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# Human-computer interaction and usability testing: application adoption on B2C Web sites

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ABSTRACT: The following research investigates issues relating to the field of Human-Computer Interaction and Usability Engineering. The project was an examination of five Greek B2C e-commerce Web sites by using methods, such as asynchronous remote usability testing, thinking aloud protocol and usability questionnaires in combination. Also, measurements for effectiveness, efficiency and satisfaction were made with the aim to measure the usability of each Web site. Furthermore, any usability problems were identified and alternative design suggestions were made.

Keywords: Usability, e-commerce, human-computer interaction, remote usability testing, thinking aloud protocol

## INTRODUCTION

During the 1980s, using computers required knowledge and experience. The interaction between user and computer was a technology available to only a few [1]. Nowadays, the interaction has been simplified dramatically and specialised knowledge or experience is no longer needed to run simple and everyday tasks. People have the ability to manage their personal lives, their jobs, their health, their education and entertainment through computing devices due to the fact that the devices and software have more user-friendly interfaces. What has contributed to this great progress? One of the biggest factors is the intensive research not only by large companies but also by universities in the field of Human-Computer Interaction (HCI) [2]. The user acquires a central role and the design and development of any technological product is made according to their needs and specifications.

Over the years and the development of the Web, the significance of proper interaction becomes even more important resulting in a high demand for specialised design guidelines, which will serve specific purposes for Web design. Media applications, e-learning applications, e-banking applications and e-commerce platforms seem to satisfy some common design principles, but the diversity of each application's purpose makes the creation of specialised guidelines mandatory by methods that can assess the final design result. In this project an emphasis will be given on the e-commerce sector and on the interaction of customers with Web sites of on-line retailers.

## LITERATURE REVIEW

From the title of this article, it can be understood that the three main areas of concern of the specific project are HCI, usability engineering and e-commerce. The most commonly accepted definition of HCI has been given as: *Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them* [3], whereas the most common definition for usability has been given as: *The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use* [4].

If the first definition is observed for a while, the words *design, evaluation* and *implementation* are those that stand out and are the link between the two fields. More specifically, HCI provides the principles, guidelines and standards for the *design* and *implementation* of interactive systems, while the usability engineering offers all the methods, techniques and tools for the *evaluation* of interactive systems. When examining the second definition, the words: *effectiveness, efficiency* and *satisfaction* arise. These three words are the key features of evaluation and the measurement units of

usability (effectiveness + efficiency + satisfaction = usability). Therefore, any attempt to evaluate the usability of a product should be made according to at least these three parameters. It is certainly worth noting that in international research, other indicators for the measurement of usability have been identified and implemented. For example, Nielsen adds the *learnability* and *memorability* and *few errors* [5], while Hornbaek presents a large number of usability indicators and how they can be measured [6].

HCI: Principles, Guidelines and Standards

As aforementioned, the sector of HCI provides the principles, guidelines and standards for the design and implementation of interactive systems. The difference between these three categories is the level of detailed design analysis. The design principles are abstract and for this reason they can be applied to many kinds of interactive systems. On the other hand, the standards are very detailed and usually cover specific goals and objectives [1]. The most distinctive design principles are the ten usability heuristics of Nielsen, the eight golden rules of Shneiderman, the 16 design principles of interaction of Tognazzini, the six design principles of Norman and the seven design principles of Governor Technology for e-commerce [2][5][7-9].

Moreover, there is also a large number of catalogues with recommendations in design guidelines. One of the most popular is the one by Smith and Mosier. The catalogue contains 994 design guidelines and is considered to be the most comprehensive list of design guidelines for the design of user interface software (UI) today [10]. This catalogue could be used either in the stage of the collection of the design requirements or in the evaluation of an already implemented software. Another catalogue of design guidelines for the Web UI was created in 2003 (renewed in 2006) by the US Department of Health & Human Services (HHS). It contains 209 guidelines, 184 of which are design guidelines and the rest are guidelines, which are related to Web usability and user-centred design [11]. Furthermore, there is also the Nielsen et al. catalogue, which specialises in designing e-commerce Web sites. The catalogue contains 207 design guidelines and is divided into five units (search engine, category pages, product description, checkout and registration). Just as the Smith and Mosier catalogue, it could also be used either at the stage of the collection of the design requirements or in the evaluation of an already implemented software [12].

As far as the standards are concerned, the most representative ones are the ISO 9241:1992 (Ergonomics of human-system interaction), ISO 13407:1999 (Human-centred design process for interactive systems) and the relatively recent ISO 9241-151:2008 (Guidance on World Wide Web user interfaces) [13]. The ISO 9241 contains 17 parts of which part 11 is of particular interest because it contains the definition and characteristics of usability. The second standard, ISO 13407, approaches issues of usability with high-level perspective [14][15]. Its purpose is not to provide detailed design guidelines but to present a user-centred design process step by step. This process is going to ensure the design of a usable system, which is going to satisfy the needs and distinctiveness of the users. The third standard, ISO 9241-151 is the first standard which is mentioned only on Web usability and design Web UI. The aim of ISO 9241-151 was the production of a list of guidelines, which in combination with the HCD approach could ensure high usability to the design of Web UI. Again, the three standards above are only the more representative ones. An article by Bevan presents all relevant standards in HCI and usability [13].

Usability Engineering: Evaluation Methods

In general, the Usability Evaluation Methods (UEM) can be categorised as: 1) analytic methods (in the laboratory without the participation of users); 2) experimental methods (in the laboratory with the participation of users); and 3) inquiry methods (out of the laboratory but with the participation of users) [2].

One of the most widespread UEMs is Heuristic Evaluation (HE). In general terms, at least two evaluators inspect the system and based on the heuristics, try to evaluate the usability, allocating a grade for each heuristic, which represents their judgment for the UI. HE could be applied both in the first stages of the design and in completed UIs. Two of the most important factors, which are being investigated and evaluated are the overall design and the dialogue elements. It should be emphasised that in a HE, different experts could add more heuristics or use alternative criteria, attaching different significance to them, based on the distinctive characteristics of each UI [16].

Another common UEM is the Thinking Aloud Protocol (TAP). TAP takes place within a laboratory, with the participation of the intended users of UI, and not experts. Ericsson and Simon, the developers of the method, suggest that the evaluation should be carried out with the participation of at least 3-4 users and with the assistance of one evaluation coordinator. Regarding the evaluation procedure, it can be characterised as simple and fast. More specifically, the test coordinator describes the tasks which should be implemented to the users. The users, during the implementation of these tasks, make comments on each action that they execute. At the same time, the coordinator keeps notes of the users' comments and prompts them to keep talking and suggest alternative solutions based on their opinions and perceptions when they face up to difficulties. Moreover, during the evaluation session, every action and all the reactions of the users are recorded by the use of special monitoring software in the desktop, so that thereafter, the moderator could analyse and correlate the reactions with the actions which were carried out [17][18].

Furthermore, the usability questionnaires are well received as a method of assessment. One of the most popular is the System Usability Scale (SUS). SUS consists of 10 questions (5-point scale) and is a high reliable tool developed by John Brook [19]. According to the Bangor et al, one of the biggest advantages of SUS is the fact that it has broad application to different types of UIs. More specifically, the high adaptability of SUS has been proved in the study of Bangor et al, as they used this evaluation tool in 206 projects. They concluded that the coefficient alpha is 0.91, something which means that SUS is reliable in any type of UI [19]. Moreover, a specific way of calculating the total satisfaction score has been identified [20].

A relatively recent method, which exploits the technologies of the Internet, is the Remote Usability Testing (RUT). Ramli et al divide RUT into two categories: synchronous remote usability testing and asynchronous remote usability testing. In the first case, during the evaluation, the usability coordinator and the users communicate and cooperate at the same time via a Web application. The presence of both participants is necessary for the completion of the session. In the second case, only the participation of users is obligatory. The coordinator typically sends users a personal e-mail with the link to the evaluation tasks and the users are able to answer whenever they want to [21].

## PURPOSE AND MOTIVATIONS OF THE STUDY

The aim of this project was to evaluate five Greek B2C e-commerce Web sites, which belong to the hardware/software and household appliances market. This sector was chosen due to the fact that it is characterised by high demand for on-line purchases from Greek e-consumers [22]. Also, the limited amount of research on evaluation methods was a major incentive for the project.

## AIMS OF THE STUDY

1. To evaluate how usable (i.e. effectiveness, efficiency, satisfaction, etc) each site is for the consumers and to examine whether e-commerce applications are being developed according to the user-centred design.
2. To measure the success rate, average task times, error rate and abandon rate through alternatives usability evaluation methods in order to understand the user experience.
3. To study whether worldwide design principles and guidelines are being applied to Greek e-commerce sites and to make certain assumptions regarding the relation of e-commerce sites with usability.
4. To conclude which site is the most usable and whether this fact is reflected in sales.
5. To identify usability problems and make alternative design recommendations.

## METHODOLOGY

### Methods and Tools

The methods which were chosen for the evaluation of the e-commerce sites are: 1) Asynchronous Remote Usability Testing (ARUT); 2) Thinking Aloud Protocol (TAP); and 3) Usability questionnaire. In particular, for the implementation of ARUT, the on-line usability tool, Loop11, was used. For the TAP, the Camntasia Studio 7 was used, whereas the usability questionnaire chosen was SUS.

### Evaluated Web Sites

The Web sites that were evaluated are plaisio.gr, e-shop.gr, multirama.gr, kotsovolos.gr and you.gr. All five Web sites belong to the hardware/software and household appliances business markets and were chosen based on the number of visits to them.

### Participants

For the implementation of ARUT, the 120 participants were invited. Of the 120 individuals, 88 responded positively, producing a participation rate of 77.3%. Of those who finally agreed to participate in the study, 41 were men (46.6%) and 47 were women (53.4%). In regard to the level of education of the participants, 29 had graduated from a technological institute, 37 had a university degree, 19 had obtained either a Master's degree or a PhD and three stated that they had other levels of education. In relation to age, 51 participants (58%) were in the age group 18-27 while the remaining 37 participants belonged to the age group 28-47. According to the data, which were obtained from Question 7 of the questionnaire, 29 (33.3%) participants were inexperienced with e-commerce purchases, 36 (40.9%) considered themselves to be neither inexperienced nor experienced, and the remaining 23 (26.1%) could be characterised as experienced e-buyers. Also, six more participants were included in the implementation of TAP. In this sample, there were 2 inexperienced, 2 experienced and the others said: *I am not an expert but neither am I unfamiliar*.

### Tasks

The five Web sites were evaluated in regard to the 10 most important components of an e-commerce site: *1) structure/navigation; 2) product's information; 3) category pages and search filters; 4) customers' support;*

*5) search engine; 6 ) registration process; 7) management account; 8) checkout process (shopping cart); 9) payment and security policies; and 10) delivery and returns policies.* The first four components were evaluated through ARUT and the six remaining with TAP [5][9][20].

Tasks' Scenarios and Typical Evaluation Process

Initially, it should be stressed that each of the tasks given had different purposes and evaluation goals. For example, in order to evaluate the five Web sites' structure/navigation, the participants were asked to find a specific product (different products and hypothetical scenarios were given for each Web site). The purpose was to understand the navigation behaviour of the users and the goal was that the participants find the requested product. For instance, from the plaisio.gr Web site, they were asked to find the most recently added mp3/mp4 player, while from multirama.gr Web site, the participants were asked to find the least expensive Micro Hi-Fi system. It should be noted that the participants started their tasks from the home page of each e-commerce Web site. Figure 1 illustrates the process of the steps, which were necessary for the participants in order to complete the evaluation process.

Table 1: Typical evaluation process.

| |
|---|
| Step 1: Introductory text |
| Step 2: The participants answer questions 1-9 |
| Step 3: Execution of the tasks for plaisio.gr |
| Step 4: The participants answer the questions of SUS (10-19) for plaisio.gr |
| Step 5: Execution of the tasks for e-shop.gr |
| Step 6: The participants answer the questions of SUS (10-19) for e-shop.gr |
| Step 7: Execution of the tasks for multirama.gr |
| Step 8: The participants answer the questions of SUS (10-19) for multirama.gr |
| Step 9: Execution of the tasks for kotsovolos.gr |
| Step 10: The participants answer the questions of SUS (10-19) for kotsovolos.gr |
| Step 11: Execution of the tasks for you.gr kotsovolos.gr |
| Step 12: The participants answer the questions of SUS (10-19) for you.gr |
| Step 13: The participants answer the question 20 |

Tasks Indicators

The following indicators were established in order to measure each task (Table 2).

Table 2: Indicators for each task.

| Tasks | Effectiveness | | | | Efficiency | | | | | Satisfaction | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Success rate | Failure rate | Abandon rate | User errors | Task duration | Number of requests for help | Success rate in a given time | Failure rate in a given time | Mental effort | Positive comments | Negative comments | Proportion of negative and positive comments |
| Task 1: Structure/navigation | X | X | X | | X | X | | | | X | X | X |
| Task 2: Product information | X | X | X | | | | X | X | | X | X | X |
| Task 3: Category pages and search filter | X | X | X | | X | X | | | | X | X | X |
| Task 4: Customer support | X | X | X | | X | | | | X | X | X | X |
| Task 5: Registration Process | X | X | X | X | X | X | | | X | X | X | X |
| Task 6: Account management | X | X | X | X | X | X | | | X | X | X | X |
| Task 7: Payment and security policies | X | X | X | | X | X | X | X | | X | X | X |
| Task 8: Delivery and returns policies | X | X | X | | X | X | X | X | | X | X | X |
| Task 9: Checkout process | X | X | X | | X | X | X | X | | X | X | X |
| Task 10: Search engine | X | X | X | | X | X | | | | X | X | X |

Results and Analysis

As can easily be understood from Table 3 that e-shop.gr had the highest completion rate for Task 1, which was rated at 23%, compared with lower ratings for the other Web sites. This means that the participants were able to navigate the e-shop.gr Web site more easily than the other Web sites. In Task 2 (Table 3), you.gr rated 26.67% and, therefore, had the most effective product description (that is, the structure of description, the hierarchy of information and the presentation of the product further facilitated the participants to find the information they were asked).

The plaisio.gr Web site had the best product classification but also more helpful search filters so that users were able to limit their search based on the criteria they wish (26%), followed by kotsovolos.gr (25.65%). Also, from Table 3, it seems that the kotsovolos.gr Web site allowed the participants to contact the representatives of the company more easily compared with the other Web sites, whereas in Task 5 (Table 3), all five Web sites received 20% because all the participants successfully completed the registration process for all Web sites. The same occurred in Task 6 as well. The participants had no problems modifying their personal data. Also, all five Web sites have very good completion rates in the checkout process. If one had to distinguish one of them from the others, plaisio.gr offers the most convenient checkout process (22%). At the same time, from Table 3, it seems that multirama.gr and plaisio.gr have the most functional and useful search engines (25% and 24% respectively).

What is worth noting from Task 9 in Table 3 is the rating of 0% received by you.gr. The 0% occurred because none of the participants was able to find the returns policy. Furthermore, the 36.35% received by the kotsovolos.gr Web site shows that the information about delivery and returns was easily accessible, but also that they were understood by the participants. In Task 10 (Table 3), similar rates of success were achieved for all the Web sites except for plaisio.gr, for which the low percentage presented caused concern.

Table 3: Distribution of results.

| | plaisio.gr | e-shop.gr | multirama.gr | kotsovolos.gr | you.gr |
|---|---|---|---|---|---|
| T1: Structure/navigation | 17,60% | 23% | 19,40% | 21% | 18,80% |
| T2: Product description | 21% | 16,23% | 21,76% | 13,68% | 26,67% |
| T3: Product categories and search filters | 26% | 14,88% | 24,17% | 25,65% | 9,30% |
| T4: Customer support | 20,97% | 15,27% | 23,28% | 25,24% | 14,42% |
| T5: Registration | 20% | 20% | 20% | 20% | 20% |
| T6: Management account | 20% | 20% | 20% | 20% | 20% |
| T7: Checkout | 22% | 21% | 19% | 19% | 19% |
| T8: Search engine | 24% | 19% | 25% | 19% | 13% |
| T9: Delivery and return policy | 27,25% | 18,20% | 18,20% | 36,35% | 0% |
| T10: Payment and security policy | 0% | 23,53% | 23,53% | 17,64% | 23,53% |

In Table 4, the total measurements for all the tasks completed on the effectiveness, efficiency and satisfaction are shown. Although at this level the authors cannot conclude with accuracy which Web site is more usable, the one which seems to stand out is multirama.gr.

Table 4: Usability metrics comparison.

| Web sites | Effectiveness (%) | Efficiency (secs) | Satisfaction (%) |
|---|---|---|---|
| plaisio.gr | 73.2 | 1.289 | 58.45 |
| e-shop.gr | 67.6 | 1.438 | 58.17 |
| multirama.gr | 74.6 | 1.499 | 61.60 |
| kotsovolos.gr | 74.1 | 1.456 | 57.23 |
| you.gr | 61.2 | 1.423 | 50.32 |

Table 5: Usability problems which identified.

| Tasks | plaisio.gr | e-shop.gr | multirama.gr | kotsovolos.gr | you.gr |
|---|---|---|---|---|---|
| Navigation | X | | | | X |
| Product description | | X | | X | |
| Product categories and search filters | | X | | | X |
| Customer support | | X | | | X |
| Registration | | X | X | X | X |
| Management account | X | | | | |
| Checkout | X | | | | X |
| Search engine | | | | | |
| Delivery and return policies | | X | | X | X |
| Payment and security policy | | | | | |

The next one is plaisio.gr, but with little difference from kotsovolos.gr. On the other hand, you.gr seems to have the most usability problems, while the measurements of e-shop.gr would also be the cause of concern. E-shop.gr is considered dominant in this e-commerce sector and the rates it gets do not represent the power of the company. The above finding seems to be the same as the one in Table 5, where the usability problems identified during the evaluation were presented. Indeed, you.gr has the most problems of interaction, whereas multirama.gr the least.

## DISCUSSION

In general, all the five Web sites ranges demonstrated good levels of usability. This means that the Web sites are fully operational and will not affect the experience of customers negatively. Nevertheless, design improvements are necessary. More specifically, in the task on navigation, the participants did not find the navigation in the plaisio.gr Web site to be difficult, but they could not find the sort button. This is a simple problem that can be solved by integrating the option into the search filters. In the you.gr Web site, the similar link labels confused the participants resulting in wasted effort. Simple and not specialised and similar names should be used in the labels.

In the task *product description*, the e-shop.gr and kotsovolos.gr Web sites should place important information such as product warranty in a more obvious spot. In the task *customer support* the same problem was detected in the you.gr and e-shop.gr Web sites. The ways of communication were not concentrated in one link (e.g. contact us) and as a result the participants did not perceive that other means of communication were available.

In the task *registration*, problems arose due to either misleading messages about confirmation of registration or internal problems. The confirmation messages were not clear in describing whether activation via e-mail is mandatory and in the kotsovolos.gr Web site, while the system replied with a message of confirmation of registration, the participants could not login for about five minutes. In the checkout process, the problems that were identified have to do with the size and position of the *buy button* and *add to basket button*. The checkout processes in all Web sites are properly structured and can be described as simple. In the task *search engine* the participants encountered several problems, mainly in the e-shop.gr, kotsovolos.gr and you.gr Web sites. In the first Web site the problem has to do with the presentation of results, while in the other two, there seems to be a major problem in the communication of the Web application with the database. Finally, in the task *delivery and returns policy* the problem is due to the fact that the information was not easily accessible. A distinctive example is you.gr, where no participant could find the returns policy.

## FUTURE WORK

A more thorough study of the components in which the most problems were identified is suggested. For example, in the search engines other methods of assessment should be used, but with participants who are experts in the field of Web development in order to identify more advance operating problems. A detailed study on the efficiency of Web applications and a segregation of the response time of each system is also suggested.

## CONCLUSION

In the project, emphasis was placed on active participation in the process of evaluation of the intended customers. Five Greek e-commerce Web sites belonging to a particular business sector were evaluated. Three different usability methods were applied through appropriate tools for data collection. The results showed that, generally, the level of usability of all five Web sites was good but significant improvements could be made. Also, usability problems were identified, which are due to either bad design decisions or internal procedure problems (e.g. server). By the results, the most usable Web site is multirama.gr, whereas you.gr is the one with the most problems. Finally, the negative results of e-shop.gr made an impression.

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BIOGRAPHIES

Vasilia Peppa graduated from the University of Bradford, UK, with a Bachelor's degree in computing with management. She then completed two Master's degrees at Bournemouth University, UK. The first was in information systems management and the second in international business finance. Once she completed her studies, she worked at ORACLE HELLAS SA as a supply chain management sales consultant. For the last 10 years, she has worked as an assistant at the Technological Education Institute of Piraeus in the General Mathematics Department and more specifically at the Computing Sector. At the same time, she worked as a module leader in the Master degree courses in cooperation with Kingston University, UK, MSc Electronic Commerce and MSc Management in Construction at the following modules: Corporate Data and Database Management Systems, Information Systems and Project and Risk Management. For about three years she was a tutor in all modules in the postgraduate programme MSc in Project Management in contribution with City University of Seattle, USA. She has supervised more than sixty postgraduate dissertations. For two academic years she was a laboratory assistant with the Hellenic Navy. Her main interests include computing, education, project management and economics.

Sarantos Lysikatos graduated from the Technological Education Institute of Thessaloniki and holds a Bachelor degree in marketing. After graduation, he worked in the Non-performing Loans Department of the National Bank of Greece. After the completion of his contract, he enrolled in the Master's course in electronic commerce at Kingston University (UK), School of Computing, Information Systems and Mathematics, in cooperation with the Technological Education Institute of Piraeus, Department of Mathematics and Accounting, which he has recently completed. He is currently working in the real estate sector as a freelancer. At the same time, he is studying business administration through the Hellenic Open University, School of Social Science. His research interests include human-computing interaction, usability engineering, e-marketing, project management and Web design and development.

George Metaxas graduated from the National Technological University of Athens (NTUA), Greece as a civil engineer. He then work as assistant lecturer in NTUA in postgraduate level giving lectures on reinforced concrete, advanced fluid engineering, applied hydraulics and methods of applied mathematics in hydraulics. Afterwards, he worked as a lecturer in the Agricultural University of Athens (AUA) in the Hydraulics Department. He was later appointed Professor at the Technological Education Institute of Piraeus (TEI) in Civil Engineering Department. He was elected four times to be Head of the Department of Civil Engineering and twice as Dean of the Faculty of Engineering. He established the postgraduate courses in TEIs in collaboration with foreign institutes, and since 2000, he has been the Field Leader of the postgraduate course of the Civil Engineering Department in collaboration with Kingston University (UK). During 2004 he completed his PhD from AUA. During his academic career he has been awarded with UNESCO International Centre for Engineering Education (UICEE) Silver Badge of Honour for distinguished contributions to engineering education, outstanding achievements in the globalisation of engineering education through the activities of the Centre, and, in particular, for remarkable service to the UICEE. He has also been awarded an honorary Doctor of Engineering by Kingston University, UK. He is a member in various scientific organisations such as the World Institute of Engineering and Technological Education. As a civil engineer he has worked as consultant engineer with large consulting firms in Greece and has designed and supervised large projects in Athens, Greece.