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Analysis of the ergonomics of e-commerce websites

Analiza ergonomii stron internetowych z branży e-commerce

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Abstract

The following paper includes research about ergonomics of e-commerce web applications. The main purpose of the experiment was to compare existing application of Morele.net shop and developed prototype of application using eyetracking examination and survey. The study carried out on a group of 40 students provided heat maps, scan paths, number of fixations and saccades, times to the first fixation in area of interest, task completion times, assessments of both applications in the form of WUP indicators. Based on the qualitative and quantitative analysis, conclusions were drawn confirming the hypothesis put forward in the work that there is an impact of ergonomic placement of navigation elements on the accessibility and usability of the application, as well as the time of performing tasks in it.

Keywords: ergonomics; usability; accessibility; eyetracking; universal design

Streszczenie

Niniejszy artykuł dotyczy badań związanych z ergonomią aplikacji internetowych z branży e-commerce. Głównym celem eksperymentu było porównanie istniejącej aplikacji sklepu Morele.net oraz opracowanego prototypu aplikacji z wykorzystaniem badania okulograficznego i ankiety. Z badań przeprowadzonych na grupie 40 studentów otrzymano mapy cieplne, ścieżki skanowania, liczby fiksacji, liczby sakkad, czasy do pierwszej fiksacji w obszarze zainteresowania, czasy wykonania zadań oraz oceny obu aplikacji w postaci wskaźnika WUP. Na podstawie analizy jakościowej i ilościowej wyciągnięto wnioski potwierdzające postawioną w pracy hipotezę o wpływie ergonomicznego rozmieszczenia elementów nawigacyjnych na dostępność i użyteczność aplikacji oraz czas wykonywania w niej zadań.

Słowa kluczowe: ergonomia; użyteczność; dostępność; okulografia; projektowanie uniwersalne

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1. Introduction

Ergonomics is a scientific discipline that deals with the optimization of the workplace and equipment in order to reduce the biological cost of work and increase its efficiency [1]. In the context of web applications, ergonomics refers to interfaces that are structured according to the user's characteristics. They should be intuitive, i.e. built in a way that does not require any prior preparation or training from a human. The ergonomics of the website interface is realized through features such as usability and accessibility. An important aspect is also the concept of Universal Design [2], which was born in 1983 from the previously known concepts of accessibility and barrier-free design. The originator was the architect Ron Mace, who argued that a design adapted for people with disabilities would also benefit the general public. Together with a group of architects, designers, engineers and environmental design researchers, Mace developed Seven Principles of Universal Design (UD).

The idea behind this approach is to design various types of products using innovative solutions that meet the requirements of various user groups and ensure equal and fair access. Over the years, universal design solutions have been used in the context of various areas of life, including web design.

The above-mentioned issues have been used in websites and web applications, including the design of online stores. The almost unlimited choice of products, bargain prices and convenience have made online shopping an indispensable part of many people's lives.

Due to the COVID-19 virus spread around the world, many people have decided to shop online for the first time in their lives. It was possible to conduct research on the behaviour of inexperienced users on the Internet [3]. Comparing the experiences of savvy and inexperienced consumers when shopping online can help retailers build satisfying e-commerce platforms with newbie digital consumers in mind. Inexperienced consumers have higher expectations of websites. If the website does not meet their requirements, they often give up the purchase.

In the sales industry, especially in online stores, visual information has a direct impact on consumers' purchasing decisions [4].

Thanks to technology such as eyetracking, and often also other auxiliary technologies and devices, web designers are able to check how the reception of a specific image affects not only the perception of a given product, but also what it evokes emotions in the user [5] [6]. This allows for the selection of graphics in such a way as to evoke specific feelings in the consumer, which translates into encouraging the user to buy the goods. It can therefore be concluded that cognitive aspects have a significant impact on the use of e-commerce websites by consumers [7].

Designing an ergonomic interface for an online store requires recognizing the elements that affect the user experience and the availability of the application. For this purpose, research methodology should be developed and conclusions on interface design should be gathered. The aim of the article is to verify the impact of ergonomic placement of navigation elements on the accessibility and usability of the application, as well as on the time of performing tasks in it. The e-commerce portal Morele.net will be compared with the prototype of the online store website, specially prepared, in accordance to universal design and features of usability and accessibility. An eye tracker and a LUT (Lublin University of Technology) survey were used for the comparison. The collected results were subjected to qualitative and quantitative analysis, as described in the discussion. The article has been summarized in the last chapter.

2. Literature review

Collecting scientific articles made it possible to deepen the knowledge of the factors that have the greatest impact on the usability and accessibility of websites.

In the article [4] research was conducted on a group of twenty students, ten women and ten men. The experiment consisted in recording participants' eye movement data after viewing a photo of a store shelf with hair shampoos, broken down by area of interest. The relationship between final consumer choice and time to first fixation in Area of Interest (AOI), duration of first AOI fixation, total duration of AOI visits, and number of AOI visits was analysed. Based on the data obtained, it was noted that the total duration of AOI visits and the number of AOI visits play a significant role in the final choice of consumers.

The conclusion of the research is that in the process of interaction with a product, customers are influenced by its location and category, and saccadic behaviour occurs frequently. Looking at a product for a long time or repeatedly correlates with the fact that customers are more likely to buy a given product, which is why it is so important to present the product in the most visually advantageous way.

The work [8] presents the operation of the algorithm for collecting and analysing data from the eye tracker in order to develop typical scanning paths (sequences of eye movements) of visual elements on websites. Forty users were asked to fill out short questionnaires to collect demographic data and then go through the selected websites twice.

First, the research was to find the elements specified in the experiment (in no more than 120 seconds), and then search for any product of their interest. The gender similarity of the results suggests that gender may cause some differences in shared scanning paths. However, the lengths of the common male and female group scan paths on the same pages for specific search tasks are mostly the same. Common scanning paths can be used to design or redesign websites to improve user experience. The authors-made algorithm can be beneficial for web designers to understand how users interact with web pages.

By using eye tracking technology, data can be obtained on how people feel and how participants use them in the process of interacting with the site. The collection of such data through a specially designed e-commerce website that uses popular templates is presented in the article [9]. The research group was selected on the basis of multilingualism, age, education and occupation, therefore twenty Northwest University students were selected equally from each gender. The research was based on eye tracking, collecting and analysing the duration of fixations and the fixation sequence. The results of the experiment show that during the template browsing process, eyesight was guided from top to bottom and from left to right. Due to the tendency of users to look from left to right, important attributes should be placed on the left side. It is also common to focus your eyesight on the upper, middle part of the page [10]. Therefore, when designing a website, this style and user's habits should be respected. Filling every centimeter of space should be avoided, because users perceive simple projects much better, and in addition, too much elements may overload the visual memory.

An equally important aspect in designing websites is their functionality and usability. Online stores are designed to make it easier for people to access an unlimited number of products from around the world in a quick and easy way. Consumers should have access to the product description and specifications before purchasing. It is very important to enable users to return to previously viewed products, as they rarely make a purchase during the first visit to the store [11].

Considering the increase in the volume of online sales and the growing proportion of elderly people in the population, efforts should be made to reduce the digital exclusion that they often experience. Reduced technical proficiency and impaired eyesight are the main factors contributing to problems with operating websites, including online shopping. Although older people are usually wary of online shopping, research [12] shows that each age group feels a certain risk. Its reduction is influenced by, among other things, buying products from larger, well-known brands and not storing your data on websites. Younger age groups have a much better experience of displaying proposed offers on websites, because they often shop online and browse products in search of new products, which is why it is interesting for them.

In order to understand the needs and expectations of users, and to optimize the design of the website, it is necessary to analyse the relationship between the website usability and user satisfaction [5]. In terms of usability, special attention should be paid to website layout issues, such as the navigation bar design and page layout, as well as to website performance indicators, including browser and error management issues.

User satisfaction is influenced by web design attributes, not the personal characteristics of users, such as gender, age, education, or Internet experience. When designing the layout of an e-commerce website, special attention should be paid to the placement and presentation of photos, as they will largely determine whether the consumer will make a purchase [2].

3. Work scope

Based on the literature research, the following thesis was formulated: "There is an impact of ergonomic placement of navigation elements on the accessibility and usability of the application, as well as the time of performing tasks in it".

3.1. Eye tracker

The eyetracking technology was used for the research. 40 students (4 females, 36 males) of the Lublin University of Technology in the field of Computer Science participated in the research. The subjects were aged 23 – 25, most of them wore glasses or contact lenses. The participants were divided into two independent groups. Each group was to perform the same tasks, but on two different e-commerce applications, respectively: Morele.net and on a prototype of a web application made in accordance with the principles of universal design. The participants' task was to follow the screen and perform specific activities (according to planned scenarios), including searching for a specific product on the page (exactly the same product was to be searched on each page).

The eyetracking metrics considered in the study are the number of fixations [4], answering the question of whether the tested interface element focuses the user's attention, as well as saccades [4] – rapid eye movements between consecutive fixations. The data obtained in the form of heat maps were also analysed. On their basis, it can be concluded which elements of the website interface are the most popular among users. It made it possible to find out where the participants direct their eyes by default, having the task of finding a specific navigation element on the page, and thus whether it is located where users expect to find it. Moreover, based on the defined areas of interest, the times to the first AOI fixation were obtained.

3.2. LUT survey

After the completion of the eye tracker study, participants were presented with a LUT survey [1] to be filled in, in which they had to answer 32 questions about the impressions related to the use of the application. Each question was answered on a five-point Likert scale to determine whether there were problems with the functionality of the application or not. On the basis of the answers, the WUP (Web Usability Points) indicators were calculated, which allowed to determine the subjective quality of the interface [13].

4. Experiment

The experiment was performed with the Gazepoint GP3 HD eye tracker [14] connected to an Acer Nitro 5 AN517-41-R48Y laptop with the following parameters: processor: AMD Ryzen 7 5800H (8 x 3.2GHz), 32GB DDR3 operating memory, Nvidia Geforce RTX 3060 6GB graphics card, 512GB SSD disk, 17.3" screen with 1920x1080 resolution, Windows 10 x64 Education.

The Gazepoint Control software was installed on the laptop, which was needed to carry out the eye tracker research. The test stand was located in the laboratory of the Department of Computer Science of the Lublin University of Technology. Before starting the study, the eye tracker had to be calibrated for each of the 40 participants. After successful calibration, participants proceeded to perform tasks designed to test the availability of content, taking into account the quality of the interface.

Figure 1: Test stand.

The research scenarios developed for the purpose of the research included the following tasks for the participants:

1. Locating the item that allows you to search for products in the application.
2. Locating the element that allows you to register / log in to the application.
3. Locating the category of smartphones and smartwatches.
4. Locating the item named smartphones / all smartphones.
5. Locating the element indicating the user's current location on the website.
6. Locating the element that allows you to change the way of displaying products on the list.
7. Locating the item that allows you to add the first smartphone on the list to the cart.
8. Locating the item that allows you to go to the cart.
9. Locating the item that allows you to remove the smartphone from the cart.
10. Locating all items that allow you to go to the previous subcategory.

The tasks were carried out using screenshots of individual, analogous subpages of both online stores. The user did not interact with the application, but his eyesight was monitored while displaying subsequent screenshots.

5. Results

The collected results from the eye tracker and the survey made it possible to compare the ergonomics of the two web applications.

The results of the tests of statistical significance (means/medians) showed that the differences between the two samples are statistically significant (Tables 2,3,4). Levene's test was used to determine the homogeneity of variance. In the case when the distribution of both samples was normal, the results of the Student's T-test were taken into account, otherwise the Mann-Whitney's test was used.

5.1. Eye tracker

Based on the research results, a quantitative analysis of selected eye tracking measures was conducted – time to first fixation in AOI, number of fixations, number of saccades and the time taken to complete each task.

The comparison of the times to the first fixation of the analyzed element for ten tasks for the application prototype and the Morele.net store (Table 1) showed that the average time for the prototype was more than two times smaller and averaged 1.12s ± 0.17s – for Morele.net this average was 2.77s ± 0.86s.

Table 1: Times to first fixation

No.	Application prototype time [*s*]	Morele.net store time [*s*]
1	1.30	2.92
2	1.07	2.76
3	1.35	2.61
4	1.12	1.74
5	0.89	2.53
6	1.16	5.00
7	1.27	2.54
8	0.99	2.75
9	0.87	2.65
10	1.19	2.17
Mean	1.12	2.77
St. Dev.	0.17	0.86
Var.	0.028	0.734
Conf. int.	0.012	0.322
Shapiro-Wilk Test	0.695	0.002
Mann-Whitney Test	1.083×10^{-5}	

Figure 2 shows the average fixation number, which is more than twice as high for the Morele.net application.

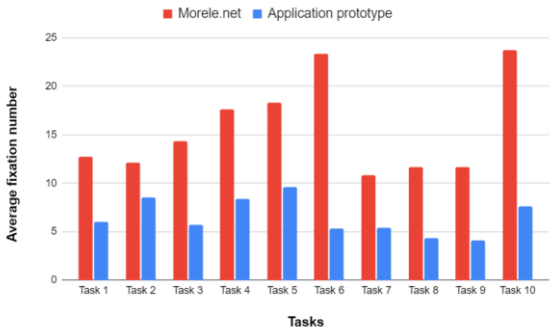

Figure 2: Average fixation number for tasks.

Table 2 presents the results of Levene, T-Student and Mann-Whitney tests calculated on the basis of the fixation numbers.

Table 2: Results of the Levene, T-student and Mann-Whitney tests for fixations number

No.	Levene Test	T-student Test	Mann-Whitney Test
1	0.0464	2.503×10^{-3}	9.234×10^{-4}
2	0.7124	9.507×10^{-2}	8.035×10^{-2}
3	0.0213	5.466×10^{-5}	5.102×10^{-5}
4	0.2958	4.539×10^{-3}	1.141×10^{-3}
5	0.6197	1.068×10^{-2}	4.720×10^{-4}
6	0.0145	4.369×10^{-8}	1.090×10^{-7}
7	0.0028	3.001×10^{-3}	6.364×10^{-3}
8	0.0071	3.336×10^{-4}	7.697×10^{-5}
9	0.0300	7.312×10^{-6}	2.435×10^{-5}
10	0.0072	3.684×10^{-5}	4.988×10^{-5}

Figure 3 presents average saccades number for each task in both applications. Based on the results, the Levene, T-Student and Mann-Whitney tests were performed (Table 3).

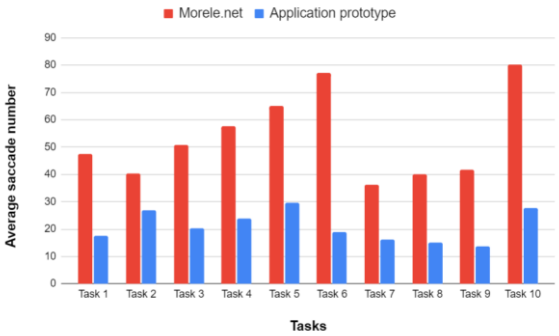

Figure 3: Average saccades number for tasks.

Table 3: Results of the Levene, T-student and Mann-Whitney tests for saccades number

No.	Levene Test	T-student Test	Mann-Whitney Test
1	0.0021	2.503×10^{-3}	3.051×10^{-5}
2	0.1428	8.327×10^{-2}	1.162×10^{-1}

3	0.0027	2.144×10^{-4}	3.061×10^{-5}
4	0.2798	7.039×10^{-3}	4.365×10^{-5}
5	0.0350	1.631×10^{-3}	3.928×10^{-4}
6	0.0001	3.228×10^{-7}	1.136×10^{-7}
7	0.0009	2.648×10^{-3}	4.668×10^{-3}
8	0.0078	1.050×10^{-3}	2.312×10^{-4}
9	0.0034	4.444×10^{-5}	3.212×10^{-6}
10	0.0001	1.268×10^{-5}	2.026×10^{-5}

A summary of the average time of completing tasks for both applications is presented in Figure 4. The prototype achieved significantly lower results. Table 4 shows the significance test results for the average task completion times.

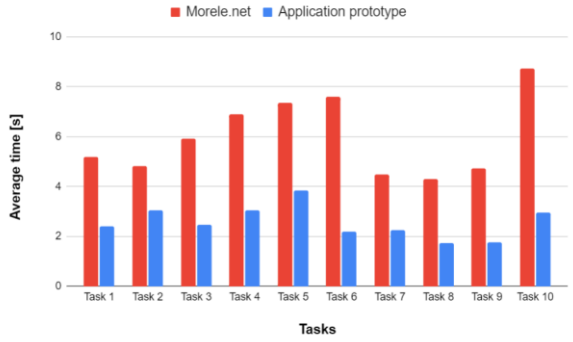

Figure 4: Average time of completing tasks.

Table 4: Results of the Levene, T-student and Mann-Whitney tests for time of completing tasks

No.	Levene Test	T-student Test	Mann-Whitney Test
1	0.0272	2.435×10^{-4}	4.909×10^{-6}
2	0.2906	1.865×10^{-2}	1.954×10^{-2}
3	0.0001	1.819×10^{-5}	2.884×10^{-6}
4	0.2653	2.721×10^{-4}	1.831×10^{-5}
5	0.5789	1.602×10^{-3}	9.105×10^{-5}
6	0.0385	5.157×10^{-8}	1.451×10^{-1}
7	0.0027	3.147×10^{-4}	3.722×10^{-4}
8	0.0333	3.804×10^{-5}	4.909×10^{-6}
9	0.0093	9.472×10^{-7}	2.317×10^{-8}
10	0.0052	8.119×10^{-7}	7.571×10^{-7}

Figures 5 and 6 present heat maps for one task performed on both applications interfaces. The colours orange, yellow and green meant less and less concentration of the respondents.

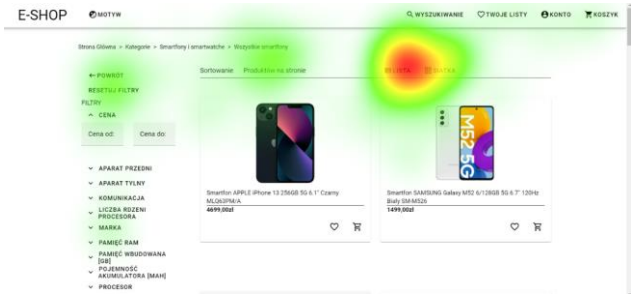

Figure 5: Heat map for application prototype for task 6.

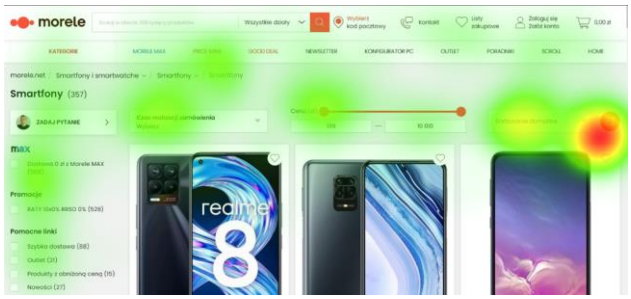

Figure 6: Heat map for application Morele.net for task 6.

Figures 7 and 8 show the scanning paths for task 8.

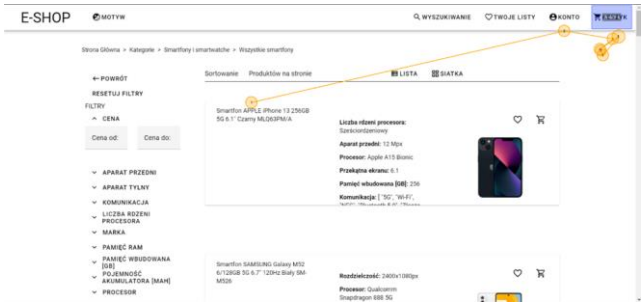

Figure 7: Scan path for application prototype for task 8.

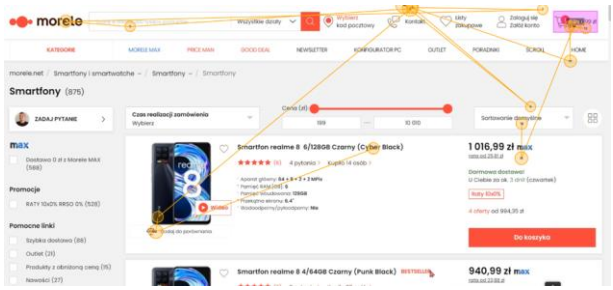

Figure 8: Scan path for application Morele.net for task 8.

The generated scan paths and heat maps allowed for a qualitative analysis.

5.2. LUT

Table 5 contains WUP indicators, which were calculated with the use of a dedicated formula [1], using the points obtained from the LUT questionnaire. Twenty participants in one group of the study evaluated the prototype of an application designed in accordance with the principles of universal design, and the other group

evaluated the application of the Morele.net store. The mean of the WUP for the prototype was 4.78, which means there were no usability issues or issues affecting the user experience. For Morele.net WUP score was 3.57, which may suggest the existence of single minor usability problems that could reduce the quality of working with the application (Figure 9).

Table 5: WUP indicators for LUT survey

Respondent	WUP – aplication prototype	WUP – Morele.net application
1	4.86	3.19
2	4.86	3.46
3	4.68	2.52
4	4.78	3.22
5	4.69	2.73
6	4.83	4.21
7	4.76	3.64
8	5.00	3.53
9	4.71	3.61
10	4.78	4.18
11	4.85	4.05
12	4.89	4.14
13	4.70	4.20
14	4.78	3.19
15	4.69	2.51
16	4.90	3.65
17	4.72	3.65
18	4.67	3.97
19	4.69	3.83
20	4.81	3.94

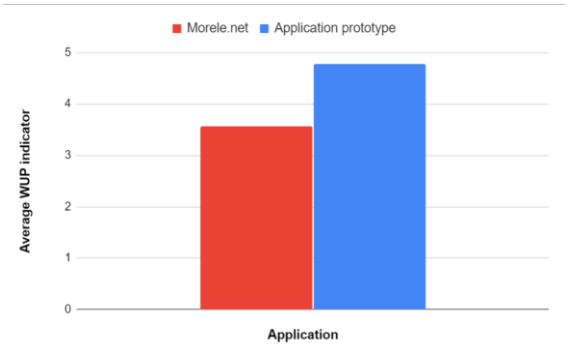

Figure 9: Average WUP indicator for both applications.

6. Discussion

The analysis of the results obtained with the eye tracker clearly showed that it was easier for users to find the elements they were looking for in the application supporting universal design. The application prototype, made in accordance with the principles of universal design, had lower number of fixations. The average number of fixations for the application prototype was lower by 58.4% than the average number of fixations for the Morele.net store (Figure 2). These results show that the application designed in a minimalistic, transparent manner and in accordance with the principles of universal design increases the usability. Users' attention was less distracted due to fewer items. The short time of searching for elements (time to first fixation) means that they are placed on the website in places that are intuitive for the user.

Similarly, in the article [6], based on the research on the number of fixations, it was found that a website rich in graphic and colour elements has a positive effect on the visual perception by users, but this translates into difficulties in searching for given elements.

In order to verify the search times, the times to the first fixation as well as the times of performing individual tasks were analysed. The comparison of the times to the first fixation of the analysed element (Table 1) for ten tasks for the application prototype and the Morele.net store showed that the average time to the first fixation for the prototype was 59.6% lower. On the other hand, in the case of task completion time (Figure 4), the time for the application supporting universal design was reduced by 57%.

When performing tasks for an application compliant with the principles of universal design, the average number of saccades was lower by 60.9% in relation to the average number of saccades on the Morele.net store website (Figure 3) [4]. It follows that users made fewer involuntary eye movements to find what they were looking for.

During the qualitative analysis, it was found that locating the item is successful for both applications. However, with Morele.net, the scanning path is longer – the user had to search longer to find the target (Figure 7, 8).

Certain patterns of behaviour are visible when searching for items. Similar conclusions were drawn in the article [9]. After performing the eye tracker tests, it was found that the first eye movement was focused on the upper left corner of the page. The typical behaviour of the study participants was to browse the page in order: top to bottom and left to right. The conclusion is that these areas are key when designing a website, because they can provide visitors with the most important content. Therefore, it is important for web designers to use this layout. This allows to work more efficiently with website or application.

The heat maps generated for individual tasks were also analysed. The red colour marks the area in which users focused their eyes most – there was the area of interest [4]. As can be seen in Figures 5 and 6, a much greater distraction of users occurs when performing a task on the Morele.net website.

The calculation of the WUP indicator (Table 5) on the basis of the data collected from the LUT survey and its analysis made it possible to conclude that universal design increases the usability of web applications. For the Morele.net application, the WUP amounted to an average of 3.57 and for the developed prototype: 4.78 (Figure 9), with the maximum possible result equal to 5.

7. Conclusion

Based on the analysis of data from the conducted research, it was confirmed that there is an impact of the ergonomic location of navigation elements on the availability and usability of the application, as well as the time of performing tasks in it. Website operations are performed much faster and without losing the user's attention. Better structure of the elements made it is also more accessible to electronic readers. Intuitive navigation and efficiency in using the website have a big impact on its usability.

From an ergonomic point of view, the web application should not contain unnecessary and distracting graphic elements, because although it positively affects the visual perception of users, they make navigation on the site difficult. The positive impact of universal design on the ergonomics of websites and internet applications is noticeable. When designing an e-commerce store, the functionality of the website is important, while maintaining its usability.

The research was conducted on a group of IT students. Due to the field of study and age, they were experienced users in using e-commerce websites. As reported in [12] and [15], there are significant differences in the way of using websites between experienced and inexperienced users, as well as those of different age groups.

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