability Heuristics**

Drawing from Nielsen's 10 Usability Heuristics (as shown in Table 2), which offer valuable guidelines for creating intuitive user interfaces, dApp designers can enhance usability by adopting a minimalist, user-centered design approach. Nielsen's principles advocate for reducing visual clutter, displaying essential information prominently, and grouping related tasks logically, which are all key to minimizing cognitive load and improving user interaction with the system (Nielsen, 1994), this means prioritizing interface elements that users frequently engage with, such as wallet balances, transaction buttons, and notifications, while keeping secondary information tucked away but easily accessible. The recognition rather than recall principle is particularly valuable in dApps, as it allows users to engage with the system without needing to memorize commands or functions. This can be applied through the use of familiar icons, clear labels, and a standardized color scheme, helping users navigate effortlessly.

Additionally, dApps benefit from error prevention and flexibility in user paths. Error prevention can be enhanced by integrating transaction previews and confirmation dialogs that summarize actions before they are finalized. Flexibility can be achieved by allowing users to modify or cancel

transactions before submission, reducing the pressure of irreversible decisions in a blockchain environment where transactions are often permanent.

- **Applying Gestalt Principles in dApp Interface Design for Cognitive Ease**

To further enhance dApp usability, designers can apply Gestalt principles such as proximity, continuity, and similarity to create visual groupings and guide the user's attention. These principles help users intuitively understand the structure and flow of the interface, enabling them to locate and interpret elements without additional cognitive effort (Todorovic, 2008). For instance, proximity to group related buttons (such as 'transfer,' 'stake,' and 'view balance') provides a clear visual structure, allowing users to find essential functions quickly.

Similarly, employing continuity—arranging elements in a linear path that aligns with the natural reading flow—can be helpful in guiding users through multi-step processes like token transfers or identity verifications. By ensuring that interactive elements follow an intuitive path, designers can reduce user frustration and create a more cohesive experience.

In summary, effective UX optimization methods in dApps combine educational support, transparency, privacy controls, and minimalist design with principles of cognitive ease. Through these strategies, dApps can become more user-friendly, especially for individuals unfamiliar with blockchain concepts. The implementation of these methods not only reduces barriers to entry but also aligns with Web3's values of decentralization, transparency, and user empowerment. By grounding UX design in both foundational and advanced usability theories, dApps can create engaging, accessible platforms that support long-term user adoption and satisfaction.

2.4 Usability Evaluation and User Experience Research Methodology

Usability evaluation and UX research are critical in understanding how users interact with dApps, especially in the evolving Web3 ecosystem. Unlike traditional applications, dApps operate on decentralized architectures, presenting unique challenges such as private key management, decentralized identity systems, and irreversible transactions. These characteristics necessitate a tailored approach to usability and UX research, combining traditional methods with blockchain-specific adaptations.

2.4.1 Usability Evaluation Methods

Usability evaluation focuses on identifying barriers that hinder efficient user interaction and satisfaction. Two primary methods are employed in this study:

- **Task-Based Usability Testing**

Task-based usability testing is widely regarded as a fundamental method for evaluating user interaction with systems, as it focuses on goal-oriented tasks performed under controlled conditions (Wichansky, 2000). Metrics such as task success rate, completion time, and error frequency provide quantitative insights into a system's usability and effectiveness. This aligns with the approach used in this study, where tasks such as wallet integration and transaction processing were designed to simulate real-world interactions and highlight pain points for Web2 users transitioning to Web3 platforms.

- **System Usability Scale (SUS):**

The System Usability Scale (SUS), developed by Brooke (1996), is a widely adopted and standardized questionnaire designed to measure the usability of systems. Consisting of ten items with alternating positive and

negative phrasing, SUS evaluates perceived ease of use, functionality, and overall user satisfaction. Participants respond using a five-point Likert scale, with scores aggregated and normalized to a range of 0 to 100. This scoring system provides a quantitative benchmark for comparing usability across systems or design iterations.

A SUS score of 68 is generally recognized as the benchmark for average usability (Lewis & Sauro, 2009). Scores below 68 indicate usability challenges, suggesting the need for significant improvements, while scores above 68 reflect systems perceived as user-friendly and satisfactory. By leveraging this benchmark, this study evaluates whether design optimizations effectively enhance the platform's usability.

To further contextualize SUS scores, this study incorporates the interpretative framework proposed by Bangor et al. (2009), as shown in Figure 6, which maps SUS scores to adjective ratings (e.g., "OK," "Good," "Excellent"), acceptability ranges (Not Acceptable, Marginal, Acceptable), and a grading scale (F to A). For instance:

- Scores below 50 are deemed "Not Acceptable" and align with a grade of F.
- Scores 50–70 are "Marginal", with 50.9–71.4 mapping to adjectives like "OK" and grades ranging from D to C.
- Scores above 70 are considered "Acceptable", correlating with adjectives like "Good" or "Excellent" and grades of B to A.

This interpretative framework complements the numerical SUS score, making it easier to communicate usability results to multidisciplinary teams and identify actionable areas for improvement. For example, a score in the "Marginal High" range (50.9–71.4) suggests the platform is functional but requires usability enhancements to reach the "Acceptable" range.

In this study, SUS was administered after each usability testing session to gauge participants' perceptions of the platform's usability. Its application facilitates direct comparisons between pre- and post-optimization iterations, enabling researchers to assess the effectiveness of design changes. The integration of the SUS benchmark and interpretative framework ensures a comprehensive and consistent evaluation of the platform's usability, satisfaction, and ease of use across both Web2 and Web3 user cohorts.

The System Usability Scale Standard Version		Strongly Disagree					Strongly Agree				
		1	2	3	4	5					
1	I think that I would like to use this system frequently.	☐	☐	☐	☐	☐					
2	I found the system unnecessarily complex.	☐	☐	☐	☐	☐					
3	I thought the system was easy to use.	☐	☐	☐	☐	☐					
4	I think that I would need the support of a technical person to be able to use this system.	☐	☐	☐	☐	☐					
5	I found the various functions in this system were well integrated.	☐	☐	☐	☐	☐					
6	I thought there was too much inconsistency in this system.	☐	☐	☐	☐	☐					
7	I would imagine that most people would learn to use this system very quickly.	☐	☐	☐	☐	☐					
8	I found the system very awkward to use.	☐	☐	☐	☐	☐					
9	I felt very confident using the system.	☐	☐	☐	☐	☐					
10	I needed to learn a lot of things before I could get going with this system.	☐	☐	☐	☐	☐					

Figure 5. The System Usability Scale Standard Version (Brooke, 1996)

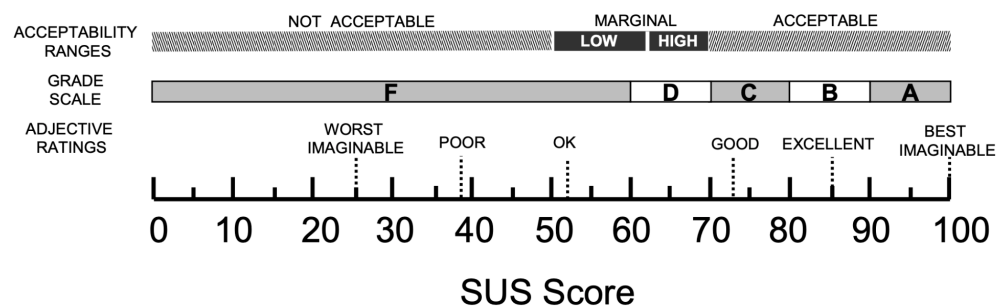


Figure 6. A comparison of the adjective ratings, acceptability scores, and school grading scales, in relation to the average SUS score (Bangor et al, 2009)

2.4.2 User Experience Research

To complement usability testing, qualitative methods are employed to capture user behaviors, perceptions, and emotional responses during dApp interactions:

- **Think-Aloud Protocols:**

Participants are encouraged to verbalize their thoughts and reactions while completing tasks. This method provides qualitative data on cognitive processes, revealing user frustrations, misconceptions, and expectations. Think-aloud protocols are widely used in usability testing due to their high face validity; they allow researchers to observe users' real-time cognitive processes during task execution, rather than relying on post-task judgment (van den Haak et al., 2003).

The concurrent think-aloud (CTA) approach, where users verbalize their thoughts as they work, is particularly effective in identifying usability problems that are observable during task performance. However, it requires participants to manage the dual workload of task execution and verbalization, which can impact task performance, especially for complex

tasks. Despite this, CTA provides valuable insights into users' immediate reactions and thought processes, making it a foundational method in usability evaluations (van den Haak et al., 2003).

- **Semi-Structured Interviews:**

Post-task interviews were conducted to gain deeper insights into participants' experiences, exploring their perceived challenges, satisfaction, and improvement suggestions. This approach aligns with Carruthers' (1990) assertion that semi-structured interviews enrich quantitative findings by capturing participants' perspectives and emotions. The flexibility of this method allows researchers to probe specific issues while maintaining consistency across interviews, as recommended by Borg and Gall (1983). Furthermore, interviews enhance the study's robustness by complementing quantitative metrics with qualitative insights, providing a triangulated perspective (Guba & Lincoln, 1982).

- **Observational Methods:**

Observational methods provide a valuable means of understanding user interactions by capturing non-verbal cues and real-time behaviors during usability testing sessions. These methods involve researchers observing participants as they interact with the platform, noting behaviors such as hesitation, confusion, or confidence. Such observations complement verbal feedback, offering a more holistic view of the user experience by documenting subtleties that users may not consciously articulate during think-aloud protocols or interviews.

According to Ciesielska, Boström, and Öhlander (2018), observational methods are particularly effective in uncovering tacit knowledge and implicit behaviors during task performance. These insights are critical for identifying usability issues that might otherwise be

overlooked, such as repeated navigation errors or pauses signaling confusion. Observational research also allows researchers to contextualize user interactions, providing deeper insights into their cognitive and emotional states, especially when dealing with complex or unfamiliar systems.

In this study, observational methods were integrated into usability testing sessions to provide a detailed understanding of participant behaviors. The insights gained from these observations informed the identification of specific pain points and areas for UX optimization, particularly for users transitioning from Web2 to Web3 platforms.

2.4.3 Data Integration and Analysis

The data collected through usability testing, SUS scores, think-aloud protocols, and interviews are integrated to provide a comprehensive understanding of dApp UX. Quantitative metrics, such as task completion rates and SUS scores, offer measurable benchmarks for usability, while qualitative insights highlight nuanced user behaviors and perceptions. This mixed-methods approach ensures a thorough analysis of both functional and experiential aspects of UX.

3. Research Methodology

3.1 Research Approach and Research Design

With a decentralized model that places an emphasis on user autonomy, data ownership, and privacy, Web3 is the next generation of the internet, departing from Web2's centralized control feature (Murray et al., 2023). In contrast to Web2 platforms such as Google and Facebook, which store data centrally and offer services in return for user information, Web3 uses distributed ledger and blockchain technologies to give users more control over their information and digital interactions (Ray, 2023). Transparency and user control are crucial in a more democratic internet, which is reflected in this decentralized structure. But moving from Web2 to Web3 presents serious user experience (UX) problems, especially when users used to centralized systems are confronted with the intricacies of decentralized platforms.

In order to assess and improve the user experience of dApps, this study uses a mixed-methods approach that combines qualitative and quantitative methodologies. Because it combines the advantages of both qualitative and quantitative paradigms, mixed-methods research is especially well-suited to examining complex phenomena like user experience. According to Migiro and Magangi (2011), this method combines the contextual depth of qualitative data with the broad, generalizable insights from quantitative analysis to give researchers a more thorough grasp of the research problem. Similar to this, Rhiu and Yun (2018) show how mixed-methods allows for a more in-depth investigation of user behaviors and perceptions, which makes it an appropriate option for iterative UX testing.

This research design consists of two iterative rounds: (1) a first round of usability testing to identify challenges and inform design optimizations, and (2) a second round to assess the effectiveness of these improvements. The iterative nature of this design is consistent with best practices in UX research, where repeated testing and refinement are essential for improving interactive systems (Bastien, 2010). By combining think-aloud protocols and semi-structured interviews with task success rates and SUS scores, this study ensures a comprehensive assessment of user interactions with the platform.

Research Process Overview The research process consists of the following steps, as illustrated in Figure 7:

1. Participant Recruitment: Participants with varying levels of familiarity with Web2 and Web3 technologies are recruited to ensure a diverse representation of user groups.
2. Round 1 Usability Testing: Participants complete predefined tasks on the platform's initial design. Data is collected through SUS scores, task-based metrics (e.g., success rates, completion times), think-aloud protocols, and interviews.
3. Data Analysis and UX Optimization: Quantitative and qualitative data from Round 1 are analyzed to identify key usability challenges. Findings inform the development of UX design improvements.
4. Implementation of Design Changes: Based on the analysis, the platform is updated to address identified pain points and improve overall usability.
5. Round 2 Usability Testing: Participants perform the same tasks on the optimized platform. Data collection follows the same methods as Round 1, enabling direct comparisons between the two iterations.

6. Comparative Analysis: Data from both rounds are compared to evaluate the impact of UX optimizations on usability and user satisfaction.
7. Final Recommendations: Insights gained are synthesized into actionable design recommendations for dApp development.

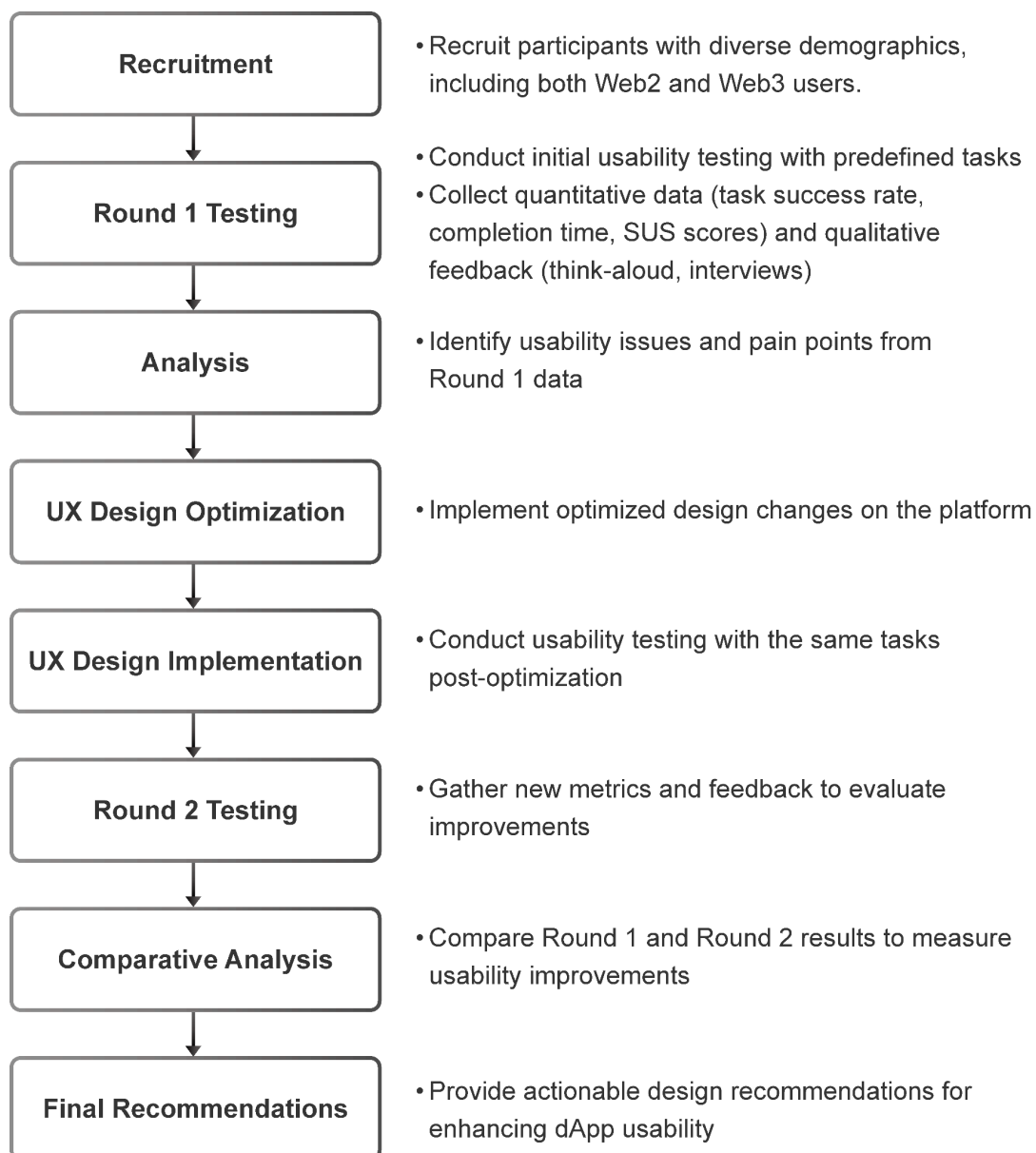


Figure 7. Research Process Flow

3.2 Participants and Recruitment

3.2.1 Participant Selection Criteria and Recruitment Process

A diverse range of demographics, including differences in age, gender, and technical expertise, were represented in the selection of study participants. In order to guarantee that the results of usability studies are reflective of a broad spectrum of user experiences and difficulties, such diversity is essential (Rubin & Chisnell, 2008). Making sure there was a balance between individuals who had previously used Web3 technologies and those who were familiar with Web2 platforms was a major goal of the recruitment process. This segmentation is in line with Nielsen and Landauer's (1993) suggestions, which stress the importance of choosing participants with a range of skill levels in order to identify various usability problem layers and create solutions.

Since decentralized application (dApp) platforms frequently require users to navigate complex systems with varying expectations and levels of technical literacy, it is especially crucial to recruit both inexperienced and seasoned users (Lazar et al., 2017). This study sought to capture the distinct usability challenges that Web2 users encounter when switching to Web3 platforms, as well as the sophisticated expectations of seasoned Web3 users, by incorporating participants from both cohorts. This strategy adheres to the "maximum variation sampling" principle, which aims to investigate the range of user experiences (Patton, 2002).

The recruitment process was carried out via an online form named "Recruitment of Participants for Usability Testing of an Anonymous Web3 Community Platform - Unirep Social Taiwan." This form includes an explanation of the study's objectives, confidentiality protocols, and a summary of the usability testing methodologies. Respondents were asked to submit personal information, explain their experience using Web2 and Web3 applications, and express their desire to participate in the study. Based on their responses, participants were divided into two basic cohorts:

- Web2 Users: Participants with minimal or no experience with Web3 technologies.
- Web3 Users: Participants familiar with blockchain-based applications, such as cryptocurrency wallets or decentralized finance platforms.

This categorization permitted targeted comparisons, allowing the study to identify and address usability difficulties for both novice and expert users. According to Jakob Nielsen and Landauer's (1993) research, each usability testing cycle had 6-8 individuals. According to Nielsen's widely recognized model, testing with 5-6 participants reveals roughly 85% of usability issues. This strategy strikes a compromise between resource efficiency and depth of insight, taking advantage of the declining returns observed with higher sample sizes to improve data gathering and analysis.

3.2.1 Participant Selection Criteria and Recruitment Process

All participants gave written informed consent prior to participation, confirming that they understood the study's procedures and consenting to be filmed during post-task interviews and usability testing. All screen recordings, observational notes, and interview transcripts were anonymized to guarantee the ethical treatment of participant data. In accordance with ethical guidelines for research involving human subjects, these data were safely stored and used only for study.

Efforts were made to recruit participants with diverse technical backgrounds and varying levels of familiarity with decentralized applications. This diversity was critical for obtaining a comprehensive understanding of user experiences across different expertise levels. Participants were compensated with a monetary reward of 800 TWD after completing each round of usability testing as recognition for their time and contribution to the study.

3.3 Data Collection Methods

Data collection for this study was conducted through two iterative rounds of usability testing, employing both quantitative metrics and qualitative feedback. This mixed-methods approach enabled a comprehensive evaluation of user interactions, uncovering usability challenges and assessing the effectiveness of design optimizations. The two rounds involved data collection before and after the implementation of design improvements, allowing for a comparative analysis of usability metrics and user experiences.

3.3.1 Round 1 : Initial Usability Testing

The first round evaluated the initial version of the platform. Participants were tasked with completing predefined scenarios designed to align with typical user interactions expected on Unirep Social Taiwan (see Table 8 for the detailed task list). These tasks were selected to reflect common activities such as registering, posting, and interacting with content, which are central to the platform's intended use cases. During these sessions, the think-aloud protocol was employed, encouraging participants to verbalize their thoughts, reactions, and decision-making processes as they navigated the platform. These verbal insights, combined with screen recordings, provided a rich dataset for qualitative analysis.

Table 8. Unirep Social Taiwan Usability Testing Tasks

Task	Title	Description	Objective
Task 1.	Log in and Explore the Whole Site	Log in and browse the platform. Pay attention to layout, navigation, and first impressions.	Assess ease of navigation and initial usability of the homepage and dashboard.
Task 2.	Publish a Post and Verify Transaction Status	Publish a post and check the transaction status. Verify the feedback for transaction progress.	Test usability of the content creation flow and transaction feedback mechanism.

Task 3.	Browse Posts, Vote, and Leave a Comment	Select a post, vote, and leave a comment.	Evaluate the user's ability to engage with social features and provide feedback.
Task 4.	Report a Post and Fill the Report Form	Choose a post to report and complete the report form.	Assess ease of identifying and reporting inappropriate content.
Task 5.	Participate in Post-Report Adjudication	Adjudicate a reported post. Provide input on decision-making clarity and confidence.	Test the usability of the adjudication system and how intuitive the process is for users.
Task 6.	Check Reputation and Action Records	Review reputation scores and reporting records.	Evaluate user comprehension of reputation metrics and interaction history.
Task 7.	Browse the Site Again and Log Out	Revisit the platform to explore overlooked features. Log out upon completion.	Test final impressions and ensure the log-out process is seamless.

Quantitative data collected during this round encompassed three key metrics (as shown in Table 9). The task success rate measured the percentage of tasks that participants completed successfully, providing insight into the platform's overall functionality. The task completion time quantified the average duration required to complete each task, offering an indication of the platform's efficiency. Finally, the System Usability Scale (SUS) scores were obtained through a standardized questionnaire, which captured participants' perceptions of the platform's usability and overall satisfaction.

Table 9. Quantitative Metrics for Usability Testing applying ISO 9241-11 Characteristic of Usability (ISO, 1998; Bevan & Carter, 2016; Wichansky, 2000; Brooke, 1996)

Metric	Description
Task Success Rate (Effectiveness)	Percentage of successfully completed tasks, indicating overall functionality.
Task Completion Time (Efficiency)	Average time taken to complete each task, reflecting platform efficiency.
SUS Scores (Satisfaction)	Standardized usability scores based on participant responses.

After completing the usability tests, participants participated in semi-structured interviews to explore their experiences in greater depth. These interviews delved into the challenges encountered during tasks, overall satisfaction, and suggestions for improvement.

3.3.2 Ethical Considerations

For both Round 1 and Round 2 usability tests, comprehensive ethical measures were implemented to ensure the protection of participant rights and the confidentiality of collected data. Prior to each testing session, informed consent was obtained from all participants, following a detailed briefing on the study's objectives, procedures, and the scope of data collection. Participants were provided with written and verbal explanations, as detailed in Appendix 1: Study Information and Consent Form, ensuring that they fully understood their involvement. The consent forms explicitly outlined their rights, including the option to withdraw from the study at any time without explanation or repercussions. Additionally, all data were anonymized and securely stored in encrypted files to maintain confidentiality and prevent unauthorized access.

To uphold data confidentiality, all collected materials—including audio and video recordings, observational notes, and transcripts—were anonymized. Identifiable information was systematically removed and replaced with pseudonyms during the transcription process to prevent any risk of participant identification. Furthermore, participants were assured that their data would only be used for research purposes and stored securely in encrypted digital files to prevent unauthorized access.

Specific steps were also taken to ensure transparency in data handling. Participants were informed of how their data would be processed, stored, and used, with clear documentation provided in the consent forms. Access to raw data was strictly limited to the research team, and measures such as password-protected storage and encrypted backup systems were employed to safeguard digital files. Physical documents, such as printed observation notes, were stored in secure, locked locations.

Finally, participants were given the opportunity to review and clarify their input during the sessions to ensure accuracy and reflect their true intentions. For a detailed description of the ethical procedures, including the informed consent forms, anonymization methods, and data security protocols, please refer to Appendix 1 and Appendix 2

3.4 Data Analysis Methods

This study uses a mixed-methods approach to data analysis in order to guarantee a thorough and trustworthy assessment of the user experience (UX) of the decentralized application (dApp). This section describes how the quantitative and qualitative data gathered during the two usability testing rounds were analyzed.

3.4.1 Quantitative Data Analysis

Quantitative data, collected through task-based metrics such as task success rates, task completion times, and System Usability Scale (SUS) scores (as

introduced in Chapter 2.4.1: Usability Evaluation Methods), were analyzed using descriptive statistics to evaluate usability performance and identify trends or improvements between the two rounds of testing.

- **Descriptive Statistics:**

Task Success Rate: The percentage of successfully completed tasks was calculated to assess the functionality of the platform. A higher success rate in Round 2 compared to Round 1 would indicate improved usability.

Task Completion Time: The average time taken to complete each task was calculated. Reduced completion times in Round 2 would suggest increased efficiency and ease of use.

SUS Scores: SUS scores from both rounds were averaged to generate usability benchmarks. Scores were compared to interpret user satisfaction and identify significant differences resulting from UX optimizations.

- **Comparative Analysis:**

Paired comparisons were conducted to evaluate differences in task success rates, task completion times, and SUS scores between round 1 and round 2.

- **Performance Metrics Visualization:**

The results of the quantitative analysis were presented in tables and charts to provide clear visual comparisons of usability performance across the two rounds.

3.4.2 Qualitative Data Analysis

Qualitative data from think-aloud protocols, screen recordings, and semi-structured interviews were systematically analyzed to uncover deeper insights into user experiences, perceptions, and challenges. The analysis process involved the following steps, as informed by qualitative analysis principles outlined by Taylor-Powell and Renner (2003):

- **Thematic Analysis:**

Transcripts of interviews and think-aloud sessions were coded into recurrent themes, including satisfaction with transaction feedback, privacy concerns, and navigation difficulties, using a methodical approach to classify and interpret narrative data. In order to comprehend user annoyances and potential areas for development, Taylor-Powell and Renner stress the significance of finding patterns and themes in the data (Taylor-Powell & Renner, 2003).

- **Content Analysis:**

Observational data from screen recordings were examined to identify behavioral patterns, such as points of hesitation, frequent errors, or confusion during task execution. This aligns with the practice of analyzing narrative data to uncover interactions or incidents that may influence user experience (Taylor-Powell & Renner, 2003).

- **Comparative Thematic Analysis:**

Themes identified in Round 1 were compared with those from Round 2 to evaluate the impact of UX optimizations. This iterative approach of analyzing across data sets ensures that improvements are assessed against initial benchmarks (Taylor-Powell & Renner, 2003).

- **Feedback Categorization:**

User suggestions from interviews were organized into actionable recommendations, following the principle of sorting narrative data into coherent categories to summarize findings and propose practical solutions (Taylor-Powell & Renner, 2003).

This structured approach, incorporating established qualitative analysis methodologies, provided a comprehensive understanding of the usability challenges and informed actionable design interventions.

3.4.3 Integration of Quantitative and Qualitative Data

The platform's usability was thoroughly understood thanks to the integration of quantitative and qualitative data. Measurable standards for assessing performance and spotting patterns were provided by quantitative data, such as task success rates, task completion times, and System Usability Scale (SUS) scores. For evaluating advancements and identifying areas in need of additional optimization, these metrics offered a precise and impartial basis.

The analysis was also enhanced by qualitative data gathered through think-aloud procedures, participant feedback, and observational notes, which provided in-depth understanding of user perceptions, difficulties, and emotional reactions. These insights added context to the quantitative findings, explaining the reasons behind certain usability trends. For instance, the improvement in task success rates was not only reflected in the numbers but also supported by qualitative feedback that highlighted clearer navigation and more intuitive instructions as contributing factors. This integrated approach addressed both the functional and experiential dimensions of user interaction, providing a well-rounded basis for evaluating platform usability. By combining quantitative metrics with qualitative insights, the analysis ensured that improvement recommendations were both data-driven and reflective of user needs.

4. Results and Data Analysis

4.1 First Round Usability Test

The platform's initial design was assessed through the first round of usability testing, which involved watching users interact with a set of pre-established tasks. To guarantee a range of viewpoints and experiences, seven participants in all, representing a combination of Web2 and Web3 users, were enlisted. Understanding the unique requirements and expectations of Web2 and Web3 users, identifying usability problems that impeded user interaction, and establishing baseline metrics for assessment were the objectives of the study. In addition to qualitative information obtained through think-aloud procedures and post-test interviews, the data collection process also included quantitative metrics like task success rates, completion times, and System Usability Scale (SUS) scores. These results gave a thorough grasp of the platform's usability and guided the course of upcoming design enhancements.

4.1.1 Characteristics of Participants in the Round 1 Usability Test

In this section, 7 participants are listed into a table (Table 10.) based on their age, occupation, Web2/Web3 experience, and social media behaviors observed during the usability testing. These participants were selected to reflect a diverse range of user characteristics commonly associated with Web2 and Web3 user populations. While the sample size is limited and may not fully capture the broader demographic diversity of all potential users, the selection process aimed to include individuals with varied technical backgrounds and social media usage patterns to represent key user archetypes.

Table 10. Characteristics of Participants in the Round 1 Usability Test

	Description	Age	Occupation	Web2/Web3 Experience	Social Media Behavior
Participant 1	Enthusiastic about meaningful posts	26-35	Engineer	Web2 Advanced	- I want to see people and things that interest me. - Compared to posting, I share social issues more often. - Hate algorithmic control.
Participant 2	Social media lurker	26-35	Healthcare Industry Worker	Web2 Advanced	- I never post; privacy is very important to me. - Social media platforms are where I search for information. - The current internet landscape makes me worry about information leaks.
Participant 3	Passionate senior social media user	55+	Homemaker	Web2 Intermediate	- Content-rich social media platforms should categorize content by topics. - I like checking out baking recipe posts on social media.
Participant 4	Curious Web3 entrepreneur	18-25	Web3 Entrepreneur	Web3 Advanced	- The purpose of using social media is to see if there's anything funny and to check out what others are up to. - I think the dislike feature is very harsh
Participant 5	Token economy expert	26-35	Blockchain researcher	Web3 Advanced	- When using Dapp platforms, I research their token economies. - I pay attention to potential security threats.

Participant 6	Zero-Knowledge believer	18-25	Student	Web3 Intermediate	- I enjoy exploring Dapp vulnerabilities and find it both interesting and rewarding. - I hope to gain a deeper understanding of Zero-Knowledge applications and their information.
Participant 7	Technology-Sensitive Inspector	26-35	Blockchain Engineer	Web3 Advanced	- When using Dapps, I often unconsciously try to analyze the underlying mechanisms and pay special attention to decentralization. - I don't pay much attention to privacy issues when using social media. - I enjoy interacting with other users on social media.

4.1.2 Task Performance Analysis and UX Optimization Strategies

The first round of usability testing assessed the success rate and average completion time for each predefined task. In addition to quantitative performance metrics, qualitative data were gathered through direct transcriptions of participants' comments and feedback. These qualitative insights provide a deeper understanding of user experiences, highlighting specific challenges and areas of friction.

The following tables present the detailed results for each usability task (see Table 8 for task descriptions), including task-specific performance metrics and participant feedback. These results identify both successful elements and areas requiring improvement within the platform's design and functionality.

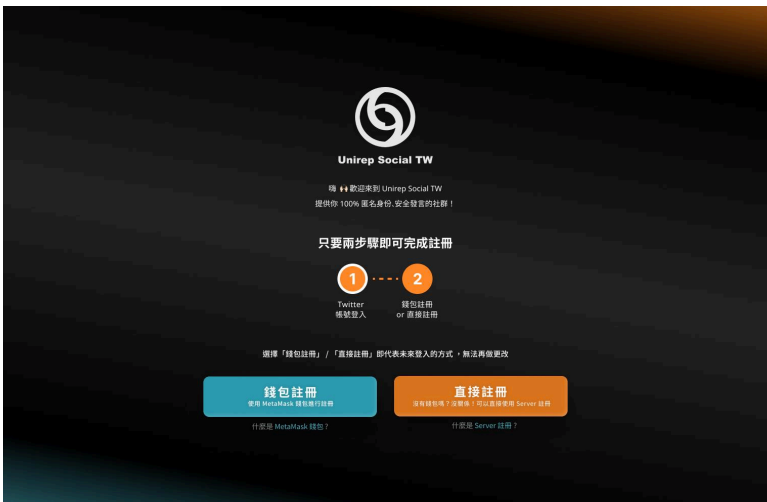
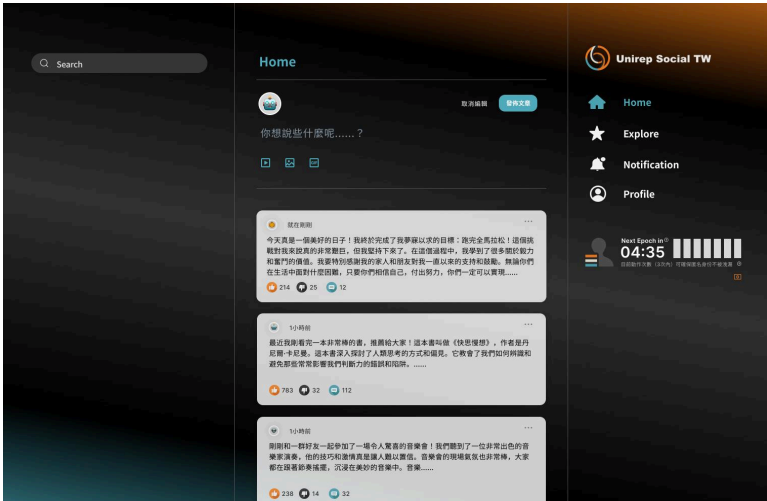
Corresponding UX optimization strategies are proposed to address identified issues and enhance the overall user experience.

4.1.2.1 Task Performance and Participant Feedback of Task 1 - Log in and Explore - Round 1

In this task, participants are asked to complete the registration process and, after successfully registering and logging in, explore the entire website. The objective is to evaluate whether the registration process is smooth, the instructional content is clear, and to capture participants’ initial impressions of the website. The table below shows user interfaces of the task execution process.

Table 11. User Interface of Task 1 - Log in and Explore - Round 1

Description	User Interface
Landing Page	

Registration Page	 The registration page for Unirep Social TW features a dark background with a central logo. Below the logo, it states 'Unirep Social TW' and '提供 100% 匿名身份, 安全堅固的社群!'. It highlights '只要兩步驟即可完成註冊' (Registration can be completed in just two steps) with a progress indicator showing steps 1 (Twitter 帳號登入) and 2 (錢包註冊 or 直接註冊). Two large buttons at the bottom are labeled '錢包註冊' (Wallet Registration) and '直接註冊' (Direct Registration).
Homepage After Login	 The homepage after login shows a dark interface with a search bar at the top left. The main content area displays a feed of posts with text and images. On the right side, there is a sidebar with navigation links: Home, Explore, Notification, and Profile. At the bottom right, a clock shows the time as 04:35.

The following table includes direct feedback and statements from participants during the round 1 usability testing of Task 1, as well as each participant's task completion status and the time taken to complete the task.

Table 12. Task Performance and Participant Feedback of Task 1 - Log in and Explore - Round 1

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
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1 (Web2, 26-35)	Yes	5 minutes 27 seconds	• Logging into X was challenging as I couldn't recall whether I registered via Google or manually. It works fine on mobile, but I often forget my account details when using it on a computer. • After registration, could there be a loading spinner while waiting to enter the homepage? • The first thing I noticed on the homepage was the countdown timer—it feels intimidating. What is it for? • (Referring action counter block) I couldn't understand what "three actions" meant or what actions it referred to.
2 (Web2, 26-35)	Yes	3 minutes 38 seconds	• Why do I need to register with a wallet or directly after logging in with my X account? I expect to go straight to the main screen. • My main confusion is about the functionality of the counter in the bottom-right corner. Since this is already an anonymous platform, why impose a limit on actions within a specific timeframe to avoid exposure?
3 (Web2, 55up)	Yes	1 minute 48 seconds	• I don't understand what the registration progress bar is showing or what it represents. • I don't quite understand what the blue bar on the counter represents. • I feel that everyone's posts cover different topics. • Some topics could be better organized to avoid scattered discussions. With more users, it might become disjointed and hard to integrate.
4 (Web3, 18-25)	Yes	3 minutes 14 seconds	• The Welcome Page feels somewhat like a placeholder or resembles a one-page phishing site. • Direct registration feels like creating a new wallet, leading to the impression that multi-factor authentication is required. • After registering and browsing, the platform feels different from

			expectations. Initially expected a fully anonymous and autonomous space, but confidence dropped by 30% due to the need to follow platform rules for posting.
5 (Web3, 26-35)	Yes	1 minute 32 seconds	• Not sure why Twitter (X) registration is needed—aside from the interface resembling Twitter (X), wondering if there's any connection? • Seeing the explanation of "What is Server Registration," I wonder if a private key signs for me, but it's still anonymous? • The wording of the counter section is unclear, and the meaning of the number "7" (the count bar) is also confusing. • There's no clear explanation of what "epoch" means.
6 (Web3, 18-25)	Yes	4 minutes 34 seconds	• I prefer using "wallet registration" because the wallet ensures uniqueness. • Whenever there's an action, I'd like to see transaction details (or something similar) • (When using "Server registration") I would like to see the signature process.
7 (Web3, 26-35)	Yes	2 minutes 58 seconds	• It feels strange to "register" because it seems like a centralized service. • I initially assumed I needed to connect my wallet and hesitated, wondering why it wasn't linked to my wallet. • I still want to verify my address ID, so I checked the profile expecting to see some form of address, private key, or mnemonic phrase.

The following sections present the usability test analysis for Task 1 - Log in and Explore, focusing separately on the Web2 and Web3 participant groups. The analysis highlights the unique challenges, behaviors, and feedback observed within each group, providing a clear comparison of their experiences during the task.

Web2 Participants:

- Unclear why wallet registration is required after registering with an X (Twitter) account. The delay with a blank screen after registration caused confusion, leaving users unsure if the system was frozen or processing the registration.
- Unfamiliar with the concepts of "Epoch" and "Epoch Keys."
- Did not understand the purpose of the countdown timer and "action counter."
- Found the homepage content scattered and lacking organization.

Web3 Participants:

- Uncertain about the connection between the X (Twitter) account and the platform, as the interface closely resembles X.
- Felt that the "registration" process seemed like a centralized service, which contradicts decentralization principles.
- Wanted access to all on-chain data, as well as their account's address ID, private key, or annotations.
- Expected full anonymity but felt disappointed by the need to follow platform rules, which diminished confidence in the platform.

To address the identified issues, this study proposes improvements that are firmly rooted in established UX theories, such as Nielsen's heuristics, ISO 9241-11 usability standards, and research on user-centered design. The proposed strategies focus on improving usability, enhancing user satisfaction, and facilitating the transition from Web2 to Web3 environments.

1. Clarify the Relationship with X (Twitter):

- Provide clear explanations of how X account data is used and the platform's connection to it. This enhances user trust and aligns with the principle of match between system and real world (Nielsen, 1994).

2. Enhance Registration Feedback and Progress Visibility:

- Introduce a loading spinner or progress bar during registration to improve system status visibility and reduce uncertainty (ISO 9241-11, Nielsen, 1994).
- Offer a completion message or feedback notification once the registration process is successful.

3. Explain Core Blockchain Terminologies:

- Add educational tooltips or pop-up guides to explain concepts like “Epoch” and “Epoch Keys,” catering to novice Web2 users transitioning to Web3 (Cai et al., 2018).

4. Display Transaction Hashes and Account Data:

- Provide users with access to transaction hashes, address IDs, and other relevant blockchain data to meet Web3 users' expectations for transparency and control.

5. Simplify Wallet Registration Explanations:

- Clearly differentiate between direct registration and wallet registration processes to reduce cognitive load for new users (Hiremath & Kenchakkanavar, 2016).

6. Increase Developer Transparency:

- Design a developer information section on the platform, including system-related details, to enhance credibility and user trust, particularly for Web3 users who value decentralization and transparency (Patel et al., 2022).

7. Design an Interactive and Detailed Onboarding Process:

- Introduce a step-by-step onboarding flow to explain key features such as the countdown timer, action counter, posting mechanism, random identities, Epoch, and Epoch Keys.
- Incorporate visualized card-style tutorials to help new users understand the platform conceptually. This aligns with the principle of learnability in ISO 9241-11 (Bevan & Carter, 2016).

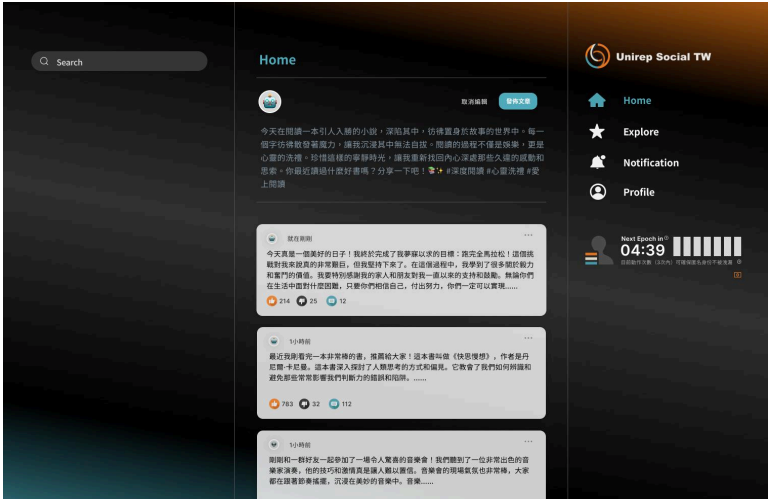
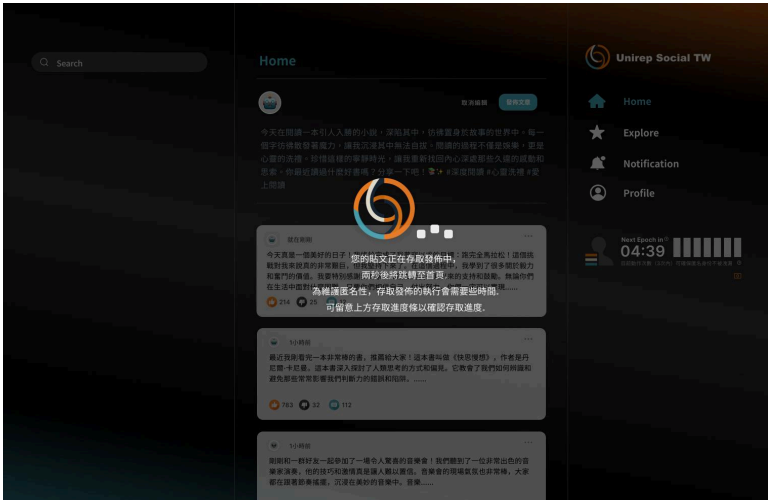
8. Develop a Platform Information Page:

- Create a dedicated section explaining platform mechanisms, including reporting, adjudication, reputation scoring, Epoch concepts, and developer transparency information.
- Address common questions and include a FAQ section to enhance user understanding. Aligns with Nielsen's heuristic of help and documentation (Nielsen, 1994).

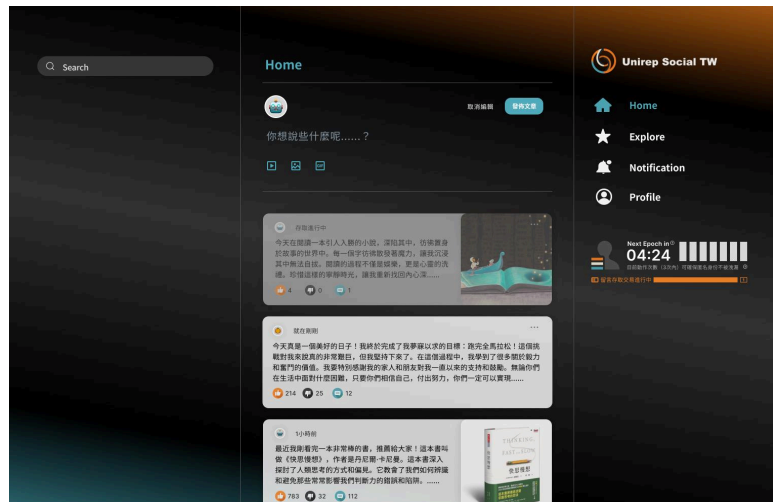
4.1.2.2 Task Performance and Participant Feedback of Task 2 - Publish a Post - Round 1

In Task 2, participants are asked to post a message on Unirep Social Taiwan. The goal is to observe whether the posting feature is easy to locate and whether the process is smooth. Table 13 displays the user interface during the task execution.

Table 13. User Interface of Task 2 - Posting - Round 1

Description	User Interface
Posting Area	
Posting Processing Animation	

Appearance Right
After Posting



The following table includes direct feedback and statements from participants during the round 1 usability testing of Task 2, as well as each participant's task completion status and the time taken to complete the task.

Table 14. Task Performance and Participant Feedback of Task 2 - Publish a Post - Round 1

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	42 seconds	- The posting process takes longer than expected. Is there an estimated completion time? - Why is the post's on-chain progress displayed in the action counter below instead of directly on the post itself?
2 (Web2, 26-35)	Yes	22 seconds	The latest posts are displayed at the top, and I think this sorting method is great.
3 (Web2, 55up)	Yes	2 minutes 22 seconds	- Initially, I couldn't find how to post, but later I discovered it by scrolling up. - Posts still being uploaded to the blockchain appear semi-transparent,

			which feels a bit confusing.
4 (Web3, 18-25)	Yes	1 minutes 02 seconds	• After reading the counter's tooltip, it feels like the three action chances should be used wisely. The countdown timer adds some pressure, like racing against time. • Seeing 'Transaction in Progress' in the counter initially made me think I needed to pay gas fees, but realizing no gas fee steps appeared, I understood it's not required. • Suggests adding a '+' button in the bottom-right corner of the page as a shortcut for creating new posts. • Reading the counter tooltip made me value the three action opportunities, but the countdown timer feels stressful, like racing against time.
5 (Web3, 26-35)	Yes	13 seconds	• The post-publishing transition animation disappears too quickly, making it difficult to fully read the message. • The transaction speed affects my behavior on the platform, making me more cautious about my actions. • I hope others see my avatar change, but I want my own view of the avatar to be easily identifiable for myself.
6 (Web3, 18-25)	Yes	31 seconds	• Would like the option to delete or edit my own posts. • Would like to see the transaction ID. • During the transaction submission process, I'd like to check the cookies to see what information is being stored. • Clicking 'Back' returns to the top of the page instead of the original browsing position, which is inconvenient.
7 (Web3, 26-35)	Yes	37 seconds	• The post-submission transition animation is too quick to read completely. I assumed the transaction hash would be visible once the

			on-chain process was complete. • I would like to know where the proof for the post is located.
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The following sections present the usability test analysis for Task 2 - Publish a Post, focusing separately on the Web2 and Web3 participant groups.

Web2 Participants:

- Unclear Feedback Mechanisms: Web2 participants struggled with understanding the progress of post-publishing. For example, one participant mentioned confusion regarding the semi-transparent state of posts and the absence of real-time progress indicators
- Inadequate Guidance: Some users couldn't immediately identify the posting function (e.g., scrolling to find the input box), indicating issues with discoverability and interface clarity.
- Post-Publishing Progress: Users expressed frustration about the lack of estimated completion times for the on-chain process, leading to uncertainty about whether their actions succeeded.

Web3 Participants:

- Lack of Transaction Details: Advanced Web3 users expected access to transaction hashes or technical details, which were missing during the post-publishing process.
- Interface Feedback: The posting process is slow to upload on-chain, while the transition animations are too fast, preventing users from reading success notifications or verifying the details of their posts.

To address these pain points and improve the overall user experience, the following UX strategies are proposed. These solutions are grounded in established usability

principles and theories, ensuring they cater to both Web2 users' need for clarity and Web3 users' demand for transparency and technical control.

1. Optimize Proofing Speed:

- Improve the on-chain posting process to reduce delays and enhance transaction efficiency. Faster proofing speed ensures a smoother experience, addressing user frustration with slow upload times.
- This aligns with ISO 9241-11 usability principles of efficiency and effectiveness, ensuring system responsiveness and reducing user uncertainty (Bevan & Carter, 2016).

2. Adjust Transition Animation Timing:

- Extend the duration of post-submission animations to five seconds to allow users enough time to read success notifications and verify post details. This addresses Nielsen's heuristic of visibility of system status (Nielsen, 1994), ensuring users receive clear, comprehensible feedback.
- Include a "close" button for users who wish to dismiss the animation early, giving them more control over the interface.

3. Clarify the Action Counter's Messaging:

- Refine the wording of the action counter to clearly explain: What actions are counted and why they are limited, and the relationship between counted actions, user activity, and platform mechanics (rather than linking actions to user identity). Providing transparent explanations aligns with match between system and real world, helping users form accurate mental models (Nielsen, 1994).

4. Educate Users on "On-Chain Transactions":

- Develop tooltips or pop-up guides to explain concepts such as "on-chain transactions," semi-transparent posts, and transaction confirmations.

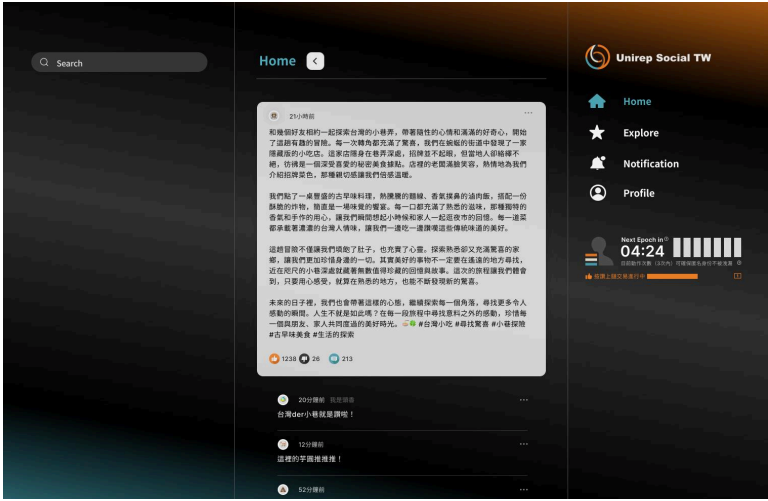
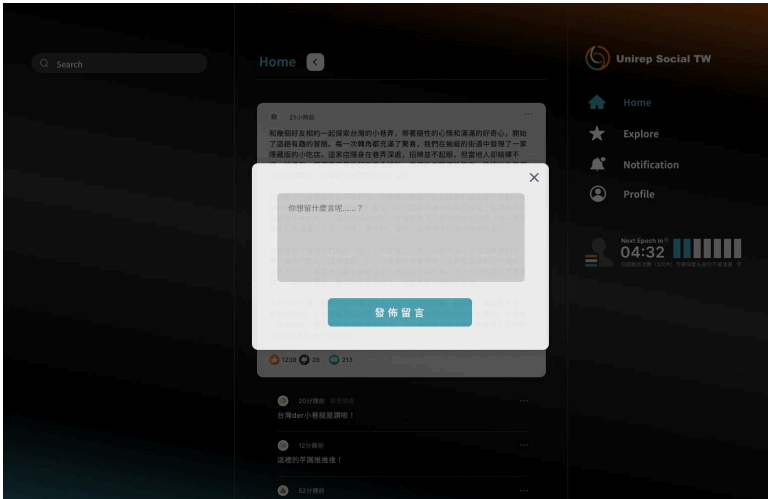
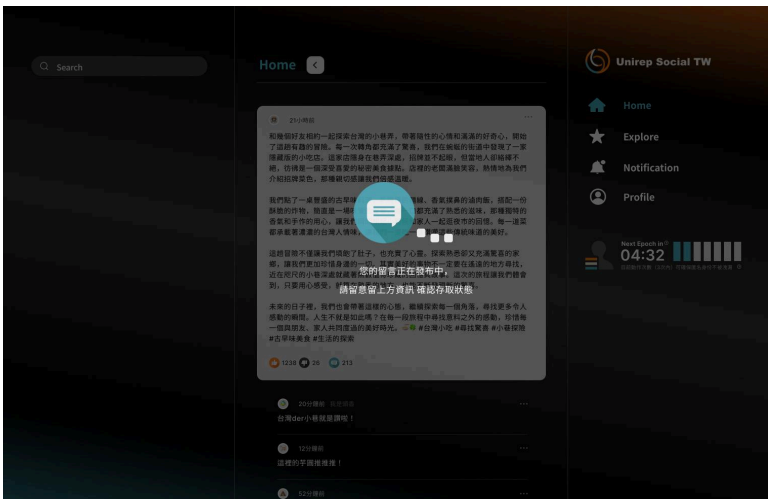
- Include a visual progress indicator or timeline to show each step of the transaction process, making it easier for Web2 users to understand. This follows progressive onboarding principles to reduce the cognitive load for Web2 users transitioning into Web3 environments (Cai et al., 2018; Qasse et al., 2020).

4.1.2.3 Task Performance and Participant Feedback of Task 3 - Interact with Posts (Voting/Comment) - Round 1

In Task 3, participants are asked to browse posts on the platform, select one post to either upvote or downvote, and leave a comment. This task aims to observe whether the upvoting, downvoting, and commenting features and processes require any optimizations. The table below displays the user interfaces during the task execution.

Table 15. User Interface of Task 3 - Interact with Posts (Voting/Comment) - Round 1

Description	User Interface
Upvote/Downvote	 The screenshot displays the 'Home' screen of the 'Unirep Social TW' mobile application. At the top, there is a search bar and navigation icons for Home, Explore, Notification, and Profile. The main content area shows a post from a user named '21小時前' (21 hours ago). The post text is in Chinese and discusses a trip to Taiwan. Below the text is a voting bar with 1238 upvotes and 213 downvotes. The bottom of the screen shows a list of comments, with the first one from '台灣der小糖就是讚!' (Taiwan's little sugar is awesome!).

Appearance After Upvote/Downvote	
Comment	
Comment Processing Animation	

The table below presents participants' direct feedback and statements from Round 1 usability testing of Task 3, along with their task completion status and the time required to complete the task.

Table 16. Task Performance and Participant Feedback of Task 3 - Interact with Posts (Voting/Comment) - Round 1

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	1 minute 07 seconds	• I'm not a fan of the dislike button on social platforms; I'd prefer to see a share button instead. • I can't click the like button. It seems very slow, doesn't it? • Why does the profile picture keep changing? Aren't these posts from the same person? These are all my posts—why is it different?
2 (Web2, 26-35)	Yes	2 minutes 35 seconds	• I feel the overall speed is quite slow. I'm not sure if it's my network, but the posting process takes longer than platforms like Facebook. • I think comments should have a text bar below where users can directly type and submit their replies. • When liking a post, I feel the cursor provides no specific feedback when hovering over the button.
3 (Web2, 55up)	No	-	• Unable to find how to leave a comment.
4 (Web3, 18-25)	Yes	2 minutes 13 seconds	• Commenting is indirect and unintuitive. There should be a visible comment section at the bottom of the post for direct input. • Liking is laggy with poor feedback. Surprised to find that commenting also requires a transaction.

			• With this speed, engaging in an argument feels too delayed to be effective. • Dislike button feels too harsh.
5 (Web3, 26-35)	Yes	58 seconds	• Would prefer to comment directly on the homepage. Clicking the comment icon redirects to the post details page, requiring an additional step to comment. • The commenting process feels unintuitive. • Noticed that the avatar after commenting was different from the one used when posting. • Expected a highlight or frame to identify my comment after clicking 'View Comment' in the counter section's 'Comment Transaction Successful,' but had to manually locate it instead.
6 (Web3, 18-25)	Yes	2 minutes 40 seconds	• When attempting to delete a comment, even though the transaction was completed, the comment was not removed from the front-end interface.
7 (Web3, 26-35)	Yes	2 minutes 21 seconds	• While attempting to comment, clicking the icon navigates to another layer, requiring an additional click on the comment icon to proceed.

The following sections present the usability test analysis for Task 3 - Browse, Vote, and Comment on a Post, focusing separately on the Web2 and Web3 participant groups.

Web2 Participants:

- Users experienced delays when liking or commenting on posts. They often noted a lack of responsive feedback, such as visual cues (e.g., button animations) indicating the action was processed.

- Participants struggled to identify where and how to leave a comment. The comment function lacked visibility and accessibility, which frustrated users.
- Comparing the platform's response time unfavorably with centralized platforms like Facebook, particularly during interactions like liking posts.

Web3 Participants:

- Web3 users experienced delays and lack of clear feedback during actions like commenting or liking posts.
- Visual inconsistencies, such as avatar mismatches and unclear indicators of completed actions, caused confusion.
- On-chain interaction delays frustrated users, impacting overall usability and satisfaction.

1. Enhance Feedback Responsiveness:

- Introduce real-time visual feedback (e.g., button animations, progress indicators) when liking or commenting to reassure users that their actions are processed.
- Theoretical Basis: Nielsen's Usability Heuristics advocate for "visibility of system status," ensuring users receive immediate and understandable feedback during interactions.

2. Improve On-Chain Interaction Speeds:

- Optimize blockchain transactions to reduce delays, especially for high-frequency actions like voting or commenting. This aligns with ISO 9241-11 by enhancing effectiveness and efficiency, minimizing user frustration caused by latency.

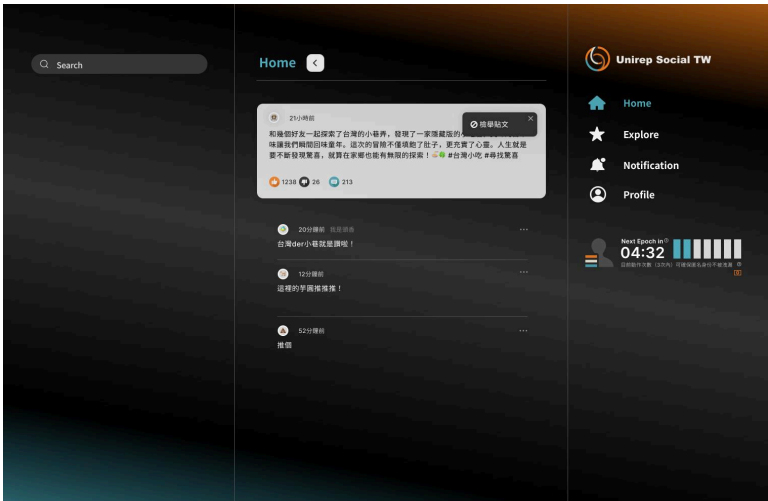
3. Educate Users on On-Chain Processes:

- Implement tooltips or onboarding guides to educate users about the reasons behind on-chain interaction delays, emphasizing how these processes enhance data security and transparency. This approach aligns with ISO 9241-11 by improving effectiveness and efficiency, thereby reducing user frustration caused by latency.

4.1.2.4 Task Performance and Participant Feedback of Task 4 - Report a Post - Round 1

In Task 3, participants will browse posts on the platform and select one to report. Through the testing process, we aim to evaluate the smoothness of the reporting flow and whether participants can understand the purpose and significance of reporting from the written instructions. The table below showcases the user interface of the task execution screen.

Table 17. User Interface of Task 4 - Report a Post - Round 1

Description	User Interface
Report Button	

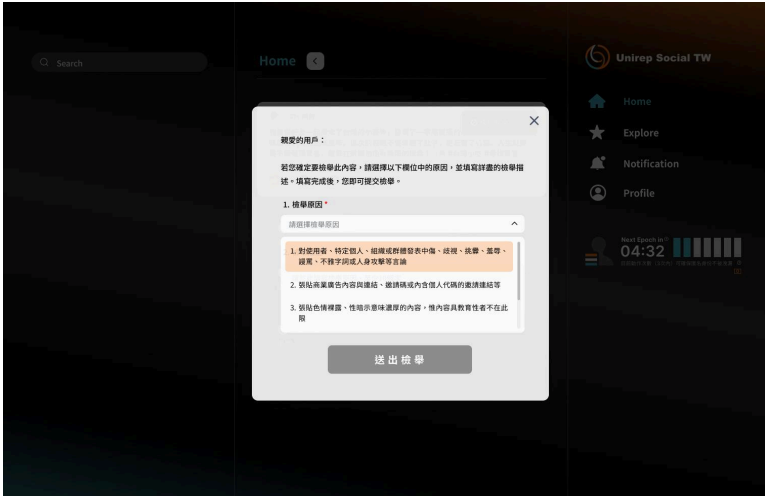
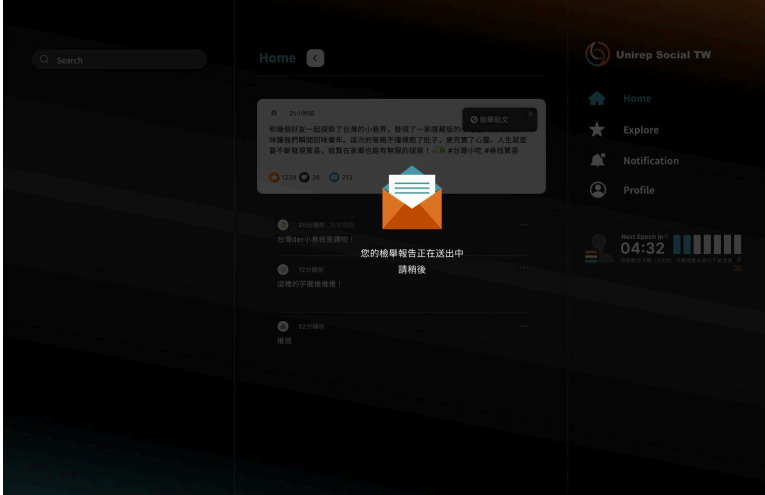
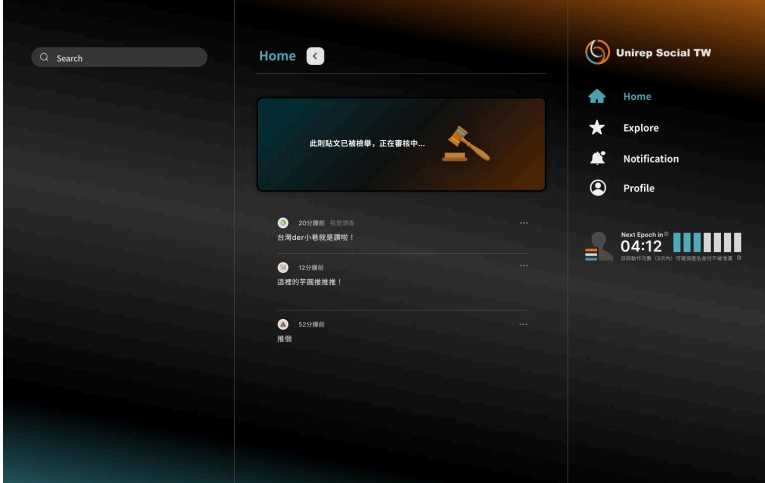
Filling Out the Report Form	
Submit Report	
Reported Content Temporarily Blocked, Pending Review	

Table 18. Task Performance and Participant Feedback of Task 4 - Report a Post - Round 1

Partici -pant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	3 minutes 01 second	• After submitting a report, it would be helpful if the animation indicated an estimated waiting time, so I don't have to wait here unnecessarily. • It's strange that reported content is immediately hidden and completely inaccessible unless you take extra steps to view it. This setup seems vulnerable to malicious reporting.
2 (Web2, 26-35)	Yes	1 minute 52 seconds	• The progress bar for the report gives a sense that the report is being taken seriously, unlike on platforms like Facebook, where reporting feels like sending canned messages with no real review.
3 (Web2, 55up)	Yes	8 minutes 49 seconds	• Forgot the content of the post I intended to report when the report popup appeared. • Unclear how long it takes for the report to be processed after submitting.
4 (Web3, 18-25)	Yes	3 minutes 22 seconds	• Requiring a minimum of ten words for the explanation discourages me from reporting. • During the wait time after submitting a report, I feel uncertain and restricted, which makes me hesitant to report again in the future.
5 (Web3, 26-35)	Yes	1 minute 26 seconds	• Being stuck on the submission screen while the report is being sent feels inconsistent with the smoother transitions of other actions, making it seem unnecessary to be held up on this step. • Initially unaware that reports are

			judged by platform users. Now realizing this, I wish I had written the content more carefully. It feels too exposed compared to submitting to a centralized platform, where more aggressive wording might be acceptable. • (Upon seeing the error message after submitting the report reason) It needs to be at least ten characters?!
6 (Web3, 18-25)	Yes	57 seconds	• Felt that submitting a report took too long and couldn't exit the screen during the process. • Upon entering the homepage, noticed many posts marked as reported. Felt that immediately blocking posts after they are reported seems inappropriate. • When reporting a post, users want to see the content they are reporting, as they may forget the details midway through the process.
7 (Web3, 26-35)	Yes	3 minutes 11 seconds	• After submitting a report, users are unsure why they cannot exit the screen. If the process takes longer, they may feel compelled to refresh the page. • Is it possible to cancel a report? Being able to review and retract submitted reports would improve the experience.

The following section presents the usability test analysis for Task 4 - Report a Post. It explores the unique challenges faced by Web2 and Web3 users, emphasizing their behaviors and feedback during the reporting process. The analysis provides a comparative overview of user experiences and identifies opportunities for improving the reporting flow.

Web2 Participants:

- Lack of clarity about what happens after a report is submitted.
- Confusion about why reported content is immediately hidden and inaccessible.

Web3 Participants:

- Mandatory minimum word count for the report explanation discourages participation.
- Uncertainty and restricted action during the report submission process lead to hesitation in future reporting.

To address the identified usability challenges and enhance the reporting process, the following UX strategies are suggested. These recommendations are designed to balance Web2 users' expectations for simplicity with Web3 users' needs for transparency and control, ensuring a seamless reporting experience..

1. Improve Access to Reported Content:

- Allow users to view reported content with clear "pending review" labels, aligning with ISO 9241-11 to maintain effectiveness and reduce user frustration with task outcomes.

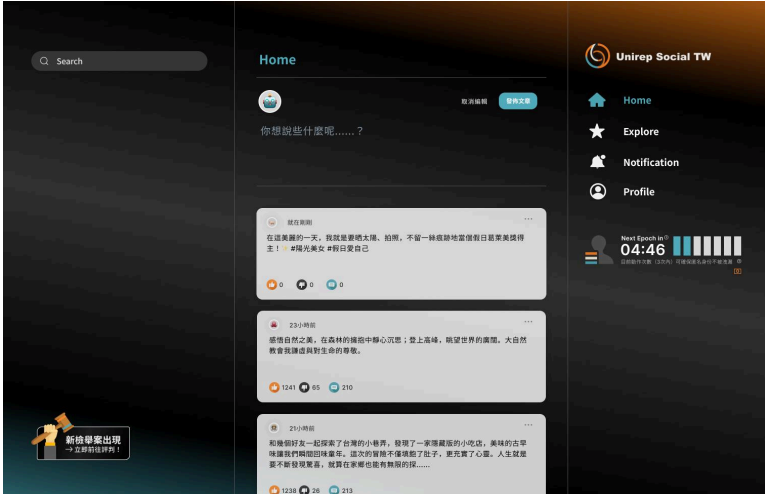
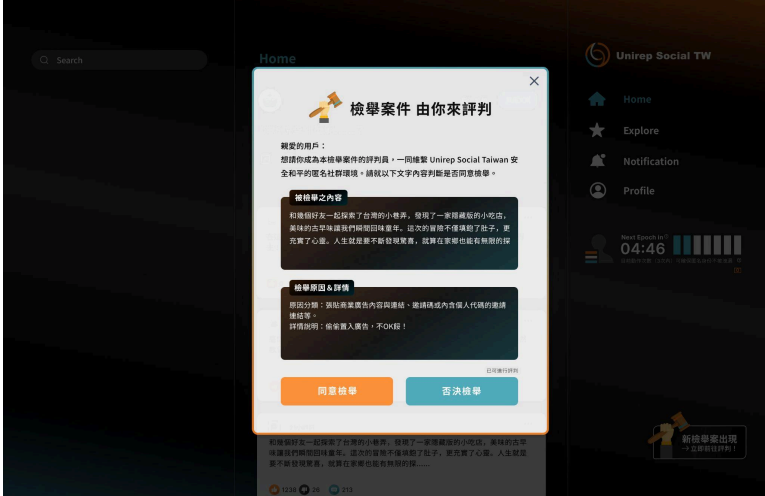
2. Provide Immediate Feedback Post-Submission:

- Add an animation or progress bar with an estimated processing time to reduce uncertainty, aligning with Nielsen's "visibility of system status" to keep users informed about ongoing processes.

4.1.2.5 Task Performance and Participant Feedback of Task 5 - Adjudicate Reports - Round 1

In Task 5, participants are asked to assist in adjudicating reported cases. The goal is to evaluate whether participants understand the purpose of adjudicating reports and to observe the overall smoothness of the user experience. The following two tables present the user interface for Task 5 and the usability testing observations along with participant feedback.

Table 19. User Interface of Task 5 - Adjudicate Reports - Round 1

Description	User Interface
"Assist in Adjudicate Reports" button appears.	
Content of "Assist in Adjudicate Reports"	

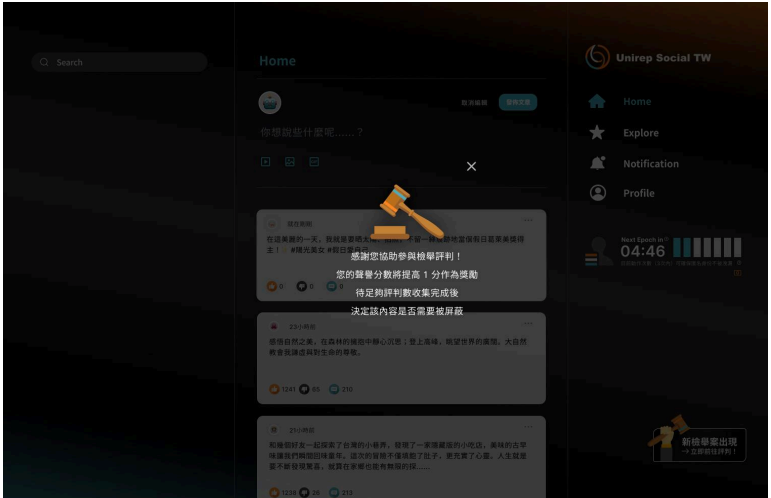
Submit Adjudicate Reports	
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Table 20. Task Performance and Participant Feedback of Task 5 - Adjudicate Reports - Round 1

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	2 minutes 14 seconds	- The report mechanism involves platform users reviewing reports, but the process lacks transparency. There are no clear rules or explanations, even during registration, making the system feel opaque and unclear. - It feels like there should be a notification in the "notification menu" indicating that my reputation score has increased by one (for assisting in adjudication)
2 (Web2, 26-35)	Yes	16 seconds	- When a new report appears, the "Assist with Judgement" button stays visible. I thought it would disappear after a few seconds, but it doesn't. I think it should just serve as a brief prompt and then fade out. - I find the "Assist with Judgement" info a bit strange. I'm not sure why I was chosen—does every user on this

			platform automatically have this right?
3 (Web2, 55up)	Yes	1 minute 18 seconds	• Oh, so assisting with report judgments earns me one reputation point!?
4 (Web3, 18-25)	Yes	1 minutes 02 seconds	• I feel like I'm being forced to act as a judge, and it's really annoying. • It feels like I have to start working as soon as I click this "Assist with Judgement" button, and I'm worried about encountering disturbing content. I also assumed there would be many cases waiting for judgment. • It seems like it's randomly assigned to five users. After judging, I'd like to see the voting results.
5 (Web3, 26-35)	Yes	30 seconds	• I originally thought it ("Assist with Judgement" button) was just a pop-up notification. • I don't really understand what the reputation points are for.
6 (Web3, 18-25)	Yes	1 minute 18 seconds	• I don't understand why only five judgments are needed; it feels too few for a community. • I don't know what reputation points are or why approving or rejecting earns them. What if I'm unintentionally helping someone do harm? • I hope everyone can see what happens during the review process. The review process should be more transparent. • I'd like to see the judgment records, simply out of curiosity.
7 (Web3, 26-35)	Yes	54 seconds	• I think the number of five judgments is fine. • I think it's not ideal if the judgments are controlled by only a few highly active users. • I feel like there are many reported posts that don't show up for me to review.

			• I want to know who reviews the reported posts. • I'd like to know the outcome of my judgment. • After completing a review, I'd like to review other reported posts. It seems like I should be able to, especially since there are still many reported posts visible on the page.
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The usability test analysis for Task 5 - Adjudicate Reports is shown in the section that follows. It examines the particular difficulties that Web2 and Web3 users encounter, focusing on their actions and comments throughout the adjudication procedure. The analysis highlights areas for flow improvement and offers a comparative overview of user experiences.

Web2 Participants:

- Lack of transparency in how the adjudication process works.
- Users unaware of the role and impact of reputation points.

Web3 Participants:

- Dissatisfaction with being randomly assigned adjudication tasks without choice.
- Concern over the low number of judgments needed for decision-making.

To improve the adjudication experience and resolve the challenges highlighted in the testing phase, the following UX strategies are proposed. These solutions aim to meet Web2 users' desire for clarity and Web3 users' expectations for fairness and transparency within the platform.

1. Educate Users on Adjudication:

- Include a tooltip or onboarding guide explaining the adjudication process and the purpose of reputation points, aligning with Nielsen's "help and documentation" to ensure users understand system functionality (Nielsen, 1994).

2. Increase User Autonomy in Adjudication:

- Allow users to select adjudication tasks voluntarily rather than assigning them randomly, aligning with ISO 9241-11 to enhance user satisfaction through increased task flexibility (ISO, 1998).

3. Enhance Transparency in Adjudication Results:

- Display collective judgment outcomes and show how reputation points are allocated, supporting the Technology Acceptance Model (TAM) principle of perceived usefulness (Davis, 1989).

4.1.2.6 Task Performance and Participant Feedback of Task 6 - View Reputation and History - Round 1

In Task 5, participants assist in adjudicating reported cases, earning one reputation point for their contribution. Subsequently, in Task 6, participants are asked to review their reputation score and examine their past activity records. The following two tables present the user interface for Task 6 and the usability testing feedback and observation records collected during the task.

Table 21. User Interface of Task 6 - View Reputation and History - Round 1

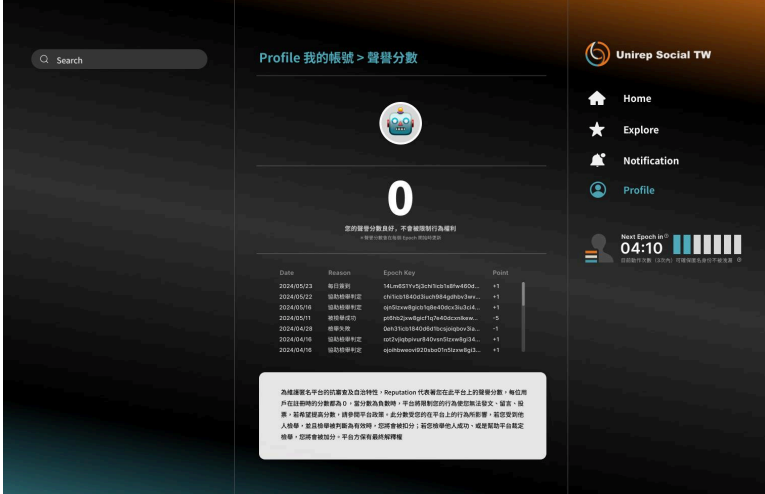
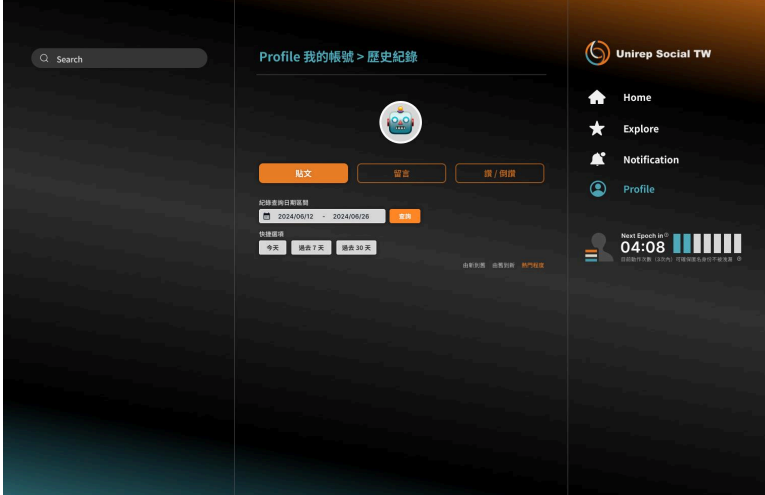
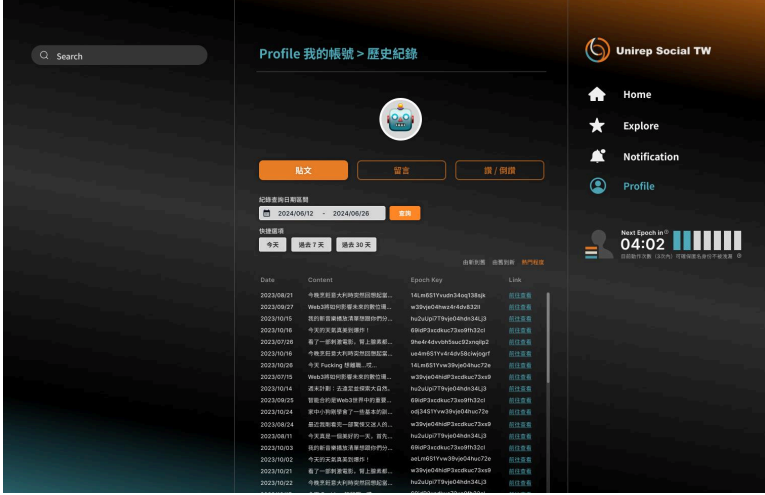
Description	User Interface
Reputation Score Page	
History Records Page	
History Records Search Results	

Table 22. Task Performance and Participant Feedback of Task 6 - View Reputation and History - Round 1

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	58 seconds	- Is this (the 🤖 on the profile page) my profile picture? If it is, why does it take up so much space? - If I'm supposed to refer to the platform policy to improve my score, I'd like to know what it is too. Why wasn't I informed about the platform policy when I joined?
2 (Web2, 26-35)	Yes	35 seconds	- The main difference from other anonymous platforms is the rewards and reputation score system. Since it uses blockchain technology, which many people don't fully understand, it might feel like its anonymity is better—truly anonymous. - When looking for the reputation score records, I have to click "Today" for them to show. Shouldn't it display everything by default? - What actions result in point deductions or additions could be explained in a separate set of rules. This would make the system more structured and help reduce irrational comments, leading to more meaningful discussions. - My reputation score updates only after waiting for a countdown, which feels a bit inconvenient. It should update in real time.
3 (Web2, 55up)	Yes	2 minutes 17 seconds	- I expect that clicking the "Search" button will display all posts at once, instead of showing them one by one. - What does an Epoch Key mean?
4	Yes	37 seconds	(On the history record query page)

(Web3, 18-25)			It's quite hard to understand since the titles are a mix of Mandarin and English, creating a sense of inconsistency. • When pressing the back button, the previously retrieved records are not retained, and I have to search again each time. • "The platform reserves the right to final interpretation" sounds very centralized, which is different from what I expected.
5 (Web3, 26-35)	Yes	7 seconds	• I can't find the platform policy. I would expect it to explain how to increase reputation points. • I'd like to study how the platform's tokenomics work and also explore potential vulnerabilities for backdoor attacks. • I hope the explanation box for the reputation score mechanism is placed higher up on the page.
6 (Web3, 18-25)	Yes	8 seconds	• I'd like to see the platform policy. In it, I'd expect to find information on how judges are selected and how many likes are needed to earn reputation points. • There could be user information, like the user ID, displayed below the profile picture because it feels a bit empty.
7 (Web3, 26-35)	Yes	24 seconds	• In the profile, accessing past records is quite intuitive. Being able to switch and view different types of records is pretty nice. • I wonder if reputation points might lead to an airdrop? • I would like to be able to see the content of my own posts that have been reported.

The usability test findings for Task 6 - View Reputation and History are presented in this section. By analyzing the interactions and feedback of Web2 and Web3 participants, this section sheds light on their experiences with viewing and interpreting reputation scores and historical records, as well as the usability issues encountered.

Web2 Participants:

- Difficulty understanding the significance of reputation scores and the actions that influence them.
- Confusion with delayed updates to reputation scores.

Web3 Participants:

- Challenges with mixed-language interfaces causing inconsistency.
- Inability to retain previous search results when navigating back.

To enhance the usability of viewing reputation scores and historical records, the following UX optimizations are proposed. These strategies are grounded in usability theories to address Web2 users' need for straightforward navigation and Web3 users' preference for system transparency and consistency.

1. Simplify Reputation Scoring Explanation:

- Include a clear and prominent section explaining how reputation scores are calculated and their implications, aligning with Nielsen's "match between system and the real world" to help users align system expectations with outcomes (Nielsen, 1994).

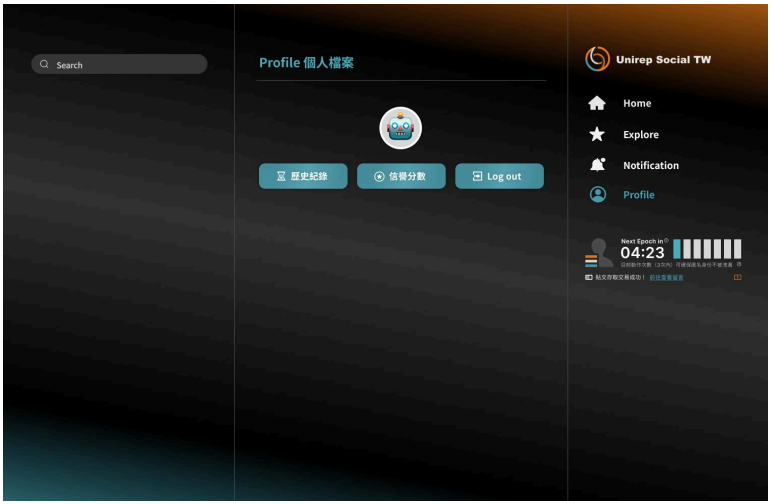
2. Increase User Autonomy in Adjudication:

- Standardize language usage and ensure seamless transitions between query and navigation states, emphasizing consistency and error prevention as outlined in ISO 9241-11 (ISO, 1998).

4.1.2.7 Task Performance and Participant Feedback of Task 7 - Log out - Round 1

In Task 7, participants are asked to find the method to log out and review the text in the logout confirmation popup to determine if it is clear and understandable. The following two tables present the user interface for Task 7 and the usability feedback and observation records from participants during the task.

Table 23. User Interface of Task 7 - Log out - Round 1

Description	User Interface
Profile Page with a Logout Button	

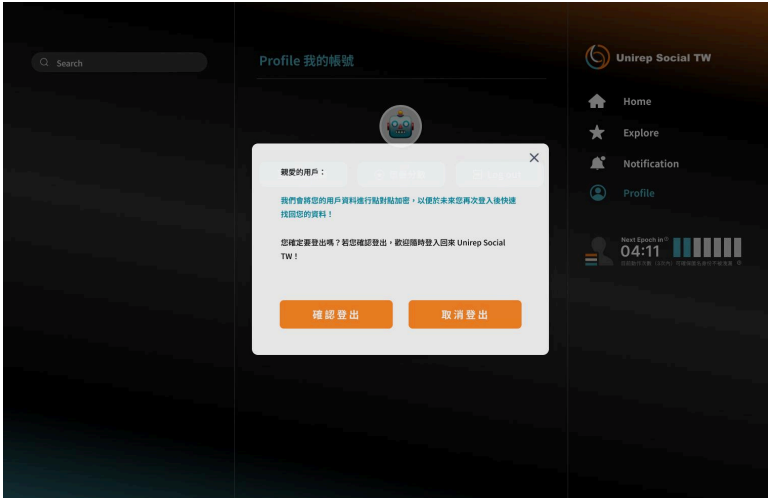
Logout Confirmation Popup	
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Table 24. Task Performance and Participant Feedback of Task 7 - Logout - Round 1

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	20 seconds	-
2 (Web2, 26-35)	Yes	19 seconds	I feel like I don't understand the point-to-point encryption part. For general users, it could just be referred to as "encryption" since the technical details might be too complex to grasp.
3 (Web2, 55up)	Yes	1 minute 13 seconds	-
4 (Web3, 18-25)	Yes	17 seconds	(When reading the logout confirmation text) It gives a feeling of being tracked, but the point-to-point encryption also seems trustworthy.
5 (Web3,	Yes	19 seconds	(On the logout confirmation page) I'm wondering what key is used for

26-35)			encryption and feeling a bit unsure about the point-to-point encryption. I think there should be an explanation, as I'd like to understand the underlying mechanism.
6 (Web3, 18-25)	Yes	25 seconds	-
7 (Web3, 26-35)	Yes	26 seconds	-

This section details the usability test analysis for Task 7 - Log Out. The focus is on understanding the behaviors, feedback, and challenges faced by Web2 and Web3 users during the logout process. The analysis underscores the usability barriers and proposes pathways for a smoother logout experience.

Web2 Participants:

- Some participants found the text in the logout confirmation popup unclear or overly technical, particularly regarding encryption-related terminology.
- Difficulty understanding the purpose of the logout process or its implications on session data.

Web3 Participants:

- Participants were unsure about the mechanism and purpose of the encryption mentioned in the confirmation popup.
- The logout process raised concerns about the security implications, with users expressing a desire for additional explanations or context.

To streamline the logout process and address the usability issues observed, the following UX strategies are recommended. These solutions focus on improving

clarity for Web2 users while maintaining the technical integrity and reliability expected by Web3 users.

1. Simplify Logout Confirmation Text:

- Replace technical jargon like "point-to-point encryption" with user-friendly terms such as "secure encryption," aligning with Nielsen's heuristic of "match between system and the real world" to ensure system language meets user expectations and understanding (Nielsen, 1994).

2. Provide Contextual Information:

- Include a concise explanation in the confirmation popup about post-logout actions, such as session clearance and data security, aligning with ISO 9241-11 to enhance effectiveness and user satisfaction by providing the necessary information for task completion (ISO, 1998).

3. Enhance Encryption Transparency:

- Provide an optional tooltip or link with detailed information about the encryption mechanism, aligning with TAM principles of perceived usefulness and ease of use to enhance user trust and adoption (Davis, 1989).

4.1.2.8 Round 1 Usability Testing Quantitative Results: Task Success Rates, Completion Times, and SUS Scores

The quantitative findings from the initial usability testing round shed light on participant opinions of the platform's usability as well as task performance. The efficacy, efficiency, and general satisfaction of the platform are evaluated by these metrics, which include task success rates, average completion times, and System Usability Scale (SUS) scores.

Table 25. Round 1 Usability Testing Results: Task Success Rates and Completion Times

Task	Success Rate	Average Completion Time
Task 1: Log in and Explore	100%	3 minutes 33 seconds
Task 2: Publish a Post	100%	37 seconds
Task 3: Interact with Posts (Like/Comment)	86%	1 minute 58 seconds
Task 4: Report a Post	100%	3 minutes 1 second
Task 5: Adjudicate Reports	100%	1 minute 19 seconds
Task 6: View Reputation and History	100%	57 seconds
Task 7: Logout	100%	22 seconds

Table 26. Round 1 Individual Participant SUS Scores and Average Score

	Partici -pant 1.	Partici -pant 2.	Partici -pant 3.	Partici -pant 4.	Partici -pant 5.	Partici -pant 6.	Partici -pant 7.	Avera -ge
Round 1 SUS Score	60	50	55	55	62.5	72.5	80	62.14

- **Task Success Rates**

The task success rate provides a clear indicator of how effectively participants were able to complete specific tasks during the usability testing. For Round 1, the majority of tasks demonstrated high success rates, with five out of seven tasks achieving a perfect 100% success rate. Task 3 (“Interact with Posts”) had a slightly lower success rate at **86%**, indicating usability challenges in this area.

The consistently high success rates across most tasks demonstrate that participants were generally able to complete the assigned actions. However, the reduced success rate for Task 3 suggests usability barriers related to interacting with posts, particularly in identifying and using the commenting features.

- **Task Completion Times**

Task completion times were recorded to assess the efficiency of the platform. The results reveal that simpler tasks, such as logging out, had shorter completion times, while more complex tasks requiring interaction or cognitive processing, such as reporting posts, took significantly longer.

These results highlight that tasks with higher interaction complexity, such as Task 3 and Task 4, required more time to complete. This suggests areas where task flows or interface design could be optimized to improve efficiency.

- **SUS Scores**

The System Usability Scale (SUS) was employed to assess participants' perceptions of the platform's overall usability. The average SUS score for Round 1 was 62.14, with individual scores ranging from 50 to 80. According to Bangor, Kortum, and Miller's (2009) interpretative framework, this score falls within the "Marginal High" range, corresponding to an adjective rating of "OK" and a grade of C.

The average SUS score of 62.14 can be interpreted using the established frameworks for usability evaluation. From the perspective of adjective ratings, this score corresponds to the label of "OK." While this indicates that the platform is usable, it suggests a lack of intuitive design and seamless interaction, which may lead to user frustration during more complex tasks.

When viewed through the lens of acceptability ranges, the score is classified within the "Marginal High" category. This classification signifies that the platform meets basic usability requirements but falls short of achieving a fully acceptable standard. Users may find the platform adequate for essential functions but experience noticeable limitations that hinder a smooth user experience.

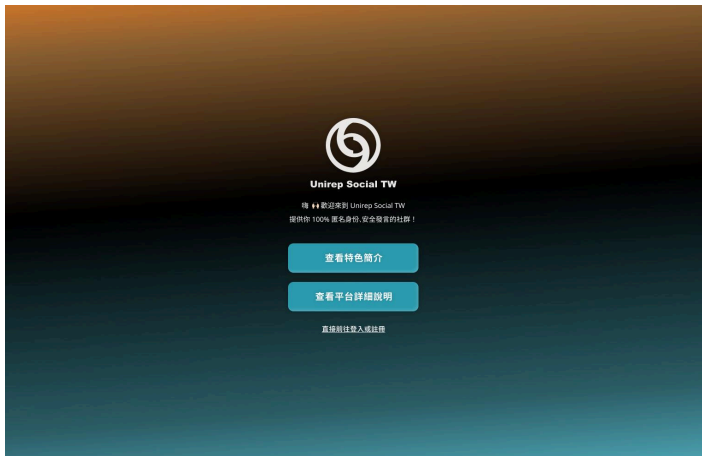
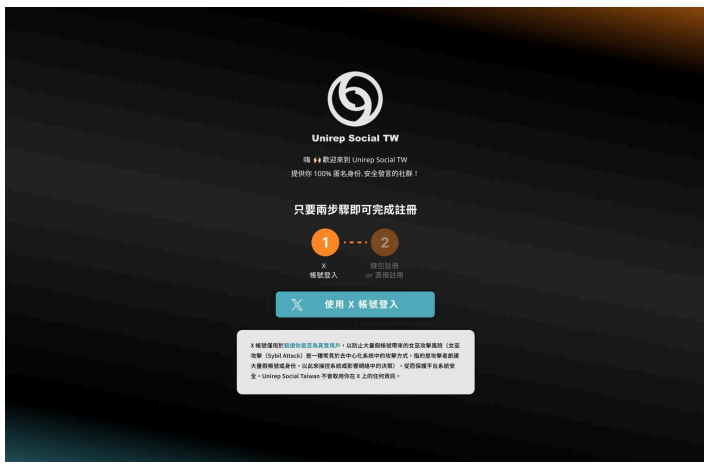
Finally, according to the grading scale, a score of 62.14 equates to a grade of C. This grade reflects an average level of usability, where users are able to complete tasks but encounter friction points that detract from overall satisfaction. Improvements in task flow, feedback mechanisms, and interface design are needed to elevate the platform's usability to a higher grade, such as B or A, which would align with a "Good" or "Excellent" user experience.

The quantitative results from Round 1 usability testing provide valuable insights into the platform's strengths and weaknesses. While the high task success rates and some "Acceptable" SUS scores demonstrate a functional baseline, the average SUS score of 62.14 underscores the need for significant improvements to enhance usability and user satisfaction. Addressing identified challenges in subsequent iterations can help raise SUS scores into the "Good" or "Excellent" categories, creating a more seamless and enjoyable user experience for both Web2 and Web3 participants.

4.2 Second Round Usability Test

After completing the collection of qualitative and quantitative data from the Round 1 usability testing, we proposed UX optimization strategies based on the analysis results. The user interface was subsequently refined, leading to a new design iteration. The optimized interface has been integrated into the Unirep Social Taiwan system. Table 27 presents the key improvements in the user interface design along with detailed explanations.

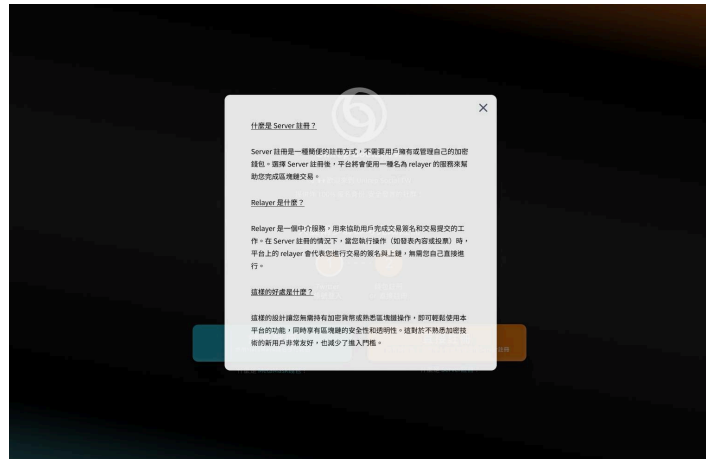
Table 27. User Interface Enhancements and Explanations

Description	User Interface
<u>Landing Page:</u> Added a "View Features Overview" option to allow users to quickly understand the platform's functionalities and highlights. Additionally, a "View Detailed Platform Description" option has been included to provide more comprehensive information about the platform.	
<u>Feature Overview Cards:</u> Provide users with a concise description to give a quick summary of the platform's functionalities and key features.	
<u>Explanation of Using X Account for Registration:</u> Added an explanation detailing why an X account is required to register for a Unirep Social Taiwan account.	

Server Registration

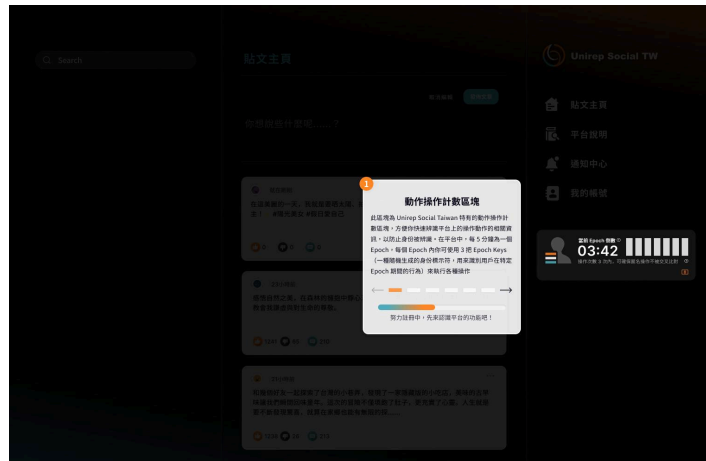
Explanation:

Provided a more detailed explanation of the server registration process and its integration with the on-chain signature mechanism.



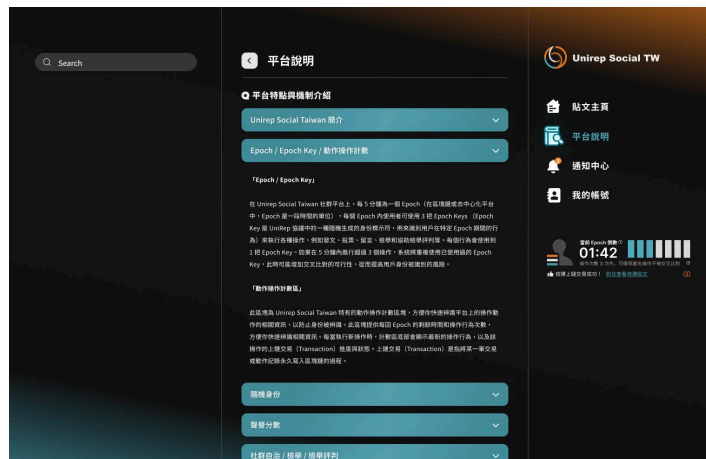
Onboarding Cards:

Introduce the platform's features and sections through onboarding cards with concise explanations, enabling first-time users to quickly familiarize themselves with the platform.



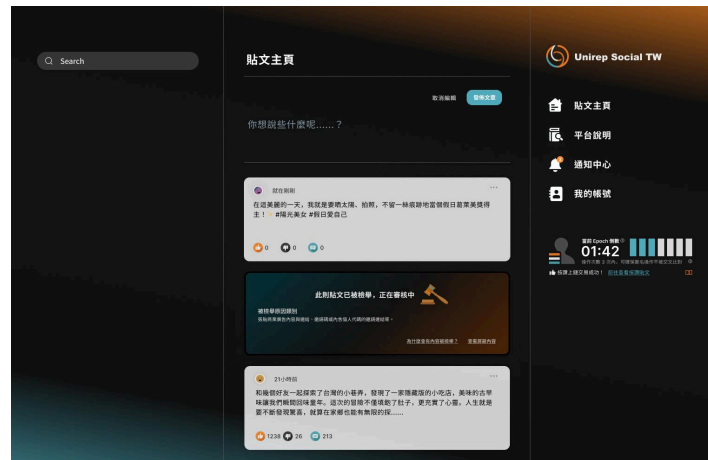
Platform Information Page:

Provides a detailed overview of Unirep Social Taiwan, including an introduction to the platform, its operating mechanism, glossary of terms, feature highlights, explanation of the reporting and adjudication mechanisms, open-source links, platform policies, and a FAQ section.



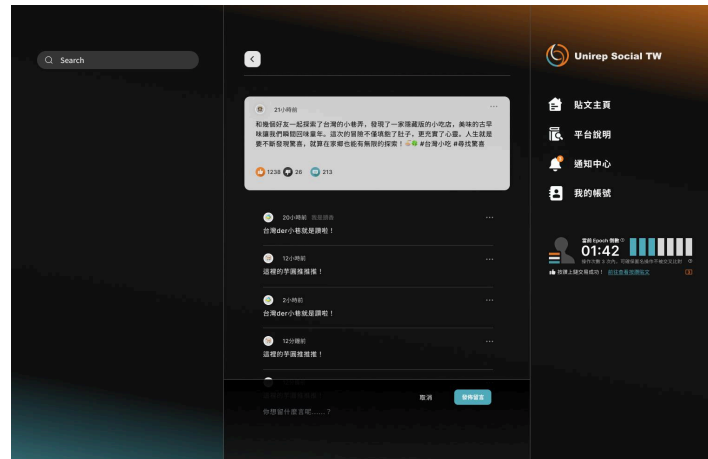
Display Format for Reported Posts Pending Review:

Includes a button to view hidden content and a link explaining why the post was reported.



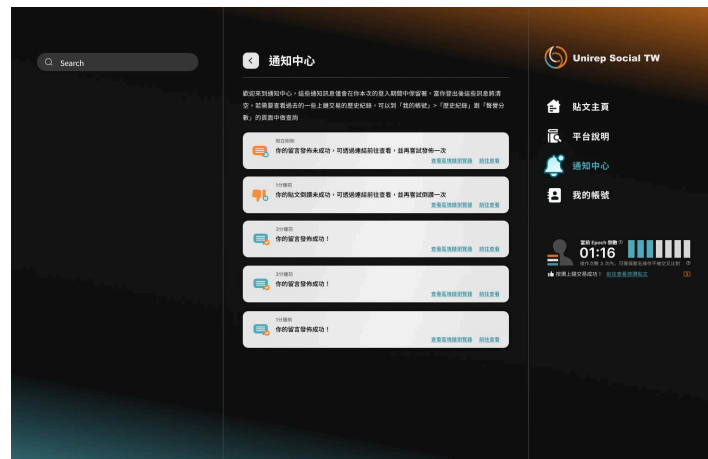
New Comment Section:

Positioned the comment section directly below the post on the page, allowing users to leave comments more conveniently.

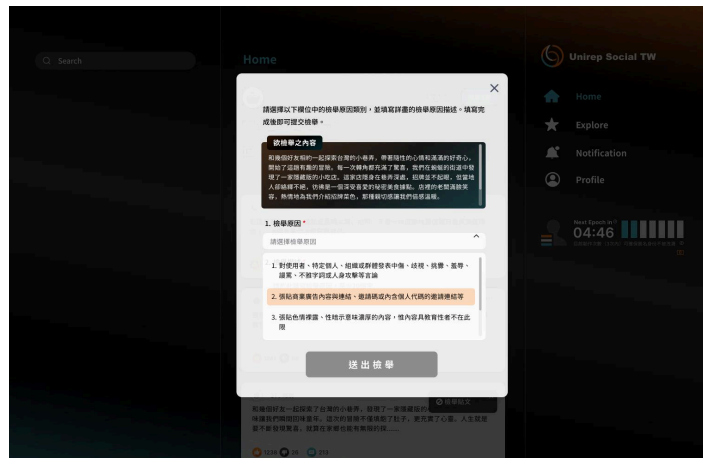


Notification Center:

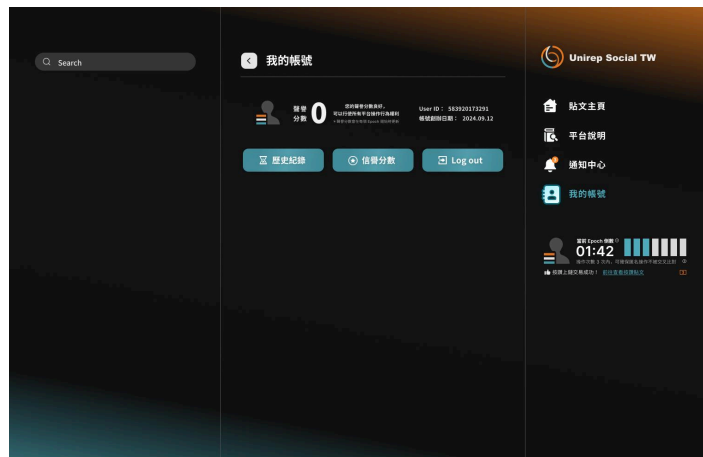
This newly added page provides users with more comprehensive and real-time notifications, including registration success alerts, blockchain transaction status updates, adjudication results, and reputation score changes.



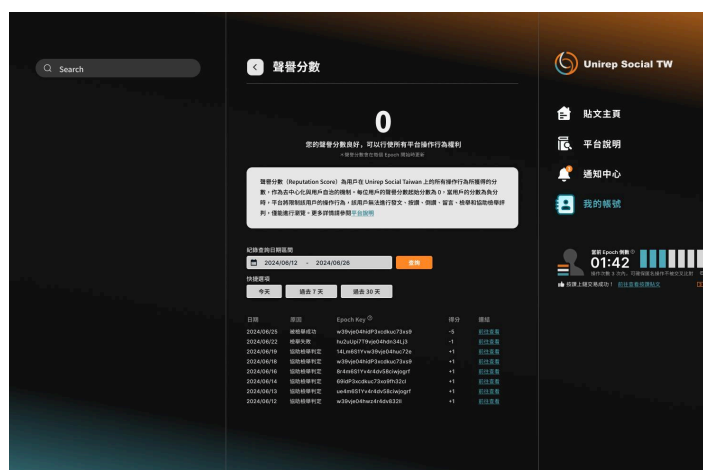
Updated Reporting Form:
Added a field displaying the content being reported, allowing reporters to view the content directly without relying on memory.



My Account:
Updated the information displayed in the "My Account" section, including the addition of User ID, account creation date, and the direct display of reputation score.



Reputation Score:
Revised the introduction to the reputation score and adjusted the priority order of presenting key information. The entire page is now displayed primarily in Mandarin.



While implementing the new iteration, we followed the same participant recruitment process to conduct the second round of usability testing. Subsequently, the tasks and procedures for the second round of usability testing were carried out in alignment with the predefined testing plan.

4.2.1 Characteristics of Participants in the Round 2 Usability Test

The seven participants from the second round of usability testing are summarized in Table 28, including their age, occupation, experience with Web2 and Web3 technologies, and observed social media behaviors. These participants were selected to reflect a diverse user population, focusing on their interactions in Web2 and Web3 scenarios, and none of them overlap with the participants from the first round.

Table 28. Characteristics of Participants in the Round 2 Usability Test

	Description	Age	Occupation	Web2/Web3 Experience	Social Media Behavior
Participant 1	Enjoys examining social media bugs and dynamics	26-35	Frontend Engineer	Web2 Advanced	- Avoids sharing personal information on social media - Previously worked in the social media industry, so understands the ecosystem and interaction patterns.
Participant 2	Privacy-Conscious User	26-35	Education	Web2 Advanced	- Does not post on social media but browses for information and updates on friends' activities.
Participant 3	Entrepreneur	55+	Entrepreneur	Web2 Advanced	- Enjoys using social media to explore information but rarely posts in recent years - Occasionally shares

					past posts as memories. - Cares deeply about privacy on social media platforms.
Participant 4	Blockchain Developer Focused on Reducing Cognitive Load	26-35	Blockchain Engineer	Web3 Advanced	- Rarely uses social media since graduating from university.
Participant 5	Blockchain Education and Investment Expert	26-35	Blockchain Education researcher	Web3 Advanced	- Interested in Web3-related platforms and has researched several SocialFi projects - Uses social media to gather information related to games - Describes themselves as introverted and never posts on social media
Participant 6	Postdoctoral Researcher with a Critical View of Social Media Platforms	26-35	Postdoctoral Researcher in Public Health	Web2 Advanced	- Values the safety of social media platforms. - Concerned that fully anonymous platforms may facilitate potential criminal activities.
Participant 7	Passionate Blockchain Marketing Professional	26-35	Marketing Specialist at Crypto Exchange	Web3 Advanced	- Enthusiastic about blockchain-related marketing and engagement strategies.

4.2.2 Task Performance Analysis and UX Optimization Validation

The second round of usability testing focused on evaluating the effectiveness of the UX optimizations implemented following the first round. This round aimed to assess improvements in success rates, completion times, and user satisfaction across predefined tasks. Additionally, qualitative data were collected to gain

insights into user perceptions of the new interface and identify any persisting or emerging challenges.

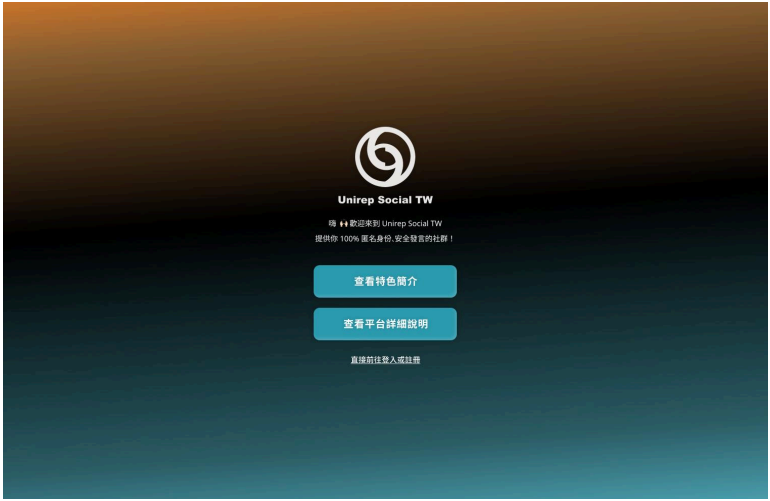
Quantitative metrics were compared with those from the first round to determine whether the new iteration successfully addressed previously identified issues. Qualitative feedback was analyzed to understand how participants interacted with the updated design and their overall impressions of the platform.

The following tables summarize the detailed results for each task, including task-specific performance metrics and participant feedback. These findings highlight areas where the optimizations succeeded and where further refinements may be needed. The section concludes with recommendations for continued improvements based on the second-round results.

4.2.2.1 Task Performance and Participant Feedback of Task 1 - Log in and Explore - Round 2

In this task, participants were asked to complete the registration process and, after successfully registering and logging in, explore the entire website. Following feedback from the first round, improvements were made to the onboarding process, including simplified instructional content and clearer navigation cues. The objective of this task was to assess whether these enhancements improved the overall smoothness of the registration process and whether participants found the initial exploration more intuitive. The following two tables present the user interface for Task 1 and the usability feedback and observation records from participants during the task.

Table 29. User Interface of Task 1 - Log in and Explore - Round 2

Description	User Interface
Landing Page	
Feature Overview Cards	

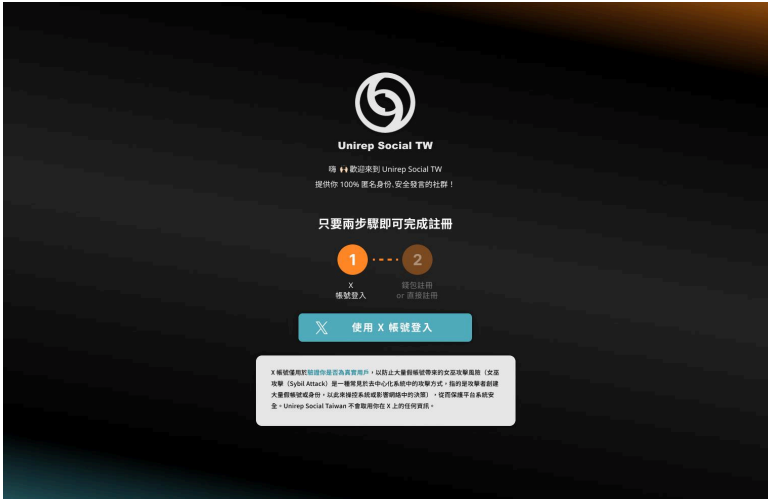
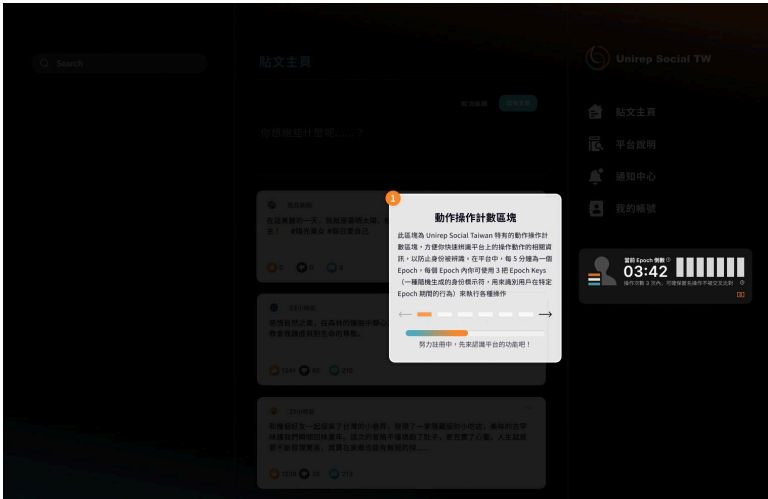
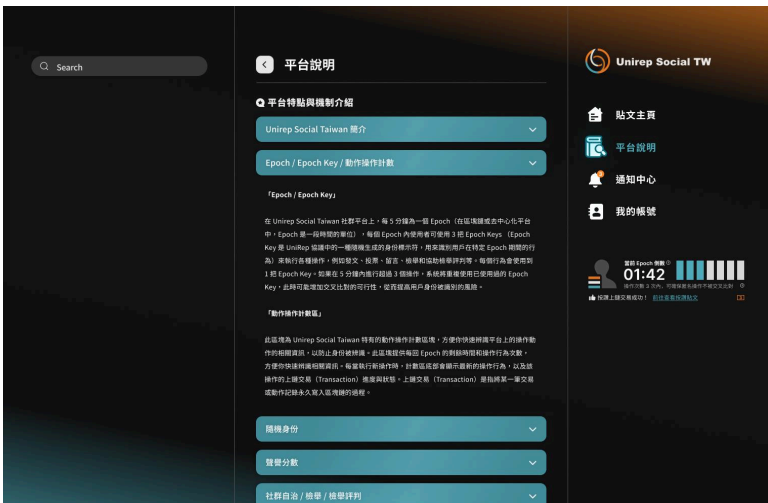
Explanation of Using X Account for Registration	 The registration page for Unirep Social TW features a dark background with a central logo. Below the logo, it states '只要兩步驟即可完成註冊' (Registration can be completed in just two steps). A progress bar shows two steps: 1. X 帳號登入 (X Account Login) and 2. 確認註冊 (Confirm Registration). A button labeled '使用 X 帳號登入' (Use X Account to Log In) is visible. A small text box explains that X accounts are used for verification to prevent Sybil attacks and ensure platform security.
Onboarding Cards	 The onboarding screen displays a '貼文主頁' (Post Home) section with a search bar and a list of posts. A prominent '動作操作計數區塊' (Action Operation Count Block) is overlaid, explaining the Epoch system. It states that each Epoch is 5 minutes long and contains 3 Epoch Keys. Users can use these keys to perform actions like posting, commenting, and voting. A progress bar indicates the user's current status. The right sidebar shows navigation links for '貼文主頁', '平台說明', '通知中心', and '我的帳號', along with a user profile card.
Platform Information Page	 The platform information page is titled '平台說明' (Platform Introduction). It includes a '平台特點與機制介紹' (Introduction to Platform Features and Mechanisms) section. Key points include: 'Epoch / Epoch Key' (Epoch is a 5-minute unit, containing 3 Epoch Keys), '動作操作計數區塊' (Action Operation Count Block), and '隨機身份' (Random Identity). The page also features a '登陸分數' (Login Score) section and a '社群自治 / 投票 / 投票評判' (Community Governance / Voting / Voting Evaluation) section. The right sidebar is identical to the onboarding screen, showing navigation links and a user profile card.

Table 30. Task Performance and Participant Feedback of Task 1 - Log in and Explore - Round 2

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	3 minutes 25 seconds	• After reading the introductory concept cards, I had a pretty good understanding of the services this platform provides. • Compared to other social media platforms, it feels somewhat basic. • It's a bit strange to use an X (Twitter) account for verification.
2 (Web2, 26-35)	Yes	2 minutes 52 seconds	• If the X account is only used to verify real identities, it should be called "X Account Verification" rather than "X Account Registration." • The section for posts feels a bit narrow.
3 (Web2, 55up)	Yes	1 minute 58 seconds	• The registration process was smooth, and it was quite easy to understand what the platform is about. • The cards explaining the platform's features were clear, but some of the terminology still felt a bit technical and hard to understand.
4 (Web3, 26-35)	Yes	2 minutes 22 seconds	• The onboarding content was too extensive; I usually wouldn't want to read so much. • The "Epoch" part is only meaningful to people familiar with ZK (Zero-Knowledge); most users wouldn't know what it is. • There are too many technical, engineering-driven terms, which unnecessarily increase the user's cognitive load. • Since there's no wallet connection, I assume I don't need to pay gas fees myself.
5	Yes	2 minute 24	• Seeing the phrase "100% Fully

(Web3, 26-35)		seconds	Anonymous" feels a bit unsettling and seems like an overstatement. • I really like the loading animations on the website. • I was confused about why the registration process didn't require a username and password. • Upon entering the platform, I didn't feel like it was a Web3 product because it lacked common Web3 elements, such as points or wallet address registration. • In general, I don't like the option to bind my wallet while using Web3 platforms. • This platform looks so much better than other Web3 Social Fi platforms.
6 (Web2, 26-35)	Yes	3 minutes 45 seconds	• The "Register/Login" button should be the most prominent on the page. • If the platform is truly anonymous, does that mean I could post illegal content, and even the police wouldn't be able to track me down? • I don't understand how an anonymous platform can remain orderly (although I guessed it might use a reporting system). • I don't understand what "Server" means.
7 (Web3, 26-35)	Yes	2 minutes 58 seconds	• The explanation cards make it easy to quickly understand what this website is about. • There are many professional terms—are they all necessary for everyone to know? • The onboarding content feels a bit overwhelming. • Seeing the countdown timer ticking down creates a sense of pressure. • I'm curious—who pays for the gas fees for the on-chain transactions?

This section presents the usability test analysis for Task 1 - Log in and Explore. The focus is on evaluating user interactions during the login process,

exploring the challenges faced by Web2 and Web3 participants, and analyzing their feedback on the onboarding and exploration experience. The findings highlight usability improvements made since Round 1 and areas requiring further refinement.

Web2 Participants:

- Many participants found the onboarding cards helpful in understanding the platform's purpose. However, technical terms like "Epoch Keys" remained a barrier, causing some confusion. Despite this, participants noted smoother navigation and fewer interruptions compared to the first round.

Web3 Participants:

- Although participants appreciated the improved clarity in registration workflows, they found the onboarding content dense and technical. However, they acknowledged that the revised instructions made the login process faster and more intuitive.

To further simplify the login process and enhance the onboarding experience, the following UX strategies are proposed. These solutions aim to reduce cognitive load for Web2 users while addressing Web3 users' expectations for transparency and control.

1. Extend Feedback Animations:

- Increase the duration of success notifications and provide clear feedback after posting. This aligns with ISO 9241-11, ensuring users receive adequate system status updates to confirm task completion (ISO, 1998).

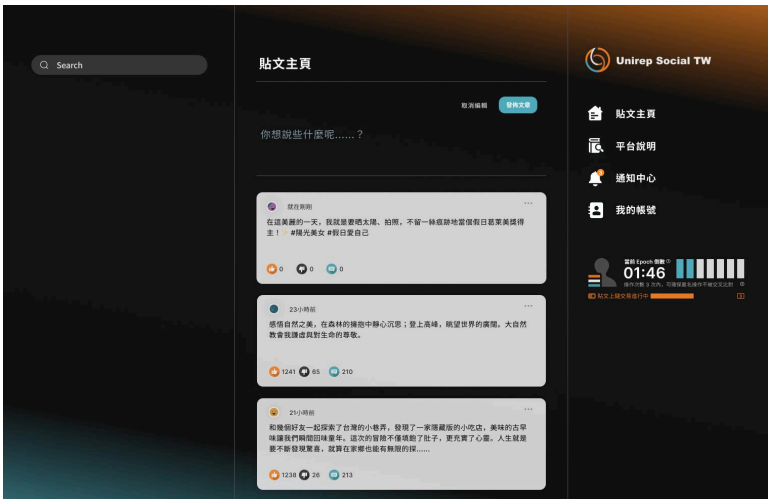
2. Add Transaction Transparency Options:

- Provide Web3 users with access to transaction hashes or on-chain confirmations. This supports TAM principles of perceived usefulness, building trust by meeting Web3 users' expectations for transparency and control (Davis, 1989).

4.2.2.2 Task Performance and Participant Feedback of Task 2 - Publish a Post - Round 2

For this task, participants were required to create and publish a post. Based on feedback from the first round, changes were implemented to improve real-time feedback mechanisms, such as adding clearer success notifications and extending animation durations. This task aimed to evaluate whether these adjustments addressed previous challenges and enhanced the participants' experience during the posting process. The following two tables present the user interface for Task 2 and the usability feedback and observation records from participants during the task.

Table 31. User Interface of Task 2 - Posting - Round 2

Description	User Interface
Posting Area	

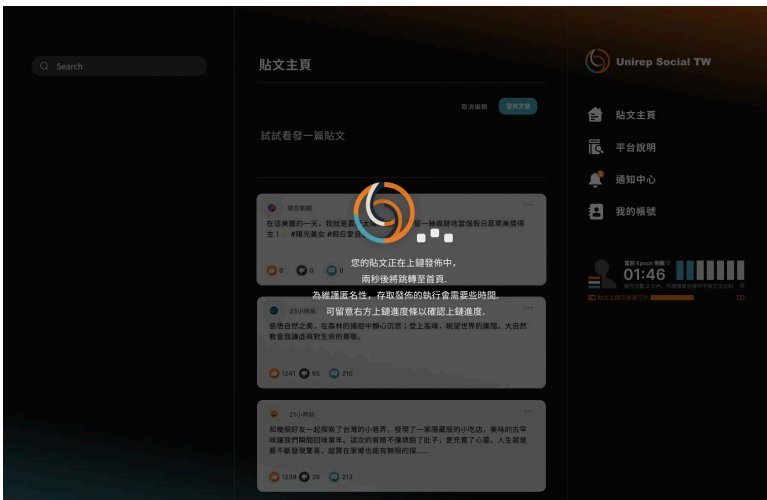
Posting is being uploaded on-chain	
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Table 32. Task Performance and Participant Feedback of Task 2 - Publish a Post - Round 2

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	36 seconds	- I need to think about what content to post. - I think this platform is pretty cool. - Uploading takes a bit of time—could it be an issue with my computer? Can I like my own posts?
2 (Web2, 26-35)	Yes	42 seconds	It seems like there's no categorization or themes for the posts.
3 (Web2, 55up)	Yes	1 minute 02 seconds	- I browsed through what others posted first to get a better idea of what kind of content to share. - I noticed that even empty content can be posted successfully.
4 (Web3, 26-35)	Yes	32 seconds	I'd like to confirm whether it's truly anonymous before deciding what to post.

5 (Web3, 26-35)	Yes	30 seconds	• I'm curious if there's a feature for categorizing articles. • There aren't many posts, and the content doesn't really catch my interest. • I realized that posting requires on-chain interaction, which indirectly helped me understand the relationship between actions and blockchain processes. • Why isn't gas fee required while using the platform? Shouldn't it be necessary if posts are being written to the blockchain? • It would be helpful if the platform information page mentioned which blockchain is being used.
6 (Web2, 26-35)	Yes	52 seconds	• The "dislike" button feels a bit harsh. • I noticed that it's not possible to view the past posts of a specific user.
7 (Web3, 26-35)	Yes	26 seconds	• Having themed categories would make it easier to decide what kind of content to post. • The posting process is slow, but I understand it could be due to the blockchain's transaction speed. • The search function is great—it helps me quickly find the information I'm looking for. • While waiting for a post to be written on-chain, I feel unsure if performing other actions might cause the on-chain process to fail.

This section examines the usability test results for Task 2 - Publish a Post. The analysis focuses on identifying participant behaviors, challenges, and feedback related to the posting process. Particular attention is given to the effectiveness of real-time feedback mechanisms and transparency enhancements introduced after Round 1.

Web2 Participants:

- Participants felt the publishing process was easier to navigate due to improved visual feedback and clearer progress indicators. However, some still experienced slight delays during the posting process.

Web3 Participants:

- Many appreciated the transparency enhancements, such as status indicators for on-chain actions, which reduced confusion. Participants reported the process felt more streamlined, though a few noted that animations disappeared too quickly for them to fully grasp the feedback.

To improve the posting experience and address the usability issues observed, the following UX strategies are suggested. These aim to enhance real-time feedback for Web2 users while meeting Web3 users' need for detailed transaction transparency.

1. Extend Feedback Animations:

- Increase the duration of success notifications and provide clear feedback after posting. This aligns with ISO 9241-11, ensuring users receive adequate system status updates to confirm task completion (ISO, 1998).

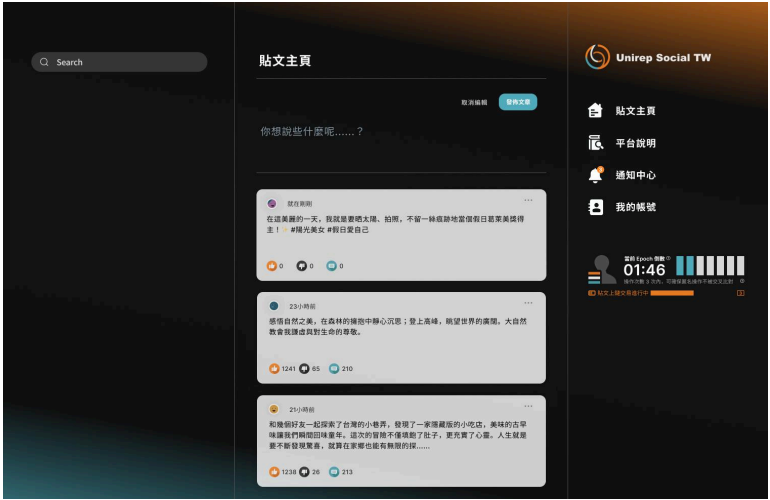
2. Add Transaction Transparency Options:

- Provide Web3 users with access to transaction hashes or on-chain confirmations. This supports TAM principles of perceived usefulness, building trust by meeting Web3 users' expectations for transparency and control (Davis, 1989).

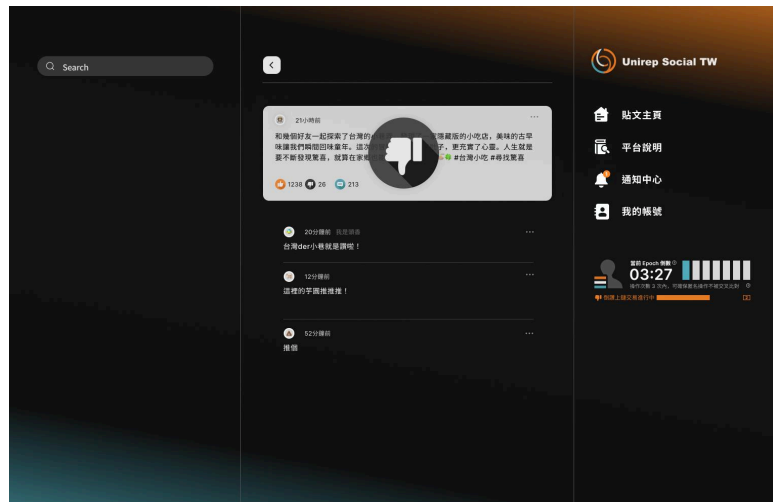
4.2.2.3 Task Performance and Participant Feedback of Task 3 - Interact with Posts (Voting/Comment) - Round 2

In this task, participants were asked to interact with posts by voting or leaving comments. Following insights from the first round, optimizations were made to reduce response delays and provide better feedback for on-chain interactions. The goal of this task was to determine whether these improvements made the interaction process more efficient and intuitive for participants. The following two tables present the user interface for Task 3 and the usability feedback and observation records from participants during the task.

Table 33. User Interface of Task 3 - Interact with Posts (Like/Comment) - Round 2

Description	User Interface
Upvote, Downvote buttons on Posts	 The screenshot displays the 'Unirep Social TW' application interface. At the top, there is a search bar and a '貼文主頁' (Post Home) header. Below the header, a prompt asks '你想說些什麼呢.....?' (What do you want to say.....?). The main content area shows a list of posts. Each post includes a profile picture, a timestamp, the text of the post, and two buttons for interaction: an orange upvote button and a blue downvote button. The first post is from '藍夜無期' (Blue Night Never Ends) and has 0 upvotes and 0 downvotes. The second post is from '22小時前' (22 hours ago) and has 1241 upvotes and 65 downvotes. The third post is from '25小時前' (25 hours ago) and has 1238 upvotes and 26 downvotes. On the right side, there is a sidebar with navigation links: '貼文主頁' (Post Home), '平台說明' (Platform Guide), '通知中心' (Notification Center), and '我的帳號' (My Account). At the bottom of the sidebar, there is a user profile section for '藍夜無期' (Blue Night Never Ends) showing a timer at '01:46' and a progress bar.

Voting Processing Animation



New Comment Function Area

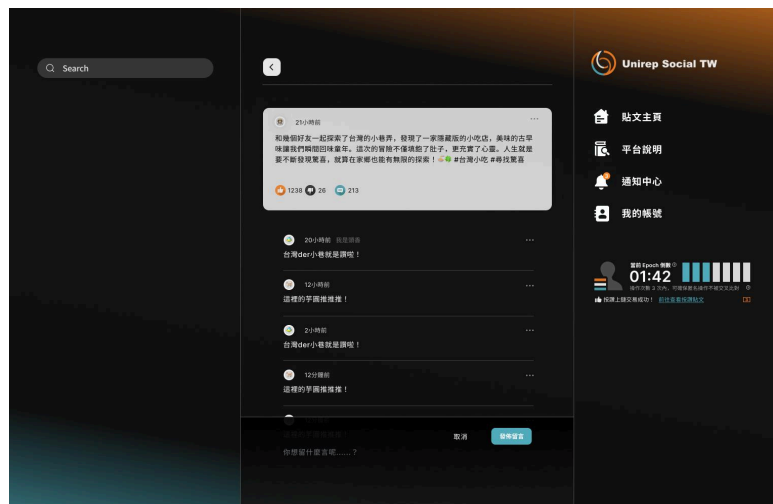


Table 34. Task Performance and Participant Feedback of Task 3 - Interact with Posts (Like/Comment) - Round 2

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	58 seconds	It feels pretty slow.
2 (Web2, 26-35)	Yes	1 minute 36 seconds	Posting takes quite a while.
3 (Web2, 55up)	Yes	1 minute 12 seconds	- When clicking the comment icon on the main posts page to enter the post detail page, the post content doesn't appear—it seems like there's a bug. - While waiting for a comment to be successfully posted, I'm worried if I need to stay on the page. If I navigate away, will the comment fail? Especially since the timer keeps counting down. - This platform seems to be designed for people to post questions and for others with answers to provide solutions.
4 (Web3, 26-35)	Yes	1 minute 24 seconds	The feedback mechanism is present, but the on-chain speed still feels too slow.
5 (Web3, 26-35)	Yes	2 minutes 10 seconds	- I really like that after leaving a comment, the progress indicator is displayed in a block at the bottom-right corner rather than as a popup that blocks my view. - During the on-chain process, I hesitate to click "back" because I'm worried it might cause the on-chain operation to fail.
6 (Web2, 26-35)	Yes	1 minute 05 seconds	After the on-chain process is complete, the comment content disappears.

7 (Web3, 26-35)	Yes	1 minute 42 seconds	• The feedback animations for liking and disliking are different from other actions—they should be consistent or at least similar for a better experience. • Comments being limited to plain text feels a bit boring.
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This section explores the usability test results for Task 3 - Interact with Posts (Voting/Comment). The analysis delves into the behaviors and feedback of Web2 and Web3 participants, with a focus on understanding their experiences when engaging with post interactions. The findings highlight the impact of recent design refinements on task efficiency and user satisfaction.

Web2 Participants:

- Noticed faster response times and clearer visual cues when interacting with posts, which they described as smoother compared to Round 1.

Web3 Participants:

- While the interaction speed improved slightly, Web3 participants highlighted the need for more detailed feedback during on-chain actions. However, they felt that the process was more intuitive overall.

To further optimize post interaction workflows and resolve remaining usability challenges, the following UX strategies are recommended. These focus on improving response times and providing more comprehensive feedback mechanisms.

1. Improve Button Responsiveness:

- Add hover effects and real-time visual feedback to buttons to enhance perceived responsiveness. This aligns with Shneiderman's direct manipulation principle, which emphasizes the importance of immediate feedback in interactive systems (Shneiderman, 1983).

2. Optimize Transaction Processing Time:

- Reduce delays in on-chain actions like voting or commenting. This supports ISO 9241-11's efficiency principle, which focuses on minimizing unnecessary delays to improve task performance (ISO, 1998).

4.2.2.4 Task Performance and Participant Feedback of Task 4 - Report a Post - Round 2

Participants were tasked with reporting inappropriate posts. Changes implemented since the first round included clearer confirmation messages and streamlined reporting steps. This task aimed to assess whether these refinements made the reporting process more straightforward and whether participants experienced fewer usability barriers. The following two tables present the user interface for Task 4 and the usability feedback and observation records from participants during the task.

Table 35. User Interface of Task 4 - Report a Post - Round 2

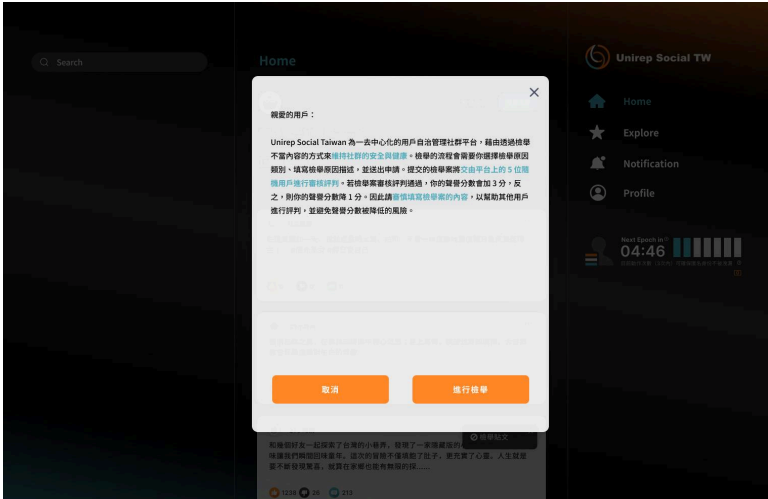
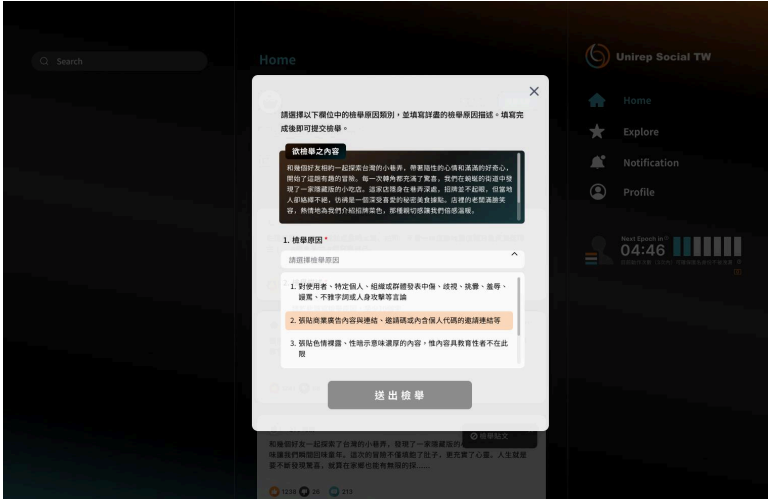
Description	User Interface
Reporting Instruction	
Updated Reporting Form	

Table 36. Task Performance and Participant Feedback of Task 4 - Report a Post - Round 2

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1	Yes	2 minutes 15	After the Epoch countdown finishes, the

(Web2, 26-35)		seconds	screen automatically scrolls back to the top.
2 (Web2, 26-35)	Yes	1 minute 58 seconds	After reporting a post, I'm not sure which post I just reported.
3 (Web2, 55up)	Yes	2 minutes 28 seconds	- At first, I wasn't sure where to find the button to report a post, but I eventually found it. - The icon design for the "Share" button looks more like a "Leave" function.
4 (Web3, 26-35)	Yes	3 minutes 15 seconds	-
5 (Web3, 26-35)	Yes	2 minutes 25 seconds	I don't usually report posts, but I think it's pretty cool to learn that this platform's governance works this way.
6 (Web2, 26-35)	Yes	56 seconds	If there are duplicate posts, how do we determine which one was posted first?
7 (Web3, 26-35)	Yes	3 minutes 22 seconds	The categories for reporting posts seem like community guidelines. I think these guidelines should appear when first using the website.

This section reviews the usability test findings for Task 4 - Report a Post. The focus is on analyzing participant feedback on the reporting process, identifying key usability barriers, and assessing the effectiveness of changes implemented since Round 1. The results highlight the participants' expectations for a straightforward and efficient reporting workflow.

Web2 Participants:

- Participants expressed that the reporting process felt more straightforward due to improved feedback mechanisms. They particularly appreciated the clear submission confirmation.

Web3 Participants:

- Found the reporting process easier to navigate compared to Round 1 but still desired more flexibility in the word count requirements for explanations.

To simplify the reporting process and enhance user confidence, the following UX strategies are proposed. These aim to streamline task completion while maintaining transparency and flexibility for diverse user needs.

1. Provide Post-Report Feedback:

- Include a confirmation message with estimated review times after a report is submitted. This aligns with Nielsen's heuristic of visibility of system status, ensuring users are informed of next steps (Nielsen, 1994).

2. Simplify Reporting Requirements:

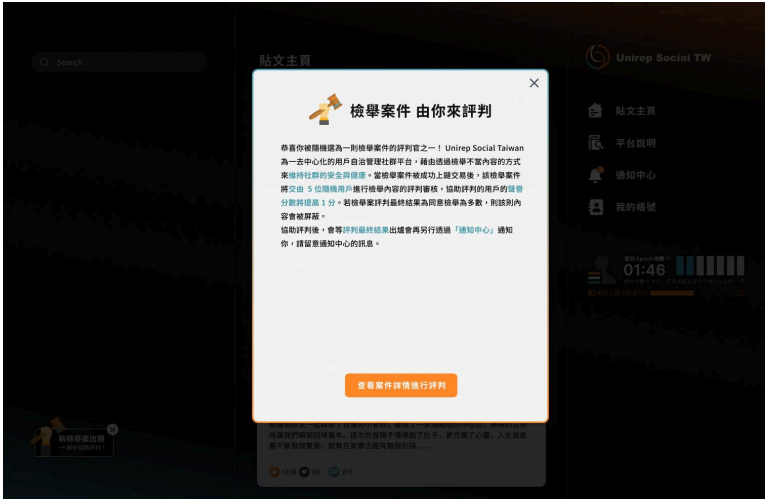
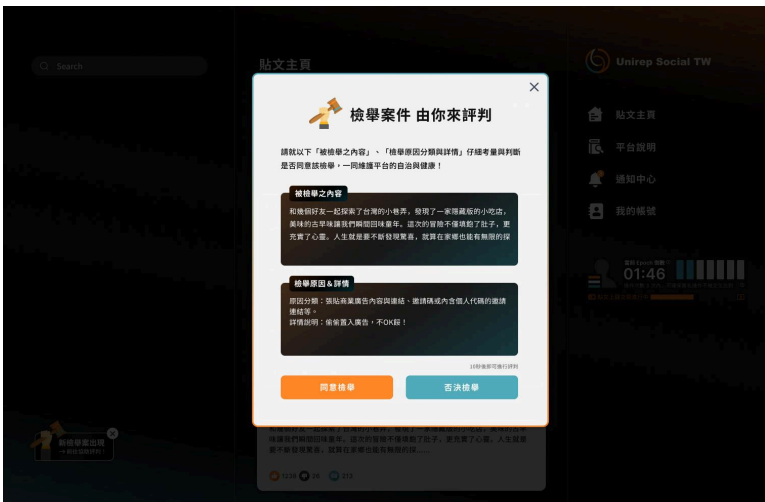
- Allow shorter explanations for report submissions to lower the barrier for participation. This follows ISO 9241-11's guidance on reducing unnecessary effort, making tasks more accessible for users (ISO, 1998).

4.2.2.5 Task Performance and Participant Feedback of Task 5 - Adjudicate Reports - Round 2

For this task, participants were required to adjudicate reports submitted by other users. Following Round 1, additional tooltips and clearer task descriptions were introduced to enhance participants' understanding of the adjudication process. The objective was to evaluate whether these improvements made the task more engaging and transparent. The following two tables present the user interface for

Task 5 and the usability feedback and observation records from participants during the task.

Table 37. User Interface of Task 5 - Adjudicate Reports - Round 2

Description	User Interface
Explanation for Adjudication	 The screenshot shows a web application interface for 'Unirep Social TW'. A central modal window titled '檢舉案件 由你來評判' (Report Case, Judge by You) is displayed. The modal contains the following text: 恭喜你被隨機選為一則檢舉案件的評判官之一！ Unirep Social Taiwan 為一去中心化的用戶自治管理社群平台，藉由提供檢舉不當內容的方式來維持社群的安全與健康。當檢舉案件被成功上提交後，該檢舉案件將交由 5 位隨機用戶進行檢舉內容的評判審核，協助評判的用戶的信息分數將提高 1 分。若檢舉案件最終結果為同意檢舉為多數，則該則內容會被刪除。協助評判後，會等評判最終結果出爐會再另行透過「通知中心」通知你，請留意通知中心的訊息。 At the bottom of the modal is an orange button labeled '查看案件詳情進行評判' (View Case Details for Judgment). The background interface includes a search bar, a post titled '貼文主頁', and a sidebar with navigation links: '貼文主頁', '平台說明', '通知中心', and '我的帳號'. The time displayed is 01:46.
Updated Adjudication Interface	 The screenshot shows the same web application interface as above, but with an updated modal window for adjudicating a report. The modal is titled '檢舉案件 由你來評判' (Report Case, Judge by You). It contains the following text: 請就以下「被檢舉之內容」、「檢舉原因分類與詳情」仔細考量與判斷是否同意該檢舉，一同維護平台的自治與健康！ 被檢舉之內容 和幾個好友一起探索了台灣的小巷弄，發現了一家隱藏版的小吃店，氣味的古早味讓我們瞬間回味童年。這次的體驗不僅填飽了肚子，更充實了心靈。人生就是要不斷發現驚喜，我們在幸福也有熱烈的課... 檢舉原因及詳情 即此分發：發現商業廣告內容與連結，應請或內含個人代碼的連續連結等。 詳情說明：偷偷置入廣告，不OK啦！ At the bottom of the modal are two buttons: '同意檢舉' (Agree to Report) in orange and '否決檢舉' (Reject Report) in blue. Below the buttons is a small text: '(以檢舉案件進行判斷)'. The background interface is identical to the previous screenshot, showing the search bar, post, and sidebar with navigation links and the time 01:46.

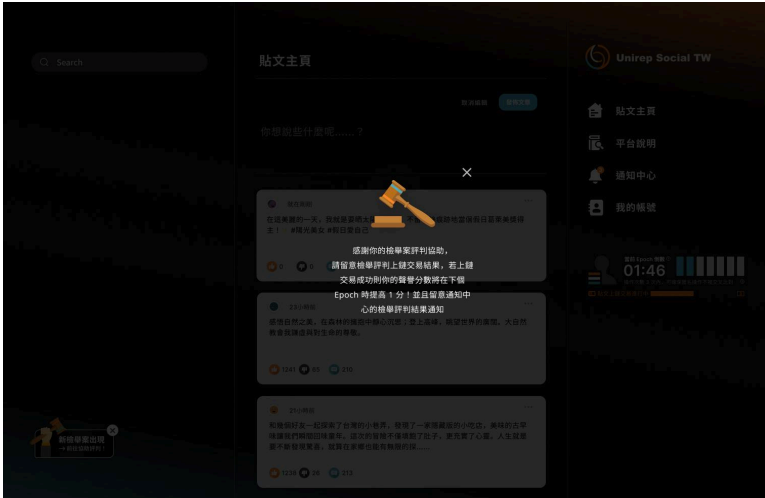
Adjudication Completion Notification	
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Table 38. Task Performance and Participant Feedback of Task 5 - Adjudicate Reports - Round 2

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	1 minute 41 seconds	- Helping with adjudication is so much fun—it makes me feel like I have a lot of authority. - After assisting with adjudication, I like to check the notification center to see if it was successful.
2 (Web2, 26-35)	Yes	32 seconds	-
3 (Web2, 55up)	Yes	56 seconds	The process feels very smooth, and I understand what assisting with adjudication is about.
4 (Web3, 26-35)	Yes	1 minute 32 seconds	The adjudication button sometimes shows the same case repeatedly.
5 (Web3, 26-35)	Yes	58 seconds	The blue color is a bit hard to see.

26-35)			• Here, I pay close attention to the wording because it feels like I'm doing something really important. • Executing adjudications gives me a strong sense of participation.
6 (Web2, 26-35)	Yes	54 seconds	-
7 (Web3, 26-35)	Yes	1 minute 16 seconds	• The reputation score should be made more prominent.

This section details the usability analysis for Task 5 - Adjudicate Reports. The focus is on understanding participant behaviors during the adjudication process, examining their feedback on task clarity, and assessing the impact of recent design optimizations on their experience.

Web2 Participants:

- Found the adjudication process smoother, with clearer task instructions and feedback. They noted that the improved reputation point system was easier to understand.

Web3 Participants:

- Reported feeling more in control of the adjudication process and appreciated the transparency in task outcomes, which enhanced their overall experience.

To enhance the adjudication process and better support user decision-making, the following UX strategies are suggested. These focus on providing clearer explanations and increasing user autonomy.

1. Provide Context for Reputation Points:

- Offer clear explanations of how reputation points are calculated and their significance. This aligns with Nielsen's heuristic of help and documentation, which emphasizes providing users with adequate information to understand and complete their tasks effectively (Nielsen, 1994).

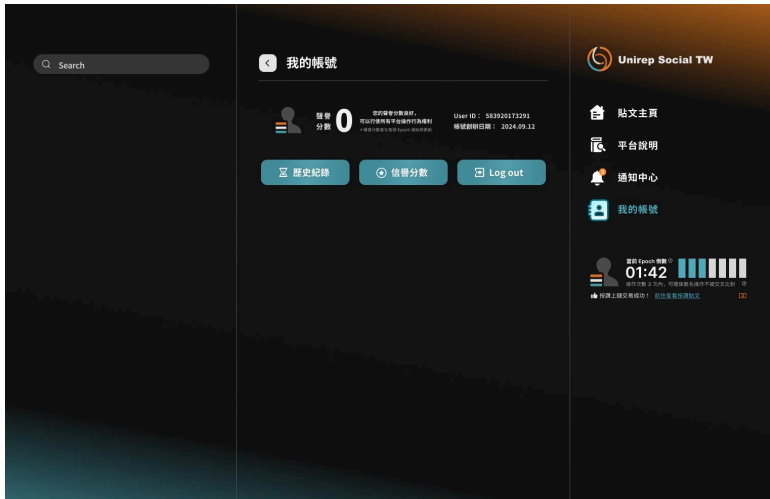
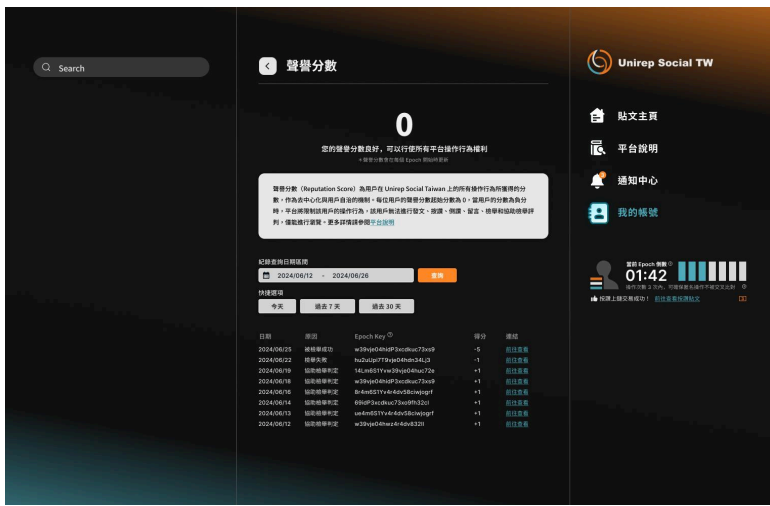
2. Allow Voluntary Task Selection:

- Enable users to choose adjudication tasks that align with their preferences or expertise. This follows TAM principles of perceived control, which enhance user satisfaction and trust by giving them more autonomy (Davis, 1989).

4.2.2.6 Task Performance and Participant Feedback of Task 6 - View Reputation and History - Round 2

In this task, participants were asked to view their reputation scores and activity history. Enhancements based on Round 1 feedback included real-time updates for reputation scores and a standardized layout for navigation. This task aimed to assess whether these updates improved the clarity and usability of the reputation and history features. The following two tables present the user interface for Task 6 and the usability feedback and observation records from participants during the task.

Table 39. User Interface of Task 6 - View Reputation and History - Round 2

Description	User Interface																																													
New Version of My Account																																														
Reputation Score Page	 聲譽分數 (Reputation Score) 為用戶在 Unirep Social Taiwan 上的所有操作行為所累積的分數。作為系統中心化用戶內部的機制，每位用戶的聲譽分數與行為數為 0。當用戶的分數為負分時，平台將限制用戶的操作行為，該用戶無法進行發文、閱讀、創建、留言、投票、發問和協助他人評分、標記進行瀏覽。更多詳情請參閱平台說明 <table><tr><th>日期</th><th>原因</th><th>EPOCH Key ID</th><th>得分</th><th>備註</th></tr><tr><td>2024/06/25</td><td>協助他人評分</td><td>w29pqc4mwp7acdfac72a5b</td><td>-5</td><td>無法查看</td></tr><tr><td>2024/06/22</td><td>協助他人評分</td><td>fu2a9p779p9d9m34u3</td><td>-1</td><td>無法查看</td></tr><tr><td>2024/06/19</td><td>協助他人評分</td><td>14u4d57v4d9p9d9m34u3</td><td>+1</td><td>無法查看</td></tr><tr><td>2024/06/16</td><td>協助他人評分</td><td>u29pqc4mwp7acdfac72a5b</td><td>+1</td><td>無法查看</td></tr><tr><td>2024/06/16</td><td>協助他人評分</td><td>fu2a9p779p9d9m34u3</td><td>+1</td><td>無法查看</td></tr><tr><td>2024/06/14</td><td>協助他人評分</td><td>68u9p3acdfac72a5b</td><td>+1</td><td>無法查看</td></tr><tr><td>2024/06/12</td><td>協助他人評分</td><td>u4u4d57v4d9p9d9m34u3</td><td>+1</td><td>無法查看</td></tr><tr><td>2024/06/12</td><td>協助他人評分</td><td>w29pqc4mwp7acdfac72a5b</td><td>+1</td><td>無法查看</td></tr></table>	日期	原因	EPOCH Key ID	得分	備註	2024/06/25	協助他人評分	w29pqc4mwp7acdfac72a5b	-5	無法查看	2024/06/22	協助他人評分	fu2a9p779p9d9m34u3	-1	無法查看	2024/06/19	協助他人評分	14u4d57v4d9p9d9m34u3	+1	無法查看	2024/06/16	協助他人評分	u29pqc4mwp7acdfac72a5b	+1	無法查看	2024/06/16	協助他人評分	fu2a9p779p9d9m34u3	+1	無法查看	2024/06/14	協助他人評分	68u9p3acdfac72a5b	+1	無法查看	2024/06/12	協助他人評分	u4u4d57v4d9p9d9m34u3	+1	無法查看	2024/06/12	協助他人評分	w29pqc4mwp7acdfac72a5b	+1	無法查看
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2024/06/14	協助他人評分	68u9p3acdfac72a5b	+1	無法查看																																										
2024/06/12	協助他人評分	u4u4d57v4d9p9d9m34u3	+1	無法查看																																										
2024/06/12	協助他人評分	w29pqc4mwp7acdfac72a5b	+1	無法查看																																										

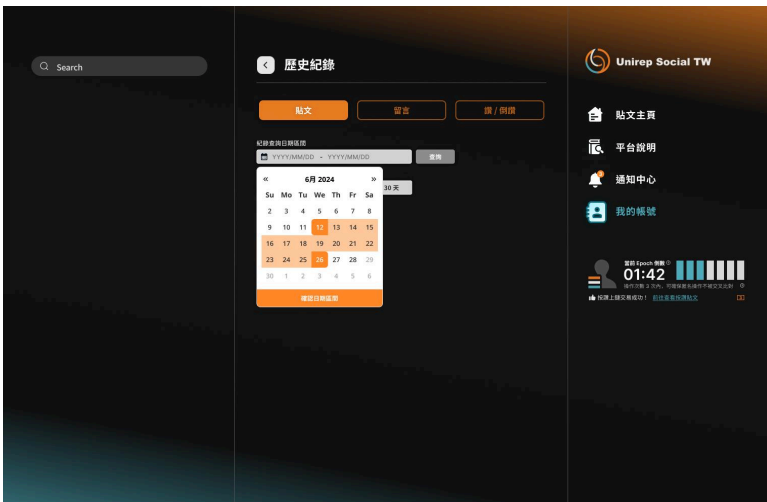
Action History Query	
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Table 40. Task Performance and Participant Feedback of Task 6 - View Reputation and History - Round 2

Participant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	38 seconds	- The reputation score doesn't update in real time. - Now I fully understand that the Epoch countdown lasts five minutes, and within this time, I can only perform three actions.
2 (Web2, 26-35)	Yes	22 seconds	The text feels a bit too dense and cramped.
3 (Web2, 55up)	Yes	36 seconds	- Even after refreshing, the reputation score still doesn't update. - The notification center seems to have a lot of adjudication-related notifications. - Since it's an anonymous community, it feels more like a platform for venting emotions.
4	Yes	35 seconds	The interface is clear, but the text in the

(Web3, 26-35)			explanations is a bit lengthy.
5 (Web3, 26-35)	Yes	37 seconds	-
6 (Web2, 26-35)	Yes	56 seconds	-
7 (Web3, 26-35)	Yes	12 seconds	• It would be great if users' reputation scores could be visible to others. • There's a flashy animation when gaining points, which is really cool.

This section outlines the usability test results for Task 6 - View Reputation and History. The analysis evaluates how participants navigated the reputation and history interfaces, highlights usability challenges, and identifies areas where further improvements could enhance clarity and accessibility.

Web2 Participants:

- Reported smoother navigation through the reputation interface compared to Round 1. They appreciated the improved consistency in layout and responsiveness.

Web3 Participants:

- Felt the history tracking was more transparent and easier to access. However, they suggested adding real-time updates for reputation changes to further improve clarity.

To improve the reputation and history viewing experience and address the challenges observed, the following UX strategies are recommended. These focus on standardizing the interface and ensuring real-time data updates.

1. Ensure Real-Time Score Updates:

- Implement a system that updates reputation scores in real time to avoid confusion and build trust. This aligns with ISO 9241-11's principle of efficiency, ensuring that users receive timely and accurate feedback for their actions (ISO, 1998).

2. Standardize Interface Design:

- Create a consistent layout for navigating reputation and history sections. This aligns with Gestalt principles of proximity and similarity, making the interface easier to navigate and understand (Todorovic, 2008).

4.2.2.7 Task Performance and Participant Feedback of Task 7 - Log out - Round 2

Participants were instructed to log out of the platform. Updates since Round 1 included simplifying the logout confirmation text and providing additional transparency about post-logout data handling. This task aimed to evaluate whether these changes made the logout process clearer and more intuitive. The following two tables present the user interface for Task 7 and the usability feedback and observation records from participants during the task.

Table 41. User Interface of Task 7 - Logout - Round 2

Description	User Interface
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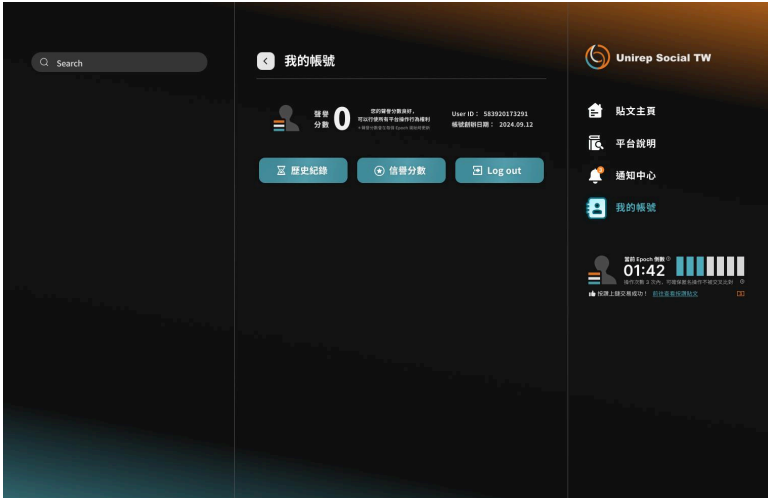
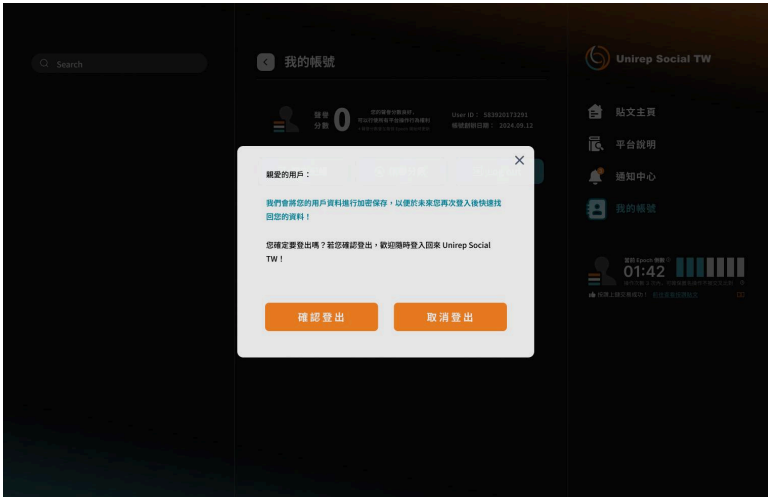
New Version of My Account with Log Out Button	
Logout Confirmation Popup	

Table 42. Task Performance and Participant Feedback of Task 7 - Logout - Round 2

Partici pant	Success or Not	Average Completion Time	Direct Transcription of Participants' Comments/Statements
1 (Web2, 26-35)	Yes	12 seconds	-
2	Yes	18 seconds	-

(Web2, 26-35)			
3 (Web2, 55up)	Yes	22 seconds	The logout process is very smooth.
4 (Web3, 26-35)	Yes	36 seconds	- There are a lot of engineering terms, like point-to-point encryption, which carry a lot of meaning, but even with this explanation, it's unclear what kind of encryption is being applied. - Providing too much technical, engineer-oriented information might be okay for a demo, but if the platform is open to the public, it should avoid such details.
5 (Web3, 26-35)	Yes	15 seconds	- It seems like there's a refresh button on the homepage. - I'm curious—how does the platform retain my data after I log out?
6 (Web2, 26-35)	Yes	10 seconds	-
7 (Web3, 26-35)	Yes	8 seconds	-

This section details the usability test analysis for Task 7 - Log Out. The focus is on understanding the behaviors, feedback, and challenges faced by Web2 and Web3 users during the logout process. The findings emphasize the importance of clear communication and transparency in ensuring a seamless logout experience.

Web2 Participants:

- Noted that the logout process was faster and more intuitive, with simplified confirmation text making the task feel smoother.

Web3 Participants:

- Acknowledged the improved clarity in encryption explanations but requested optional links to detailed descriptions for users seeking technical depth.

To streamline the logout process and address the usability issues observed, the following UX strategies are recommended. These solutions focus on improving clarity for Web2 users while maintaining the technical transparency and security expected by Web3 users.

1. Simplify Logout Confirmation Text:

- Replace complex terms like "point-to-point encryption" with simpler language, such as "secure encryption." This aligns with Nielsen's heuristic of match between system and the real world, ensuring users easily understand system language (Nielsen, 1994).

2. Provide Data Handling Transparency:

- Include a tooltip or optional link explaining how user data is handled post-logout. This aligns with TAM principles of perceived usefulness, as it reassures users of the security and reliability of the platform (Davis, 1989).

3. Add Clear Post-Logout Feedback:

- Show a confirmation message that details the completion of the logout process, such as session clearance and account security. This supports ISO 9241-11's guidance on visibility of system status, ensuring users feel confident about their actions (ISO, 1998).

4.2.2.8 Round 2 Usability Testing Qualitative Results: Usability Improvements Across Two Rounds of Testing

- Web2 Users:

In Round 1, Web2 participants struggled to understand blockchain topics like transactions and private key management. These difficulties increased cognitive load, making it harder for participants to use the platform naturally. Furthermore, the lack of clear advice and feedback methods exacerbated their perplexity, especially when dealing with elements foreign to traditional Web2 users.

By Round 2, changes in onboarding and feedback mechanisms had significantly enhanced user confidence. Web2 participants benefited from features such as interactive lessons, tooltips, and visual progress indicators, which helped them better comprehend platform functionality. However, despite these improvements, advanced blockchain concepts such as "Epoch Keys" and transaction processes remained challenging, emphasizing the need for clearer explanations and a more Web2-friendly design approach.

- Web3 Users:

In Round 1, Web3 participants complained about performance delays and a lack of transparency in platform interactions. The lack of detailed transaction logs and technical feedback made it impossible for these technically savvy users to trust the system or determine the progress of on-chain activity. This sparked unhappiness, particularly among individuals used to the high levels of openness and control found in Web3 apps.

In Round 2, the platform addressed some of these concerns by increasing transparency with full transaction feedback and more visible

progress indicators. Participants appreciated the increased clarity and felt better informed during their exchanges. However, new issues arose when some users grappled with the platform's usage of zero-knowledge (ZK) technology and the prominence of engineering-heavy languages. These elements were perceived as overly technical, even for Web3 users, indicating a need for more accessible communication of complex terms and processes.

4.2.2.9 Round 2 Usability Testing Quantitative Results: Task Success Rates, Completion Times, and SUS Scores

The quantitative results from the second round of usability testing shed light on the effectiveness of the UX optimizations that were performed, as well as their impact on task performance and participant impressions. These metrics—task success rates, average completion times, and System Usability Scale (SUS) scores—were used to assess platform usability improvements, with an emphasis on effectiveness, efficiency, and user satisfaction in comparison to the first round.

Table 43. Round 2 Usability Testing Results: Task Success Rates and Completion Times

Task	Success Rate	Average Completion Time
Task 1: Log in and Explore	100%	2 minutes 49 seconds
Task 2: Publish a Post	100%	40 seconds
Task 3: Interact with Posts (Like/Comment)	100%	1 minute 26 seconds
Task 4: Report a Post	100%	2 minutes 22 seconds
Task 5: Adjudicate Reports	100%	1 minute 07 seconds
Task 6: View Reputation and	100%	34 seconds

History		
Task 7: Logout	100%	17 seconds

Table 44. Round 2 Individual Participant SUS Scores and Average Score

	Partici -pant 1.	Partici -pant 2.	Partici -pant 3.	Partici -pant 4.	Partici -pant 5.	Partici -pant 6.	Partici -pant 7.	Avera -ge
Round 1 SUS Score	65	77.5	72.5	65	65	70	77.5	70.36

- **Task Success Rates**

In Round 2, all tasks achieved a 100% success rate, showing that participants were able to complete every task without any failure. This is a significant improvement compared to Round 1, where Task 3 (“Interact with Posts”) had a lower success rate of 86%, highlighting usability challenges in that area.

The consistent 100% success rate across all tasks in Round 2 demonstrates the effectiveness of the optimizations implemented after Round 1. These changes successfully removed prior barriers and created a seamless experience for participants.

- **Task Completion Times**

Round 2 showed considerable increases in task completion efficiency, as reflected by a noticeable decrease in completion times across all tasks. Simpler operations, such as signing out, were accomplished in an average of 17 seconds, a significant improvement over the longer durations recorded in Round 1. Similarly, more complicated operations, such as reporting a

post, demonstrated significant efficiency increases, with an average completion time of 2 minutes and 22 seconds, indicating a notable reduction from the longer durations recorded in Round 1.

These findings imply that the changes made to the interface and task workflows effectively lowered cognitive burden, allowing participants to perform tasks more quickly and confidently. This improvement underscores the success of the iterative design process in enhancing usability and streamlining user interactions.

- **SUS Scores**

The average SUS score in Round 2 improved significantly, rising to 70.36 from 62.14 in Round 1. This upward change suggests a significant improvement in users' perceptions of the platform's usefulness. The highest SUS score in Round 2 was 77.5, while the lowest was 65, indicating a narrower range of user satisfaction than in Round 1. This consistency shows that design modifications lead to a more unified and trustworthy user experience for all participants.

According to Bangor, Kortum, and Miller's (2009) interpretative framework, the SUS score of 70.36 falls within the "Good" usability range, an improvement above the "Marginal High" range obtained in Round 1. This categorization emphasizes the effectiveness of iterative design improvements in improving the platform's usability and addressing previously identified issues.

These findings suggest that Round 2 participants found the platform more intuitive and user-friendly than the previous iteration. Following Round 1, refinements such as improved task workflows and clearer feedback mechanisms significantly improved the overall user experience. This emphasizes the importance of iterative testing and design in providing a more seamless and satisfying interaction for users.

- **Comparison with Round 1**

Task success rates improved, increasing from an average of 98% in Round 1 to 100% in Round 2, showing that previous usability challenges were effectively addressed. Task completion times were also reduced across all tasks, with noticeable improvements for complex tasks like Task 3 and Task 4. Additionally, the SUS scores increased by 8.22 points, from 62.14 in Round 1 to 70.36 in Round 2, moving the platform into a higher usability category and reflecting greater overall user satisfaction.

The improvements in task success rates, completion times, and SUS scores demonstrate the effectiveness of the iterative design process. By addressing specific usability barriers identified in Round 1, the platform achieved a higher level of user satisfaction and efficiency. These results underscore the importance of continuous testing and refinement in creating a seamless and intuitive user experience. However, further testing could focus on fine-tuning areas where completion times for complex tasks, while improved, still require relatively longer durations compared to simpler tasks.

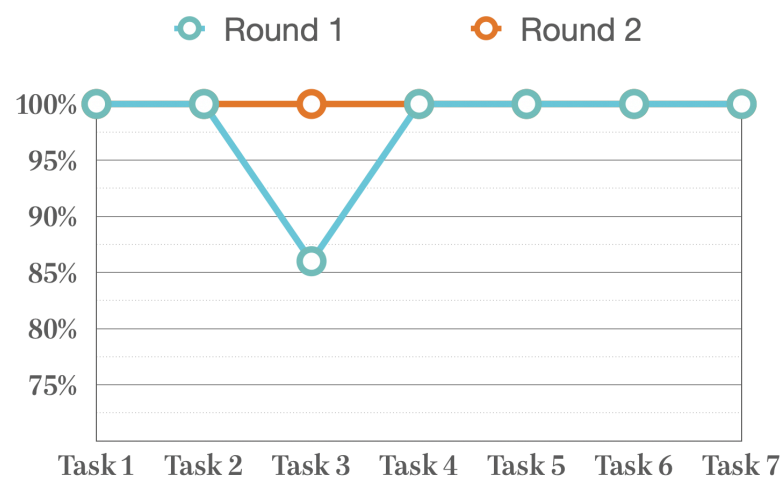


Figure 8. Task Success Rate Comparison

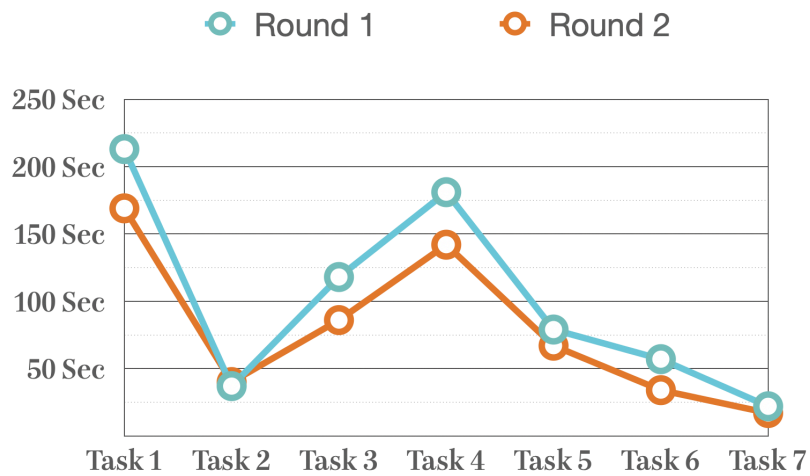


Figure 9. Task Completion Time Comparison

The Round 2 quantitative results highlight the success of the design optimizations made after Round 1. The improvements in task success rates, completion times, and SUS scores demonstrate significant enhancements in usability and overall user experience. Achieving 100% task success rates and moving into the “Good” SUS score range underscores the effectiveness of the iterative process. Future iterations should continue refining task efficiency and user satisfaction to maintain these improvements and elevate the platform’s usability to an “Excellent” standard.

5. Discussion

5.1 Answer to Sub-research Question 1: What specific challenges do Web2 users face when interacting with decentralized applications, and how does this impact their overall user experience?

Web2 users face significant challenges transitioning to decentralized applications (dApps), primarily due to unfamiliarity with blockchain concepts and decentralized system mechanics. These challenges include:

- Challenges with Understanding Decentralized Systems

Web2 users struggle to grasp decentralized mechanics, such as transaction concepts, private key management, and the absence of a central authority to oversee interactions. For example, one participant expressed confusion about why "transactions" were necessary for basic actions like posting or liking content. This aligns with the findings of Qasse et al. (2020), which emphasize the importance of addressing technical barriers through education and simplified design.

- Complex Onboarding Processes:

Concepts like "Epoch Keys" and wallet integration create significant cognitive barriers for Web2 users, who are more accustomed to straightforward registration processes in centralized systems. Without clear guidance or interactive support, these processes deter user engagement and heighten frustration during initial interactions.

- Lack of System Feedback:

The absence of real-time transaction progress indicators, such as progress bars or confirmation messages, leaves Web2 users uncertain about whether their actions—such as liking or posting—were successfully completed. This issue reflects a lack of adherence to Nielsen’s (1994) visibility of system status heuristic, which is critical for building user confidence.

- Cognitive Load Associated with Web3 Mechanics:

The responsibility of managing private keys and understanding on-chain processes imposes a high cognitive load, particularly for non-technical users. This challenge undermines ISO 9241-11’s usability principles, which emphasize the importance of minimizing complexity to enhance user efficiency and satisfaction (Bevan & Carter, 2016).

- Interface Discoverability:

Web2 users often struggle with navigating dApp interfaces, such as locating posting options or understanding action counters. These issues highlight the need for design improvements tailored to users with limited technical expertise.

5.2 Answer to Sub-research Question 2: What UX features and design considerations are prioritized by Web3 users in decentralized applications, and how can these be integrated to enhance their satisfaction?

Web3 users prioritize features that align with decentralization, transparency, and autonomy, reflecting their familiarity with blockchain systems. Key priorities include:

- Transparency in Transactions:

Web3 users demand detailed transaction logs, including hash IDs and progress indicators, to independently verify their actions. This aligns with the Technology Acceptance Model (TAM), which identifies perceived usefulness and transparency as critical factors in user satisfaction (Davis, 1989).

- Exploration of Airdrop and Tokenomics:

Web3 users actively explore whether their actions on the platform, such as earning points or engaging with features, might connect to potential airdrop rewards. They show a strong interest in understanding the platform's underlying tokenomics, analyzing how these mechanisms influence user behavior and long-term sustainability.

- Comparison with Other Web3 Applications

Web3 users often compare the platform with other decentralized applications, assessing its features, usability, and adherence to Web3 principles. This benchmarking reflects their expectation for innovation and alignment with decentralized values.

- Enhanced System Feedback:

Clear feedback mechanisms, such as extended animation durations and transaction summaries, help mitigate delays in on-chain processing. The importance of feedback loops for reducing user anxiety is also supported by Hiremath & Kenchakkanavar (2016).

- Expectations for Autonomy:

Web3 users expect full control over their interactions on a platform, reflecting the core values of decentralization. Features like editing or deleting posts exemplify this autonomy, allowing users to manage their content without relying on administrators. As Cai et al. (2018) highlight, dApps prioritize user control over data and actions, aligning with the principles of transparency and decentralization. Without these features, Web3 users may feel restricted and lose trust in the platform. Conversely, providing such functionalities enhances user satisfaction, fostering a sense of freedom and security in managing their interactions.

5.3 Answer to the Main Research Question: How can the user experience of decentralized applications be optimized to support both Web2 and Web3 users?

Optimizing the user experience of decentralized applications requires addressing the distinct needs of Web2 and Web3 users while bridging the usability gap between them. Key strategies include:

- Progressive Onboarding:

Interactive tutorials and tooltips can guide Web2 users through unfamiliar concepts like "Epoch Keys" and wallet setup, reducing the cognitive load, as suggested by Qasse et al. (2020). For Web3 users, offering customizable onboarding features supports their advanced expectations for autonomy.

- Real-Time Feedback and Transparency:

Incorporating transaction progress indicators and detailed logs is essential for enhancing user confidence during critical interactions. For Web2 users, real-time feedback reduces uncertainty by clearly displaying transaction states, such as "pending" or "completed," making blockchain processes more understandable. For Web3 users, access to transaction details, like hash IDs and timestamps, aligns with their expectation for transparency and control. These features address ISO 9241-11's focus on satisfaction and efficiency (Bevan & Carter, 2016) and reinforce trust by ensuring users feel informed and in control of their actions.

- Balancing Anonymity and Usability:

Anonymity features, such as dynamic avatars, are essential for Web3 users who value privacy and decentralization. However, these mechanisms can confuse Web2 users, who may struggle to understand their purpose or functionality. Simplifying these features through clear explanations and intuitive design can help bridge this gap, ensuring usability for Web2 users while maintaining the trust and satisfaction of Web3 users. This aligns with Hassenzahl's (2008) emphasis on experiential design, which prioritizes meeting users' emotional and functional expectations.

5.4 Limitations of the Study

This study has a number of limitations that may affect the generalizability and scope of its findings. While the research sheds light on the usability issues and design considerations of decentralized apps, significant limitations inherent in the study design and methodology must be noted. These limitations originate from practical, social, and technological considerations that may have influenced the findings and limited their general applicability. Identifying these limits not only provides a transparent review of the study's scope, but also identifies crucial topics for future research to improve understanding of user experience in decentralized apps.

- Sample Size and Participant Diversity:

While we attempted to recruit participants from both Web2 and Web3 user groups, the overall sample size was limited to seven each round of testing. Although this is consistent with Nielsen and Landauer's (1993) guideline for usability studies, a bigger and more diverse participant pool may provide better insights and improve the generalizability of the results. Furthermore, the study primarily involved participants familiar with either Web2 or Web3 technologies, which may not capture the full range of experiences from users with hybrid or limited technical backgrounds.

- Single Case Study Focus:

The study centered on Unirep Social Taiwan, a specific decentralized social platform, as the primary case study. While this provided in-depth insights into the platform's usability challenges, the findings may not fully reflect the broader landscape of decentralized applications. Other dApps with different designs, features, or user demographics may present distinct usability challenges not addressed in this study.

- Technological and Contextual Constraints:

The study was carried out in a controlled usability testing setting, which may not accurately reflect real-world usage conditions. The predetermined activities and testing environment altered participants' interactions, which may have limited the spectrum of observed behaviors. Furthermore, the platform's reliance on blockchain technologies may have caused performance delays during testing, which influenced the results.

- Focus on Usability Over Other UX Dimensions:

While the study focused on usability, including measures like task success rates, completion durations, and SUS scores, other aspects of user experience, such as emotional responses, long-term involvement, and social dynamics, were not thoroughly investigated. These variables may be essential in understanding user retention and happiness on decentralized social platforms.

- Limited Longitudinal Data:

This study used two iterative rounds of usability testing over a relatively short period of time. Due to a lack of longitudinal data, the study does not reflect how user behavior or satisfaction evolves over time with the platform. Future research could include extending the evaluation period to analyze the impact of proposed design modifications on user uptake and retention.

- Evolving Nature of Web3 Technologies:

The rapidly changing Web3 ecosystem may limit the study's relevance over time. As decentralized applications and blockchain technologies continue to evolve, new features, standards, and user expectations may emerge, potentially outdating some of the findings and recommendations presented here.

These limitations highlight areas for future research to address, including larger and more diverse participant groups, comparative studies across multiple dApps, and longitudinal evaluations to better understand the evolving nature of user experiences in decentralized applications.

6. Conclusion and Future Research Directions

6.1 Conclusion and Concluding Remarks

This study explored how the user experience (UX) of decentralized applications (dApps) may be improved to accommodate both Web2 and Web3 users. By conducting iterative usability testing with a varied group of participants over two rounds, the study gave crucial insights into the usability difficulties faced by users with varying levels of technical skill.

Key findings revealed that Web2 users initially struggled with high cognitive load and unfamiliar blockchain ideas, limiting their participation with the site. However, modifications to onboarding processes and interface feedback mechanisms dramatically decreased these problems, resulting in a more seamless user experience. On the other side, Web3 users expressed a desire for sophisticated capabilities such as transaction transparency and control over on-chain actions. While some improvements, such as thorough transaction logs, were well appreciated, technical jargon and engineering-specific terminology remained a challenge.

Overall, the study advances the field of UX design for dApps by offering concrete techniques for closing the gap between Web2 and Web3 user expectations. By increasing transparency, explaining blockchain concepts, and customizing design components to diverse user groups, this study presents a realistic approach for boosting usability in decentralized networks. The findings emphasize the significance of iterative testing and user-centered design in the expanding Web3 ecosystem.

6.2 Future Research Directions

While this study offers significant information, some limitations suggest areas for further investigation. The sample size, while adequate for preliminary usability testing, was limited to seven participants per round, limiting the generalizability of the findings. Future study should broaden the participant demographics to include users with hybrid or limited technical experience, capturing the complete range of user needs.

Additionally, the study employed Unirep Social Taiwan as a case study. Exploring several dApps with varying functionality and user bases may provide a more comprehensive understanding of usability issues and solutions across the decentralized environment. Longitudinal study would also be useful for determining how user satisfaction and behavior change over time, especially as users grow more familiar with the platform's capabilities.

Finally, as Web3 technologies evolve, new tools and standards may emerge that challenge user expectations. Future research should look into how future technologies, like zero-knowledge proofs or decentralized identity systems, affect UX design and user uptake. These areas of research could help to improve the convergence of Web2 and Web3 concepts, ensuring that decentralized systems remain accessible, intuitive, and engaging.

6.3 Final Thoughts

Reflecting on this research journey, it is clear that the convergence of Web2 and Web3 creates both obstacles and opportunity for UX design. The process of optimizing decentralized applications necessitates balancing the technical intricacies of blockchain with straightforward design ideas known to typical Web2 users. This study has given me a better understanding of the various needs of users in decentralized ecosystems, as well as the strategies required to meet them.

Looking ahead, I envision dApps that smoothly blend Web2 and Web3 principles, resulting in increased acceptance and usability across all user groups. Developers and designers can create platforms that not only adhere to the decentralization ideal, but also provide outstanding user experiences, by stressing user-centric design and iterative testing.

This study is a step toward that aim, and I hope it spurs more studies and breakthroughs in the field of decentralized application design. We can work together to make the Web3 ecosystem more inclusive and accessible.

References

- Althubaiti, M., Zaman, N., Ansari, M., & Attique, M. (2022). User perspectives on blockchain technology: User-centered evaluation and design strategies for DApps. *Electronics, 11*(3), 3004.
- Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of Usability Studies, 4*(3), 114–123.
- Bevan, N., & Carter, J. (2016). ISO 9241-11 revised: What have we learnt about usability since 1998? In P. Kotzé, A. Gerber, W. Motara, C. Kourie, & R. Looock (Eds.), *Interdisciplinary advancements in information technology research* (Vol. 2, pp. 143-151). Springer.
- Cai, W., Wang, Z., Ernst, J. B., Hong, Z., Feng, C., & Leung, V. C. M. (2018). Decentralized applications: The blockchain-empowered software system. *IEEE Access, 6*, 53019–53033.
- Carruthers, J. (1990). A rationale for the use of semi-structured interviews. *Journal of Educational Administration, 28*(1).
- Chen, T., Guo, W., Gao, X., & Liang, Z. (2021). AI-based self-service technology in public service delivery: User experience and influencing factors. *Government Information Quarterly, 38*(4), 101520.
- Ciesielska, M., Boström, K. W., & Öhlander, M. (2018). Observation methods. In *Qualitative methodologies in organization studies: Volume II: Methods and possibilities* (pp. 33-52).
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340.

Hassenzahl, M. (2008, September). User experience (UX) towards an experiential perspective on product quality. In *Proceedings of the 20th Conference on l'Interaction Homme-Machine* (pp. 11-15).

Hassenzahl, M., & Tractinsky, N. (2006). User experience: A research agenda. *Behaviour & Information Technology*, 25(2), 91-97.

Hiremath, B. K., & Kenchakkanavar, A. Y. (2016). An alteration of Web 1.0, Web 2.0, and Web 3.0: A comparative study. *Imperial Journal of Interdisciplinary Research*, 2(4), 705–710.

International Standardization Organization. (2010). ISO DIS 9241-210:2010. Ergonomics of human-system interaction: Part 210: Human-centred design for interactive systems. International Standardization Organization.

ISO. (1998). ISO 9241-11: Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability. International Organization for Standardization.

Jang, H., & Han, S. H. (2022). User experience framework for understanding user experience in blockchain services. *International Journal of Human-Computer Studies*, 158, 102733.

Lacity, M. C., & Carmel, E. (2024). Web2 versus Web3 information privacy: An information systems discipline perspective. In *Human privacy in virtual and physical worlds: Multidisciplinary perspectives* (pp. 111-140). Cham: Springer Nature Switzerland.

Lazar, J., Feng, J. H., & Hochheiser, H. (2017). *Research methods in human-computer interaction*. Morgan Kaufmann.

Lewis, J. R. (2018). The system usability scale: Past, present, and future. *International Journal of Human-Computer Interaction*, 34(7), 577-590.

- López, E., Fernández-Caramés, T. M., & Fraga-Lamas, P. (2022). Responsive blockchain-based systems for IoT: Tackling latency issues in real-time applications. *International Journal of Distributed Systems*, 18(4), 415-431.
- Migiro, S. O., & Magangi, B. A. (2011). Mixed methods: A review of literature and the future of the new research paradigm. *African journal of business management*, 5(10), 3757-3764.
- Morville, P. (2005). User experience design unplugged. Semantic Studios.
- Murray, A., Kim, D., & Combs, J. (2023). The promise of a decentralized internet: What is Web3 and how can firms prepare? *Business Horizons*, 66(2), 191–202.
- Nielsen, J. (1994). *Usability engineering*. Morgan Kaufmann.
- Nielsen, J., & Landauer, T. K. (1993). A mathematical model of the finding of usability problems. In *Proceedings of the INTERCHI '93 Conference on Human Factors in Computing Systems* (pp. 206–213).
- PSE. (2024). UniRep protocol. Privacy and Scaling Explorations. Retrieved from <https://pse.dev/zh-TW/projects/unirep-protocol>.
- Patel, A., Thakar, D., Patel, D., Dave, A., Patel, D. M., & Shukla, B. (2022). Web 3.0: the risks and benefits of web 3.0 no web 2.0, web 1.0. *Journal homepage: www.ijrpr.com ISSN*, 2582, 7421.
- Patton, M. Q. (2002). *Qualitative research and evaluation methods*. SAGE Publications
- Qasse, I. A., Spillner, J., Talib, M. A., & Nasir, Q. (2020). A Study on DApps Characteristics. In *2nd IEEE international conference on decentralized applications and infrastructures*.
- Ray, P. P. (2023). Web3: A comprehensive review on background, technologies, applications, zero-trust architectures, challenges, and future directions. *Internet of Things and Cyber-Physical Systems*, 3, 213–248.

- Renner, M., & Taylor-Powell, E. (2003). Analyzing qualitative data. *Programme Development & Evaluation, University of Wisconsin-Extension Cooperative Extension*, 1-10.
- Rhiu, I., & Yun, M. H. (2018). Exploring user experience of smartphones in social media: A mixed-method analysis. *International Journal of Human-Computer Interaction*, 34(10), 960-969.
- Rubin, J., & Chisnell, D. (2008). *Handbook of usability testing: How to plan, design, and conduct effective tests*. Wiley Publishing.
- Sambra, A., Guy, A., Capadisli, S., & Greco, N. (2016). Building decentralized applications for the social web. In *Proceedings of the 25th International Conference on World Wide Web Companion* (pp. 1033–1034).
- Shneiderman, B. (1983). Direct manipulation: A step beyond programming languages. *Computer*, 16(08), 57-69.
- Todorovic, D. (2008). Gestalt principles. *Scholarpedia*, 3(12), 5345.
- Unirep Social Taiwan. (2024). *Launch*. Retrieved from <https://social-tw-website.pages.dev/launch>
- Van Den Haak, M., De Jong, M., & Schellens, P. J. (2003). Retrospective vs. concurrent think-aloud protocols: Testing the usability of an online library catalogue. *Behaviour & Information Technology*, 22(5), 339-351.
- Vermeeren, A. P., Law, E. L. C., Roto, V., Obrist, M., Hoonhout, J., & Väänänen-Vainio-Mattila, K. (2010, October). User experience evaluation methods: Current state and development needs. In *Proceedings of the 6th Nordic conference on human-computer interaction: Extending boundaries* (pp. 521-530).
- Wichansky, A. M. (2000). Usability testing in 2000 and beyond. *Ergonomics*, 43(7), 998–1006.

Yang, K., Choi, J. G., & Chung, J. (2021). Extending the Technology Acceptance Model (TAM) to explore customer's behavioral intention to use Self-Service Technologies (SSTs) in Chinese budget hotels. *Global Business & Finance Review (GBFR)*, 26(1), 79-94.

Yin, Y., Liu, L., & Gao, Y. (2022). Portrait of decentralized application users: An overview based on large-scale Ethereum data. *Digital Finance*, 4, 219–242.

Appendices

Appendix 1. Study Information and Consent Form

1. Study Title:

User experiences (UX) of an anonymous decentralized social platform after first time UX optimization

2. Usability Test Recruitment Brief:

Unirep Social Taiwan, sponsored by the Ethereum Foundation, is an innovative Web platform offering a fully anonymous social space, designed to ensure a safe and free environment for user interaction. Our goal is to leverage decentralized technology and high levels of anonymity, allowing users to express themselves and share thoughts with greater peace of mind, privacy, and respect from others. This usability test aims to explore ways to enhance the user experience and satisfaction for both Web and Web users. We appreciate your participation in helping us improve the platform experience

3. Usability Test Details:

- Duration: Approximately minutes
- Format: Remote session via video call (participants are required to share their screens during the usability test session, no need to turn on the camera to show face)
- Content:
 - a. Usability Test (around minutes, screen recording will be conducted without revealing participant's face)
 - b. Survey (around minutes)
 - c. Follow-up Interview (around minutes, audio recording will be conducted)
- Incentive: 800 TWD
- Participants are completely free to participate in the research and to withdraw from participation whenever they wish and for whatever reason.

4. Potential Risks:

During the test, there may be accidental displays of non-test-related content, especially when screen sharing. Additionally, participants may experience frustration while navigating the platform due to a lack of familiarity, which could impact their performance and overall experience in the test. Given the relatively

long duration of the testing sessions, participants might also feel fatigued. To address this, you could take breaks or pause the test at any time to rest or attend to personal needs, such as using the restroom.

5. Potential Risks:

All data from this usability study will be anonymized, ensuring no personal information is disclosed. The screen and audio recordings will be transcribed into text and anonymized. The original screen and audio recordings will be deleted once the transcription is complete. The usability test analysis, system usability scale survey results, and interview results will be stored in the Unirep Social Taiwan user experience research database until 31.12.2025, at the latest. This data will be used for current and future user research. Only Unirep Social Taiwan UX researchers will have access to this data.

6. Consent Content:	Yes	No
I have read and understood the study information, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
I understand the interview process and agree to share my screen during the interview. The interview results will be used solely for internal team analysis and will not be shared with others or used for other purposes without my permission.	☐	☐
I consent to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
I understand that taking part in the study involves a usability test that requires screen sharing, and a survey.	☐	☐
I understand that taking part in the study involves the following risks: there may be accidental display of non-test-related content during screen sharing. Additionally, I may experience some frustration while navigating the platform due to lack of familiarity, which could affect my performance and overall experience in the test.	☐	☐

I understand that the information I provide will be used for Chien-Cheng Hou's Master's Thesis, "Optimizing User Experience of Decentralized Applications for Web2 and Web3 Users - Case Anonymous Decentralized Social Platform", as well as for internal reference by the Unirep Social Taiwan development team to inform user experience optimization.	☐ ☐
I give permission for the anonymized transcripts of the usability test, interview, and survey data I provide to be archived in the Unirep Social Taiwan user experience research repository for future research and learning. All data will be fully anonymized by removing any personal identifiers before deposit. The data will be stored until 31.12.2025, at the latest. Access to the archived data will be restricted to research and educational purposes only, excluding commercial use, with safeguarded access measures in place to protect the data's integrity.	☐ ☐
7. Consent Content: Researcher Chien-Cheng Hou chien-cheng.hou@aalto.fi c.hou-2@student.utwente.nl If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscom-mittee-CIS@utwente.nl	