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Learning in Dynamic Decision Making: The Usability Process

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***Abstract*—Usability of websites is an important issue for any entity operating in the virtual environment. Dynamic decision refers to the ability to choose (evaluate) between different actions at different points in time, in order to control and optimize performance. Currently, increasing attention is paid to the role of informal learning in the adaptation of learning to individual needs and circumstances in order to maximize knowledge. This paper approaches usability in the context of the theory of dynamic decisions. In the authors' view, the usability evaluation of a website becomes efficient on condition that it is repeated over time with the same group of individuals, resulting in a learning situation. The experiment consisted of measuring usability on a sample of individuals (experts) at consecutive time points to determine the degree of similarity of their behavior during the evaluation process. Starting from these assumptions, we demonstrated that usability may be considered a dynamic process, which could be very useful in reorganizing websites by identifying areas of intervention for the purpose of allowing users to learn and thus getting maximum effect from dynamic decisions.**

Keywords — learning; dynamic decision making; usability; k-means; e-tourism; neural network (ANN).

I. INTRODUCTION

The development of technology, particularly of the Internet, has had direct effect on all sectors of activity. Being centered mostly on information, tourism is an area that has been completely remodeled by the emergence of the Internet. Tourism companies use the Internet network for marketing and selling their products, engaging consumers in complex activities before, during and after visiting their websites. The online presence of the travel companies is marked by two types of websites: (a) simple, static, mostly for marketing and advertising purposes, informing users/consumers about travel packages and services; (b) complex and dynamic, playing the role of travel agencies, assisting the client throughout the process of configuration of the desired travel product/service.

Complex tourism websites have been the target of usability studies, based on which it has been tried either to develop the profile of their users or to determine the problems faced by these websites in order to increase the number of users [1].

In Romania, the Internet was introduced in the mid-1990s in universities and in the early 2000 for the general public. It is only after 2004-2006 that accessing the Internet from home became relatively common practice. Romanian E-commerce followed a similar development. According to data provided by the International Telecommunication Union, there was a significant increase in the Internet users, from 7, 786, 700 (June 2010), representing 35.5% of the population, to 9,642,383, representing 44.1% penetration rate (June 2012) [2]. The findings of a study carried out recently (2010) on Romanian tour operators show that nearly half (46.7%) of buyers use tourism websites to purchase services and products. However, the number of travel agencies adopting e-commerce is still relatively small [3].

This confirms that tourism is one of the most dynamic e-commerce sectors, with many companies marketing and selling their products online.

In this context, we conducted a usability analysis of some Romanian leading travel companies. We approached the topic from the perspective of websites seen as dynamic environments, with usability considered as an attribute of the website quality. The definition of usability accepted in this study is “the ease by which a user may learn to use a system to extract the information he/she needs” [4]. More exactly, the usability of a website illustrates the behavior of the user of that website. Users evaluate a website based on their skills, knowledge, according to their level of education and culture, and the mental state they have upon visiting a particular website.

Usability may also be seen as a property of the interaction among the website, the user and the task that the user wants to achieve [5]. The degree of usability may vary depending on the purpose for which the website is used and the Internet user’s level of knowledge.

This particular approach allowed us to assume that usability is a dynamic action [6]. Therefore, the degree of usability of a website may rely not only on its characteristics (efficiency, effectiveness and satisfaction in a specified context of use), but also on the context in which it is used.

Jordan contends [5] that users’ performance in relation to a product is likely to improve significantly if repeated over time.

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Within the context of usability assessment, the evaluators' performance in evaluating the ease with which they learn increases if done repeatedly.

This research started from these assumptions and tried to demonstrate that the process of assessing the usability of a website becomes effective if it is repeated over time with the same group of individuals, resulting in a situation of "dynamic usability". The paper is divided into four main sections: the first section is a brief literature review, the second presents the research purpose, methods and data, the third part presents the statistical analyses and, finally, the fourth is dedicated to conclusions, brief comments and future research directions.

II. LITERATURE REVIEW

Simon and Langley (1981) define learning as "a process that modifies a more or less irreversible system (it improves it, increases its value)" [7]. The task solved following the process of learning will determine that all subsequent tasks should be solved identically. Moreover, the persons who participate in the same learning process will solve the tasks in a similar manner [8].

The literature also includes studies related to the aesthetics of the websites as part of usability. In these studies [9], it is demonstrated that the graphics of the website play an important role in users' decision to stay on the site to achieve their goals. In other words, there is strong evidence that users decide to use a website based on both content and design [10]. This research is based on the finding that Internet users take their decision in relation to the site visually within 50 milliseconds [11], [12]. These authors argue that the time required for users to make their decision on the content, aesthetics, credibility and authority of the website is a key factor and should be taken into account when devising a method to measure the usability of the websites [9].

Further, the studies conducted by [13], [14] demonstrate that users' decision to stay on and use a website is based mostly on its content and the aesthetics / environment of the website does not influence their decision.

Our approach draws on Nielsen's ideas, as demonstrated in our previous studies [15], [16], [17]. The research was conducted In Romania, against the background of a society where the Internet and websites were accessible relatively late, more exactly in the early 2000s.

While the concept of usability evolved, it was accompanied by research on best methods to determine it, with several contributions such as [18], [19], [20]. These studies provide an understanding of the field based on processes of multiple evaluations. Multiple evaluation processes are necessary in any field, but it is deemed that in the case of usability, they are difficult to conduct because of the lack of standard criteria. An attempt to set standards in this area is illustrated in the comparative research of Hertzum and Jacobsen [21]. The authors focus on the investigation of the evaluators' effect on usability evaluations [22]. The findings show that the same evaluators with the same criteria reveal different sets of problems at every assessment. In the opinion of Hertzum and Jacobsen [21], there are three major categories of causes generating these differences. They are [22]:

- the lack of clear explanations of the objectives of the analysis and of the evaluators' tasks;
- the use of a low number of evaluators;
- the lack of clear explanations on the evaluation procedure and the criteria used.

In the work of [23], the authors make comparative evaluations of an academic website by means of four widely used usability assessment methods: heuristic evaluation, cognitive walkthroughs, think-aloud protocol and co-discovery learning. Their research is intended to be an example of a comparative usability study focused on the evaluator. The conclusion of their study [23] states that the decision on the usability of a website may be made only after conducting parallel usability studies with several different teams. It is not clear, however, which of the four methods is more relevant or which should be used for similar investigations applied to websites in other areas of activity.

In Romania, usability studies were pioneered by Andrei Radu and Liviu Taloi, who have developed the methodology and organized usability tests based on international standards for the Romanian e-Commerce Awards – GpeC (2007-present). Being applied only once, the purpose of these usability tests is to identify customers' potential problems when buying online [24].

III. RESEARCH OBJECTIVES AND METHOD

A. Research Objectives

In the present research, we intend to test the assumption that the evaluation of the usability of some web systems enters within the scope of dynamic decision (DD) systems. As the evaluation is made by evaluators who are supposed to be experts in the field of tourism, we consider that it is relevant to establish if after learning a web system, the same evaluators determine different sets of problems. According to Instance Based Learning Theory (IBLT), each cycle of decision-making may be described by an entity by taking into account the circumstances for making the decision, the decision taken and expected utility of the decision for the present situation. The similarity between the decisions is defined by [25], [8] as a metrics of matching – mismatching the characteristics resulting from the decision making process, from the past to the present.

Consequently, our hypothesis is that dynamic decision making (DDM) performance is closely related to the ability to recognize similar stimuli.

In specialist literature, there are several assessment methods for usability, as for example Inspection, DRUM, QUIS, SUMI MUSIC, and Empirical testing [4]. In this research, we used the Inspection method.

According to our view, usability tests performed by experts are conclusive if applied consecutively not in parallel. We argue that, due to the fact that instead of being a unique

isolated activity, usability testing becomes a repeated measuring activity, the evaluators learn the environment and become more exigent; hence, their assessment is more accurate, helping to improve the quality of virtual business by attracting more customers.

Thus, we consider that the measurement of the usability of websites is a part of dynamic environments where decisions become dynamic. Additionally, we want to determine if practice generates a change in the decisions taken by individuals participating in the study. Our assumption is that evaluators' decision at the two points in time when the assessment is made (dynamic decisions) improves along three directions: increase, decrease and similarity of the rating. The increase of the rating given after learning the environment is justified by the fact that individuals get accustomed to the environment (have learned the system/ the website and may appreciate it). An explanation could be that the initial concentration or the emotion of novelty caused by their not knowing the environment diminishes. Next, the decrease of the rating as a result of learning the environment may be justified by the fact that users have an overview of the environment and know its strengths and weaknesses, therefore becoming more exigent. Within this context, we believe that specialists may appreciate better the usability of the website, being able to focus only on comparing the features of the investigated environment with the regulations in the field. More exactly, the stress generated by the assessment of an unfamiliar environment is removed from the equation, leaving only the assessment process. Finally, we think that constant ratings, namely similarity throughout the study, represent either the inability of the evaluators to discriminate between classes of familiar objects (for example, erroneous recognition), or the fact that practice has no effect on the evaluation of websites; hence, the study would need to be extended over a longer time period to be able to support this idea.

B. Research Method

As previously stated, one of the most dynamic e-commerce sectors is tourism, with more companies marketing and selling their products online than in other areas. Our decision to select only the top five tourism companies (according to traffic.ro, the most reliable Romanian Internet activity monitoring and measuring company) is based on the fact that e-commerce is still in its early days.

Due to the relatively recent appearance of the concept of usability in Romania, the number of experts is still very low. Two initiatives stand out: the Romanian ecommerce Awards – GpeC (2007-present) and an e-Business master program launched in 2007 within Business Information Systems Department, from Babes-Bolyai University. Finding a representative sample at national level is still difficult.

Consequently, for reasons of convenience, we opted for a relatively small sample of 16 students enrolled in the e-Business Master program (second year) as representative for would-be experts in the area of e-anything. The experiment was conducted with participants having average to high knowledge in the field of tourism and the use of websites. They were subject to testing at two different moments fewer than two sets of conditions. The first test was conducted in an examination-like environment. The second test was taken in a more relaxed environment.

The experiment consisted in the analysis of the usability of top five Romanian tourism companies. The participants were provided with a computer with internet access, as well as the support of six criteria to check against, analyze and evaluate. The assessment consisted of ratings with values ranging between [0, 1]. The requirements introduced in the support were formulated in accordance with the standards ISO 9241-11 and ISO 13407 [26], [27], [28].

Our purpose was to confirm if the experts, namely individuals with superior knowledge in the field, make identical/similar decisions if they evaluate the same instrument several times. The second test represented, in our opinion, a repetition of a past action, thus allowing us to study whether the learning of the environment would generate an accurate appreciation, different from the first, while not taking into account the potentially disturbing factors such as stress or relaxation.

In this study, we considered experts as decision-making factors who, relying on previous experiences can identify the moment when it is important to intervene to get the maximum effect during dynamic decision making process.

Parameter optimization methods by error minimization were reviewed in the context of Artificial Neural Networks (ANNs). ANNs have been integrated or fused with other methods of soft computing and signal processing [29] , [30]. The fusion is to combine or cascade different computing methods with ANN to improve system performance over an individual technique. In many cases, the problems can be solved more effectively by combining one or two other techniques rather than implementing ANN exclusively. In this way, the fused methods complement each other to enhance the ability of data interpretation and modeling and to avoid subjectivity in the operation of the training algorithm with ANN individually. New learning methods, especially multiple classifier systems, are now actively studied and applied in many studies. In specialist literature [31], there are different kinds of ANNs, and these include multilayer perceptron (MLP), radial basis functions (RBF), and PNNs - this ANN is a variant of RBF systems. In particular, PNN is a type of neural network that uses a kernel-based approximation to form an estimate of the probability density functions of classes in a classification problem [32]. In the current study, we compared a model developed by k-means analysis with several different models developed by ANN, looking for the best model for our study.

C. The Data Sets and the Method for Generating the Training Data

For processing data we used the following software: SPSS13 (Statistical Package for the Social Sciences) for Windows, Statistica 6.0. We used the ANN module of the Statistica 6.0 software package [33] and Forward Stepwise algorithm for a variable selection. We used ANNs model in order to improve the accuracy of the classifier. We processed our data with different ANNs looking for a better model. Four

types of ANNs were used, namely, Probabilistic Neural Network (PNN), Radial Basic Function (RBF), Linear Neural Network (LNN), and Four Layer Perceptron (MLP-4). The quality of all the ANNs was determined calculating values of Specificity, Sensitivity, and Total Accuracy to determine the quality-of-fit to data in training. The validation of the model was corroborated with external prediction series. We also reported ROC-curve analysis (ROC curve can be used to select an optimum decision) for both training and validation series [34], [35].

Evaluators assessed 6 criteria (C1-C6), with various sub-criteria (S_n), namely:

#C1 Homepage and site (the 3-click rule up to third page) with 11 sub-criteria meant to measure navigability, design and information content.

#C2: Legal & Trust, with 2 sub-criteria related to contact information, Terms and Conditions, legal provisions as to Distance Contracts, link to ANPC (the Agency for Consumer Protection) or information on payment processing and transaction security.

#C3: Product/Service/ Category page with 27 sub-criteria measuring the way in which the site presents the product offer.

#C4: Sign-up facility with 4 sub-criteria measuring the site's strengths and weaknesses within this criterion.

#C5: Purchasing modality, with 10 sub-criteria measuring the site's strengths and weaknesses within this criterion.

#C6: Payment and reservation confirmation, with 1 sub-criterion measuring the strengths and weaknesses within this criterion

The statistical analysis generated 55 records for a company, therefore 275 records for the 5 targeted companies and a total of 4440 records for the 16 evaluators. In our view, these data are sufficient to conduct the study, namely to determine whether the process of usability evaluation becomes efficient when it is repeated over time (consecutively) with the same group of individuals (experts), resulting in a learning situation. The study validated the fact that usability is a dynamic decision process, with evaluators becoming more exigent in the second evaluation session.

Next, the statistical study is presented, with three steps. The first step consisted of the descriptive analysis of the data within a reliability-validity analysis of the five websites for the first evaluation test. The second step used k-means algorithm to generate clusters with objects (evaluators) that have the same behavior in the process of site usability evaluation. It ended with the ROC curve test, which verified the results of the classification obtained previously. Step three consisted of determining a better model for our theory. For this purpose, we used different Artificial Neural Networks (ANNs).

This method was chosen in accordance with specialist literature as described below.

Firstly, [36] offer an overall view of the way data clustering methods are used within the statistical domain of Exploratory Data Analysis. We drew on [37], Kohonen, for using Artificial Neural Networks of the so called "unsupervised learning" with the purpose of identifying/producing small scale maps called Self Organizing Feature Map (SOFM). The studies carried out by [37], [38] demonstrated that SOFMs function similarly or even identically with the statistical clustering procedure called k-means. Finally, [39] argue that the k-means method is so frequently used due to its ease of interpretation, simplicity of implementation, speed of convergence and adaptability to sparse data.

Further on, we identified two different sets of opinions regarding the capacity of ANN and k-mean methods to create clusters. While [36], [37], [38] maintain that the clustering abilities of the Artificial Neural Networks are different from those of k-means algorithm, with the latter considered to yield results closer to reality,[41] argue that the k-means algorithm and ANN yield similar results. Within the current research, the k-means algorithm provided more significant results than ANN models, which were not essential for the improvement of our model, thus consolidating the results of [36], [37], [38].

IV. STATISTICAL STUDY

The first step was to conduct a descriptive analysis of the data within a reliability-validity analysis of the five websites of the first test. The result of the analysis was:

1. There are differences among the assessments of the criteria studied by evaluators;

2. There was no need to reorganize the tool used for the analysis of the usability of the investigated websites;

3. The degree of precision of the questionnaire items to measure the existence / non-existence of the six criteria is acceptable;

4. The evaluators proved moderate agreement in assessing the existence / non-existence of the criteria considered in the study.

In this context, we deemed it necessary that our research should focus on the approach of the entire study from the perspective of the theory of dynamic decisions, because we believe that the assessment of the usability of the websites may be interpreted as a decision-making process

Next, the following working hypothesis was formulated: there are no significant differences between the first evaluation of the sites and the second evaluation due to the learning process. We applied the Marginal Homogeneity test and the results are shown below:

TABLE I. RESULTS OF MARGINAL HOMOGENEITY TEST -PARTI

Statistics	Company Site 1 - first evaluation - 2nd evaluation	Company Site 2 - first evaluation - 2nd evaluation	Company Site 3 - first evaluation - 2nd evaluation	Company Site 4 - first evaluation - 2nd evaluation	Company Site 5 - first evaluation - 2nd evaluation
Distinct Values	24	24	24	24	28
Mean MH Statistic	661.500	564.500	505.500	513.000	602.500

TABLE II. RESULTS OF MARGINAL HOMOGENEITY TEST -PARTII

Statistics	Company Site 1 - first evaluation - 2nd evaluation	Company Site 2 - first evaluation - 2nd evaluation	Company Site 3 - first evaluation - 2nd evaluation	Company Site 4 - first evaluation - 2nd evaluation	Company Site 5 - first evaluation - 2nd evaluation
Std. Deviation of MH Statistic	19.203	21.488	22.108	17.507	27.125
Std. MH Statistic	3.880	3.607	3.189	3.313	4.701
p-value	**.000**	**.000**	**.001**	**.001**	**.000**

The findings show that usability measurement after the learning stage caused a change in users' opinions. The next step was to determine the evaluators' behavior.

At this stage, we applied the k-means method by MacQueen, which was perfected by the method of dynamic clouds of E. Diday [41]. The implementation of this method generated the k-means algorithm, which is applied to solve problems in which the number of clusters is known a priori.

The k-means algorithm was used to generate clusters with objects (evaluators) that have the same behavior during the site usability evaluation process.

The following hypothesis was formulated: there are differences between the evaluators seen as rating "behaviors". The results demonstrated that evaluators can be grouped into two clusters based on differences in scoring obtained at the two points in time. These clusters are characterized by the fact that inter-classes inertia values significantly exceed the intra-class inertia values.

The representative set of attributes forming clusters (homogeneous and well-defined groups of objects) are: C1S1 (F=13.583, p=0.04; G-square=14.62442, p=0.04), C1S7 (F=26.3, p=0.001; G-square=27.26, p=0.001), C3S17 F=17.898, p=0.001; G-square=20.778, p=0.0003), C3S19 (F=26.436; p=0.0001; G-square=27.357, p=0.0001), C3S22 (F=48.717; p=0.0000; G-square=60.469, p=0.000); C3S23 (F=34.029, p=0.0001, G-square=36.059, p=0.000), C3S25 (F=26.831; p=0.0001; G-square=29.062, p=0.0001) C5S7, (F=28.831; p=0.0001; G-square=31.062, p=0.0001) C3S8 (F=15.38, p=0.001 ;G-square=15.55, p=0.0004), where: "C" is the criterion and the "S" sub-criterion attached. So, symbol "C1" represents the first criterion - measuring the homepage and the rule of three clicks (website navigation, information search, etc.). S1 means the simplicity and clarity of design / layout well organized / visual attraction; S7 means PR elements and interaction with users (newsletter, blog, social networking, press releases, etc.).

Symbol "C3" represents the third criterion focused on the analysis of the elements of a tourism website; S8 means information about the destination search; S17 means highlighting Price (font size, bold, price location near the button "add to cart"); S19 means highlighting button "buy or pay on-line"; S22 means information about how the cost and delivery time of product purchase in installments, about bonuses and discounts granted on the payment methods, etc; S23 means visible location as phone numbers can be contacted representatives agencies, live chat, customer support, email for details/recommendations; S25 means clear, accurate, complete, relevant detailed description / technical products ;

Symbol "C5" represents the fifth criterion - intended to assess the degree of difficulty of the procedure for selecting the tourism product/package; S7 means ability to edit "shopping cart / online booking.

The representative set of attributes forming clusters (homogeneous and well-defined groups of objects) are:

- Cluster 1 contains evaluators who at the second rating gave lower scores to attributes, so they developed a more exigent attitude.

- Cluster 2 comprises evaluators who have not changed their attitude after learning the environment and gave all criteria the same scores.

Next, the ROC curve procedure was applied to test if the attributes taken into study are predictive for the model chosen to detect the types of behavior, namely a model of involvement in the evaluation of sites at the two time points. The area under the curve is 0.822, p=0.001; 95% CI (0.802;1). The set is a discriminate model for 82% of cases.

In the next phase of the research we sought a better model for our theory, and we used different artificial neural network (ANN). We used four types of RNA: Radial Base Function (RBF), Three Layers Perceptron (MLP-43), and Four Layer Perceptron (MLP-4). Figures 1 and 2 present the network topology of some of the tested ANN models. For instance, PNN 55:55-83-2-2:1 is an ANN with 55 inputs, 55 neurons in the first layer, 83 neurons in the second layer, and two sets of cases (Training and Validation). Generally, at least one of each tested ANN type was statistically significant. We noted that each network profile indicated that there are five nonlinear and complicated models.

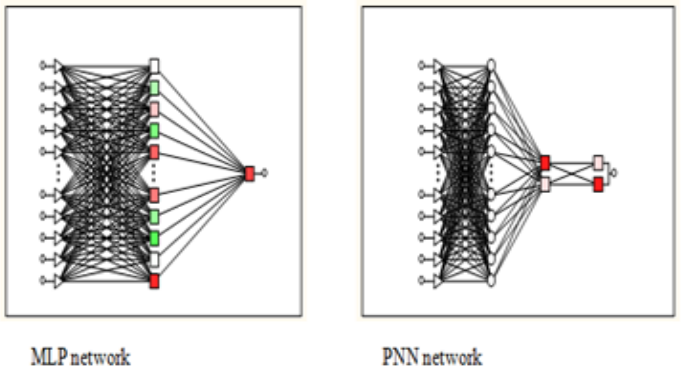

Fig. 1. Representation of ANN´s models tested

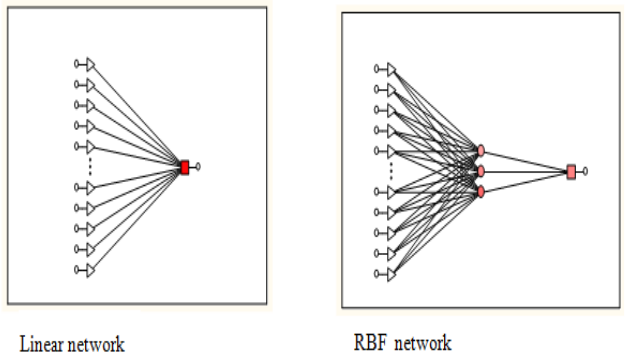

Fig. 2. Representation of ANN´s models tested

Figure 3 presents the ROC curves for the ANN models tested above. We obtained a value for the models presented, with ROC curves greater than 0.5, which is a very good result.

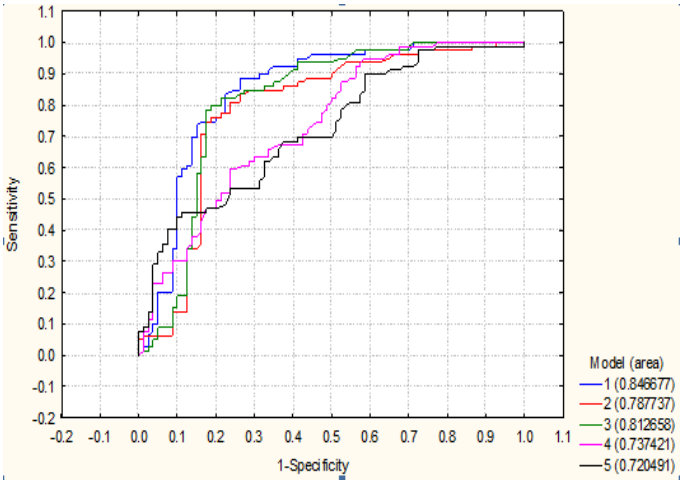

Fig. 3. ROC curve of different ANN´s models tested

The best network found was a PNN which showed training performance higher than 81%. The other networks were MLP 51:51-17-2-2:1, RBF 32:32-2-2:1. We used the ANN direct inspection method whose results showed *that there is no need to use a complex ANN method to obtain a classification model for our problem*.

To sum up, following the classical statistical analysis we obtained two groups of evaluators, a group who learned and changed their behavior and a second, who did not learn and had the same behavior in both rating sessions. After applying the ANN models, the results validated the classical statistical analysis. Consequently, for the present study, ANN models are not essential for improving our model.

V. CONCLUSIONS

The present study started from the assumption that usability may be considered a dynamic decision process whereby the evaluation of a website becomes efficient on condition that it is repeated over time with the same group of individuals, resulting in a learning situation.

The data were analyses in three steps: a descriptive analysis, the reliability-validity analysis and the application of the k-means method. The k-means algorithm was used to generate clusters with objects (evaluators) that have the same behavior in the site usability evaluation. The ROC curve procedure was applied to test if the attributes taken into study are predictive for the model chosen to detect the types of behavior in the evaluation of sites at the two time points. Then, we compared a model developed by k-means analysis with several different models developed by ANN, looking for the best model for our study, which was obtained by direct inspection, showing there is no need for more complex approaches.

As a result, the evaluators were divided into two groups: while group 1 determined different sets of problems after learning the web system, group 2 maintained their first opinion. The behavior of the first group may be interpreted as a result of evaluators' having learned the environment and becoming more exigent. Moreover, their being experts in the field facilitated their focus on the relevant features.

In spite of the limitations due to the small sample of participants, we noted that it is important for the usability of the sites to be approached through a multiple test effort, in consecutive sessions by the same group of evaluators and not in parallel, as stated in other studies. A possible reason is that the first visual contact with a site may trigger the emotion of novelty, of the unknown while the second attempt of using any object, in our case a system, has a learning effect and facilitates the process; hence, the need for a second evaluation.

Since the study validates the fact that usability can be interpreted as a dynamic decision-making process, with the evaluators (experts) becoming more exigent during the second evaluation session, the findings may have a practical application in that websites could be designed relying on a deductive learning process to improve usability.

In the future, we intend to conduct more experiments with a larger, more representative, sample and derive more practical applications.

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