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Original Research

Transforming E-Commerce UX: A User-Centered Design Approach to Enhance Usability and Web Performance

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ABSTRACT

E-commerce platforms require optimal user interface (UI) and user experience (UX) alongside robust technical performance to retain users, particularly in specialized markets like mother-and-baby products. Initially, the Boonaboo e-commerce website exhibited critical deficiencies, achieving a poor System Usability Scale (SUS) score of 47.75 and a failing mobile Google Lighthouse performance score of 41. To address these dual challenges, this study implemented a comprehensive UI/UX redesign using the User-Centered Design (UCD) methodology. A mixed-methods, pretest-posttest evaluation was conducted involving 20 respondents, utilizing a novel dual-metric approach that combined subjective usability measurement (SUS) with objective technical auditing (Core Web Vitals via Google Lighthouse). Following the UCD intervention—which encompassed information architecture restructuring, navigation simplification, and asset optimization—the platform demonstrated remarkable enhancements. Mobile performance surged by 104.8% (from 41 to 84), while desktop performance reached near-perfection at 99. Concurrently, the mean SUS score escalated to 87.75, shifting the usability grade from Not Acceptable (Grade F) to Excellent (Grade A). These findings empirically prove that user-centered interface improvements inherently correlate with enhanced machine-measured web performance. This study contributes a validated dual-metric framework for evaluating e-commerce redesigns, offering actionable insights for optimizing digital retail environments where cognitive ease, speed, and user trust are paramount.

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1. INTRODUCTION

The rapid expansion of digital commerce has transformed e-commerce websites from simple product catalogues into complex service environments that shape users information search, product evaluation, and purchasing decisions. In this context, the quality of the user interface (UI) and user experience (UX) has become a critical determinant of perceived usefulness, trust, satisfaction, and conversion performance [1, 2]. A well-structured layout, transparent product information, efficient navigation, and responsive interaction can reduce users cognitive effort and increase their willingness to complete transactions [3]. Therefore, e-commerce platforms should be designed based on users needs, tasks, and contextual constraints rather than solely on visual preferences.

Prior studies have emphasized the importance of user-centered design and measurable usability evaluation in online retail systems. Zuo et al. [3] highlighted that UX research in digital environments increasingly integrates user-centered principles to improve engagement, satisfaction, and service quality. Sugosha [4] demonstrated that the System Usability Scale (SUS) can effectively identify interface weaknesses and support iterative improvement

in an e-commerce pharmacy platform. Similarly, Lun et al. [5] found that perceived usability, measured through standardized usability instruments, is closely associated with users behavioral intentions in interactive digital services. These studies confirm that usability evaluation is essential not only for improving interface quality but also for sustaining user trust and retention in e-commerce. In parallel with subjective usability, objective website performance has become a crucial component of UX, particularly for mobile users. Nichifor et al. [6] emphasized that mobile page speed and Core Web Vitals influence users continuation behavior in digital commerce journeys. Król [7] further reported that websites conforming to Core Web Vitals guidelines are less likely to be abandoned, indicating that technical performance directly affects user persistence and satisfaction. Nevertheless, Ghattas et al. [8] observed that many existing studies still treat subjective usability and objective performance as separate evaluation streams, leaving limited guidance for integrated UX redesign in specialized e-commerce domains.

This research gap is particularly relevant for niche e-commerce platforms serving caregivers, such as maternal and infant product stores. Users in this segment often access the platform under time pressure, primarily through mobile devices, while seeking trustworthy product details, clear categorization, and a reassuring transaction process. The platform examined in this study initially exhibited significant weaknesses in these aspects. A preliminary usability evaluation using SUS involving 20 respondents produced a mean score of 47.75, classified as Not Acceptable, Grade F, with an adjective rating of Poor [9, 10]. Observational analysis identified several interface problems, including excessive homepage scrolling, weak navigation structure, absence of product filtering, dense visual layout, and unoptimized image assets. Google Lighthouse testing confirmed these performance deficiencies, with mobile and desktop performance scores of 41 and 76, respectively. These findings indicate a dual problem: the interface was difficult to use from the users perspective, while the system also demonstrated inefficient loading behavior from a technical perspective.

The novelty of this research lies in its integrated dual-metric evaluation of a UX redesign within a mother-and-baby e-commerce context. Unlike previous studies that primarily rely on questionnaire-based usability outcomes [11–13] or focus independently on technical performance optimization, this study combines SUS with Google Lighthouse to evaluate both perceived usability and objective web performance after a User-Centered Design (UCD) intervention. This approach demonstrates that improvements in information architecture, navigation, product filtering, visual hierarchy, and asset optimization can simultaneously enhance human-centered usability and machine-measured performance indicators [4, 14]. Accordingly, the study contributes a practical evaluation framework for specialized e-commerce platforms where speed, clarity, and trust are essential. Based on these issues, this study aims to redesign the UI/UX of the studied e-commerce platform using the UCD method and to evaluate the improvement through SUS and Google Lighthouse. The findings are expected to provide evidence-based guidance for enhancing usability, performance, and overall user experience in niche e-commerce environments.

2. RESEARCH METHOD

2.1. Research Design

This study employed a mixed-methods approach with a dominant quantitative design supported by qualitative data. The quantitative component consisted of usability measurement using the System Usability Scale (SUS) and technical performance measurement using Google Lighthouse. The qualitative component consisted of observational notes and open-ended questionnaire responses used to identify user problems, needs, and expectations [15–18]. The research used a one-group pretestposttest design. The initial condition of the platform was evaluated before the redesign, and the improved condition was evaluated after the redesign. The research design can be expressed as follows:

$$O_1 \rightarrow X \rightarrow O_2 \tag{1}$$

where O_1 = initial evaluation before redesign, including SUS and Google Lighthouse testing; X = UI/UX redesign intervention using the User-Centered Design (UCD) method; O_2 = evaluation after redesign, including SUS and Google Lighthouse testing. This design allowed the researchers to compare the usability and performance conditions of the platform before and after the redesign intervention.

2.2. Population and Sample

The population in this study consisted of users and potential users of a mother-and-baby products e-commerce platform. Because the platform primarily serves parents and caregivers, the respondents needed to reflect users

who have relevant needs, tasks, and contextual constraints when searching for baby and maternal products online.

The sampling technique used in this study was purposive sampling. Purposive sampling was selected to ensure that the respondents had characteristics relevant to the research objectives. The inclusion criteria were as follows:

- respondents were at least 18 years old;
- respondents were parents, caregivers, or potential buyers of mother-and-baby products;
- respondents had experience using e-commerce websites or online shopping platforms;
- respondents were able to access the website through a mobile device or desktop browser.

The number of respondents involved in this study was 20 people. This number was considered sufficient for usability evaluation using SUS because it can provide a relatively stable estimation of perceived usability while also supporting descriptive comparative analysis.

2.3. Research Variables

This study used two main variables.

1. **Independent variable / intervention variable**: The independent variable was the UI/UX redesign of the e-commerce platform using the User-Centered Design (UCD) method. The redesign included improvements in navigation structure, homepage layout, product presentation, filtering features, visual clarity, and performance optimization.
2. **Dependent variables**: The dependent variables were:
   a. perceived usability, measured using the System Usability Scale (SUS);
   b. technical web performance, measured using Google Lighthouse.

2.4. Data Collection Techniques

Data were collected through three main techniques: observation, questionnaire distribution, and literature study.

a. Observation Observation was conducted by examining the existing condition of the platform before the redesign process. The observation focused on several aspects, including homepage structure and length, navigation clarity, product search and filtering features, layout density and information organization, responsiveness on mobile and desktop devices, and loading performance and visual stability. The observation results were used to identify initial usability problems and to formulate design requirements.

b. Questionnaire A questionnaire was distributed online using Google Forms. The questionnaire was administered in two stages: before the UI/UX redesign and after the UI/UX redesign. The questionnaire consisted of two parts. The first part contained the 10 standard SUS statements. The second part contained open-ended questions used to collect qualitative feedback regarding user experience, difficulties, suggestions, and expectations. The SUS statements were measured using a five-point Likert scale.

c. Literature Study A literature study was conducted to support the theoretical foundation of the research. The literature review covered topics related to UI/UX design, e-commerce usability, User-Centered Design, System Usability Scale, and website performance evaluation using Google Lighthouse.

2.5. User-Centered Design Procedure

The redesign process followed the User-Centered Design (UCD) approach. UCD was selected because it emphasizes user needs, tasks, and contexts throughout the design process. The UCD process in this study consisted of four main stages [4].

Stage 1: Understanding the Context of Use. The first stage involved identifying the characteristics of users, their goals, tasks, devices, and usage contexts. Since the platform provides mother-and-baby products, the main users were parents or caregivers who typically require fast access, clear information, simple navigation, and trustworthy product presentation.

Stage 2: Specifying User Requirements. Based on the initial evaluation, several user requirements were formulated: the homepage should present information more concisely and reduce excessive scrolling; navigation

should be clearer and more consistent; users should be able to find products more easily; a product filtering feature should be provided; the layout should be less dense and more organized; images and visual assets should be optimized to improve loading speed; the platform should perform well on mobile devices.

Stage 3: Producing Design Solutions. The third stage involved developing design solutions based on the identified requirements. The design process included restructuring the homepage layout, improving the navigation menu, designing clearer product categories, adding product filtering functionality, improving visual hierarchy and spacing, optimizing image assets, and designing responsive interfaces for mobile and desktop devices. The design solutions were then implemented into a functional prototype using HTML, Tailwind CSS, and the Next.js framework.

Stage 4: Evaluating the Design. The final stage involved evaluating the redesigned platform. The evaluation was conducted using two instruments: SUS, to measure perceived usability; and Google Lighthouse, to measure technical performance. The evaluation results were then compared with the initial evaluation results to determine the improvement achieved after the redesign.

2.6. Usability Measurement Using System Usability Scale

The System Usability Scale (SUS) is a standardized questionnaire consisting of 10 statements. Five statements are positively worded, and five statements are negatively worded. Respondents rated each statement using a five-point Likert scale.

Let $R_{i,j}$ represent the rating given by respondent i to item j, where $i \in \{1, 2, \ldots, n\}$ and $j \in \{1, 2, \ldots, 10\}$.

The item score conversion is calculated as follows. For odd-numbered items, which are positive statements:

$$S_{i,j} = R_{i,j} - 1 \tag{2}$$

For even-numbered items, which are negative statements:

$$S_{i,j} = 5 - R_{i,j} \tag{3}$$

Thus, the converted item score $S_{i,j}$ ranges from 0 to 4.

The SUS score for each respondent is calculated as:

$$\mathrm{SUS}_i = \left(\sum_{j=1}^{10} S_{i,j} \right) \times 2.5 \tag{4}$$

where SUS_i = SUS score of respondent i; $S_{i,j}$ = converted score for respondent i on item j; and 2.5 = multiplier used to convert the total score to a scale of 0100.

The mean SUS score for all respondents is calculated as:

$$\overline{\mathrm{SUS}} = \frac{1}{n} \sum_{i=1}^{n} \mathrm{SUS}_i \tag{5}$$

where $\overline{\mathrm{SUS}}$ = average SUS score; and n = number of respondents.

The resulting SUS score ranges from 0 to 100. In general, higher SUS scores indicate better perceived usability. The interpretation used in this study is summarized as follows: < 50 (Not Acceptable), 50–70 (Marginal), > 70 (Acceptable). In addition, the SUS result was interpreted using adjective rating and grade scale categories, where a higher grade indicates better usability quality.

2.7. Web Performance Measurement Using Google Lighthouse

Google Lighthouse was used to evaluate the technical performance of the platform. The testing was conducted on both mobile and desktop devices. The main performance metrics observed in this study were First Contentful Paint (FCP), Largest Contentful Paint (LCP), Total Blocking Time (TBT), Speed Index (SI), and Cumulative Layout Shift (CLS).

Google Lighthouse produces a performance score from 0 to 100. The performance score is derived from normalized metric scores and their corresponding weights. The general formulation can be expressed as:

$$P = \sum (m_k \times w_k) \tag{6}$$

where P = Lighthouse performance score; m_k = normalized scores for each metric; and w_k = weights assigned to each metric.
The Lighthouse performance score is interpreted as follows: 0–49 (Poor), 50–89 (Needs Improvement), and 90–100 (Good).

2.8. Data Analysis Technique

The data analysis was conducted using descriptive quantitative analysis and beforeafter comparative analysis. The analysis aimed to determine the improvement in usability and performance after the UI/UX redesign. The improvement in each measured variable was calculated using the following formula:

$$\Delta = X_{\text{after}} - X_{\text{before}} \tag{7}$$

where Δ = improvement score; X_{before} = score before redesign; and X_{after} = score after redesign.
The percentage improvement was calculated as:

$$\%\Delta = \left(\frac{X_{\text{after}} - X_{\text{before}}}{X_{\text{before}}} \right) \times 100\% \tag{8}$$

where $\%\Delta$ = percentage improvement; X_{before} = initial score; and X_{after} = score after redesign.
This formula was applied to both the SUS score and the Google Lighthouse performance score. For example, the SUS improvement can be expressed as:

$$\Delta\text{SUS} = \overline{\text{SUS}}_{\text{after}} - \overline{\text{SUS}}_{\text{before}} \tag{9}$$

$$\%\Delta\text{SUS} = \left(\frac{\overline{\text{SUS}}_{\text{after}} - \overline{\text{SUS}}_{\text{before}}}{\overline{\text{SUS}}_{\text{before}}} \right) \times 100\% \tag{10}$$

Similarly, the Lighthouse improvement can be expressed as:

$$\Delta P = P_{\text{after}} - P_{\text{before}} \tag{11}$$

$$\%\Delta P = \left(\frac{P_{\text{after}} - P_{\text{before}}}{P_{\text{before}}} \right) \times 100\% \tag{12}$$

where P_{before} = Lighthouse score before redesign; and P_{after} = Lighthouse score after redesign.
Qualitative data obtained from open-ended questionnaire responses and observations were analyzed thematically. The responses were grouped into recurring themes such as navigation, layout clarity, product search, filtering functionality, loading speed, and overall user comfort. These qualitative findings were used to explain the quantitative results and to support the interpretation of the redesign impact.

2.9. Research Reliability and Validity

The validity of this study was supported by the use of established measurement instruments. SUS is a widely used and validated usability measurement method, while Google Lighthouse is a standardized tool commonly used for auditing website performance. In addition, the same questionnaire structure and testing procedure were used before and after the redesign to ensure comparability. The qualitative data were used as supporting evidence to strengthen the interpretation of the quantitative findings.

3. RESULTS AND DISCUSSION

3.1. Initial Website Evaluation Results

The initial evaluation was conducted to obtain a comprehensive overview of the condition of the Boonaboo website before the redesign process was carried out. This evaluation covered two main aspects: technical website performance and usability level based on user perception. Technical performance was measured using Google Lighthouse on desktop and mobile devices, while usability was measured using the System Usability Scale (SUS) questionnaire. The initial evaluation results were used to identify the main problems and to determine the improvement requirements for the redesign stage.

a. Google Lighthouse Test Results The Google Lighthouse test was conducted on desktop and mobile versions to identify technical aspects that affect performance and user experience when accessing the Boonaboo website. This test is important because website performance directly affects user comfort, information access speed, and visual stability during interaction. The test results before the redesign are presented in Figure 1 and Figure 2.

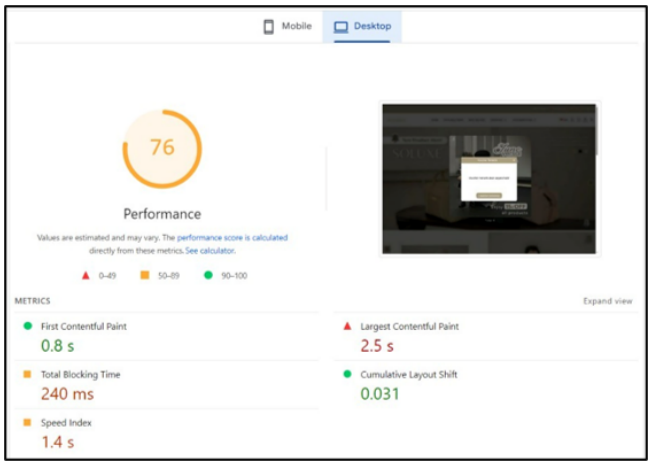

Figure 1. Google Lighthouse Desktop Test Result Before Redesign

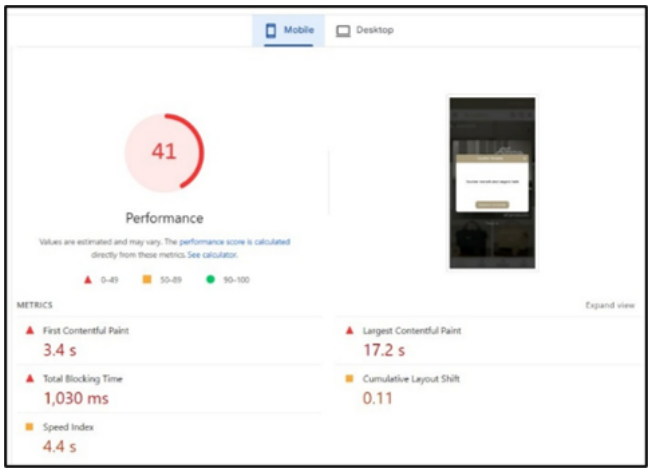

Figure 2. Google Lighthouse Mobile Test Result Before Redesign

Based on Figure 1 and Figure 2, the initial performance of the Boonaboo website still required improvement, particularly in the mobile version. The website obtained a Google Lighthouse score of 41 in the mobile test and 76 in the desktop test. These results indicate that the website performance on mobile devices was in the poor category, while the performance on desktop devices was moderate and still required further optimization. In the mobile test, the Boonaboo website obtained a score of 41, with a First Contentful Paint (FCP) of 3.4 seconds, a Largest Contentful Paint (LCP) of 17.2 seconds, a Total Blocking Time (TBT) of 1,030 ms, a Speed Index (SI) of 4.4 seconds, and a Cumulative Layout Shift (CLS) of 0.11. These values indicate that the page loading process was relatively slow, the response time was quite high, and the visual stability was not yet optimal. This condition potentially reduced user comfort, especially for users accessing the website through mobile devices. In the desktop test, the Boonaboo website obtained a score of 76, with an FCP of 0.8 seconds, an LCP of 2.5 seconds, a TBT of 240 ms, an SI of 1.4 seconds, and a CLS of 0.031. Although the performance on desktop devices was better than on mobile devices, several metrics still indicated that the website required further optimization to improve loading speed, responsiveness, and overall user experience.

b. Usability Test Results Using SUS Before Redesign After the technical performance testing, the initial evaluation was continued with usability measurement based on user perception. This test used the System Usability Scale (SUS) questionnaire, which consists of 10 statements. Each statement was measured using a five-point Likert scale, ranging from Strongly Disagree (1) to Strongly Agree (5). The test results were used

to determine the usability level of the Boonaboo website and to provide a basis for the redesign process. The recapitulation of the converted responses and SUS score calculations from 20 respondents is presented in Table 1. The table shows the calculated score for each statement, the total score for each respondent, the multiplication by the factor of 2.5, and the final SUS score of each respondent [19–22].

Table 1. Score Calculation Results

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	TOTAL	×2,5	SUS Score
R1	2	1	1	1	2	5	2	1	1	0	16	2.5	40
R2	1	1	2	1	2	5	1	1	2	1	17	2.5	42.5
R3	3	2	3	3	3	5	3	2	2	1	27	2.5	67.5
R4	2	3	2	2	3	5	3	2	3	2	27	2.5	67.5
R5	1	1	2	1	2	5	1	1	1	0	15	2.5	37.5
R6	1	1	2	1	2	5	1	1	1	0	15	2.5	37.5
R7	2	1	1	1	2	5	2	1	1	0	16	2.5	40
R8	1	1	2	1	2	5	1	1	1	0	15	2.5	37.5
R9	2	1	1	1	2	5	2	1	1	0	16	2.5	40
R10	3	2	3	3	3	5	3	2	2	1	27	2.5	67.5
R11	1	1	2	1	2	5	1	1	1	0	15	2.5	37.5
R12	2	1	1	1	2	5	2	1	1	0	16	2.5	40
R13	3	2	3	3	3	5	3	2	2	1	27	2.5	67.5
R14	2	1	1	1	2	5	2	1	1	0	16	2.5	40
R15	1	1	2	1	2	5	1	1	2	1	17	2.5	42.5
R16	3	2	3	3	3	5	3	2	2	1	27	2.5	67.5
R17	1	1	2	1	2	5	1	1	1	0	15	2.5	37.5
R18	2	1	1	1	2	5	2	1	1	0	16	2.5	40
R19	3	2	3	3	3	5	3	2	2	1	27	2.5	67.5
R20	1	1	2	1	2	5	1	1	1	0	15	2.5	37.5
Total SUS Score													**955**

Based on Table 1, the total SUS score obtained from 20 respondents was 955. This value represents the sum of the final SUS scores obtained from all respondents. In general, the respondents SUS scores ranged from 37.5 to 67.5, indicating that no respondent gave an excellent evaluation of the initial Boonaboo website. To determine the overall usability level, the mean SUS score was calculated by dividing the total SUS score by the number of respondents, as shown in Equation (14).

$$\overline{\mathrm{SUS}}_{\mathrm{before}} = \frac{955}{20} = 47.75 \tag{13}$$

The calculation result shows that the average SUS score of the Boonaboo website before the redesign was 47.75. This score is classified as Not Acceptable, with Grade F and an Adjective Rating of Poor. This result indicates that the Boonaboo website still had significant usability problems from the users perspective. Therefore, improvements in interface design, user experience, navigation, and technical performance were required through the redesign process.

3.2. Identification of User Problems

Based on the initial evaluation of the Boonaboo website, several user experience problems were identified. These problems were obtained through direct observation of the interface, analysis of user responses, and evaluation of technical performance using Google Lighthouse. The findings indicate issues related to layout structure, navigation, product discovery, visual organization, and page performance. The main problems are summarized as follows.

1. The homepage was excessively long, requiring users to scroll repeatedly to find specific information or products. This condition reduced browsing efficiency and increased the effort required by users to locate relevant content.
2. The page loading time was relatively slow, particularly on mobile devices. This issue affected user comfort and was consistent with the low mobile performance score obtained from the Google Lighthouse test.
3. The navigation structure of the website was not yet optimal. Users experienced difficulty in finding information and products, indicating that the information architecture required improvement to support more efficient navigation.
4. The website did not provide a product filtering feature. As a result, users could not narrow down product searches based on specific categories or attributes, which limited the effectiveness of the product discovery process.

5. The layout of several interface elements appeared too dense. The presentation of information was less organized, potentially increasing users cognitive load and reducing the clarity of the interface.
6. Several image assets were not sufficiently optimized. The large size of visual assets increased the overall page size, contributing to slower loading performance and negatively affecting the websites technical performance.

Overall, these findings show that the Boonaboo website requires improvements in information architecture, navigation design, interface layout, filtering functionality, and asset optimization. These problems were then used as the basis for formulating user requirements and design solutions in the UI/UX redesign process.

3.3. Analysis of User Requirements

User requirements analysis was conducted based on the initial evaluation results of the Boonaboo website, including Google Lighthouse testing, direct observation of the interface, and identification of user experience problems during the evaluation process. This analysis aimed to transform the identified problems into concrete user requirements that could guide the UI/UX redesign. The results of the user requirements analysis are presented in Table 2.

Table 2. User Requirements Analysis

No.	Identified Problem	User Requirement / Design Response
1	The homepage was excessively long, requiring users to scroll repeatedly to find the desired information or products.	The homepage should be restructured to present priority information and products more concisely, with clearer sections and reduced unnecessary scrolling.
2	Page loading time was relatively slow, especially on mobile devices, affecting user comfort.	The website performance should be optimized, particularly for mobile access, by improving loading speed and reducing resource-heavy elements.
3	The navigation structure was not yet optimal, causing difficulty for users in finding information or products.	The navigation system should be redesigned to provide clearer categories, a consistent menu structure, and easier access to main features.
4	No product filtering feature was available to support product search based on specific categories.	A product filtering feature should be added to help users narrow down product choices based on relevant categories or attributes.
5	Several interface elements appeared visually dense, making the information less organized.	The interface layout should be improved through better spacing, visual hierarchy, and grouping of related information.
6	Image assets were not sufficiently optimized, increasing page size and affecting website performance.	Image assets should be compressed and optimized to reduce page weight and improve overall loading performance.

Based on Table 2, the user requirements focus on improving browsing efficiency, navigation clarity, product discoverability, visual organization, and technical performance. These requirements were subsequently used as the foundation for developing the redesigned UI/UX of the Boonaboo website using the User-Centered Design approach.

3.4. UI/UX Website Design

The UI/UX design stage was carried out to translate the user requirements identified in the previous analysis into concrete design solutions for the Boonaboo e-commerce platform. The design process focused primarily on the homepage, as it serves as the main entry point and the first point of interaction between users and the system. The initial stage of this process involved developing interface mockups that served as a visual representation of the proposed layout, information architecture, and interaction flow. These mockups were designed to address the problems identified during the initial evaluation, particularly those related to excessive page length, dense visual layout, unclear navigation, and the absence of product filtering features. By establishing a clear visual blueprint, the design phase aimed to reduce unnecessary scrolling, strengthen the content hierarchy, and present product information in a more concise and user-friendly manner before the actual development began. After the interface design was finalized and validated against the formulated user requirements, the next stage was the implementation of the design into a functional website [11,12]. The implementation process utilized modern web technologies, specifically HTML for structuring the page content, Tailwind CSS for developing a responsive and consistent visual style, and the Next.js framework for supporting component-based development and enhancing overall website performance. The use of Next.js was particularly strategic for improving rendering efficiency

and optimizing the loading behavior of the Boonaboo platform, which directly addressed the performance issues identified in the initial Google Lighthouse evaluation. The implementation of the redesigned Boonaboo homepage is presented in Figures 3, 4, and 5, which respectively illustrate the upper, middle, and lower sections of the developed interface.

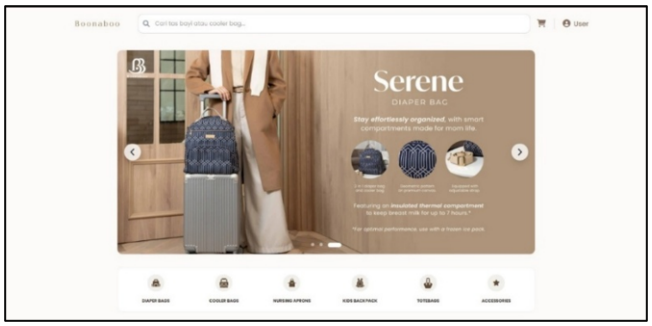

Figure 3. Implementation of the Boonaboo Homepage (Upper Section)

Figure 3 depicts the upper section of the implemented homepage, which includes the main navigation bar and the primary visual introduction to the Boonaboo brand. This section was carefully structured to provide users with immediate and clear access to the main menu categories while establishing a clean, informative, and trustworthy first impression. The visual hierarchy was simplified to ensure that users could quickly orient themselves and begin their product exploration without cognitive overload.

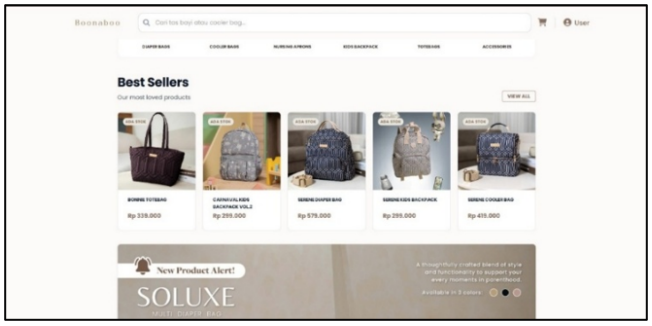

Figure 4. Implementation of the Boonaboo Homepage (Middle Section)

Figure 4 shows the middle section of the homepage, which presents the core product-related content in a more structured and visually organized format. The layout in this section was specifically arranged to reduce visual density and help users browse product categories more efficiently. By grouping related products and applying consistent spacing and typography, this section reflects the design improvement intended to minimize the excessive scrolling and disorganized information presentation that characterized the original Boonaboo interface.

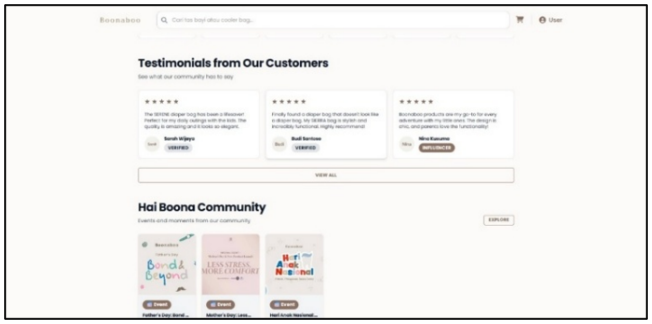

Figure 5. Implementation of the Boonaboo Homepage (Lower Section)

Figure 5 illustrates the lower section of the homepage, which provides supporting information, promotional content, and footer navigation to complete the overall page structure. This section was designed to maintain visual consistency with the upper and middle portions, improve readability, and ensure a balanced composition across the entire homepage. Together, the three sections demonstrate how the redesigned Boonaboo homepage provides a clearer structure, a more organized layout, and a more efficient browsing experience compared to

its initial condition. The implemented design successfully aligns with the user requirements formulated in the analysis stage and sets a strong foundation for the subsequent usability and performance evaluations.

3.5. Results of Post-Redesign Evaluation

Following the completion of the UI/UX redesign and development process, a comprehensive evaluation was conducted to measure the effectiveness of the improvements applied to the Boonaboo website. The post-redesign evaluation employed the same instruments used in the initial assessment, namely Google Lighthouse for technical performance measurement and the System Usability Scale (SUS) questionnaire for usability assessment. This approach ensured a consistent and comparable before-and-after analysis of the platform's quality. The Google Lighthouse test was conducted on both desktop and mobile devices to evaluate the technical performance of the redesigned Boonaboo website. The post-redesign test results are presented in Figures 6 and 7. As shown in Figure 6, the Boonaboo website achieved a performance score of 99 on the desktop platform, indicating a substantial improvement from the initial score of 76. This result demonstrates that the optimization efforts implemented during the redesign process, including asset compression, layout restructuring, and code efficiency improvements, significantly enhanced the desktop performance of the website. Figure 7 presents the mobile test results, which show a performance score of 84, representing a considerable increase from the initial mobile score of 41. This improvement confirms that the redesign successfully addressed the critical performance issues that previously affected mobile users, including slow loading times, high Total Blocking Time, and suboptimal visual stability. The significant improvement in mobile performance is particularly important given that the majority of Boonaboo's target users, primarily parents and caregivers, tend to access e-commerce platforms through mobile devices.

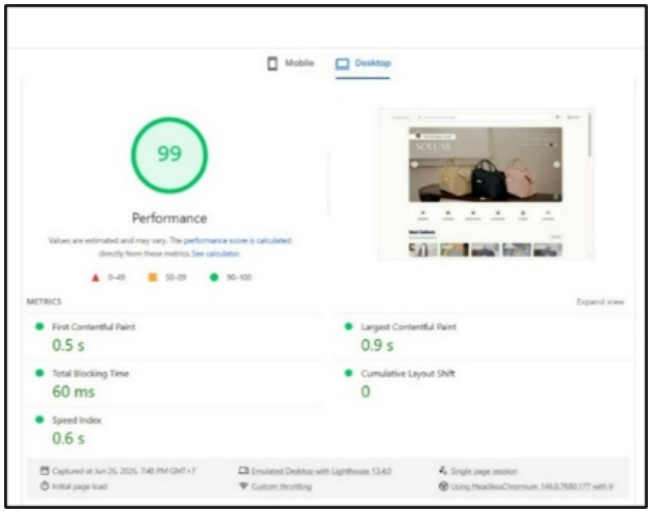

Figure 6. Google Lighthouse Desktop Test Result After Redesign

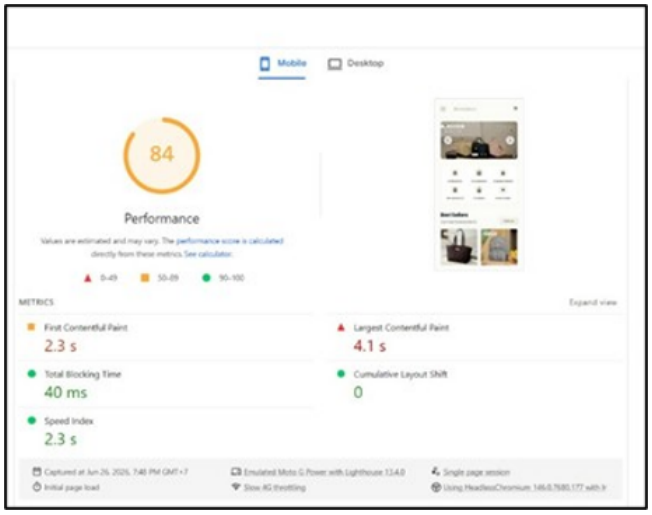

Figure 7. Google Lighthouse Mobile Test Result After Redesign

In addition to the technical performance evaluation, the post-redesign usability assessment was conducted using the SUS questionnaire administered to the same 20 respondents. The questionnaire consisted of 10 statements measured on a five-point Likert scale, ranging from Strongly Disagree (1) to Strongly Agree (5). The recapitulation of the converted responses and SUS score calculations after the redesign is presented in Table 3.

Table 3. Post-Redesign SUS Score Calculation Results

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total	×2,5	SUS Score
R1	4	4	4	4	4	4	4	4	4	4	40	2.5	100
R2	4	3	4	4	4	3	3	4	4	3	36	2.5	90
R3	3	3	3	4	4	1	4	3	4	3	32	2.5	80
R4	4	4	3	4	3	3	4	4	2	2	33	2.5	82.5
R5	3	4	4	3	4	4	3	4	4	4	37	2.5	92.5
R6	3	3	4	3	4	3	3	4	4	3	34	2.5	85
R7	3	3	4	3	4	3	4	4	4	3	35	2.5	87.5
R8	4	4	3	3	4	4	3	4	4	3	36	2.5	90
R9	3	3	4	4	3	3	4	4	4	3	35	2.5	87.5
R10	3	3	3	4	4	3	3	4	4	2	33	2.5	82.5
R11	4	4	3	3	4	4	3	4	4	3	36	2.5	90
R12	4	3	3	4	3	3	4	4	3	3	34	2.5	85
R13	3	3	4	4	3	3	4	4	4	3	35	2.5	87.5
R14	3	4	3	3	4	4	3	3	4	4	35	2.5	87.5
R15	3	4	4	3	4	4	3	4	4	3	36	2.5	90
R16	4	3	3	4	4	3	3	4	4	3	35	2.5	87.5
R17	3	4	3	4	3	4	3	4	4	3	35	2.5	87.5
R18	3	4	4	3	4	3	3	4	4	3	35	2.5	87.5
R19	3	4	4	3	4	3	3	4	4	3	35	2.5	87.5
R20	3	3	4	4	4	3	3	4	4	3	35	2.5	87.5
Total SUS Score													**1755**

Based on the calculation results presented in Table 3, the total SUS score obtained from 20 respondents after the redesign was 1755. The respondents' individual SUS scores ranged from 80 to 100, indicating a substantially positive perception of the redesigned Boonaboo website. To determine the overall usability level, the mean SUS score was calculated by dividing the total SUS score by the number of respondents, as expressed in Equation (15).

$$\overline{\mathrm{SUS}}_{\mathrm{after}} = \frac{1755}{20} = 87.75 \tag{14}$$

The calculation result demonstrates that the average SUS score of the Boonaboo website after the redesign was 87.75. This score is classified as Acceptable, with Grade A and an Adjective Rating of Excellent. Compared to the initial SUS score of 47.75, which fell within the Not Acceptable category, the post-redesign score represents a significant improvement of 40 points. This substantial increase confirms that the UI/UX redesign implemented through the User-Centered Design approach successfully addressed the usability problems identified during the initial evaluation. The redesigned Boonaboo website now provides a significantly improved user experience, characterized by easier navigation, clearer information architecture, more efficient product discovery, and better overall usability from the users' perspective.

3.6. Comparison of Results Before and After Redesign

To evaluate the overall effectiveness of the UI/UX redesign implemented on the Boonaboo e-commerce platform, a comprehensive comparison was conducted between the evaluation results obtained before and after the redesign process. The comparison encompassed two primary dimensions of assessment: technical website performance, measured using Google Lighthouse, and user-perceived usability, measured using the System Usability Scale (SUS). This comparative analysis aimed to provide empirical evidence of the improvements achieved through the User-Centered Design approach and to determine whether the redesign successfully addressed the usability and performance issues identified during the initial evaluation.

The Google Lighthouse test results revealed a significant improvement in the technical performance of the Boonaboo website following the redesign. As summarized in Table 4, the mobile performance score increased from 41 to 84, representing an improvement of 43 points or approximately 104.88%. This substantial increase indicates that the optimization efforts applied during the redesign process, including image compression, layout restructuring, code efficiency improvements, and responsive design implementation, effectively resolved the critical performance issues that previously affected mobile users. The desktop performance score also demonstrated a notable improvement, increasing from 76 to 99, which corresponds to an improvement of 23 points or approxi-

mately 30.26%. The near-perfect desktop score of 99 confirms that the redesigned Boonaboo website delivers an exceptionally fast and stable browsing experience on desktop devices. These results collectively demonstrate that the redesign successfully transformed the Boonaboo platform from a poorly performing website, particularly on mobile devices, into a highly optimized e-commerce platform capable of providing a seamless user experience across different devices.

Table 4. Comparison of Google Lighthouse Results Before and After Redesign

Aspect	Before Redesign	After Redesign	Improvement
Performance (Mobile)	41	84	+43
Performance (Desktop)	76	99	+23

In addition to the technical performance improvements, the usability evaluation conducted using the SUS questionnaire also demonstrated a significant enhancement in user-perceived usability after the redesign. As presented in Table 5, the mean SUS score increased from 47.75 before the redesign to 87.75 after the redesign, representing an improvement of 40 points or approximately 83.77%. This substantial increase indicates that the redesigned Boonaboo website successfully addressed the usability problems identified during the initial evaluation, including excessive scrolling, unclear navigation, dense layout, absence of product filtering, and unoptimized visual assets. The improvement in SUS score also reflects a shift in the usability classification from Not Acceptable (Grade F, Poor) to Acceptable (Grade A, Excellent), confirming that the redesigned interface now meets a high standard of usability from the users' perspective.

Table 5. Comparison of System Usability Scale (SUS) Results

Evaluation Phase	SUS Score	Category	Grade	Adjective Rating
Before Redesign	47.75	Not Acceptable	F	Poor
After Redesign	87.75	Acceptable	A	Excellent

The combined results from both evaluation instruments provide strong empirical evidence that the UI/UX redesign of the Boonaboo e-commerce platform, conducted using the User-Centered Design approach, successfully improved both the technical performance and the user-perceived usability of the website. The improvement in Google Lighthouse scores demonstrates that the redesign effectively optimized the website's loading speed, responsiveness, and visual stability, while the increase in SUS scores confirms that users perceived the redesigned interface as significantly easier to use, more intuitive, and more satisfying. These findings validate the effectiveness of the User-Centered Design methodology in addressing both technical and experiential dimensions of website quality, and they confirm that the redesign process successfully transformed the Boonaboo platform from a poorly performing and difficult-to-use website into a high-quality e-commerce platform that meets users' needs and expectations.

3.7. Discussion

The substantial concurrent improvement in both subjective usability (SUS) and objective technical performance (Google Lighthouse) observed in this study underscores the intrinsic relationship between user-centered interface design and computational efficiency. While previous literature often treats cognitive usability and technical performance as distinct evaluation domains, the findings from the Boonaboo redesign demonstrate that resolving user pain pointssuch as excessive scrolling, dense visual layouts, and convoluted navigation, necessitates structural code and asset optimizations that inherently improve Core Web Vitals. For instance, the implementation of a streamlined information architecture and optimized image assets not only reduced the users' cognitive load, thereby elevating the SUS score from a failing 47.75 to an excellent 87.75, but also drastically minimized the Largest Contentful Paint (LCP) and Total Blocking Time (TBT), propelling the mobile Lighthouse score from 41 to 84. This synergy is particularly critical for niche e-commerce platforms targeting caregivers, a demographic that typically interacts with digital services under time constraints and high cognitive fatigue, thereby demanding both immediate visual clarity and rapid system responsiveness. By validating a dual-metric evaluation framework, this research extends the theoretical boundaries of the User-Centered Design methodology, proving that empathetic, human-centric design interventions do not merely satisfy psychological user needs but also serve as a catalyst for achieving rigorous, machine-validated technical excellence in modern web development.

4. CONCLUSION

This study successfully demonstrated the efficacy of the User-Centered Design (UCD) methodology in transforming a poorly performing e-commerce platform into a highly optimized digital retail environment. By addressing the specific contextual needs of the mother-and-baby market, the UI/UX redesign of the Boonaboo website yielded exceptional improvements across both human-centric and machine-centric evaluation metrics. The dual-metric evaluation revealed that the intervention not only elevated the perceived usability from an unacceptable level (SUS score of 47.75) to an excellent standard (87.75) but also resolved critical technical bottlenecks, increasing the mobile Google Lighthouse performance score from 41 to 84 and achieving a near-perfect desktop score of 99. Theoretically, this research contributes a validated framework proving that user-centered structural and visual optimizations inherently enhance Core Web Vitals, bridging the gap between subjective UX research and objective web engineering. Practically, the findings provide e-commerce developers and stakeholders with actionable evidence that investing in empathetic, user-driven interface design directly correlates with faster loading times, reduced bounce rates, and higher potential conversion. Future research should expand this dual-metric approach to other specialized e-commerce niches and incorporate longitudinal A/B testing to measure the long-term impact of these UI/UX improvements on actual sales conversion rates and customer retention.

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