

# QUANTITATIVE ANALYSIS OF VISUAL UI COMPLEXITY IN DECENTRALIZED APPLICATIONS BY USING METRICS APPROACH

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**Abstract:** Decentralized applications (dApps) are still on the rise in many areas, but at the same time, their acceptance mainly depends on the difficulty of their user interfaces (UIs). Users with high visual and interaction complexity usually have a hard time to process at all, the very UI, and finally, they leave the application. This research quantitatively compares the dApps Uniswap and Decentraland in terms of their visual UI complexity by means of a comprehensive metrics-based framework that includes usability, user engagement, transaction performance, esthetic design, behavioral patterns, and user satisfaction as criteria. Evaluating the model from a psychometric angle, the framework introduced demonstrates sufficient discriminant validity in the assessment of perceived visual UI complexity among dApps. A new dApp named StudyChain, which involves an in-app guide for onboarding, is evaluated against the now established threshold to understand if guided onboarding can actually lower UI complexity. It turns out that StudyChain not only Uniswap but Decentraland as well by a considerable number at all metrics, the highest success rate of the 94.5%, the lowest error rates of 3.5%, and transaction efficiency far superior, besides that it was also getting much more esthetic appeal and user satisfaction almost doubling the scores. A guided onboarding method can thus be seen in this study as both an ally and a way to make visual UI complexity more manageable, through faster task completion and user satisfaction winning overall. The study has come up with a quantitative framework for measuring UI complexity in dApps that can be easily replicated and it also points out the areas where Web3 usability can be improved through design.

**Keywords:** Decentralized Applications (dApps), Visual User Interface (UI) Complexity, User Satisfaction Score (USAT), User Experience (UX).

## INTRODUCTION

Decentralized applications (dApps) have become a game-changer in the digital landscape, and at the same time, blockchain technology has made them reliable, trustworthy, and transparent (Zheng et al., 2023). Generally, in contrast to conventional applications, decentralized apps work based on decentralized networks, thus providing users with the advantages of trustworthiness, superb protection, minimal downtime, and no censorship at all (Zheng et al., 2023). This sea change in the paradigm is visibly transforming entire industries from finance and gaming, with Uniswap, decentraland, and MakerDAO standing tall (Mukherjee et al., n.d.). However, it is the truth that widespread dApp adoption greatly depends on the complexity of their user interfaces (UI) (Bobrova & Perego, 2025). The User Interface (UI) represents a significant interaction point for users, and their experience and engagement would be affected significantly by it. The lower the entry barriers for new users and the higher the overall user satisfaction and experience if the UI design is good. On the other hand, the complex and poor UI design will confuse the users and will eventually lead to the application growth blockage (Bobrova & Perego, 2025).

The UI complexity in the case of dApps takes into account multiple factors or dimensions like user engagement, usability, transaction performance, aesthetic design, user behavior, and user satisfaction (Guan et al., 2025). Should we aim at making the user interfaces, or dApps, to be more comfortable to use then it will be necessary first of all to grasp and improve these components that can have a huge impact on the acceptance of the decentralized technologies in general (AI Tech Ethics & Narayanan, 2025). Decentralized applications (dApps) are gradually being recognized as a powerful force for change in different sectors due to their qualities, such as trustless interaction, transparency, and user empowerment, among others. One of the main problems that hinder their mass adoption is the issue of user interfaces: the GUI of dApps, in most cases, is quite complex and it might turn off and bewilder novice users. As of the last few years, researchers have been

identifying cognitive load, lack of clear state visualization, and no progressive disclosure among the factors responsible for making Web3 applications difficult to use as the main reasons for that (Bobrova & Perego, 2025). The main objective of this study is to quantitatively analyze the visual UI complexity of two prominent dApps (Uniswap, and Decentraland) using a matrix based approach. And we have to compare the results with the interface of our developed dApp.

There are several components involve in the development of matrix in order to evaluate the visual user interface complexity of decentralized applications.

1- Usability and User Engagement: are one of the critical aspect of visual UI complexity. User-friendliness of the application, ease of use of the interface, and user interest in the application will be the metrics one would consider as main factors. The study of Jiang and Yin reveals that through the application of quantifiable metrics such as error rate, task success rate, and user satisfaction ratings, we can create a basis for statistical assessment of UI design (Jiang et al., 2019).

2- Transaction performance and Aesthetic Design: The application's transaction performance and aesthetic design are major determinants in the Visual UI complexity. Blockchain-based big data visualization research points to the necessity of very fast transactions, which in turn would guarantee that the user experience is seamless. Besides, the aesthetic quality of the interface is very crucial in attracting and keeping users. Ottakath's critique underpins the vital need of pairing up effective transaction processes with the pleasing design elements if the overall user experience is going to be enhanced (Shahzad et al., 2022).

3- Behavior and User satisfaction: The first step toward an effective interface design is the assurance of user satisfaction and the understanding of user behavior. The blockchain-based ChainAgile framework for distributed software development must be integrated into the design process for the analysis of user behavior and comprehension of satisfaction feedback. If our goal is to create or develop interfaces that are not only functional but also pleasing to users, this method is very helpful in the realization of such interfaces (Qureshi & Farooq, 2024).

The objective of study is twofold: first, to measure the UI complexity in mature dApps; and second, to find out if StudyChain's design can significantly lessen that complexity. In the end, this research provides a standardized framework for assessing and contrasting dApp interfaces, which has real-world consequences for designers who want to improve the usability and acceptance of blockchain applications. The study's structure is as follows. Section 2 presents a review of the most recent literature. Section 3 describes the research methodology used to conduct the study. Section 4 analyzes the results obtained through the methodology outlined in Section 3.

## LITERATURE REVIEW

The solution of quantitative analysis of visual user interface (UI) complexity is therefore becoming more and more important for improving the usability and user experience, particularly in the case of decentralized applications (dApps) where system complexity, as well as the users' trust, are of major concern. The recent studies have revealed that there is a significant increase in the use of metric-based methods to carry out the objective evaluation and management of UI complexity across the entire range of platforms from traditional to decentralized.

There have been different measures suggested to quantify visual complexity, such as alignment, balance, density, symmetry, color variability, and entropy-based measures. User studies usually validate these metrics, demonstrating strong associations with perceived usability and cognitive load and, consequently, giving designers the opportunity to make changes and improve UI layouts quickly through the use of such valuable insights. A study (Akça et al., 2025) presents a cutting-edge technique that applies metrics such as alignment, balance, density, and distance-to-focal-area to create UI layouts with least visual complexity, confirmed by experiments demonstrating fast and efficient production of best layouts. Another study by "Riegler" (Riegler & Holzmann, 2018) presents the employment of computational metrics for the evaluation of mobile app UI complexity based on screenshots and interaction data. The authors also report a strong relationship between these metrics and perceived usability and workload in user studies.

The paper examines a comparison of spatial frequency-based and traditional image metrics for visual complexity, resulting in the conclusion that some metrics like RMSE and spatial detectability exhibit good agreement with human complexity ratings (Durmus, 2020). Visual complexity analysis through deep intermediate-layer features (Saracé et al., 2020), Employs deep neural network intermediate-layer activations as a tool for quantifying visual complexity, achieving very high correlation with human evaluations and exceeding conventional techniques on benchmark datasets. the work of (Y. Nehmé et al. 2022) creates an extensive dataset and a deep learning metric for the evaluation of visual quality of 3D meshes, the performance of which in predicting perceived quality under different distortions is at the cutting-edge level (Nehmé et al., 2023). An approach is proposed for the automatic segmentation of dashboard UIs in order to facilitate the analysis of metrics based on objects, taking into account user perception and the principles of Gestalt grouping (Hynek & Hruška, 2019).

The majority of the research regarding UI complexity based on metrics has been directed at web and mobile applications; however, there is a new trend of studies that are assessing the impact of software metrics on dApps. Researchers have used metrics like the number of contracts, functions, and object coupling to gauge

the complexity and potential security risks of dApps and analyzed their structural and behavioral characteristics with scalability in mind. A device is characterized that leverages visual identification to derive spatial measurements from screenshots of web user interfaces, resulting in data that is machine-readable for automatic evaluation of complexity and interlinking with other metric suppliers (Bakaev et al., 2019). A study by Aliaksei Miniukovich et al. Suggests a set of six automatic metrics (such as visual clutter, symmetry, etc.) for measuring GUI complexity through the use of screenshots and backs them up with user studies that demonstrate a strong correlation between perceived complexity, and also aesthetics (Miniukovich & De Angeli, 2014). One of the main objectives of the paper of Eren Akça et al., is to review and classify the visual complexity analysis studies reviewed and to identify areas where metrics and models are not suitable. Furthermore, it supports the need for machine learning-based, generalizable solutions (Akça & Tanriöver, 2021). In a research conducted by S. Schnur and others, they compared the ratings of map complexity given by machines and humans and discovered that feature congestion and entropy metrics correspond very closely with the user's perceptions (Schnur et al., 2018).

The recent research on "Integration of Visual and Functional Metrics" stresses the necessity of unifying UI metrics with conventional source code metrics, in order to acquire a complete picture of the application's complexity, maintainability, and user effort estimation. This all-encompassing method is especially applicable to dApps since the complexity and usability of the entire system depend on both the smart contract layout and the user interface (Corral et al., 2021; Ibba et al., 2023; Samreen & Alalfi, 2023). Deep learning and computer vision techniques have been successfully employed to estimate visual complexity, surpassing traditional approaches and being very close to human perception as far as correlation is concerned. With the help of these methods, automatic tools for real-time UI assessments can be developed, which can be further customized for the interfaces of decentralized applications (Bakaev et al., 2019; Keselj et al., 2022; Saraee et al., 2020).

Readjusting the focus onto the visual UI complexity in dApps from a quantitative metrics perspective, research has not been able to bridge the gap which exists despite the advances made. The majority of UI studies on blockchain are limited to usability or to general design guidelines and metric-based complexity evaluation is little or no discussed (Tharani et al., 2022; Tharatipyakul & Pongnumkul, 2021). The use of quantitative metrics-based analysis for visual UI complexity is already a well-established practice for web and mobile applications. While it is slowly gaining acceptance in the area of decentralized apps, the application is still very limited. Future research in the area of dApp UI complexity assessment could take the integration of visual and functional metrics, as well as the use of automated and deep learning methods, as a promising path.

### **Research Gap**

A notable number of studies have gone into the metrics-based evaluation of visual UI complexity in traditional web and mobile applications; nevertheless, those approaches have seldom been applied in a systematic way to decentralized applications (dApps). Currently, the research on usability, security, or general design principles in dApps is the main area of focus, while the quantitative evaluation of visual complexity is largely neglected. Besides, although deep learning and automated metrics have been very much in tune with human perception in traditional UIs, their application to dApp-specific interfaces has not been extended, where, for example, the factors of transaction flow, smart contract interactions, and user onboarding frameworks are critical. This situation points out the necessity for a full, metrics-based framework that will be able to evaluate and categorize the visual UI complexity of dApps and at the same time take into account user interaction, transaction efficiency, aesthetic design, and satisfaction, as the present research suggests.

## **RESEARCH METHODOLOGY**

This research will begin with a literature review to identify the required elements and methodology for relevant metrics to measure visual UI complexity in dApps (Hassan et al., 2024). Among the elements of these metrics, task success rate, error rate, user satisfaction, and transaction efficiency will be defined.

Usability testing with participants will be the part of data collection process, and performance metrics analysis will be used to assess transaction speed and reliability. dApps (Uniswap, and Devcentraland) used in this research will establish a benchmark for visual user interface complexity analysis. The results obtained results will be compared with the visual UI complexity of the newly developed dApp "StudyChain" (Farooq, 2024/2024).

### **Sampling**

dApp's visual interface complexity results are going to be compared with the metrics established in this study to such an extent that recruitment of 10 to 20 participants was done so that potential dropouts would still be accounted for. The goals of the dApps project guarantee that a varied and heterogeneous group of users is represented; among them are the users who know the least about the dApp and those who are the most familiar with it. This method implies that the visual interface of dApp is going to be understood very well and the areas that need improvements will be easily pointed out.

As far as the experimental environment setup is concerned, a lab with 10 computers, each of them is equipped with Intel Core i7 processors and connected with high-speed internet. This also ensures that all PCs have the same version of operating system and dApp, along with the necessary tools for usability test.

To measure the visual UI complexity of the above two dApps and compare them with StudyChain, we need to define tasks before measuring each metric.

### Task-1

This task includes the integration of a wallet and successfully swaps ETH for USDC on Uniswap application. There are following steps for task-1 (figure 1).

- First open the UniSwap application
- Navigate the application and find swap interface
- Connect Uniswap application and MetaMask wallet
- Choose the ETH token to swap from and USDC token to swap to.
- Enter any amount of ETH you have in your wallet.
- Confirm the swap
- Check and verify the transaction details
- Complete the swap and approve the transaction on the wallet

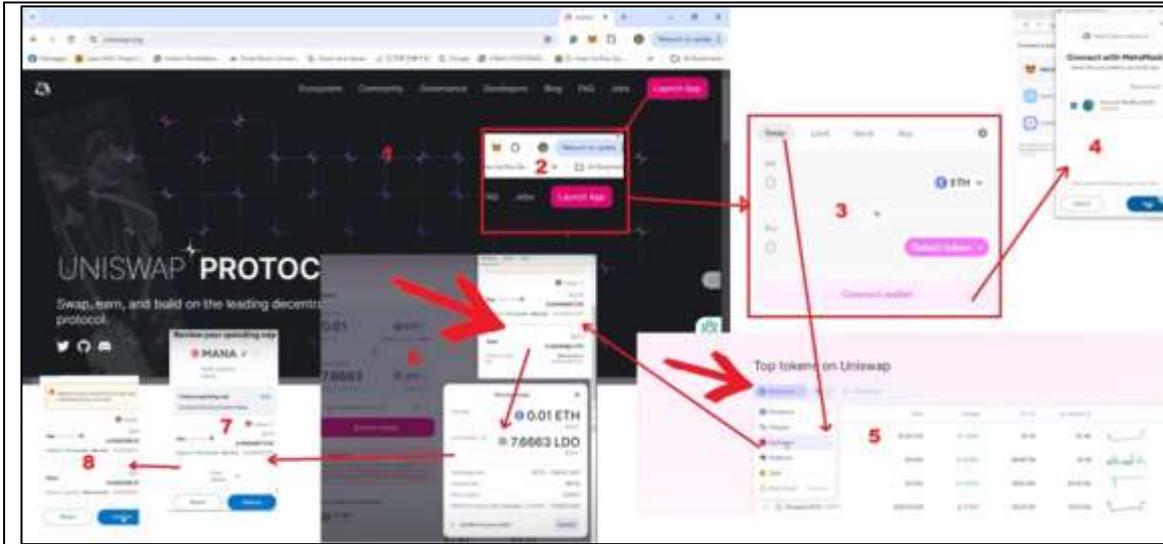


FIGURE 1 Task-1 step for UniSwap transaction

### Task-2

This task is for Decentraland application which includes the signup, the integration of a wallet, navigation of App and performing the transaction. There are following steps for task-2 (figure 2).

- Open the Decentraland dApp
- Create Login and Sign in
- Connect the MetaMask wallet with Application
- Navigate the app and explore the main interface of dApp
- Navigate and select any digital item and purchase this item
- Perform transaction
- Confirm and verify the transaction details

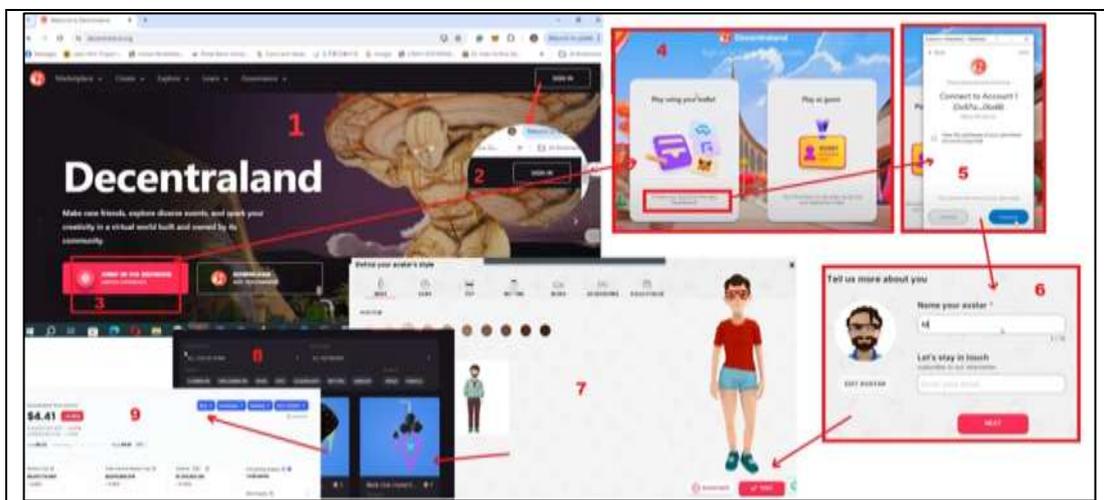


FIGURE 2 Task-2 step for Decentraland

**Task-3**

This task is for the newly developed “StudyChain” dApp available at github (Farooq, E. M. 2024). This task includes the login, wallet integration with dApp, navigating and performing transaction. There are following steps for task-3 (figure 3).

- Open the StudyChain dApp, complete the procedures, and pass through in-App guide
- Login as Student or teacher
- Get free ETHs from Ganache (a free platform for developers that provides ETHs for research) (Council, 2023).
- Connect your MetaMask wallet with application
- Select you course if you are a student or upload you course material if you are a teacher
- Perform transaction
- Confirm and verify the transaction details

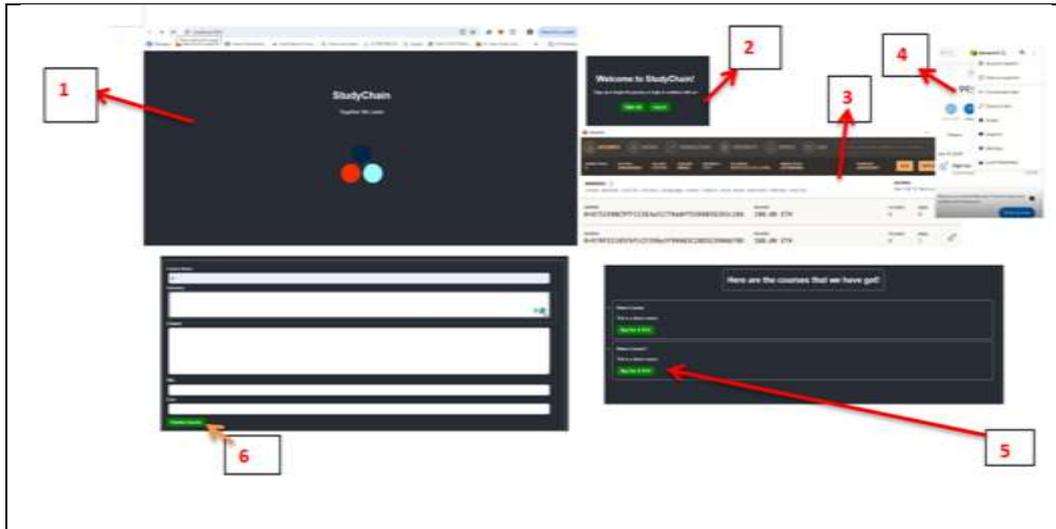


FIGURE 3 Task-3 step for StudyChain

**Usability Matric for dApps**

**Success Rate**

When a user completes the swap without errors, it will be considered a successful.

Formula

$$Task\ Success\ Rate = \left( \frac{Number\ of\ Successful\ Tasks}{Total\ Number\ of\ Tasks} \right) \times 100 \text{ (Hafiz Abdul Basit Muhammad et al., 2022; Ramadan et al., 2019)}$$

**Time for task**

A user takes time to complete the entire process, from connecting wallet to the final step of the task

Formula (Time-on-Task or Task Completion Time - OKRify, 2023)

**Error Rate**

$$Average\ Time\ on\ Task = \left( \frac{Total\ time\ spent\ on\ tasks}{Number\ of\ Tasks} \right)$$

Any error encountered during the user process is recorded such as connection problems, transaction failures, or user errors.

Formula (Sauro, 2016)

$$Error\ Rate = \left( \frac{Number\ of\ Errors}{Total\ Number\ of\ Tasks} \right) \times 100$$

TABLE 1 Results of Usability Matric for dApps

Task (dApp)	Success Rate %	Time for task	Error rate %
Task-1 (Uniswap)	64.5%	12.85	9.0%
Task-2 (Decentraland)	68%	13.74	11%
Task-3 (StudyChain)	94.5%	7.45	3.5%

### User Engagement Metrics

#### Active Users

The numbers of unique users interacting with dApps was tracked during the period of the experiment. And we also noted the user's reaction and attention. How much user attention was on dApp (Clifton, 2012).

Formula:  $Active\ User = Number\ of\ Unique\ Users\ during\ a\ period$

#### Session Duration

During the experiment, the average length of time users spend in a session on dApp has been measured

Formula (Clifton, 2012)

$$Average\ Session\ Duration = \left( \frac{\sum session\ length}{Total\ number\ of\ sessions} \right)$$

TABLE 2 Results of User Engagement Metrics

Task (dApp)	Active Users	Session Duration
Task-1 (Uniswap)	98%	12 minutes
Task-2 (Decentraland)	96%	14
Task-3 (StudyChain)	99%	8

### Transaction Metrics

#### Transaction volume

Total number of transactions completed by user within the period of experiment session (Wu, 2023).

Formula

$$Transaction\ Volume = Total\ Number\ of\ Transactions\ During\ a\ Period$$

#### Transaction volume

The average time a user takes to complete a transaction on the dApp (Shahriar Hazari & Mahmoud, 2020).

Formula

$$Average\ Transaction\ Speed = \left( \frac{Total\ Number\ of\ Transactions}{Total\ Time\ to\ Complete\ Transaction} \right)$$

TABLE 3 Results of Transaction Metrics

Task (dApp)	Transaction volume	Average Speed of Transaction
Task-1 (Uniswap)	98%	12 minutes
Task-2 (Decentraland)	96%	14
Task-3 (StudyChain)	99%	8

### Aesthetic and Design Metrics

#### Visual Appeal

There are two approaches are used for measuring interface aesthetic, first is objective approach based on screen interface design features and layout elements in context of users (Bauerly & Liu, 2006; Ngo et al., 2003). The second approach is subjective approach based on the responses from user through survey (Lavie & Tractinsky, 2004). For the evaluation of the overall attractiveness of the dApp's interface as perceived by user, this metric is used.

Formula

$$Visual\ Appeal\ Score = \left( \frac{\sum User\ Rating}{Number\ of\ Ratings} \right)$$

#### Consistency

This score is obtained by identifying and counting the compatible design elements in dApp and dividing by the total number of these elements, and then multiply by 100 to get the score.

Formula

$$Consistency = \left( \frac{Number\ of\ Consistency\ Elements}{Total\ Number\ of\ Elements} \right) \times 100$$

TABLE 4 Results of Aesthetic and Design Metrics

Task (dApp)	Visual Appeal	Consistency
Task-1 (Uniswap)	30%	40 %
Task-2 (Decentraland)	20%	15
Task-3 (StudyChain)	70%	75

### Behavior Metrics

#### Clicks

By aggregating the total number of clicks on different elements of the dApp, this metric helps to understand which part of the dApp the user experienced the most engagement or trouble with (Nicholas, 2018).

Formula

$$Total\ Clicks = \sum (Clicks\ on\ Each\ Element)$$

#### Navigation Path

Understanding the navigation path during the use of the dApp helps to identify the potential obstacles encountered.

Formula

$$Navigation\ Path = \left( \frac{Sequence\ of\ Path}{Element\ Visited} \right)$$

TABLE 5 Results of Behavior Metrics

Task (dApp)	Visual Appeal	Consistency
Task-1 (Uniswap)	30%	40 %
Task-2 (Decentraland)	20%	15
Task-3 (StudyChain)	70%	75

Every user task was recorded from the screen to determine the number of clicks and to trace the navigational route of each dApp. The tool for screen capturing was Camtasia.

### Satisfaction Metrics

#### Net Promoter Score (NPS)

The NPS is the measurement of the likelihood that users recommend the dApp to others. Here promoters are users who give the rating the dApps from 9-10, passives rate it 7-8, and Detractors rate it 0-6.

Formula

$$NPS = \%Promoters - \%Detractors$$

A higher ratio of NPS indicates that users find the dApp's UI visually appealing and easy to use, contributing to overall satisfaction (Bradner & Sauro, 2012).

#### User Satisfaction Score (USAT)

This is the measurement of the satisfaction of users with the dApp's visual user interface. For this metric, data is collected through survey form asking users to rate either Satisfaction on a scale (1-5). It helps gauge immediately user reaction to the UI complexity (What Is Net Promoter Score (NPS)?, n.d.).

Formula

$$USAT = \left( \frac{\sum Satisfied\ Responses}{\sum Responses} \right) \times 100$$

#### User Effort Score (UES)

This is a measurement of how much effort users have to exert to use the dApp's UI. This is a survey where users rate the effort needed to complete tasks. A lower ratio of UEF indicates a more intuitive and user friendly UI (Korczynska, 2024).

Formula

$$UES = \left( \frac{\sum Effort\ Score}{\sum Responses} \right)$$

TABLE 6 Results of Satisfaction Matric

Task (dApp)	NPS	USAT	UES
Task-1 (Uniswap)	41%	60%	76%
Task-2 (Decentraland)	30%	45%	89%
Task-3 (StudyChain)	60%	82.5%	32.5%

## RESULTS AND ANALYSIS

If we talk about the results, in terms of usability metrics as mentioned in table 1, shown in Figure-4, StudyChin stands out with a high success rate (94.5%) and a low error rate (3.5%). Users can complete tasks quickly and successfully (7.45 seconds), which indicates a well- designed interface. One of the main reasons

why StudyChain's dApp has good results is that user has to go through an in-App guide step before using it. Uniswap and Decentraland have good success rate (64.5% and 68%) but high failure rates (9% and 11%).

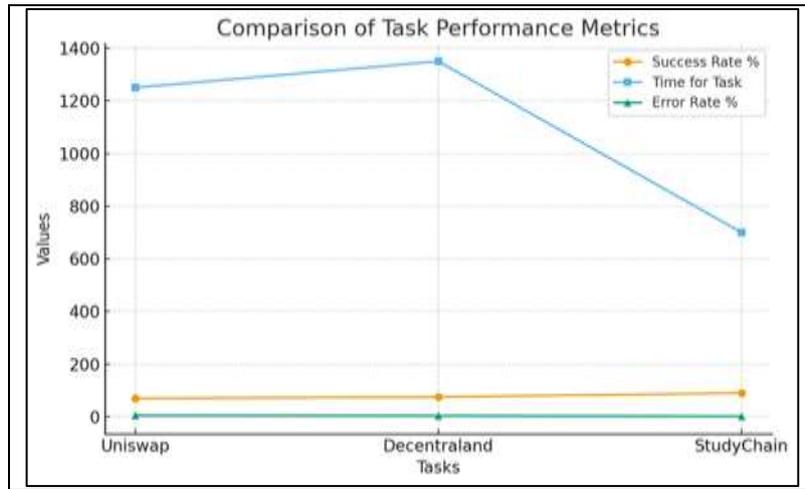


FIGURE 4 Results Analysis of usability metrics

All three dApps have a very high active user rate (96-99%) mentioned in table 2, and graph show in figure-5. Decentraland has the longest session duration rate (14 minutes), which indicates that user experienced more difficulties is using the app. This suggests immersive gameplay or exploration. StudyChain's short session duration (8 minutes) may indicate a more task-oriented application. StudyChain has low session duration because the user already knows how to complete each task.

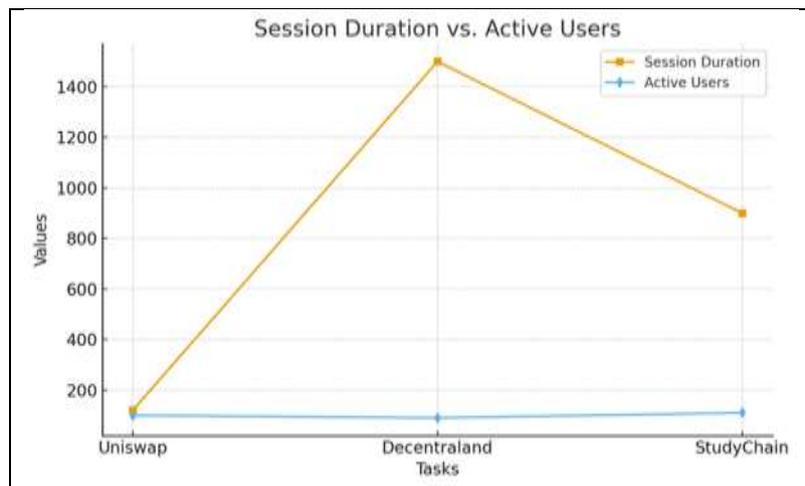


FIGURE 5 Results Analysis of User Engagement Metrics

In the transaction metrics results shown in table 3, StudyChain leads with the highest transaction volume and fastest transaction speed, indicating an efficient and functional platform as shown in figure-6. While the volume and speed of transaction in Uniswap are slightly lower than in StudyChain, Decentraland, while still performing well, has the lowest transaction volume and speed, possibly affecting user satisfaction.

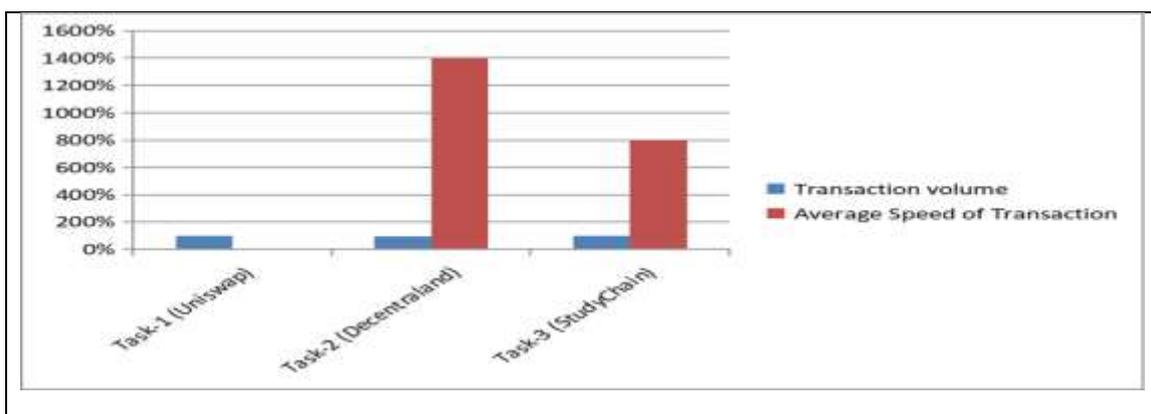


FIGURE 6 Results Analysis of User Transaction Metrics

StudyChain score is highly in visual appeal (70%) and design consistency (75%) according to aesthetic and design metrics results (table 4) as shown in figure-7. From the user's perspective, however decentraland and Uniswap received low scores rate, Suggesting that their user interface design need more work.

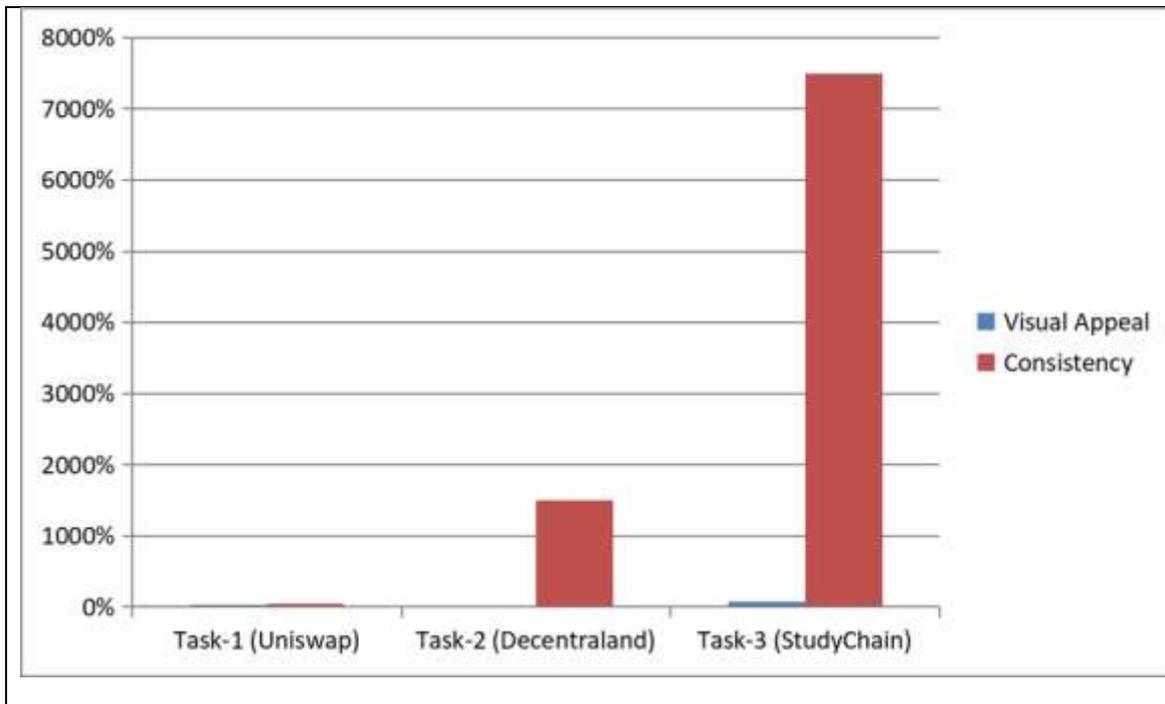


FIGURE 7 Results Analysis of User Aesthetic and Design Metrics

In the behavior metrics results mentioned in table 5, StudyChain shows high user interaction and smooth navigation path, which correlates to its high usability and satisfaction score, shown in figure-8. The main reason for this is the in-app guide framework that provides the user with complete information, skills and expertise before use. The results show that uniswap has moderate engagement and navigation efficiency. While Decentraland has the lowest scores, indicating potential difficulties in user interaction and navigation.

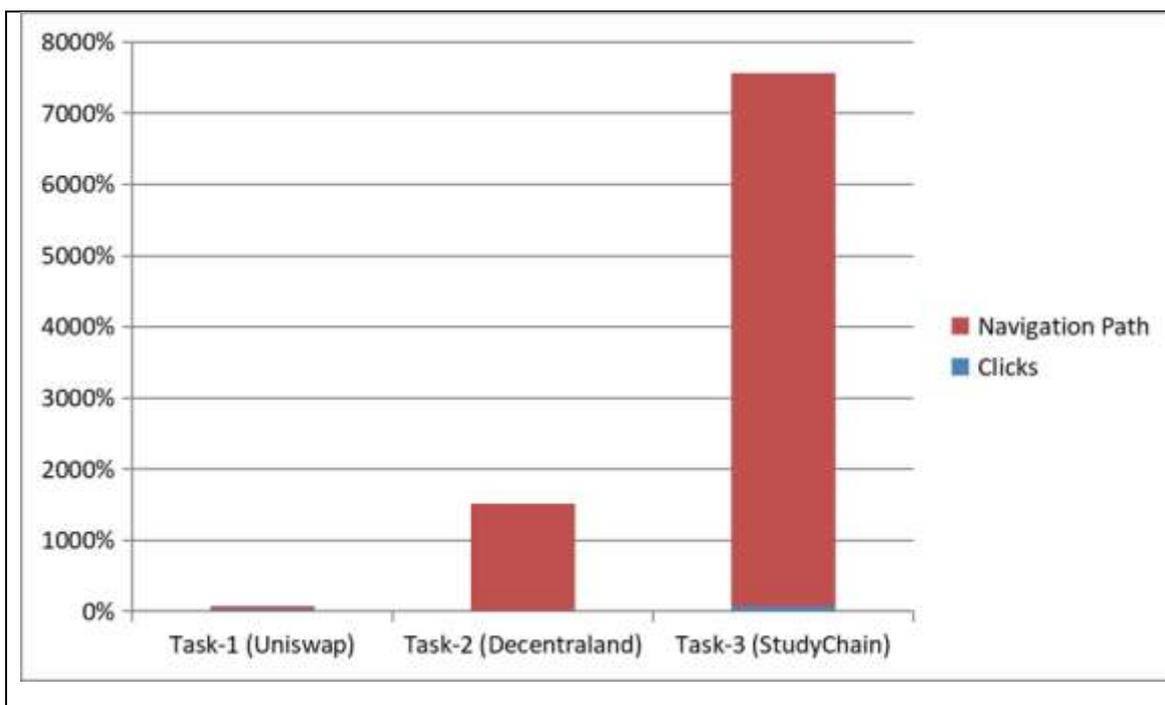


FIGURE 8 Results Analysis of Behavior Metrics

In satisfaction metrics results mentioned in table 6, StudyChain tops the list with highest NPS (net promoting score) of 60% and USAT (user satisfaction) of 82.5%. Users are happy with their experience with it, according to figure-9. Uniswap here has a decent USAT (60%) but a low NPS (41%), which suggests that some user may find it disappointing while other user satisfied. Decentraland has the lowest NPS (30%) but a surprisingly

high UES (Usability Efficiency Score) of 89%. This may indicate that the 3D world usable despite the overall low satisfaction.

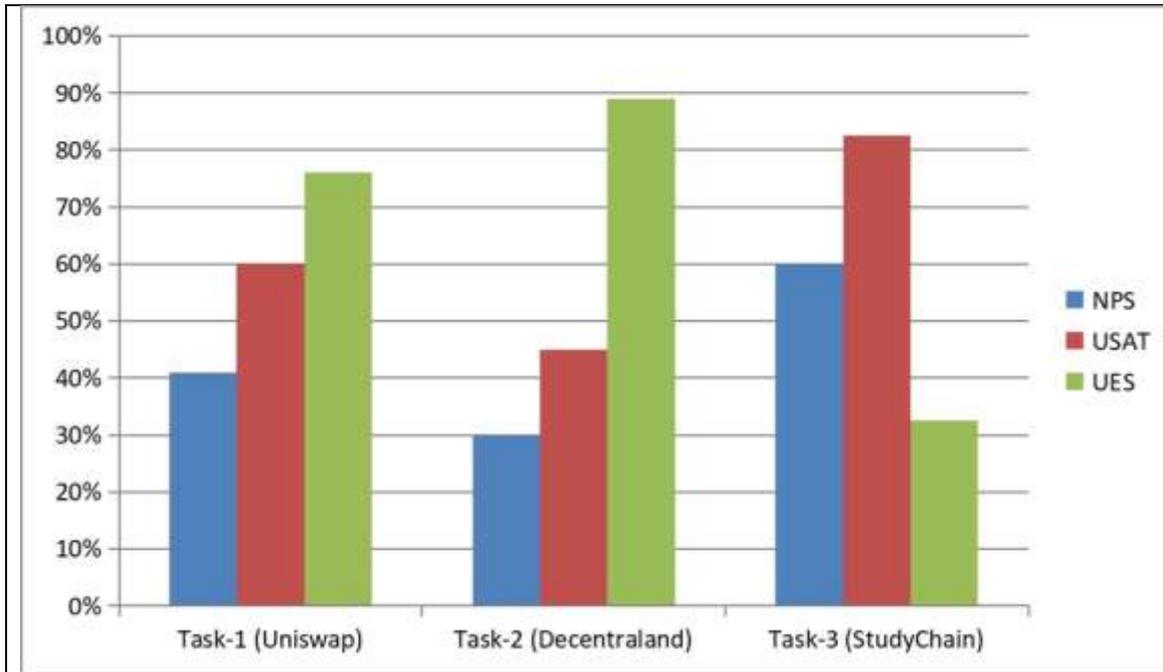


FIGURE 9 Results Analysis of satisfaction Metrics

### Psychometric Properties of the UI Complexity Metrics

For the purpose of evaluating methodological robustness, the consistency and sensitivity of the proposed visual UI complexity framework were analyzed across applications. The framework proved to be able to separate interfaces with different visual complexity levels very effectively. StudyChain had metrics related to complexity that were lower and user satisfaction that was higher, thus indicating strong capability of discrimination. The degree of correspondence between objective performance measures and subjective user ratings that was further reinforced by the framework's validity as a trustworthy tool for comparative assessment of visual UI complexity in dApps.

## CONCLUSION

The study was carried out by applying a structured metrics-based framework through which the visual UI complexity of Uniswap, Decentraland and the newly developed StudyChain dApp were analyzed and compared. StudyChain proudly took the lead among the three platforms concerning usability, engagement, performance, design quality, and others. End users reported being quicker in task execution, committing fewer errors, and enjoying better navigation. The User Interface was acclaimed to be excellent in visual clarity and consistency of layouts, and it won very high satisfaction ratings (NPS 60%, USAT 82.5%) making it very simple and requiring little effort to grasp. Uniswap revealed a somewhat complicated interface that could enhance its aesthetics and enjoyment through improvements. Decentraland's interface was classified as the most complex due to its very long task completion times, inconsistent layouts, and low satisfaction, which reflect the problems faced in 3D blockchain environments. Giving directions that are very clear and providing step-by-step help were the major findings resulting from StudyChain's built-in guide which significantly alleviated the cognitive load. The outcome indicates that onboarding with guidance can indeed lessen UI complexity and improve users' overall satisfaction. Future steps for the project could involve incorporating an automated UI complexity assessment based on deep learning and testing other Web3 platforms.

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## REFERENCES

1. AI Tech Ethics, & Narayanan, S. (2025). Towards building a comprehensive evaluation framework for Human Computer Interaction with a specific focus on AutoML. *INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT*, 09(10), 1–9. <https://doi.org/10.55041/IJSREM53221>
2. Akça, E., Özgür Tanrıöver, Ö., & Egemen Yılmaz, A. (2025). A Multi-Criteria Perceptual Visual Complexity Metrics-Based Optimization Approach to User Interface Design Layouts. *IEEE Access*, 13, 140046–140060. <https://doi.org/10.1109/ACCESS.2025.3596286>
3. Akça, E., & Tanrıöver, Ö. Ö. (2021). A comprehensive appraisal of perceptual visual complexity analysis methods in GUI design. *Displays*, 69, 102031. <https://doi.org/10.1016/j.displa.2021.102031>
4. Bakaev, M., Novosibirsk State Technical University, Novosibirsk, Russia, Heil, S., Technische Universität Chemnitz, Chemnitz, Germany, Khvorostov, V., Novosibirsk State Technical University, Novosibirsk, Russia, Gaedke, M., & Technische Universität Chemnitz, Chemnitz, Germany. (2019). Auto-Extraction and Integration of Metrics for Web User Interfaces. *Journal of Web Engineering*, 17(6), 561–590. <https://doi.org/10.13052/jwe1540-9589.17676>
5. Bauerly, M., & Liu, Y. (2006). Computational modeling and experimental investigation of effects of compositional elements on interface and design aesthetics. *International Journal of Human-Computer Studies*, 64(8), 670–682. <https://doi.org/10.1016/j.ijhcs.2006.01.002>
6. Bobrova, P., & Perego, P. (2025). The Development of User-Centric Design Guidelines for Web3 Applications: An Empirical Study. *Computers*, 14(2), 46. <https://doi.org/10.3390/computers14020046>
7. Bradner, E., & Sauro, J. (2012). Software User Experience and Likelihood to Recommend: Linking UX and NPS.
8. Clifton, B. (2012). *Advanced Web Metrics with Google Analytics* (3rd ed). John Wiley & Sons, Incorporated.
9. Corral, L., Fronza, I., & Mikkonen, T. (2021). User Interface Matters: Analysing the Complexity of Mobile Applications from a Visual Perspective. *Procedia Computer Science*, 191, 9–16. <https://doi.org/10.1016/j.procs.2021.07.039>
10. Council, B. (2023, May 18). Ganache Blockchain—Blockchain Council. <https://www.blockchain-council.org/blockchain/ganache-blockchain-all-you-need-to-know/>
11. Durmus, D. (2020). Spatial Frequency and the Performance of Image-Based Visual Complexity Metrics. *IEEE Access*, 8, 100111–100119. <https://doi.org/10.1109/ACCESS.2020.2998292>
12. Farooq, E. M. (2024). EngineerFarooq/dApp-Study-chain- [JavaScript]. <https://github.com/EngineerFarooq/dApp-Study-chain-> (Original work published 2024)
13. Guan, M. Y., Yu, Y., & Wang, K. Y. (2025). Using Affordance to Understand Usability of Web3 Social Media. *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*, 1–19. <https://doi.org/10.1145/3706598.3713263>
14. Hafiz Abdul Basit Muhammad, Muhammad Basit, Khalid Hamid, & Muhammad Waseem Iqbal. (2022, September 12). Usability Impact of Adaptive Culture in Smart Phones. *VIPERC2022. 1st International Virtual Conference on Visual Pattern Extraction and Recognition for Cultural Heritage Understanding*. [https://www.researchgate.net/publication/365683592\\_Usability\\_Impact\\_of\\_Adaptive\\_Culture\\_in\\_Smart\\_Phones](https://www.researchgate.net/publication/365683592_Usability_Impact_of_Adaptive_Culture_in_Smart_Phones)
15. Hassan, M. A., Jamshidi, M. B., Manh, B. D., Chu, N. H., Nguyen, C.-H., Hieu, N. Q., Nguyen, C. T., Hoang, D. T., Nguyen, D. N., Van Huynh, N., Alsheikh, M. A., & Dutkiewicz, E. (2024). Enabling Technologies for Web 3.0: A Comprehensive Survey (Version 1). *arXiv*. <https://doi.org/10.48550/ARXIV.2401.10901>
16. Hynek, J., & Hruška, T. (2019). Segmentation of Dashboard Screen Images: Preparation of Inputs for Object-based Metrics of UI Quality: Proceedings of the 14th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, 199–207. <https://doi.org/10.5220/0007312301990207>
17. Ibba, G., Khullar, S., Tesfai, E., Neykova, R., Aufiero, S., Ortu, M., Bartolucci, S., & Destefanis, G. (2023). A Preliminary Analysis of Software Metrics in Decentralised Applications. *Proceedings of the Fifth ACM International Workshop on Blockchain-Enabled Networked Sensor Systems*, 27–33. <https://doi.org/10.1145/3628354.3629533>
18. Jiang, Z., Yin, H., Luo, Y., Gong, J., Yang, Y., & Lin, M. (2019). Quantitative Analysis of Mobile Application User Interface Design. *2019 IEEE 38th International Performance Computing and Communications Conference (IPCCC)*, 1–8. <https://doi.org/10.1109/IPCCC47392.2019.8958722>
19. Keselj, A., Milicevic, M., Zubrinic, K., & Car, Z. (2022). The Application of Deep Learning for the Evaluation of User Interfaces. *Sensors*, 22(23), 9336. <https://doi.org/10.3390/s22239336>
20. Korczynska, E. (2024, May 17). What Is Customer Effort Score (CES) and How to Measure It. *Thoughts about Product Adoption, User Onboarding and Good UX | Userpilot Blog*. <https://userpilot.com/blog/what-is-customer-effort-score/>
21. Lavie, T., & Tractinsky, N. (2004). Assessing dimensions of perceived visual aesthetics of web sites. *International Journal of Human-Computer Studies*, 60(3), 269–298. <https://doi.org/10.1016/j.ijhcs.2003.09.002>

22. Miniukovich, A., & De Angeli, A. (2014). Quantification of interface visual complexity. *Proceedings of the 2014 International Working Conference on Advanced Visual Interfaces*, 153–160. <https://doi.org/10.1145/2598153.2598173>
23. Mukherjee, S., Labde, V. V., Peri, S. S. S. R. G., Praveen, R. V. S., Gudimella, A., Deshmukh, R., & Shrivastava, A. (n.d.). Decentralized Finance (DeFi): A Paradigm Shift in Global Financial Systems. Retrieved November 21, 2025, from <https://acr-journal.com/article/decentralized-finance-defi-a-paradigm-shift-in-global-financial-systems-1053/>
24. Nehmé, Y., Delanoy, J., Dupont, F., Farrugia, J.-P., Le Callet, P., & Lavoué, G. (2023). Textured Mesh Quality Assessment: Large-scale Dataset and Deep Learning-based Quality Metric. *ACM Transactions on Graphics*, 42(3), 1–20. <https://doi.org/10.1145/3592786>
25. Ngo, D. C. L., Teo, L. S., & Byrne, J. G. (2003). Modelling interface aesthetics. *Information Sciences*, 152, 25–46. [https://doi.org/10.1016/s0020-0255\(02\)00404-8](https://doi.org/10.1016/s0020-0255(02)00404-8)
26. Nicholas, M. (2018, March 21). Click-Through Rate(CTR) vs Conversion Rate: Definition, Formula, Calculation | VWO. Blog. <https://vwo.com/blog/conversion-rate-and-click-through-rate-difference/>
27. Qureshi, J. N., & Farooq, M. S. (2024). ChainAgile: A framework for the improvement of Scrum Agile distributed software development based on blockchain. *PLOS ONE*, 19(3), e0299324. <https://doi.org/10.1371/journal.pone.0299324>
28. Ramadan, A. B., Jackson-Thompson, J., & Schmaltz, C. L. (2019). Usability Assessment of the Missouri Cancer Registry’s Published Interactive Mapping Reports: Round Two. *Online Journal of Public Health Informatics*, 11(2). <https://doi.org/10.5210/ojphi.v11i2.9483>
29. Riegler, A., & Holzmann, C. (2018). Measuring Visual User Interface Complexity of Mobile Applications With Metrics. *Interacting with Computers*, 30(3), 207–223. <https://doi.org/10.1093/iwc/iwy008>
30. Samreen, N. F., & Alalfi, M. H. (2023). An empirical study on the complexity, security and maintainability of Ethereum-based decentralized applications (dApps). *Blockchain: Research and Applications*, 4(2), 100120. <https://doi.org/10.1016/j.bcra.2022.100120>
31. Saraee, E., Jalal, M., & Betke, M. (2020). Visual complexity analysis using deep intermediate-layer features. *Computer Vision and Image Understanding*, 195, 102949. <https://doi.org/10.1016/j.cviu.2020.102949>
32. Sauro, J. (2016). *Quantifying the user experience: Practical statistics for user research*. Morgan Kaufmann.
33. Schnur, S., Bektaş, K., & Çöltekin, A. (2018). Measured and perceived visual complexity: A comparative study among three online map providers. *Cartography and Geographic Information Science*, 45(3), 238–254. <https://doi.org/10.1080/15230406.2017.1323676>
34. Shahriar Hazari, S., & Mahmoud, Q. H. (2020). Improving Transaction Speed and Scalability of Blockchain Systems via Parallel Proof of Work. *Future Internet*, 12(8), 125. <https://doi.org/10.3390/fi12080125>
35. Shahzad, I., Maqbool, A., Rana, T., Mirza, A., Khan, W. Z., Kim, S. W., Zikria, Y. B., & Din, S. (2022). Blockchain-based green big data visualization: BGV. *Complex & Intelligent Systems*, 8(5), 3707–3718. <https://doi.org/10.1007/s40747-021-00466-y>
36. Tharani, J. S., Zelenyanszki, D., & Muthukumarasamy, V. (2022). A UI/UX Evaluation Framework for Blockchain-Based Applications. In S. Chen, R. K. Shyamasundar, & L.-J. Zhang (Eds.), *Blockchain – ICBC 2022* (Vol. 13733, pp. 48–60). Springer Nature Switzerland. [https://doi.org/10.1007/978-3-031-23495-8\\_4](https://doi.org/10.1007/978-3-031-23495-8_4)
37. Tharatipyakul, A., & Pongnumkul, S. (2021). User Interface of Blockchain-Based Agri-Food Traceability Applications: A Review. *IEEE Access*, 9, 82909–82929. <https://doi.org/10.1109/ACCESS.2021.3085982>
38. Time-on-Task or Task Completion Time—OKRify. (2023, January 14). <https://okrify.com/time-on-task-or-task-completion-time/>
39. What is Net Promoter Score (NPS)? How to Calculate & Interpret. (n.d.). Retrieved July 17, 2025, from <https://contentsquare.com/guides/net-promoter-score/>
40. Wu, C.-H. (2023). An Empirical Study on the Application of Blockchain Technology in E-Agriculture: An Innovative Service UIS Application System. *Journal of Global Information Management*, 31(3), 1–20. <https://doi.org/10.4018/JGIM.326128>
41. Zheng, P., Jiang, Z., Wu, J., & Zheng, Z. (2023). Blockchain-Based Decentralized Application: A Survey. *IEEE Open Journal of the Computer Society*, 4, 121–133. <https://doi.org/10.1109/OJCS.2023.3251854>