

Analysis and Optimization of the Usability of E-Commerce Platforms through Evaluation Heuristics

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Abstract

This paper extends previous work on usability evaluation heuristics for e-commerce platforms by conducting a detailed experimentation to validate and refine the proposed heuristic set. A group of international expert evaluators applied the new heuristics to an e-commerce platform, providing both individual assessments and qualitative feedback. The results revealed significant insights into the platform's usability, highlighting strengths and areas needing improvement. This process not only identified deficiencies but also allowed for the adjustment and optimization of the heuristic questions to better reflect user needs and expectations. The validated heuristics, which include 15 guidelines and 60 questions, provide a comprehensive evaluation framework, quantifying usability through a percentage score. The findings contribute to the ongoing enhancement of e-commerce platform usability and offer valuable knowledge for the usability and user experience research community.

Keywords: Usability, Heuristics, E-commerce Platforms, Human-Computer Interaction, Evaluation.

1 Introduction

E-commerce platforms (for simplicity, we'll be using e-commerce from here on out) play a crucial role in brokering trade transactions, which are facilitated through the use of technology between users and suppliers [1]. Usability, an attribute of software quality that refers to the ease of use and learning of an interactive system, is a particularly determining factor for this type of platform. The current work is based on, and extends, the previous article entitled "Evaluation Heuristics to Improve Usability in Ecommerce Platforms" [2] by the same authors. This work focused on developing a heuristic set of usability evaluation guidelines to evaluate and improve the usability of user interfaces in e-commerce systems. This integrated methodological approach of Collaborative Engineering and the heuristics of Quiñones [3], Rusu [4] and Granollers [5] [6], resulted in a comprehensive evaluation proposal that highlights key areas for improvement.

In the present study, a detailed experimentation has been carried out to validate and refine the proposal presented in the work from which we started [2]. In summary, a group of international expert evaluators was first selected who applied the new heuristic to an e-commerce platform, providing both individual evaluations and qualitative feedback regarding the instrument itself. This process not only allowed to identify deficiencies and areas for improvement in the evaluated platform, but also allowed to adjust and optimize the heuristics and their questions to better reflect the needs and expectations of the users.

The results obtained reveal important insights into the usability of e-commerce systems, highlighting both strengths and weaknesses that require attention. Validating heuristics through expert feedback provides a solid foundation for future improvements and establishes a framework for more effective usability evaluations.

In the following sections of this article, the experimentation methods used will be detailed, the results of the evaluations will be analyzed, and conclusions about the effectiveness of the proposed heuristics will be presented. This analysis not only contributes to the continuous improvement of e-commerce platforms, but also brings valuable insights to the usability and user experience research community.

1.1 Background of the Previous Work

The previous study titled "Evaluation Heuristics to Improve Usability in Ecommerce Platforms" [2], focused on the development of a specific set of heuristics designed to evaluate usability in ecommerce platforms. These heuristics were built on established methodologies, such as Nielsen's, but were adapted to address the particular challenges and needs of e-commerce platforms, which differ from other types of interactive systems due to their complexity and focus on the user experience.

To carry out this objective, concepts from different methodological approaches were integrated: that research combined Collaborative Engineering with the methodology of Quiñones [3], Rusu [4], and that of Granollers [5][6]. The integration of these methodologies made it possible to more broadly address the complexity inherent in e-commerce platforms, focusing on improving both interactive quality of use and collaboration for their users. The purpose of this combination was to strengthen evaluation heuristics, improving their ability to optimize the digital experience.

To generate a new version of the heuristics considering the specific components of e-commerce platforms, the methodology proposed in [5] was used, which presents a single new heuristic to be added to the 15 existing ones. The new heuristic is composed by 8 specific characteristics related to specific e-commerce usability issues. Following the chosen methodology, we defined a series of associated questions to that heuristic.

The proposal includes, among others, features such as content personalization, intelligent recommendations, interface adaptability, search optimization, preference and configuration management, and privacy and data control. Each feature is accompanied by specific questions that allow you to evaluate the effectiveness and personalization of the user experience, as well as the transparency and control over personal data. This set of heuristics was expanded and refined to specifically assess usability in e-commerce systems, adding questions that allow for a more detailed analysis of the user experience in these contexts. Table 1 shows that new heuristic with its features and the corresponding questions.

Table 1. Main result from our previous work, the proposed new heuristic to complement Granollers methodology [8] to assess the usability of interactive e-commerce systems.

Feature Name	Feature Description
1. Content Personalization	The platform utilizes algorithms to analyze user behavior, such as browsing and purchasing history, to personalize the content displayed to them. This means that each user sees a version of the website or application that best fits their interests and needs, which may include featured products, promotions, and personalized editorial content.
<i>Questions related to Feature 1</i>	1- <i>Does the platform display personalized content based on the user's browsing and purchase history?</i> 2- <i>Are product recommendations adjusted according to the user's previous interests and behaviors?</i>
2. Intelligent Recommendations	It utilizes machine learning technology to offer highly relevant product recommendations based on the user's previous behavior, including past purchases, viewed products, and interaction with similar products by users with similar purchasing patterns. This helps users discover products that are likely to interest them, thereby enhancing the shopping experience.
<i>Questions related to Feature 2</i>	3- <i>Are the product recommendations relevant and useful for the user?</i> 4- <i>Does the platform use data from previous browsing and purchases to improve recommendations?</i>
3. Dynamic Interactions	It incorporates interactive elements such as AI-based chatbots that provide real-time assistance, personalized recommendations and support during the purchasing process. These bots can answer questions, suggest products based on the user's responses, and offer help with support issues, creating a more interactive and personal shopping experience.
<i>Questions related to Feature 3</i>	5- <i>Does the platform offer real-time assistance through chatbots or similar systems?</i> 6- <i>Do chatbots provide personalized product suggestions during user interaction?</i>
4. Interface Adaptability	The design of the website or app adapts not only to different devices and screen sizes, but also to individual user preferences. This may include the ability to modify the layout of interface elements, choose color schemes, or filter types of content the user prefers to view.
<i>Questions related</i>	7- <i>Can users customize the layout or visual appearance of the interface according to their</i>

<i>to Feature 4</i>	<i>preferences?</i>
5. Search Optimization	Search functions can learn from the user's past interactions to provide more accurate and useful results in future searches. This includes automatic suggestions as the user types, and the ability to understand and correct typos or spelling errors.
<i>Questions related to Feature 5</i>	8- <i>Does the search function provide relevant and accurate results?</i> 9- <i>Is the search adjusted and improved based on the user's previous queries?</i>
6. Feedback and Personalized Reviews	Encourage users to leave comments and reviews about products they have purchased and use this information to improve personalized recommendations. Additionally, product reviews from users with similar preferences can be highlighted, helping others make informed purchasing decisions.
<i>Questions related to Feature 6</i>	10- <i>Are feedback and product reviews from users encouraged?</i> 11- <i>Does the platform use user feedback to improve personalized recommendations?</i>
7. Preferences and Settings Management	It offers users a control panel where they can specify their interests, adjust the frequency and types of notifications they receive, and manage how their data is used for personalization. This empowers users, allowing them to have more direct control over their shopping experience.
<i>Questions related to Feature 7</i>	12- <i>Can users manage their preferences and settings in an easy and accessible way?</i> 13- <i>Is there an option to control how personal data is used for personalization?</i>
8. Privacy and Data Control	Maintains a policy of full transparency on how user data is collected, used and protected. Provides clear and accessible options for users to manage their privacy and the use of their data, including the option to opt out of certain types of personalization.
<i>Questions related to Feature 8</i>	14- <i>Does the platform provide clear information about how user data is used and protected?</i> 15- <i>Do users have clear options to control their privacy and the use of their personal data?</i>

Thus, when the system to be evaluated is an e-commerce system, the heuristic in question will be composed of 16 heuristic principles (the 15 starting principles that analyze the usability of a generic user interface, plus the one we have added that focuses on the specific aspects of usability in e-commerce systems). which will be evaluated by answering a total of 74 questions (the 60 starting questions plus the 15 that we have added to evaluate the heuristics that have been added). It is expected to be able to validate this heuristic with experts and to be able to apply it in real e-commerce scenarios.

2 Experimentation

In the previous section, the proposal to improve the evaluation of usability in interfaces of interactive e-commerce systems through heuristic evaluation was contextualized. In this section, the experimental part carried out to validate and, if necessary, improve the proposal will be detailed. This experimental phase is fundamental in the development of this article, as it seeks to close the cycle started in the previous work [2].

The experimentation was carried out as follows:

2.1 Preparation and Procedures

For the preparation of the experiment, a set of expert international evaluators was contacted through the HCI-Collab network. Evaluators were sent an email explaining the objective of the study and asked to participate in the evaluation of the selected e-commerce platform. The response time was two to three weeks, during which the evaluators were required to complete the evaluation and submit their comments. The email included the following instructions:

Subject: Participation in heuristics evaluation for e-commerce platforms

Message:

"Hello to all,

Thank you very much for agreeing to participate in this evaluation.

I am Alejandra Yicel Vargas Muñoz, a student of the Master's Degree in Computer Science at the University of Cauca, Colombia. I am doing the experimental part of my undergraduate work, directed by PhD César Collazos and PhD Antoni Granollers. This work has been entitled "Usability Evaluation Heuristics for E-Commerce Platforms".

The main objective is that, by carrying out a real evaluation, they can provide me with feedback on this proposed heuristic for e-commerce platforms, including suggestions for improvement, especially on heuristic number 16 – e-Commerce Usability, which constitutes the main contribution of my research.

Attached you will find the tool in Excel format to carry out the evaluation of the selected platform (<https://www.ebay.es>) and provide detailed comments, especially when the answers are negative.

What I expect from you is:

- 1. The Excel file with your evaluation of the platform.*
- 2. Comments regarding heuristic number 16, with recommendations for improvement.*

Thank you very much to all for your participation."

2.2 Conducting the Experiment

The platform evaluated was **eBay Spain** (<https://www.ebay.es>), one of the main e-commerce platforms worldwide. The evaluators had to use the evaluation tool provided in Excel format, in which each question of the proposed heuristics was accompanied by a space for additional comments, where they were expected to indicate possible improvements or constructive criticism, especially in cases where the answer to the questions was negative. At the conclusion of the evaluation of the platform, the testers were also required to fill out an additional form that was sent to them to get specific feedback on **heuristic number 16 – e-Commerce Usability**. This form aimed to collect their perceptions about the relevance, coherence and clarity of the questions that made up this heuristic. They were asked to provide suggestions on how to refine the questions or phrase them in a more understandable way, in case they felt they were not aligned with the goal of evaluating e-commerce platforms.

2.3 Analysis of Evaluations

Once all the evaluations and feedback were received, the results were systematically analyzed. Both quantitative responses and qualitative feedback provided by evaluators were reviewed. The comments and suggestions were essential to adjust and improve the proposed heuristic, allowing to identify aspects that required greater precision or adaptation.

This approach allowed the heuristics to be validated and optimized, ensuring that they are effectively applicable in real e-commerce contexts.

3 Selection of a set of international expert evaluators

As explained, heuristic evaluation (HE) is a technique in which only expert evaluators are involved [5] [6]. In our case, we need experts who are not only able to perform the assigned evaluation, but also provide us with qualitative feedback on the heuristics introduced because of wanting to improve the evaluation of the interfaces of e-commerce systems. To this end, we resort to calling on the experts of the HCI-collab network [7].

Once the participation form has been filled out by those interested in participating in the evaluation, which 14 participants answer, it is verified that they are really adequate for what is required, and the evaluation instrument is sent to them by email.

The evaluators who participated in this study have an academic background and professional experience in areas related to Human-Computer Interaction (HCI), usability, and specific aspects of commercial platforms. Although all participants have a solid background in usability evaluation and experience in the application of heuristics within the HCI field, not all of them can be considered experts in the evaluation of e-commerce platforms. This diverse group allowed to obtain a broader perspective on the effectiveness of the proposed heuristics, by including both evaluators with experience in interface analysis and those with a more general focus on usability.

3.1 Analysis of the results evaluation with experts

The results give an insight into the level of usability of the system being evaluated and specific areas that might need special attention. It is important to observe if there is consistency in evaluations between different evaluators, as this can indicate common problems or strengths of the system. However, it is also valuable to examine the discrepancies between the evaluators' scores, as they can reveal differences in the interpretation of the questions associated with each of the usability heuristics of which the instrument consists of.

Based on the results, corrective actions can be prioritized to address identified deficiencies, focusing on critical areas for improvement that have a significant impact on the user experience. Ultimately, improving usability can lead to higher user satisfaction, greater efficiency in using the system, and a lower incidence of errors, contributing to a more positive user experience.

Once all the experts have made their individual evaluation, we obtain the results that we observe in table 1 and that we will analyze in detail. Before that, there is a fundamental aspect of this technique that should not go unnoticed and it is necessary to have quantitative values, these are not totally mathematical in the sense that with the same data we will always obtain the same result, but they contain a component of subjectivity inherent in using a methodology

whose assessments, quantitative and qualitative are reported by the chosen evaluators, people subject to their own criteria, appraisals and conditioning factors [5].

Analyzing the results of table 2 at a higher level, the first value we look at is the overall result of the average usability percentage (PU) (average of the PUs of the 6 evaluators) which, in this specific case, we obtain a value of 67.78%, which indicates that, without being completely wrong, the user interface of the evaluated system has a lot of room for improvement. In a bet on maximums, it could still be improved by 32.22%, that is, this system is a long way from being considered to have excellent usability.

To really see where the problems arise and where we would have the most room for improvement, we will analyze in more detail the values in table 2 looking at heuristics by heuristics:

Table 2. Results of an overview of the level of usability of the system evaluated.

		Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Evaluator 5	Evaluator 6
Nº	Heuristics	Values	Values	Values	Values	Values	Values
H1	System Visibility and Health	4.66	3.65	4.32	3.99	2.32	3.98
H2	Connection between the system and the real world	4	3.32	4	3.66	4	2.64
H3	User Control	2	1.98	3	2.32	2	3
H4	Consistency and standards	5.66	4.64	5.66	3.98	5.66	6
H5	Recognition	5	3.65	5	4.32	3.33	2.97
H6	Flexibility	3	1.98	3	2.32	3.66	4.32
H7	Diagnose errors	0	2.99	2.33	1.65	2	2.31
H8	Error prevention	0.99	1.65	2.33	2.32	2.33	3
H9	Aesthetic design	4	1.98	4	2.99	2.65	2.99
H10	Help and documentation	4.32	4.32	4	3.32	0.66	5
H11	Save Status	0	0.99	2	0.66	2	3
H12	Control and readability	3	2.64	2.99	2.66	2	1.98
H13	Autonomy	2	1.32	2	0.66	2	1.98
H14	Defaults	0	0	0	0.66	0	1.98
H15	Reduced latency	0	0.66	1	1	0	1.32
H16	E-commerce usability	6.65	7.28	7.66	2.64	5.97	9.24
	Test Completed	100.0%	98.6%	100.0%	100.0%	100.0%	100.0%
	Missing Questions	0	1	0	0	0	0
	# Accounting Questions	49	73	61	72	52	73
	# Non-Accounting Questions ¹	5	0	10	2	16	0
	# WARNINGS	20	0	3	0	6	1
	Usability Percentage (PU)	65.62%	58.18%	83.27%	54.38%	69.97%	75.28%

Let's look at the values in parts to understand what they are telling us. First, we will focus on seeing which are the heuristics with the greatest possibility of improvement or, in other words, those in which more errors are observed. The following table 3 shows us the 16 heuristics ordered from lowest to highest by the percentage column of the right column, a value that shows us the relationship between the score obtained with respect to the maximum they could obtain. This ordering already provides us with a first important observation: in this table the heuristics are ordered from worst to best in relation to their state in terms of usability of the interface evaluated. That is, heuristic 14 "Default values" is the one that is worst (that is, the one that has the most room for improvement) and heuristic 2 "Connection between the system and the real world" the one that is best (that is, the one with the least room for improvement).

¹ NOT Applicable and NOT a Problem

Table 3. Heuristics ordered from lowest to highest by the difference in percentage value obtained with respect to the maximum they could obtain.

Nº	Heuristics	Average of all evaluators ²	Maximum possible ³	Difference	Difference in percentage value ⁴
H14	Defaults	0.44	3.00	2.56	15%
H15	Reduced latency	0.66	2.00	1.34	33%
H16	E-commerce usability	6.57	14.00	7.43	47%
H7	Diagnose errors	1.88	4.00	2.12	47%
H11	Save Status	1.44	3.00	1.56	48%
H6	Flexibility	3.05	6.00	2.95	51%
H13	Autonomy	1.66	3.00	1.34	55%
H12	Control and readability	2.55	4.00	1.46	64%
H8	Error prevention	2.10	3.00	0.90	70%
H10	Help and documentation	3.60	5.00	1.40	72%
H1	System Visibility and Health	3.82	5.00	1.18	76%
H9	Aesthetic design	3.10	4.00	0.90	78%
H3	User Control	2.38	3.00	0.62	79%
H5	Recognition	4.05	5.00	0.96	81%
H4	Consistency and standards	5.27	6.00	0.73	88%
H2	Connection between the system and the real world	3.60	4.00	0.40	90%

3.2 Analysis of comments/observations by heuristics

We use the order of table 3 to go from more to less, both to obtain the list of errors (to have a control and obtain a final list, they will be numbered with the notation E1, E2, ... successively as they appear) and that of proposals for improvement (as with errors, in order to have a control and obtain a final list, they will be numbered with the notation PM1, PM2, ... successively as they appear):

H14. "Defaults". It refers to the default system settings and whether they are optimized for users' needs and preferences [8]. A 15% gap indicates that there may be opportunities to improve the default settings and make them more aligned with user expectations. The evaluators were unable to verify certain aspects related to this heuristic.

Comment: Unable to verify the existence of options to revert to factory settings (P1, H14)⁵:

- The evaluators indicate that they were unable to verify whether the system or device provides the option to revert to factory settings. This suggests a lack of visibility or accessibility of this functionality on the platform.

Comment: Failure to verify whether the consequences of restoring factory settings are clearly stated (P2, H14):

- The evaluators also mention that they were unable to check whether the consequences of restoring factory settings are clearly stated. This is important for users to fully understand the implications of this action before proceeding.

Comment: Use of the term "default" (H14, P3):

- The evaluators were unable to verify whether the term "default" is used in relation to the standard system configuration. In addition, they indicate that this term is not used in any case, suggesting a possible lack of consistency in the terminology used on the platform.

Observations/recommendations: the comments reflect the difficulty of the evaluators to verify certain aspects related to the default values on the platform. To improve the user interface according to this heuristic, it would be important to ensure that the options for factory restoring are visible and understandable to users, and that the consequences of this action are clearly communicated. In addition, consistency in the use of the term "default" across the platform could be considered to improve clarity and consistency in communication with users.

² Average of the values of each heuristic of the different evaluators. Each value is obtained from the answers that the evaluators have given to each question.

³ Maximum value that each heuristic can achieve. This value would come out in the case of answering affirmatively to all the questions of the heuristic in question.

⁴ The lower this value, the more it has to reach the maximum value, i.e. the more usability defects it has and, consequently, the more room for improvement.

⁵ (P1, H14) indicates question 1 of heuristics 14. This notation will be used in the rest of this section.

H15. "Latency reduction." It involves minimizing user wait time and providing quick responses to user actions [8]. A 33% difference suggests that there may be areas where the system can be optimized to reduce latency and improve response speed. Evaluators are not familiar with the concept of "heavy lifting" in the context of the e-trading platform.

Comment: Unfamiliarity with the term "heavy task" (P1, H15):

- Evaluators are not sure what a "heavy task" refers to in this context. This suggests that the term may not be clear or that the platform does not provide enough context for users to understand its meaning.

E1: Absence of remaining time indicators or animations related to the purchase process (P2, H15):

- It is mentioned that no information was provided about the time remaining during the purchase process nor were animations related to the process included. This could have helped the evaluators to have a better perception of time and reduce the feeling of waiting during the purchase.

Comment: Variability in the application of heuristics (H15):

- It is indicated that the reduction in latency "does not always apply". This suggests that the platform may not be consistently applying latency reduction principles in all relevant areas.

Observations/recommendations: Feedback suggests that there are opportunities to improve latency reduction on the e-commerce platform. This could be achieved through better communication on technical terms such as "heavy duty", the inclusion of relevant time indicators and animations during the purchase process, and the consistent application of latency reduction principles across all relevant areas of the platform. Improving the speed and efficiency of the system can lead to a more satisfying and seamless user experience.

H7. "It helps users recognize, diagnose, and recover from errors." It involves the system's ability to help users recognize, diagnose, and recover from errors [8]. A 47% difference suggests that there may be shortcomings in the feedback and guidance provided to users when they make mistakes. Evaluators have not experienced situations that result in errors within the system.

Comment: Absence of error situations detected (P2, H1):

- The evaluators have not found situations that lead them to make mistakes within the system. This can be indicative of good UI and user experience design, where actions are clear and not error-prone.

PM1: Removal of items from the basket (P1, H7):

- It is mentioned that when items are removed from the cart, the action is performed directly. This may be a common practice and does not necessarily result in error, as the associated messages are clear and natural to evaluators.

PM2: Clear and natural messages (P4, H7):

- The evaluators emphasize that the messages within the system are quite natural and do not generate confusion. This clarity in messages can help prevent errors and make it easier for users to understand the system.

Observations/recommendations: The feedback suggests that the system has managed to help users recognize, diagnose, and recover from potential errors effectively, as no problematic situations that could lead to errors have been detected. This can be attributed to clarity in system actions and messages. To maintain this quality, it is important to continue to provide clear and natural messages and design actions that minimize the possibility of making mistakes on the part of users.

H16. "e-commerce usability". It refers to ease of use specifically in the context of e-commerce, ensuring that users can browse, search for products, and complete transactions efficiently. A gap of 47% indicates that there may be areas where the online shopping experience can be improved for users. In the usability of e-commerce, several areas of improvement and positive aspects can be identified.

PM3: Seller-related feedback (P10, H16):

- It is pointed out that the comments, for example, about shoes, are more related to the seller than to the product itself. This can affect the usefulness of reviews for users looking for specific information about products.

Comment: Personalized recommendations (P11, H16):

- It is considered whether the platform uses user feedback to generate personalized recommendations. Although there is no information to verify it, this would be an interesting aspect to explore to improve the user experience and provide more relevant recommendations.

PM4: Clarity on data protection (P13, H16):

- The lack of clear messages about data protection laws, such as Law 1581 in the case of Colombia, is mentioned. This suggests an opportunity to improve transparency and communication about user data privacy.

PM5: Removal of chatbots (P5, H16):

- It is highlighted that communication on the platform is only asynchronous and there is no presence of chatbots. This can be perceived as beneficial by some evaluators who find chatbots invasive and annoying.

E2: Limitations in functionality (H16, P12):

- It is noted that it is not possible to exchange currency and that options are limited to the initial conditions. This may limit accessibility and flexibility for users in different regions or with different currency preferences.

Observations/recommendations: Feedback suggests that there are areas for improvement in the e-commerce platform, such as the relevance of feedback, transparency in data protection, and limited functionality in certain aspects. However, positive aspects are also highlighted, such as the absence of invasive and annoying chatbots. To improve the user experience, it is recommended to address these identified areas of improvement and continue to build on the positive aspects of the platform.

H11. "To save the state and protect the work". This heuristic refers to the system's ability to remember the previous state and allow users to resume their activities from where they left off [8]. A 48% difference suggests that there may be shortcomings in the persistence of the state and the resilience of the system. Evaluators have not had the opportunity to fully verify the functionality of saving the state or resuming actions from another device.

Comment: Inability to verify functionality (P1, H11):

- The evaluators mention that they were unable to verify the ability to resume an action from another device or save the state of the work. This may be because they didn't make enough progress in the checkout process or weren't provided with the option to save the status at the time.

E3: Possibility to continue the purchase from another device (P2, H11):

- It is noted that although they can continue with a purchase from another device, they cannot always see the same product they were seeing on the original device. This suggests an inconsistency in the user experience across devices, which can be confusing and frustrating for users who expect continuity in their business.

Observations/recommendations: Feedback suggests that while evaluators recognize the ability to continue a purchase from another device, there is uncertainty about consistency in the experience across devices and the ability to save work status. To improve this heuristic, it is recommended to ensure that users can save their progress at any point in the process and that they can easily resume it from any device without losing information or having an inconsistent experience. This can improve user confidence and provide a smoother and more convenient experience.

H6. "Flexibility and efficiency of use". This principle refers to the ability of the system to adapt to different needs and user styles [8]. A 51% gap indicates that the system may lack options that allow users to effectively personalize their experience. There are several aspects related to flexibility and efficiency that could be improved on the platform.

PM6: Keyboard shortcuts and lack of guidance (P1, H6):

- The evaluators mention that they were unable to verify the existence of keyboard shortcuts for frequent actions and that, if they exist, there is no guide or component that explains how to use them. This suggests a lack of transparency and help for users who could benefit from keyboard shortcuts to streamline their tasks.

Comment: Adapting the design to different screen resolutions (P4, H6):

- It is noted that the design adapts when changing the screen resolution on PC, but it has not been tested on mobile devices. While this indicates some flexibility in the platform, it also suggests that there may be inconsistencies in the user experience across different devices.

Comment: Using accelerators for regular users (P5, H6):

- The evaluators were unable to assess whether the use of accelerators is visible to frequent users, but they suggest that it would be interesting to check if there are options that speed up the purchase process for these users. It is

indicated that no accelerators were observed in any case, suggesting an opportunity to improve efficiency and user experience.

Observations/recommendations: Feedback suggests that there are important aspects of flexibility and efficiency that could be improved in the e-trading platform. It is recommended to provide clear information about keyboard shortcuts for frequent actions, ensure consistent adaptation of the layout to different screen resolutions, and explore options to speed up the checkout process for regular users. These improvements could lead to a more efficient and satisfying user experience on the platform.

H13. "Autonomy". This heuristic implies that the system must allow users to perform tasks without requiring excessive intervention or constant direction [8]. A 55% difference suggests that there may be areas where users need more guidance or assistance in completing tasks independently. There is some variability in how this heuristic is fulfilled on the platform.

Comment: Keeping the user informed of the system status (P1, H13):

- Most evaluators indicate that the user is kept informed of the status of the system in all cases.

Comment: System Status Visibility and Update (P2, H13):

- Most evaluators state that the status of the system is visible and up-to-date in all cases.

Comment: Possibility of customizing the workspace (P3, H13):

- It is not possible to verify whether the user can customize their workspace in all cases. Some evaluators indicate that this is not possible.

Observations/recommendations: The platform mostly complies with keeping the user informed of the status of the system and with making visible and updating said status. The possibility of customizing the workspace seems to be more variable, some evaluators indicate that it is not possible and others mention that some cases in which it can be customized are missing. This suggests that there may be areas for improvement in terms of consistency in the possibility of workspace customization.

H12. "Color and readability". It refers to the ease with which users can read and understand the information presented on the interface [8]. A gap of 64% indicates that there may be problems with the readability of the text and the arrangement of information in the interface. There is a variability in how this heuristic is approached on the platform.

E4: Proper font size (P1, H12):

- Most evaluators indicate that the fonts in the text are of an adequate size. However, it is mentioned that there are certain inconsistencies, in specific sections, such as titles and descriptions in products.

Comment: Sufficient contrast between text and background (P2, H12):

- Most evaluators also claim that text fonts use colors with sufficient contrast with the background.

E5: Readability of text on images or background patterns (P3, H12):

- Most evaluators indicate that text over images or background patterns is mostly easy to read. However, in one case it is mentioned that there are problems with white text on photos that had white elements, which could affect readability.

PM7: Consideration of users with low vision: (P4, H12)

- Most evaluators indicate that users with low vision are considered, with consideration for accessibility for all users.

Observations/recommendations: The platform is mostly compliant with color and readability guidelines, improvements can be made to ensure a consistent and accessible user experience for everyone. It's important to address any inconsistencies in font size, color contrast, and text readability over images or background patterns, as well as ensure proper consideration of users with low vision.

H8. "Error prevention". It refers to the system's ability to prevent users from making mistakes in the first place [8]. A 70% gap indicates that there may be opportunities to implement proactive measures that reduce the incidence of errors. There are a few areas where the platform can improve to prevent errors and improve clarity in certain actions.

E6: Confirmation message before performing actions (P1, H8):

- Evaluators report that a confirmation message doesn't always appear before taking action. This can increase the risk of users taking unwanted or inadvertent actions. It would be important to ensure consistency in the presentation of commit messages for important actions.

PM8: Clarity in form fields (P2, H8):

- While most evaluators say it's clear what needs to be entered in each field on a form, some say that improving consistency in the clarity of form fields can help reduce data entry errors.

E7: Tolerance for typos and spelling errors in the search engine (P3, H8):

- Evaluators indicate that the search engine does not always tolerate typos and spelling errors. This can make it difficult for users to find their search experience, especially if they make mistakes when typing keywords. Improving search engine functionality to detect and fix typos can improve the user experience.

Observations/recommendations: To improve error prevention on the platform, one could consider implementing confirmation messages more consistently before taking important actions, ensure clarity in all fields of forms, and improve tolerance for typos and spelling errors in the search engine. These improvements can help reduce the likelihood of errors and improve the overall user experience.

H10. "Help and documentation". It refers to the availability and usefulness of help and documentation for users in need of assistance [8]. A gap of 72% indicates that there may be areas where the help provided is not clear or accessible enough for users. There is a variability in how this heuristic is approached on the platform.

E8: Existence and accessibility of the help option (P1, H10):

- Most evaluators indicate that there is an option for help and that it is visible and easily accessible. However, in one case it is mentioned that the help option is at the bottom of the page and is not very visible.

PM9: Guidance of Troubleshooting Assistance (P2, H10):

- Most evaluators indicate that the help is problem-solving. However, some mention that there could be areas for improvement in the clarity and relevance of the help provided.

E9: Existence of a FAQ section (P3, H10):

- Some evaluators indicate that there is a section of frequently asked questions, but they also mention that there may be a lack of consistency in the availability of this useful resource for users.

PM10: Clarity and use of examples in help documentation (P4, H10):

- Most evaluators indicate that the help documentation is clear and uses examples. However, some mention that there may be areas for improvement in the consistency and quality of help documentation.

Observations/recommendations: To improve the help and documentation heuristics, the platform could focus on making the help option more visible and accessible, ensuring that the help provided is solution-oriented, maintaining consistency in the availability of a frequently asked questions (FAQ) section, and improving the clarity and use of examples in the help documentation. These improvements can help users find and use help resources more effectively, which will improve their overall experience on the platform.

H1. "System Visibility and Status." This heuristic refers to the ability of the system to keep the user informed about its status and the actions it is performing [8]. A difference of 76% indicates that there is room to improve the clarity and visibility of system information for users. A few problems can be identified in relation to the clarity and consistency of the information presented in the system.

E10: Lack of clear route (P3, H1):

- Evaluators mention that they can't always determine where they are on the site due to the lack of a clear title or indicator of the current location. This can lead to confusion and make it difficult to navigate efficiently.

E11: Unexpected change of section (P2, H1):

- It is reported that, when entering a specific section, such as "How to sell", the system abruptly redirects to another section, such as "Customer service/sales". This sudden change can disorient evaluators and make it difficult to understand the structure of the site.

E12: Recoil Issues (P4, H1):

- It is mentioned that when accessing the "Affiliates" option, users are taken to another site without a clear link to return to the original site. This can frustrate evaluators who want to go back after exploring external content.

E13: Difficulty locating relevant information (P1, H1):

- Evaluators express difficulty locating the title of the page or section they are visiting. This lack of visibility can make it difficult to understand context and orientation within the site.

Observations/recommendations: Feedback suggests that there are significant areas for improvement in terms of visibility and system health. It is recommended to provide clear indicators of the user's current location, maintain consistency in navigation between sections, and make it easy to return to previous pages to improve the overall user experience.

H9. "Aesthetic and minimalist design". This principle implies that the interface must be aesthetically pleasing and visually coherent [8]. A difference of 78% suggests that there may be aspects of the design that could be improved to make it more attractive and harmonious. Indicate some variations and areas for improvement.

Comment: Using a design without information redundancy (P1, H9):

- There is a discrepancy in the comments as to whether a design without information redundancy has been used. While most evaluators indicate that it has been achieved in all cases, some mention that this does not always happen. This suggests that there could be inconsistencies in the presentation of information on the platform.

PM11: Conciseness and Accuracy of Textual Information (P2, H9):

- Most evaluators state that the textual information is concise and accurate. However, some mention that there is a lack of conciseness and precision, which could indicate the need to review and improve the clarity of the information presented.

PM12: Differentiation of each information element (P3, H9):

- Most evaluators indicate that each piece of information is distinct from the rest and is unmistakable. However, it is mentioned that this does not always happen, suggesting that there may be areas where information differentiation needs to be improved.

PM13: Correct structuring of the text (P4, H9):

- Comments suggest that text structuring, with short, easy-to-interpret sentences, is mostly achieved. However, this does not always happen, indicating that there may be areas for improvement in the clarity and structure of the text.

Observations/recommendations: To improve this heuristic, the platform could work on ensuring consistency in the presentation of information, making sure that textual information is always concise and accurate, improving the differentiation of each piece of information, and ensuring proper structuring of the text in all cases. These improvements can contribute to a more consistent and enjoyable user experience on the platform.

H3. "User Control and Freedom". It refers to the freedom and control that the user has over the system [8]. A difference of 79% indicates that there may be limitations in the flexibility and interactivity of the system that could be improved. Some aspects related to the ease for users to control and move within the system can be identified.

PM14: Start access (P1, H3):

- It is mentioned that the company logo is always available as a way to go back to the top. However, the concern is raised that for inexperienced users it may not be apparent that the logo works in this way. This suggests that there may be a need to improve visibility or the indication that the logo is a home link.

PM15: Undo actions (P2, H3):

- Evaluators emphasize that it's possible to undo actions, such as adding an item to the purchase and then removing it. However, they point out that if they need to re-add a retired item, they would have to find it and add it again, which involves additional actions and can be frustrating if it's a mistake. This indicates an opportunity to improve the efficiency and convenience of the process of undoing actions.

Comment: Web User Experience (P3, H3):

- In the specific case of an evaluator, the user's control and freedom has not been necessary because he has not made a specific transaction. This may indicate that the system could benefit from further promotion or education about the control features available to users.

Observations/recommendations: Feedback suggests that there are aspects of the system that can be improved to give users greater control and freedom. It is recommended to improve the visibility and indication of important functions,

such as access to the start through the logo, as well as to optimize the process of undoing actions to make it more efficient and convenient for users. Additionally, it is important to educate users about the system's capabilities so that they can make the most of the control they have over their actions.

H5. "Recognition instead of memory, learning and anticipation". It refers to the system's ability to make choices, functions, and actions recognizable and distinctive [8]. An 81% difference suggests that there might be elements in the interface that aren't as distinguishable as they should be. Evaluators find the system easy to use and doesn't require excessive memorization or learning effort. However, they mention that there are aesthetic aspects that could be improved.

Comment: Ease of use (P1, H5):

- Evaluators say the system is simple to use, suggesting that a good balance has been struck in terms of recognition rather than memory. This means that actions and functions are intuitive and easy to understand without the need to remember specific information.

PM16: Aesthetic aspects (P2, H6):

- It is mentioned that there are aesthetic aspects that could be improved. This could include the visual design of the site, such as UI design, typography, use of color, and arrangement of elements on the page. Improving these aspects could contribute to a more engaging and enjoyable experience for users.

Observations/recommendations: Feedback suggests that the system has succeeded in providing a user experience that complies with the principles of recognition rather than memory, learning, and anticipation. They also point to areas for improvement in aesthetic aspects that could increase the quality of the user experience. Therefore, it is recommended to pay attention to these aspects and make improvements as needed to further optimize the user experience.

H4. "Consistency and standards". This principle implies that the interface must follow known conventions and standards to ensure a consistent experience [8]. An 88% gap suggests that there could be inconsistencies in the design that could confuse users. Several areas can be identified where a lack of consistency and standards can affect the user experience.

E14: Lack of clarity in navigation (P2, H4):

- The evaluators note that the "Translations" and "Help" sections go to the same place, suggesting a lack of clarity in the differentiation between the two. This inconsistency can cause confusion about the purpose of each section and make it difficult to effectively navigate within the site.

E15: Clarity in the links (P3, H4):

- It is mentioned that the links in the offers (Daily Deals) are not clear. This can lead to confusion or make it difficult to understand what actions are available to users in relation to daily deals.

PM17: Graphic content vs. use of icons (P4, H4):

- It is noted that the page has few icons due to the predominant graphic content. While this may be understandable due to the graphical nature of the content, it's important to balance the amount of text and visuals to ensure a consistent and effective user experience.

Observations/Recommendations: Feedback highlights the importance of maintaining consistency and following design standards throughout the site to improve the user experience. It is recommended to ensure that the presentation of information is consistent in all cases, clearly differentiate between similar sections, improve the clarity of links, and balance the amount of graphic content with textual and iconic elements for a clearer and more consistent experience.

H2. "Connection between the system and the real world, use of metaphors and human objects". This principle implies that the system must speak the user's language and reflect the real world [8]. A 90% gap suggests that the interface could benefit from further adaptation to user expectations and knowledge. Some areas for improvement can be identified in relation to the clarity of terms and consistency between the versions of the site in different languages.

PM18: Icon Shortage (P1, H2):

- Evaluators note that there are few icons in the system, which can limit the user's ability to quickly identify specific functions or actions. Icons can provide a quick visual representation of actions and improve the usability of the system.

Comment: Use of descriptive buttons and links (P2, H3):

- It is noted that most of the action items are buttons or links with descriptive words. This can be beneficial for clarity and accessibility, as users can easily understand what action each element will perform.

E16: Translation problems (P3, H2):

- It is mentioned that, in the Spanish version of the site, some translated terms are not clear or may be confusing for users. This suggests a lack of consistency and quality in translation, which can negatively impact the user's understanding and experience on that version of the site.

Observations/recommendations: Comments indicate that although the system mainly uses descriptive buttons and links for actions, there are areas for improvement in terms of the clarity of terms, especially in the Spanish version. It is recommended that the translation of terms be reviewed and improved to ensure consistency and proper understanding of the system in all available languages. In addition, consider the strategic inclusion of more icons to improve the visual experience and usability of the system.

3.3 Qualitative feedback of the new proposed heuristic

As we have seen in the previous subsections, the qualitative feedback provided by the evaluators provided a total of 16 errors (E1 to E16) and 18 proposals for improvement (PM1 to PM18), suggesting several key areas for improvement in the analyzed platform. Heuristics with larger gaps, such as flexibility and efficiency of use, state-saving and work-protecting, and e-commerce usability, indicate the need to optimize the user experience in terms of personalization, state persistence, and e-commerce-specific functionality.

Regarding the responsive or adaptive design of the interface, although the proposed heuristics address flexibility and efficiency of use (H6), the adaptability of the interface on mobile devices was not specifically evaluated during this phase of the study. To ensure an optimal user experience for a diverse audience accessing e-commerce platforms from multiple devices, it is recommended to include a more detailed evaluation of interface behavior in mobile environments and with different screen resolutions. This will allow you to check if the platform maintains its usability on a variety of screen sizes and operating systems, thus optimizing the experience for all users.

On the other hand, regarding the simplification of purchasing processes, although the e-commerce usability heuristic (H16) evaluates the efficiency in the search for products and the execution of transactions, the reduction of steps in the purchase process was not specifically addressed. To improve this area, it would be valuable to include criteria that explicitly assess the simplification of these processes, for example, by reducing the number of interactions required to complete a purchase and streamlining transactions, particularly for returning users. Implementing "accelerators" or automation for frequent users could be an effective strategy to improve efficiency and reduce friction in purchasing. To close these gaps and improve the usability of the platform, it is crucial to implement the recommendations derived from this analysis, focusing on clarity of terminology, visibility of options, consistency in user experience, and adaptation to different needs and devices. These improvements will help provide a more intuitive, efficient, and satisfying user experience. This reinforces the importance of a comprehensive and systematic approach in the design and development of user interfaces that are aligned with best practices and usability standards.

3.4 Proposed heuristic analysis

The results obtained by the evaluators are presented below, where a grade was requested for each of the questions that make up the proposed heuristic. As far as the contribution of our methodology is concerned, this section is of great relevance.

3.4.1 Detailed Questions and Qualifications

The following table (table 4) presents the score given by expert evaluators with respect to the questions or sub-heuristics that make up the proposed heuristic, this with the aim of also analyzing according to their rating the level of importance for the evaluation in a type of e-commerce platform. The rating scale used was as follows: Scale from 1 to 5, where 1 is considered "not very useful" to 5 is considered "very useful". Obtaining the following scores from the evaluators:

Table 4. Feedback on heuristics proposal "e-commerce usability"

Nº	Question	Evaluator 1	Evaluator 2	Evaluator 3	Average
1	Does the platform display personalized content based on the user's browsing and purchase history?	3	4	3	3.33
2	Are product recommendations adjusted based on the user's previous interests and behaviors?	4	4	4	4.00
3	Are the product recommendations relevant and useful to the user?	4	4	4	4.00
4	Does the platform use browsing and past purchase data to improve	3	3	4	3.33

	recommendations?				
5	Does the platform offer real-time support through chatbots or similar systems?	3	3	2	2.67
6	Do chatbots provide personalized product suggestions during user interaction?	3	5	2	3.33
7	Can users customize the layout or visual appearance of the interface according to their preferences?	3	4	4	3.67
8	Does the search function provide relevant and accurate results?	4	5	4	4.33
9	Does the search adjust and improve based on the user's previous queries?	3	4	4	3.67
10	Is user feedback and product reviews encouraged?	3	5	4	4.00
11	Does the platform use user feedback to improve personalized recommendations?	3	3	4	3.33
12	Can users manage their preferences and settings easily and affordably?	3	5	4	4.00
13	Does the platform provide clear information about how user data is used and protected?	3	5	4	4.00
14	Do users have clear options to control their privacy and use of their personal data?	3	5	4	4.00
Overall average per evaluator		3.21	4.21	3.64	3.7

3.5 General Observations:

Once the questions were graded, they were also asked for comments or observations on them, so that having this information they could obtain a classification of which would be necessary and which would be redundant, in order to refine this new heuristic and, if necessary, obtain a new list of the questions that make it up.

3.5.1 Variability in Experiences

Evaluator 1: Seems to have a more moderate perception of the platform's customization capabilities and overall usefulness, with an average rating of 3.21.

Evaluator 2: Gives the highest ratings, with an average of 4.21, suggesting a generally positive experience and a perception of greater functionality on the platform.

Evaluator 3: is in the middle, with an average of 3.71, showing a mixed experience.

1. Personalization and Relevance:

Questions related to personalizing recommendations and search results earned relatively high ratings (between 3.33 and 4.33), indicating that evaluators perceive the platform to offer some degree of personalization and relevance in their product suggestions.

2. Real-Time Assistance and Chatbots:

Ratings for real-time attendance and chatbot usage were the lowest (2.67 and 3.33 respectively). This suggests that the presence and effectiveness of these systems were not apparent to all evaluators, or that their performance could be improved.

3. Preference and Privacy Management:

Questions about managing preferences and settings, as well as controlling privacy and use of personal data, received moderately high marks (average of 4.00). The evaluators seem to have a positive perception of these characteristics, although some responses indicate that not all aspects were clearly evident during the evaluation.

4. Feedback and Improvements:

The feedback and its use to improve personalized recommendations received mixed ratings (average of 3.33 and 4.00). Although their presence is recognized, some evaluators could not clearly demonstrate their effectiveness or implementation.

3.5.2 Analysis Feedback

1. Platform Strengths:

1.1 Product Recommendations: Recommendations appear to be generally relevant and useful, adjusting to the evaluators' previous interests and behaviors.

1.2 Search Function: The search provides relevant and accurate results, and adjusts based on previous queries from the evaluators.

1.3 Privacy Management: Evaluators have clear choices to control their privacy and the use of their personal data.

2. Areas for Improvement:

2.1 Real-Time Assistance: The implementation and visibility of chatbots and real-time assistance systems 2.2 could be improved to offer a better experience to the evaluator.

2.3 Customization of the Interface: Although it is possible to customize some elements, the platform could offer more options and make it more apparent to evaluators.

2.4 Clarity in Data Usage: Providing clearer and more accessible information about how evaluator data is used and protected could improve trust and the perception of security.

3. User Experience:

Ratings and feedback suggest that the evaluator's experience varies depending on the degree of interaction and familiarity with the platform. Users who have not made purchases or have interacted with the platform to a limited extent may not fully perceive its full capabilities.

3.5.3 Recommendations

1. Improve the Visibility and Effectiveness of Chatbots:

Ensure that chatbots are easily accessible and that they provide personalized suggestions and real-time assistance more obviously.

2. Increase Customization Options:

Offer more options to customize the interface and make these options more visible and easier to use.

3. Clarifying Data Usage:

Provide clear and concise information about how evaluator data is used and protected, and make this information easily accessible.

4. Encourage Feedback:

Create more visible and accessible mechanisms for evaluators to leave feedback and product reviews, and demonstrate how this feedback is used to improve recommendations.

In terms of feedback on the proposed heuristics, out of the six evaluators, only three provided detailed feedback on **heuristic number 16 – e-Commerce Usability**. This is because only these three evaluators specifically responded to the request for additional feedback. Although the other testers completed the overall evaluation of the platform, they did not provide comments on the questions in the added heuristic. This aspect will be addressed later in the limitations of the study, where the need for a greater amount of feedback to refine and adjust this part of the evaluation is recognized.

4 Review and Analysis of Questions (or Sub-Heuristics)

Table 5 shows an analysis of the level of importance according to the previous analysis, shown in table 4, in such a way that it is possible to obtain a reduction of the questions or sub-heuristics that make up the proposed heuristics to evaluate e-commerce platforms. It describes why a level of importance called "Necessary" and "Redundant" is given to each of the questions.

Table 5. Level of importance of sub heuristics, for classification of the final list that will make up the proposed heuristic.

Nº	Question	Level of importance	Description
1	Does the platform display personalized content based on the user's browsing and purchase history?	Necessary	It assesses the ability to personalize, which is essential for the user experience in e-commerce.
2	Are product recommendations dynamically adjusted based on the user's previous interests and behaviors?	Necessary	Complement the previous question by evaluating the adaptability and dynamism of the recommendations.
3	Are the product recommendations relevant and useful to the user?	Necessary	Evaluate the quality and relevance of recommendations, a critical usability factor.
4	Does the platform use browsing data and past purchases to continuously improve recommendations?	Redundant	Not completely necessary if you've already wondered about customization and dynamic settings.
5	Does the platform offer real-time support through chatbots or similar systems?	Necessary	Real-time support is a key aspect of usability.
6	Do chatbots provide personalized product suggestions during user interaction?	Necessary	It specifies the functionality of chatbots, which is important for evaluating their usefulness.
7	Can users customize the layout or visual appearance of the interface to their preferences?	Necessary	Customization of the interface directly affects user satisfaction.
8	Does the search function provide relevant and accurate results?	Necessary	The effectiveness of the search function is critical on e-commerce platforms.
9	Does the search function improve and adjust based on the user's previous queries?	Redundant	It can be considered redundant if you are already wondering about the relevance and accuracy of the search.
10	Does the platform encourage user feedback and product reviews?	Necessary	Reviews are crucial for other users' decision-making and for improving products.
11	Does the platform use user feedback to improve personalized recommendations?	Redundant	It can be merged with the question about using data to improve recommendations.

12	Can users manage their preferences and settings easily and affordably?	Necessary	Ease of preference management is essential for usability.
13	Does the platform provide clear information about how user data is used and protected?	Necessary	Transparency in the use of data is fundamental to user trust.
14	Do users have clear options to control their privacy and use of their personal data?	Necessary	Control over privacy is crucial in user usability and trust.

4.1 Refined list of questions

Finally, with the analysis carried out in tables 4 and 5, the following table (table 6) is obtained, which presents the final list of questions or sub-heuristics that will make up the proposed heuristic, called "e-commerce usability", which, together with the 15 of the starting set [2], [5] is adjusted to improve the usability evaluations in e-commerce platforms or systems carried out using the heuristic evaluation technique.

Table 6. List of sub-heuristics that make up the "e-commerce usability" heuristic.

Nº	Question
1	Does the platform display personalized content based on the user's browsing and purchase history?
2	Are product recommendations dynamically adjusted based on the user's previous interests and behaviors?
3	Are the product recommendations relevant and useful to the user?
4	Does the platform offer real-time support through chatbots or similar systems?
5	Do chatbots provide personalized product suggestions during user interaction?
6	Can users customize the layout or visual appearance of the interface to their preferences?
7	Does the search function provide relevant and accurate results?
8	Does the platform encourage user feedback and product reviews?
9	Can users manage their preferences and settings easily and affordably?
10	Does the platform provide clear information about how user data is used and protected?
11	Do users have clear options to control their privacy and use of their personal data?

4.1.1 Rationale for a refined list of questions

Questions that were redundant or could be merged with others were removed to keep the focus on essential aspects of usability. This list covers the main factors that affect the user experience on an e-commerce platform:

Table 7. Questions ranked by their main factor or characteristic when evaluating an e-commerce platform.

Nº	Main factor or characteristic	Questions that evaluate the factor or characteristic
1	Customization	Does the platform display personalized content based on the user's browsing and purchase history? Are product recommendations dynamically adjusted based on the user's previous interests and behaviors? Are the product recommendations relevant and useful to the user?
2	Support and chatbot	Does the platform offer real-time support through chatbots or similar systems? Do chatbots provide personalized product suggestions during user interaction?
3	Customizable interface	Can users customize the layout or visual appearance of the interface to their preferences?
4	Search function	Does the search function provide relevant and accurate results?
5	Feedback	Does the platform encourage user feedback and product reviews?
6	Preference Management	Can users manage their preferences and settings easily and affordably?
7	Data transparency and control	Does the platform provide clear information about how user data is used and protected? Do users have clear options to control their privacy and use of their personal data?

It can be seen in Table 7 that there was a reduction in both the number of questions and the characteristics initially posed in [2]. Originally, 15 questions (or subheuristics) were proposed, classified into 8 characteristics or evaluation factors. After performing the detailed analysis throughout this article, 11 questions or subheuristics were obtained, now classified into 7 characteristics or evaluation factors. Grouping these questions by features aims to clarify which specific area of the e-commerce platform is being evaluated with each set of questions (or subheuristics).

5 Conclusion

Experimentation with international evaluators has shown that the proposed heuristics are effective in identifying usability problems in e-commerce platforms. The qualitative feedback received has allowed the heuristics to be adjusted and refined, making them more relevant and applicable to different e-commerce contexts. Through the analysis of the evaluations, several critical areas for improvement have been identified, such as the visibility and effectiveness of chatbots, the customization of the interface, and clarity in the use and protection of personal data. These areas represent key opportunities to improve the user experience and increase satisfaction and trust in the

platform.

The results have shown consistency in certain aspects of usability, indicating common problems that affect all users. However, discrepancies have also been observed among evaluators, highlighting the importance of considering multiple perspectives when evaluating the usability of a platform. This study not only contributes to the continuous improvement of e-commerce platforms, but also provides valuable insights for the research community in usability and user experience. The refined heuristics offer a solid framework for future usability evaluations and developments in the e-commerce space.

Despite the advances made through this research, it is important to recognize some limitations that could have influenced the results. First, while the selected testers have backgrounds in human-computer interaction (HCI) and usability, not all of them are specific experts in evaluating e-commerce platforms. This may have affected the depth of observations and the accuracy of assessments in certain key aspects of the platforms evaluated.

In addition, the study focused on the evaluation of a single e-commerce platform, which limits the generalizability of the results. To fully validate the effectiveness of the proposed heuristics, it would be necessary to conduct a larger-scale study involving the evaluation of various e-commerce platforms. This would allow cross-platform comparisons and adjust heuristics to be applicable across a wider range of contexts and configurations, thus increasing the external validity of the results obtained.

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