Modeling the Usability of University Websites as a Tool for Their Online Competitiveness in the Context of COVID-19

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Abstract: In the article, the formulation and solution of the problem of generalization and conceptualization of the methodology for the study of the usability of the websites of higher educational institutions is carried out in order to substantiate the system of support for making managerial decisions to increase its level. The authors supplemented the classical understanding of the study of the usability of websites with the tasks of analyzing the behavior of stakeholders in higher educational institutions by methods of fractal and recurrent analyzes in order to track the nature of online behavior of stakeholders in different periods of time and the reaction of online users to the content and structure of the site. At the same time, the results of sociological research were supplemented by the methodology of fuzzy mathematics with minimization of uncertainty and subjectivity in the process of evaluating usability, which made it possible to substantiate the rules for supporting decision-making on improving the usability of eight websites of higher education institutions within the limits of the expressed online interest of stakeholders in different periods of the educational process.

1 INTRODUCTION

In the face of a pandemic, all activities moved automatically to an online environment, where quarantine restrictions did not hold back on the way to achieving results. The new conditions of existence revealed those entity who were not touched or partially touched by digitalization. Limited use of digital opportunities and insufficient digital literacy significantly hinder market relations in all spheres of socio-economic activity. The extent to which quarantine rules were limited in each country was partly different, so the markets did not function in the same conditions. The main success factor was the 100% willingness to work online and the ability to maximize online demand.

A significant transformation has taken place in the education sector, where the online mode of activity dominated during periods of quarantine. This greatly influenced the quality of education, showed the unwillingness of individual organizations to quickly adapt , revealed areas of non-coverage of educational and related processes with digital technologies. Sites have become the main instrument of interaction between higher educational institutions and users of educational services in the online environment, and educational institutions share educational platforms, software tools for online learning and information sites (their business cards). The variety of digital

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educational technologies has made it necessary to find the right ones for a particular institution. Educational websites have also been a product of educational institutions 'aspirations to simultaneously comply with Ministry of Education regulations and education stakeholders' information needs, which are inherently quite different. This raises the question of the openness of all areas of activity of educational institutions online, ensuring free access to the results of activities on sites, completeness of disclosure of information online, which is the basis for making decisions by stakeholders regarding further interaction and, thereby, a tool of competitiveness (Uchitel et al., 2020).

Therefore, one of the key tasks of today is the development of modern approaches, models and research methods, usability management as a phenomenon that is a factor in the effectiveness of modern educational reforms, digitalization, requirements for openness and transparency of the information society in the online environment. Educational institutions again need to gain confidence in themselves, in their educational product, which has been transformed in accordance with the online requirements of educational processes, provided, at least, to maintain, and maximum – to improve the quality of education and provide a system to support information transparency of activities in general.

The functioning and development of the sphere of higher education as a participant in market relations under conditions of quarantine restrictions must obey modern trends in the development of the economy, taking into account its digitalization, changes in the interests of all groups of stakeholders, and the educational space as a whole.

Usability is an effective tool for providing participants in educational processes with effective interaction in an online environment, which must be skillfully used in order to ensure competitiveness not only offline, but also online (Abran et al., 2003; Manzoor et al., 2012). Given the sufficient popularity and development of the tasks of ensuring usability in modern conditions, each website of a higher educational institution is unique in its own way, therefore, it requires an autonomous and independent assessment of usability in order to maintain a high level of communication development and its own competitiveness. At the same time, each entity is faced with a number of problems regarding the way and method of conducting a usability study, the results of which will be unambiguous and accurate assessments. This is due to the weak structure of the very concept of usability and the human nature of its definition.

The purpose of the article is to substantiate the methodology for obtaining unambiguous and accurate assessments of the usability of websites of higher education institutions and ways to improve it.

The object of the research is the process of achieving the usability of the websites of higher education institutions.

The subject of the research is the conceptual, methodological foundations of assessment, modeling of the values of the parameters of the usability of sites.

2 USABILITY RESEARCH METHODOLOGY

The essence of site usability is usually understood as the degree of user satisfaction from the convenience of using the site for making decisions on further interaction with the owner of the site (Nielsen, 1996). In the study of usability, the reaction of users to a certain state of the system is studied, that is, the content of the existing content, its visualization, the structure of the site, in order to find effective interaction between subjects and objects of research in the online environment. To increase the reliability of assessments of the usability of the website of higher education institutions, it is necessary to take into account the specifics of the activity, the specifics of the information interests of stakeholders, the frequency of interest shown in different periods of the scientific process, the requirements of the Ministry of Education for information content, and more.

The authors' conceptual vision of the methodology for researching the usability of the website of a higher educational institution and the results of applying the methods that are presented in individual publications are shown in Figure 1.

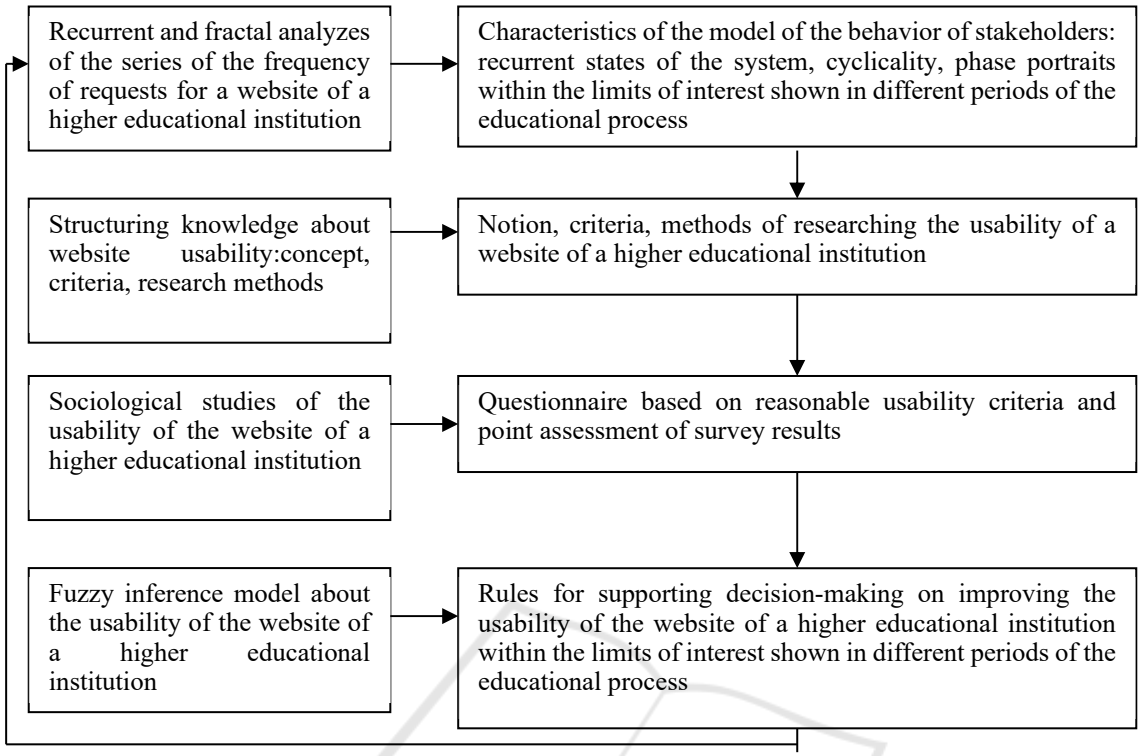

Figure 1: The methodology for researching the usability of the website of a higher educational institution.

The authors carried out a preliminary study and proved that the series of dynamics of the frequency of requests for university websites in the study make it possible to characterize the model of online stakeholder behavior in terms of seasonality, identify trajectory segments and cycles, assess the stability of the system and measures of recurrence, in general, the degree of predictability of behavior (Kucherova et al., 2021). Data on the nature of online behavior of stakeholders is valuable from the point of view of the need to manage the behavior of stakeholders in the context of ensuring information transparency of interaction, distributing the attention of stakeholders online for the entire period of the educational process, assessing the reaction of stakeholders to changes in the information content of the site, promoting career guidance events, and more.

The essence of the concept of usability is based on the nature of human perception of information, images, therefore, the main method of usability research is based on the methodology of conducting sociological research in terms of surveys, questionnaires, etc (Kaur et al., 2016; Inal, 2018; Sivaji et al., 2011). Therefore, it is difficult to achieve clarity of reliability of estimates. The weak point in the study remains the choice of criteria for evaluating usability, since there are many sets of indicators that, according to different author's approaches, partially coincide, but differ in individual indicators (Harrati et al.,2016; Honcharenko et al., 2020; Hornbæk, 2010; Inal, 2018; Jabar et al., 2014; Kalra et al., 2011; Ozkan et al., 2009; Santos et al., 2014; Unal et al., 2011). The criterial selection is based on marketing markers for evaluating the site, its content, and structure. It should be borne in mind that all the results of a questionnaire, a survey, and other methods of sociological research will be relevant only as of the date these results are obtained due to the variability of the opinions of the respondents. Nevertheless, the approach is relevant and provides some valuable results. Research shows that the leaders of the ratings of higher educational institutions decided the issue of ensuring site usability a long time ago and continue to maintain its quality. Higher educational institutions that have not come to the fore have a number of online challenges, which are also partly related to usability issues.

By virtue of their inaccurate nature and subjectivity of the results of the study of usability, the formation of its multidimensional and multifaceted estimates is quite difficult to summarize. The search for the appropriate method of research remains relevant, the use of which would leverage limb and supplement the results of sociological research. The

authors consider it appropriate to use the apparatus of fuzzy logic. The input variables will perform the usability criteria, an output linguistic variable - an indicator characterizing the level of usability of the sites of highest educational institutions. The model will include a knowledge base that will contain a sequence of obtaining fuzzy logical conclusions to determine the quantitative importance of the usability of the highest educational institution.

The resulting model of fuzzy logical conclusion of users of higher educational institutions makes sense to use to conduct an experimental study of the impact of factors for users of sites. In a result of an alternate change in the values of the factors by 10%, it is possible to establish the factors of the implementation of direct and maximum impacts and factors that do not lead to changes in the source indicator of usability, the indirect effect of which can be activated and enhanced by the simultaneous influence of an additional factor, which is more responsible for reality, because in real environment factors really affect simultaneously.

Thus, the classical understanding of the study of the usability sites is supplemented by the tasks of analyzing the stakeholders of higher educational institutions by methods of fractal and recurrent analyzes in order to track the nature of online behavior of stakeholders in different periods of time and user response on content, site structure. At the same time, the results of sociological studies are complemented by the methodology of fuzzy mathematics with minimizing uncertainty and subjectivity in the process of appreciation of usability, which will justify the rules for supporting the decision to increase the usability of the highest educational institution within the desired interest of stakeholders online in different periods of the educational process. Thus, the methodology for studying the usability sites of universities is significant expanded and supplemented.

3 USABILITY RESEARCH PRACTICE

3.1 Results of Recurrent and Fractal Analysis

The authors conducted a study of the behavior of higher education institutions' stakeholders by quantitative indicators that characterize the online behavior of their stakeholders and represent the frequency of requests for eight higher education institutions(NTUU “Igor Sikorsky Kyiv Polytechnic Institute”, Taras Shevchenko National University of Kyiv, Lviv Polytechnic National University, V.N. Karazin Kharkiv National University, Sumy State University, Interregional Academy of Personnel Management, Kharkiv University, Academy of Advocacy of Ukraine) in the Google Trends service for the period from November,18 2015 to June,18 2020.The methodology was used fractal and recurrent analyzes according to (Kucherova, et al., 2021). The results of fractal analysis testified to the persistence of all studied time series of the frequency of online inquiries of stakeholders. It has been proven that time series have trends, future values depend on past ones, and are predicted based on data on previous values. Therefore, the expressed interest of stakeholders in the highest educational institutions is trend-stable.

Based on the results of a recurrent analysis of the series of dynamics of the frequency of online queries about the studied institutions of higher education (Kucherova, et al., 2021), it was revealed that the online behavior of stakeholders has a periodic, pronounced seasonal character with bursts of information activity of stakeholders in the summer, which corresponds to certain stages of the educational process. Incoming data studies have identified trajectory segments that return to the same region of phase space at different periods, but in a different qualitative state. For a significant period, the online behavior of stakeholders is more stable, and the system tends to be laminar. Phase portraits of the behavior of stakeholders in the studied institutions in terms of the frequency of online requests are characterized by the presence of cycles, the diameter and length of which changes, which corresponds to changes in the activity of stakeholders at different time intervals of the educational process. To compare the constructed recurrent time series diagrams of online behavior of stakeholders the quantitative analysis was carried out.

The value of the recurrence measure for all studied time series proves the regularity and definiteness of the dynamics of changes in time series of online behavior of stakeholders. According to the value of the indicator measure of determinism, the most predictable and unpredictable in behavior among the studied higher educational institutions were identified. However, the average predictability time for all higher education institutions is rather low. The length of the trend is also insignificant for all institutions of higher education. In the online behavior of the stakeholders of higher education institutions, short-term losses of the recurrence of states are traced in a certain period of time, or the

dynamic system showed fewer recurring states than in the previous study period.

3.2 Synthesis of Sociological and Marketing Research of Website Usability

The author's experience of using the synthesis of sociological and marketing research is presented in (Honcharenko, et al., 2020), where a survey was carried out of "potential applicants and students in order to determine the compliance of the websites of higher educational institutions with the usability criteria," where, as a result, 1170 stakeholders were surveyed according to a reasonable set of criteria, namely:x_1 – download speed;x_2–convenience; x_3 – effectiveness, x_4 – relevance; x_5 – availability; x_6 – interactivity; x_7 – cross browser compatibility; x_8 – lack of forced content; x_9 – attractiveness of design; x_{10} –satisfaction allocated and researched in a certain period of timet (Honcharenko, et al., 2020). Diagram of the distribution of respondents by answering about the level of satisfaction from working with the site is on the Figure 2.

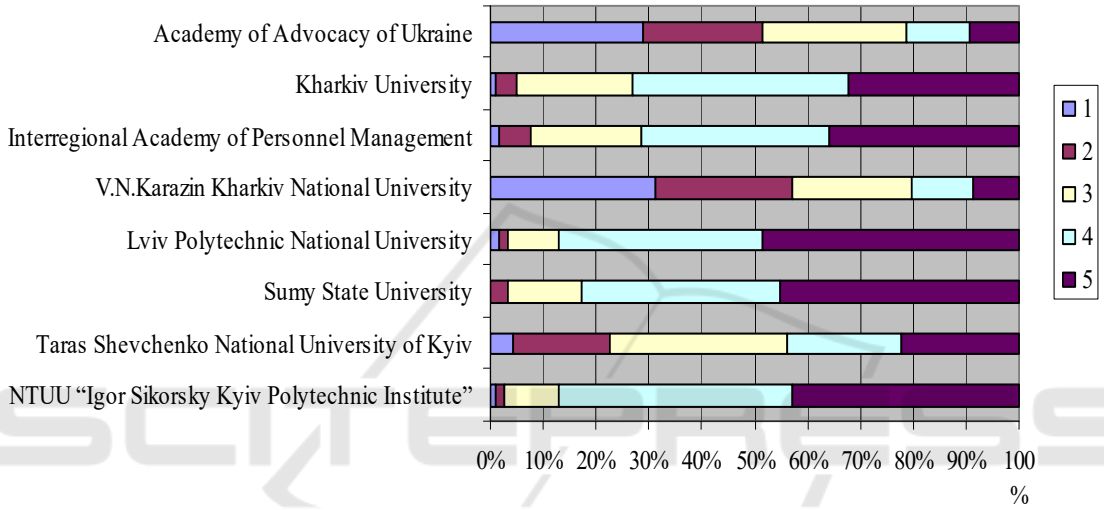

Figure 2: Diagram of the distribution of respondents by answering the question: rate the level of satisfaction from working with the site on a 5-point scale (1 point – not satisfied, 5 points – completely satisfied), for the period of August 2020.

Based on the results of the point assessment and taxonomic analysis, the following values of the integral indicator of the usability of the sites were obtained: NTUU "Igor Sikorsky Kyiv Polytechnic Institute" – 0.801; Taras Shevchenko National University of Kyiv– 0.647;Sumy State University– 0.787; Lviv Polytechnic National University– 0.785;N. Karazin Kharkiv National University– 0.532;Interregional Academy of Personnel Management– 0.77; Kharkiv University– 0.697; Academy of Advocacy of Ukraine– 0.562, where usability is in the interval from 0 to 1.These results served as a starting point for improving the usability of sites and conducting system monitoring of the values of its parameters.carried out.

Separately, the study was conducted on the indicators of web-analytics sites of the leading universities of Kryvyi Rih region (Table 1).

The results of the comparative analysis, shown in Table 1, once again prove the importance of website usability research. High values of usability indicators were observed at Kryvyi Rih State Pedagogical University, average value has Kryvyi Rih National University. Low level of values of the usability parameters have the State University of Economics and Technology and Mykhailo Tuhan-Baranovskiy Donetsk National University of Economics and Trade. According to the above, the indicators of web analytics differ significantly. For example, Kryvyi Rih State Pedagogical University and Kryvyi Rih National University have the lowest refusal rate (the percentage of sessions during which users viewed only one page of the site without initiating additional requests).

Table 1: Comparative analysis of the main indicators of web analytics of the leading institutions of higher education in Kryvyi Rih for the period June 2021 - November 2021. (Generated by the authors using the SpyMetrics service).

Institutions of higher education	Visits, attendance	Time on site, min.	Pages per visit, units	Refusal rate, %
State University of Economics and Technology	10780	1,25	1,20	79,87
Kryvyi Rih National University	25330	2,58	3,17	34,15
MykhailoTuhan-Baranovskiy Donetsk National University of Economics and Trade	10600	5,55	6,29	67,40
Kryvyi Rih State Pedagogical University	987500	8,28	9,20	34,64

This can be explained, among other things, by the fact that it is easy to find the necessary information on the websites of these establishments. The same cannot be said about the remaining establishments. State University of Economics and Technology has the highest refusal rate at 79.87%. The situation can be explained by the fact that the sections are not conveniently located on the site: it is difficult for students, especially applicants and parents, to find the information they need. In addition, such important sections as, for example, "Admission to the magistracy" and "Cost of Education" were not completed for a long time. Some sections ("Student", "Leisure", "Sports") contained outdated information. In general, there was no section dedicated to the international activities of the university. From the point of view of students, a special problem was identified – the schedule, which was provided without distribution to faculties, specialties and courses.

An in-depth study of the usability of the official website of the State University of Economics and Technology was carried out. The research methodology was based on conducting desk research through a survey (Google form) and personal communication with students. The results showed a low level of usability parameters, which is why the university website is not popular either among students or among applicants. Some principles of usability were violated, namely:

- the rule of three clicks - in order to get to some sections (for example, specialties and cost of education), it was necessary to make a long transition;
- logical and structured content – the site contained a variety of information that prevented the user from finding what he needed (for example, windows with events and news overlapped any page);
- convenient navigation - the majority of respondents (30.2%) indicated the difficulty of finding the necessary information on the site (for example, the schedule of classes in a specialty and course);
- fast loading of site pages – this is especially true for mobile phones and other gadgets. The site was not adapted to the specified devices.

To correct the situation with the usability of the State University of Economics and Technology, improvements were proposed in several areas, in particular: adaptation of the site to mobile devices; revision of the site navigation, namely:

- bringing to the fore, in addition to information about the university, its structural divisions and the conditions of admission, also information about the schedule, MOODLE, specialties, international activities and the "Student" section;
- updating information in the sections dedicated to sports, leisure, the Student Council of the self-government;
- complete change of the "Schedule" section in the context of providing information on structural divisions, specialties and courses; creation and filling of a section dedicated to the international activities of the university.

Special attention was paid to the "Student" section, where it was proposed to improve navigation; add the Student Communications Center to the contact's section; create a subdivision "Our Achievements", sections on parallel learning and dual education; add visual content to a subsection of the university library. It should be noted that most of the recommendations were implemented, which significantly affected the level of site usability and the number of visits.

Thus, introspection and self-assessment of the usability of university websites should become a tradition in the context of an active online regime for

the provision of educational services. The frequency of research depends on the specialization of the higher education institution, but at least once a year. The systematic results of the usability analysis will form the basis of the knowledge base about the preferences, reactions and information requests of stakeholders in order to maximize their satisfaction. As a result, a higher education institution will respond as quickly as possible to the needs of stakeholders, thereby increasing its competitiveness.

3.3 Fuzzy Inference of Site Usability

For a complex solution of the problem of leveling subjectivity and uncertainty, the apparatus of fuzzy logic was used (Huang, et al., 2010; Muhammad, et al., 2021).The input variables of the constructed model are ten usability criteria $x_i(i=1,...,10)$, justified by the authors, and the output linguistic variable is the indicator, which characterizes the level of usability of the website of a higher educational institution (I_{us}).A symmetric Gaussian form of the membership function is chosen for both input and output variables, which is due to its sufficient flexibility and ease of use. The model was implemented in the Fuzzy Logic Toolbox MatLab environment using the Mamdani algorithm:

$$I_{us} = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}), \quad I_{us} \in [0;1]. \tag{1}$$

As the input parameters of the model, the ratio of the scores obtained for each usability criterion for the survey results to the maximum possible number of points for a separate criterion was used. A base of 180 fuzzy production rules was formed, which contains a fuzzy inference mechanism, which allows us to draw a conclusion about the level of site usability. The simulation results provide a more accurate understanding of the directions for making further effective management decisions to ensure the usability of the site.

As a result of the simulation, it was revealed that the NTUU site "Igor Sikorsky Kyiv Polytechnic Institute" has a high level of usability, sites of Sumy State University, Lviv Polytechnic National University, Interregional Academy of Personnel Management, Kharkiv University and Taras Shevchenko National University of Kyiv have sufficient degree. Middle degree have sites of the Academy of Advocacy of Ukraine and V. N. Karazin Kharkiv National University.

To support the adoption of managerial decisions about ensuring the usability of sites, decision-making models were substantiated on the basis of an experimental study of the influence of the values of the criteria on the usability of sites of higher educational institutions:

$$\Delta I_{us} = f(\Delta x_1, \Delta x_2, \Delta x_3, \Delta x_4, \Delta x_5, \Delta x_6, \Delta x_7, \Delta x_8, \Delta x_9, \Delta x_{10}) \tag{2}$$

For this purpose, the input variables of the model were divided into two sets – criteria for direct and criteria for indirect impact. The influence of the criteria of direct influence on the value of the initial indicator is determined. For the criteria of indirect impact, pairs of criteria have been identified, the simultaneous action of which enhances and activates their cumulative effect on the level of the initial value of the site usability.

So, the set of us ability criteria $X=\{x_i\}$ $(i=1,...,10)$ was presented in the for mofauni on of two sets $P \cup N$, where P is a set of factors of direct in fluence, N is a set of factors of indirection fluence, and the intersection of the sesetsisanemptyset

$$P \cap N = \varnothing \tag{3}$$

To determine whether the criterion $x_i(i=1,...,10)$ belongs to one of the two sets (P or N), dependency graphs are built:

$$I_{us} = g_i(x_i) \; (i = \overline{1,10}) \tag{4}$$

Then

$$\begin{cases} if\ g_i(x_i) \neq const, then\ (x_i \in P) \\ if\ g_i(x_i) = const, then\ (x_i \in N) \end{cases} \tag{5}$$

The effect of a simultaneous increase in the value of all criteria was determined. As a result, decision-making models for finding reserves and unlocking the potential for ensuring the convenience of using the site were built for each higher educational institution.

For site of NTUU "Igor Sikorsky Kyiv Polytechnic Institute" changes in the values of convenience (x_2) and relevance (x_4) act as a reserve for ensuring online information transparency in terms of site usability:

$$f(x_1, 1{,}1x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}) = 1{,}024 I_{us}, \tag{6}$$

$$f(x_1, x_2, x_3, 1{,}1x_4, x_5, x_6, x_7, x_8, x_9, x_{10}) = 1{,}013 I_{us} \tag{7}$$

The usability of the site will improve by 2,6%, provided that all criteria are improved by 10%

The ways of unlocking the potential of information transparency of the site Taras Shevchenko National University of Kyiv is to simultaneously increase the values of efficiency (x_3) and interactivity (x_6) and, separately, relevance (x_4):

$$f(x_1, x_2, 1, 1x_3, x_4, x_5, 1, 1x_6, x_7, x_8, x_9, x_{10}) = 1,071I_{us} \quad (8)$$

,

$$f(x_1, x_2, x_3, 1, 1x_4, x_5, x_6, x_7, x_8, x_9, x_{10}) = 1,077I_{us} \quad (9)$$

The best usability effect of the site will improve by 10,42%, provided that all criteria are improved by 10%

Forsite of Sumy State University changes in the values of convenience (x_2), efficiency (x_3) and relevance (x_4) act as a potential for ensuring online information transparency in terms of site usability:

$$f(x_1, 1, 1x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}) = 1,011I_{us} \quad (10)$$

,

$$f(x_1, x_2, 1, 1x_3, x_4, x_5, 1, 1x_6, x_7, x_8, x_9, x_{10}) = 1,008I_{us} \quad (11)$$

,

$$f(x_1, x_2, x_3, 1, 1x_4, x_5, x_6, x_7, x_8, x_9, x_{10}) = 1,005I_{us} \quad (12)$$

Increasing all factors at the same time gives a better result (usability improvement by 2,64%)

The potential for information transparency of site Lviv Polytechnic National University is realized subject to an increase in the values of convenience (x_2) by 40% and accessibility (x_5) by10%, as well as convenience (x_2) by 40% and design (x_9) by 10%:

$$f(x_1, 1, 4x_2, x_3, x_4, 1, 1x_5, x_6, x_7, x_8, x_9, x_{10}) = 1,09I_{i} \quad (13)$$

,

$$f(x_1, 1, 4x_2, x_3, x_4, x_5, 1, 1x_6, x_7, x_8, 1, 1x_9, x_{10}) = 1,08I \quad (14)$$

However, a simultaneous increase in factor convenience (x_2) by 40%, and all other factors by 10% is more effective elements of influencing the usability of the site (increase by 9,29%).

It is possible to ensure information transparency of the site V. N. Karazin Kharkiv National University by increasing the value of convenience (x_2), efficiency (x_3), loading speed (x_1) and interactivity (x_6), accessibility (x_5) and interactivity (x_6):

$$f(x_1, 1, 1x_2, x_3, x_4, x_5, x_6, x_7, x_8, 1.1x_9, x_{10}) = 1,044I_{us} \quad (15)$$

,

$$f(x_1, x_2, 1, 1x_3, x_4, x_5, x_6, x_7, x_8, 1.1x_9, x_{10}) = 1,031I_{us}, \quad (16)$$

$$f(1, 1x_1, x_2, x_3, x_4, x_5, 1, 1x_6, x_7, x_8, x_9, x_{10}) = 1,084I_{us} \quad (17)$$

,

$$f(x_1, x_2, x_3, x_4, 1, 1x_5, 1, 1x_6, x_7, x_8, x_9, x_{10}) = 1,042I_{us} \quad (18)$$

.

A simultaneous increase in all factors by 10% will cause an increase in the value of the usability indicator by 12.25%.

For site Interregional Academy of Personnel Management, the reserves of ensuring online information transparency are concentrated in convenience(x_2) by 30% together with the attractiveness of design(x_9) by 10%, as well as increasing the value of convenience(x_2)by 30% and accessibility(x_5) by 10%:

$$f(x_1, 1, 3x_2, x_3, x_4, x_5, x_6, x_7, x_8, 1, 1x_9, x_{10}) = 1,036I_{us} \quad (19)$$

,

$$f(x_1, 1, 3x_2, x_3, x_4, 1, 1x_5, x_6, x_7, x_8, x_9, x_{10}) = 1,02I_{us} \quad (20)$$

A simultaneous increase in factor convenience (x_2) by 30%, and all other factors by 10% is more effective elements of influencing the usability of the site (increase by 4,32%).

It is recommended to ensure information transparency of site Kharkiv University from the point of view of stakeholders by increasing the value of convenience (x_2) by 40% and accessibility (x_5) by 10%, increasing the value of convenience (x_2) by 40% and attractiveness of the design (x_9) by 10%:

$$f(x_1, 1, 4x_2, x_3, x_4, 1, 1x_5, x_6, x_7, x_8, x_9, x_{10}) = 1,025I_{us} \quad (21)$$

,

$$f(x_1, 1, 4x_2, x_3, x_4, x_5, x_6, x_7, x_8, 1, 1x_9, x_{10}) = 1,023I_{us} \quad (22)$$

.

A simultaneous increase in factor convenience (x_2) by 40%, and all other factors by 10% is more effective elements of influencing the usability of the site (increase by 6,58%).

For site Academy of Advocacy of Ukraine, the factors of an effective influence on information transparency are to increase the importance of the relevance of the site (x_4) and the satisfaction of stakeholders from using the site (x_{10}):

$$f(x_1, x_2, x_3, 1,1x_4, 1,1x_5, x_6, x_7, x_8, x_9, x_{10}) = 1,026I_{u.} \quad (23)$$

,

$$f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, 1,1x_{10}) = 1,014I_{us} \quad (24)$$

.

A simultaneous increase in all factors by 10% is more effective elements of influencing the usability of the site (increase by 2,73%).

The implementation of the models will make it possible to ensure the quality of the provision of educational services within the boundaries of building stakeholder interactions in the online environment.

4 CONCLUSIONS

The article summarizes the results of previous studies of the usability of websites of higher education institutions. The essence of usability in work is taken as the degree of user satisfaction from the convenience of using the site for making decisions on further interaction with the owner of the site. In the study of usability, the reactions of users to a certain state of the system are studied, that is, the content of the existing content, its visualization, the structure of the site, in order to search for effective interaction between subjects and objects of research in the online environment, taking into account their specificity of activity and the features of information requests.

The authors supplemented the classical understanding of the study of the usability of websites with the tasks of analyzing the conduct of stakeholders of higher educational institutions by methods of fractal and recurrent analyzes in order to track the nature of online behavior of stakeholders in different periods of time and the reaction of online users to the content and structure of the site. The basis of the study of online behavior is the confirmed hypothesis that the online behavior of stakeholders can be studied by the indicator of the frequency of requests for the websites of educational institutions in search engines, the recurrent analysis of the series of dynamics of which revealed seasonal bursts of information activity and the manifestation of stable interests of the target audience during the annual admission campaigns, the presence of a random component and concentration overload of active entry companies in the studied higher education institutions.

At the same time, the results of sociological studies (questionnaires) of usability were supplemented by the methodology of fuzzy mathematics with minimization of uncertainty and subjectivity in the process of assessing usability, which made it possible to substantiate the rules for supporting decision-making on improving the usability of the websites of the studied higher educational institutions within the limits of the expressed interest of stakeholders online at different periods of the educational process.

For a qualitative change in sites with a high level of usability, it is recommended to revise the site structure and content in principle, since the system has reached its peak. Sites with a sufficient and average usability score have the potential to meet the information needs of stakeholders, for which guidelines for its disclosure have been developed. The practical implementation of the decision support rules will ensure the quality of the provision of educational services within the framework of established online interaction between higher educational institutions and their stakeholders.

Thus, the methodology for studying the usability of websites of higher education institutions has been significantly expanded and supplemented.

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