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Analytical Roadmap to Usability Definitions and Decompositions

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Abstract:
The demand for quality software system is increasing day by day, but most software system fails to fulfill the expectations of its users due to lack of usability. Since usability is recognized as an important quality factor of software system, so to develop quality system it is necessary to have single and precise definition of usability. Researchers have not developed yet any model that precisely describes usability definition and all its attributes that takes into account the varying aspects of usability. This paper provides a roadmap by analytical review of usability definitions and their decomposition in various attributes. The aim of review is that it may help to software systems' designers, developers and users to select the usable system on the basis of various parameters defined in the paper.

Keywords: usability, software, usability analysis, system, model

1. Introduction

The growth in demand for efficient systems has increased greatly in recent years, but there has been also criticism of the quality of the systems being currently used. Problems include low performance and poor usability, which make it difficult to serve the specific needs of different users. Unusable systems are probably the single largest reasons that they fail in actual use (Seffah *et al.*, 2006). An appropriate usability definition may act as guideline to develop efficient software system, yet there is no definition that is consistently accepted by developers. Several definitions of usability and its attributes have been proposed, however no agreement has as yet been achieved by researchers or standards bodies in regard to the concept of usability (Abran *et al.*, 2003). Though software usability is described in terms of attributes of software product (Holcomb and Tharp, 1991) yet, the different view on usability attributes and lack of authentic definitions of usability is the reason for poor usability of software system. By considering these situations this paper reviews and analyzes usability definitions and identifies the attributes that fully reflects the usability of software system in a structured and non-redundant way and shows that how researcher's view of usability has changed over more than three decades. Analysis of various usability definitions from different literatures may help the software systems' developers to develop efficient and usable software system. It is important to take into account that space limitations do not permit this paper to fully describe all the attributes in detail. The main objective of this paper is to: (i) review usability definitions and its attributes in detail (ii) identify those attributes, which perform greater impact to decide the usability of software system.

The remaining part of paper is structured as follows: section 2 introduces some different aspects of usability and explains the motivation for the analytical survey approach. Section 3 describes literature survey about usability definitions and attributes associated with them. Section 4 gives methodology behind the review. Section 5 represents result and discussion from this study. Section 6 is the conclusion and future scope of this paper.

2. Aspects of Software usability

Usability has multidimensional view that can be examined from various aspects. In the literature the term usability has been used broadly and means different things to different people. Single aspect of usability is critical, because it is affected by different factors. According to Porteous *et al.* (1993) usability is a key component to define overall quality of computer of software system. Usability is also widely and mostly recognized as quality factor with its technical aspects. It is the field of human computer interaction (HCI) that provides theoretical background and proposes techniques for producing quality user interface. Usability can be also viewed as usefulness and ease of use of the system. Usability has several other aspects also, including interface design, functional design, data and metadata, and computer systems and networks (Arms 2000). Collectively these different usability aspects are of interest to software designers, developers and users to acquire usable system. Usability has been used so often in the different context that it may lose its precise meaning (Pack, 2003). Because of many aspects of usability, it is necessary to review different usability definitions and to analyze the comprehensive set of usability attributes that

constitute usability, so that a clear vision about usability can be obtained. Figure 1 represents a comprehensive view of usability from ISO model (ISO 9126, 1991).

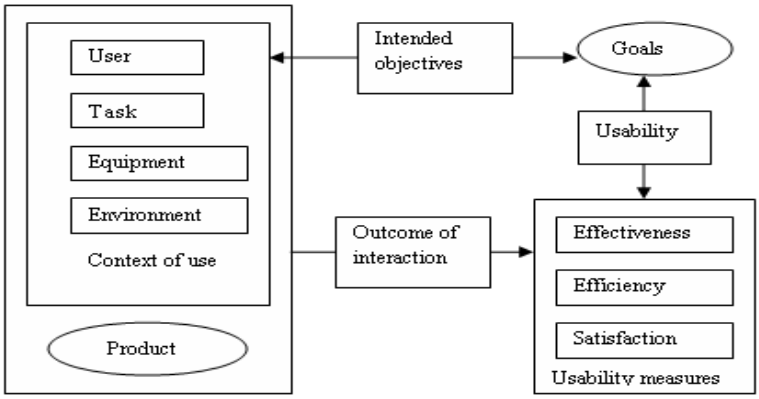

Figure 1: ISO diagram of usability (ISO 9126, 1991)

3. Literature Survey

Eason (1984) indicated that although the concept of usability had increasingly played an important role in human computer interaction, it had not been well-defined and there was no universally accepted definition of usability. According to Alred *et al.* (2003), clear and accurate definitions are critical. There are many different definitions of usability and its decomposition in different literatures, standards and models, which is described in following sub-sections.

3.1. Usability Definitions

Makoid *et al.* (1985) suggested that different definitions of usability may include different parameters such as user's satisfaction or type of errors. Butler (1985) suggested that a system is considered usable if the users can complete a given task within a predetermined amount of time. Reed (1986) defines usability as the ease with which a system can be learned and used. In same year, Shackel (1986) presented an operational definition of usability that allows a system to be evaluated throughout the development life cycle. He presented one of the most widely used definitions of usability. He suggests that a system is usable to the extent that it is effective, learnable, flexible and subjectively pleasing. Goodwin (1987) state that usability is not easily defined since it is affected by the types of tasks to be accomplished. Booth (1989) thought it is difficult to specify and measure the flexibility of a system and believed that being useful should be fundamental to usability, thus he modified Shackel's criteria into usefulness, effectiveness, learnability (or ease of use), and attitude (or likeability).

ISO 9126 (1991) contains 21 attributes, arranged in six areas: functionality, reliability, usability, efficiency, maintainability, and portability, from which usability attracted the attention of most researchers. A standard body, the Institute of Electrical and Electronics Engineers (IEEE), proposed definition for usability as: the ease with which a user can learn to operate, prepares inputs for, and interprets outputs of a system or component (IEEE std. 1061, 1992). Nielsen (1993) defines usability as containing at least the aspects of learnability, efficiency, memorability, error recovery and satisfaction. ISO 9126 (1991) and Nielsen (1993) mainly focused on the attributes that constitute usability while other definitions emphasize on how usability should be measured, e.g. (Bevan *et al.* 1991; ISO 9241-11, 1998). Dumas and Redish (1993) stated that usability means that the people who use the product can do so quickly and easily to accomplish their own tasks and focused on four main points: users, productivity, tasks, and ease of use. Rubin (1994) expressed that definition with one or more of the four components outlined by Booth (1989) are generally accepted by the usability community. He described that likeability is also an important attribute of usability which constitutes user's perceptions, feelings and opinion of product. ISO 9241-11 (1998) defines usability 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. Lecerof *et al.* (1998) provided usability definition by addressing relevance of a system to users' needs, efficiency, users' subjective feelings, learnability, and system's safety feature, such as granting users the right to undo actions that may lead to errors. Clairmont *et al.* (1999) stated that usability is the degree to which a user can successfully learn and use a product to achieve a goal. Head (1999) defined usability as a set of attributes that bear on the effort needed for use and on the individual assessment of such use, by a stated or implied set of users (ISO 9126-1, 2001). Campbell *et al.* (2003) explicitly stated that usability refers to the relationships between tools and their users. Krug (2006) looked at usability from the

user's perspective with the need for an intuitive experience. Seffah A. (2008) argued that there is a need to develop novel usability testing environments and methodologies because technical environments are evolving and the current labs are limited. Bevan N. (2009) argued that despite the authoritative nature of international standards for usability, many of them are not widely used. Gardner-Bonneau D. (2010) discussed that how much human factors and usability of system will be effective when there are more and more changes are in technological environment.

3.2. Usability Decomposition

Another major and important area of usability research focuses on attributes, principles, and features of usability. A model first used by McCall *et al.* (1977) which described usability as operability, training and communicativeness. Gould (1988) classified usability into system performance, system functions, user interface. Booth (1989) outlines that usability has four factors viz. usefulness, effectiveness, learnability, and attitude. Bevan *et al.* (1991) discussed that usability based on the product, the user, ease of use and acceptability of product for a particular class of users carry out specific tasks in a specific environment. In the FURPS quality model (Grady, 1992), usability include human factors, aesthetics, consistency in the user interface, online and context sensitive help, wizards and agents, user documentation, and training materials. IEEE Std. 1061 model (1992) suggested that usability depends on comprehensibility, ease of learning, and communicativeness factors. Hix and Hartson (1993) classified usability into performance, learnability, retainability, advanced feature usage, first impression, and long-term user satisfaction. Löwgren (1993) told that usability is a result of relevance, efficiency, learnability and attitude. There is a method Software Usability Measurement Inventory (SUMI), which also describes usability in terms of its attributes viz. efficiency, effectiveness, helpfulness, control and learnability (Porteous *et al.*, 1993). Lewis (1995) introduces Post Study System usability questionnaire (PSSUQ), which identify usability attributes in terms of three subscales viz. system usefulness, information quality, and interface quality. Thomas (1998) categories usability attributes into outcome, process, and task. Dix *et al.* (1998) represented usability of a system into three categories: learnability, flexibility, and robustness in their model.

Arms (2000) described that usability has several aspects, including interface design, functional design, data and metadata, and computer systems and networks. Frokjaer *et al.* (2000) argues that the components effectiveness, efficiency and satisfaction should be considered as separate and independent aspects of usability. In the ISO 9126-1 (2001) model usability was described as the combinations of understandability, learnability, operability, attractiveness and usability-compliance sub-characters. Donyaee *et al.* (2001) developed quality in use integrated measurement (QUIM) model. The attributes included in QUIM as effectiveness, efficiency, satisfaction, productivity, safety, internationality and accessibility. Battleson *et al.* (2001) suggested that to improve usability an interface must be easy to learn, remember, and use, with few errors for its target users and the specific tasks it is designed to support. Blandford *et al.* (2002) suggest that usability is technical, cognitive, social, and design-oriented and it is important to bring these different perspectives together. Brinck et. al. (2002) suggested that usability is: functionally correct, efficient to use, easy to learn, easy to remember, error tolerant, and subjectively pleasing. Bass *et al.* (2003) described that usable software systems may have qualities like modifiability, scalability, reusability, performance, security etc. Shneiderman *et al.* (2005) identified five usability measures as time to learn, speed of performance, rate of errors by users, retention over time, and subjective satisfaction. Majority of reviewed attributes can be also identified in the literature (e.g., Jeng, 2005). Seffah *et al.* (2006) developed a model of usability which incorporates more than 127 specific measures in 10 attributes. A latest review of usability measurement used in HCI research listed more than 54 kinds of measures (Hornbæk, 2006). Juristo *et al.* (2007) presented certain usability features by taking inspiration from number of real applications. Sauro *et al.* (2009) computed correlations from a database with prototypical usability attributes like task times, completion rates, errors, post task satisfaction, and post-test satisfaction from 90 distinct summative usability studies. The results of this study help to clarify the attributes that affect the correlation structure of usability studies. The summary of reviewed usability attributes are given in following table 1.

Table 1: Usability attributes in different standards, models and definitions

Source	Attributes
Arms (2000)	interface design, functional design, data and metadata, computer systems networks
Bass *et al.* (2003)	modifiability, scalability, reusability, performance, security
Battleson *et al.* (2001)	easy to learn, rememberability, few errors, support
Bevan *et al.* (1991)	product, user, ease of use, acceptability of product
Booth (1989)	usefulness, effectiveness, learnability, attitude

Source	Attributes
Brinck *et al.* (2002)	functionally correct, efficient to use, easy to learn, easy to remember, error tolerant, subjectively pleasing
Butler (1985)	task, predefined time
Campbell *et al.* (2003)	easy to learn, easy to use, easy to remember, error tolerant, subjectively pleasing
Constantine (1999)	learnability, efficiency in use, rememberability, reliability in use, user satisfaction
Dix *et al.* (1998)	learnability, flexibility, robustness
Donyaee *et al.* (2001)	effectiveness, efficiency, satisfaction, productivity, safety, internationality, accessibility
Dumas *et al.* (1993)	users, productivity, tasks, ease of use
Gluck (1997)	usableness, usefulness
Gould (1988)	system performance, system functions, user interface
Grady, 1992	human factors, aesthetics, consistency in the user interface, online and context sensitive help, wizards and agents, user documentation, training materials
Hix *et al.* (1993)	initial performance, long-term performance, learnability, retainability, advanced feature usage, first impression, long term user satisfaction
IEEE Std. 1061 (1992)	comprehensibility, ease of learning, communicativeness factors
ISO 9126-1 (2001)	understandability, learnability, operability, attractiveness, usability-compliance
ISO 9241-11 (1998)	efficiency, effectiveness, and satisfaction
Kengeri *et al.* (1999)	effectiveness, likeability, learnability, usefulness
Kim (2002) Delete it	interface effectiveness
Lecerof *et al.* (1998)	users' needs, efficiency, users' subjective feelings, learnability, system's safety
Lewis (1995)	system usefulness, information quality, interface quality
Löwgren (1993)	result of relevance, efficiency, learnability, attitude
Makoid *et al.* (1985)	user satisfaction, type of errors
McCall's (1977)	operability, training, communicativeness
Nielsen (1993)	learnability, efficiency, memorability, few errors, satisfaction
Oulanov (2002)	affect, efficiency, control, helpfulness, adaptability
Porteous *et al.* (1993)	efficiency, affect, helpfulness, control, learnability
Preece (1994)	learnability, throughput, attitude, flexibility
Reed (1986)	ease of learn, ease of use
Sauro *et al.* (2009)	task times, completion rates, errors, post task satisfaction, post-test satisfaction
Shackel (1981, 1986,1991)	ease of use, effectiveness, learnability, flexibility, user attitude
Shneiderman *et al.* (2005)	time to learn, speed of performance, rate of errors by users, retention over time, subjective satisfaction
Thomas (1998)	outcome, process, task
Wixon (1997)	learnability, efficiency, memorability, satisfaction , flexibility, first impressions, advanced feature usage, evolvability

4. Methodology

We believe that a more usable and more efficient software system is achieved by developers, who are working with a set of consistent guidelines based on a clearly defined concept of usability. We undertook our methodology to explore published definitions of usability. We searched a citation index database Scopus, for specific publications with usability definitions, published prior to 2010. We selected 63 titles under the Computer Science and Information Systems category. For the searches, each journal title was entered into the "source title" field for Scopus. In addition, we combined the title search with the phrase "usability definition and usability attributes" in the "titles, abstracts and keywords" option in Scopus. The searches retrieved a total of 234 records. Individually we looked through the 234 articles to identify formal definitions of 'usability'. From the articles that contain definitions cited from other sources, we located those cited sources and included them in the data set. In total, 37 formal usability definitions were compiled and constituted the core data for this work. The formal definitions from these publications were content analyzed. Initially, we individually extracted the key attributes from each definition and used them as our recording units. Then together we identified attributes' patterns among the attributes and grouped similar attributes into similar categories of usability attributes; for example, users and human factor were all placed in the 'users' category. The 37 formal definitions produced a total of 152 attribute, which fell under 22 categories.

5. Results and Discussion

This paper, discussed how the usability definitions and their attributes are evolved. During the decades, different literature described various definitions and attributes of usability. However, we found that the proposed definitions are informal, too brief and ambiguous. This paper reviewed total 152 attributes, as shown in table 1. Those attributes, which have frequency 2 or more, are represented in table 2. There are 22 such attributes and their total frequency is 128. Because the 24 attributes have only 1 frequency in the reviewed table, so we are not including name of such attributes individually, but giving collectively a name 'others' in the table 2. The analytical representation of all attributes is shown by graph in figure 2.

Table 2: Reviewed usability attributes and their frequency

Attribute	Frequency	Percentage
Advance Features	2	1.3
Communication	2	1.3
Effectiveness	9	5.9
Efficiency	13	8.6
Error	5	3.3
Error-Tolerance	2	1.4
First Impression	2	1.4
Flexibility	14	9.2
Functionality	4	2.6
Helpfulness	4	2.6
Interface Design	4	2.6
Learnability	20	13.2
Memorability	8	5.3
Operability	2	1.3
Productivity	3	2.0
Safety	3	2.0
Satisfaction	17	11.1
Task	4	2.6
Training	2	1.3
Usefulness	4	2.6
User	4	2.6
Others	24	15.8
Total	152	100.0

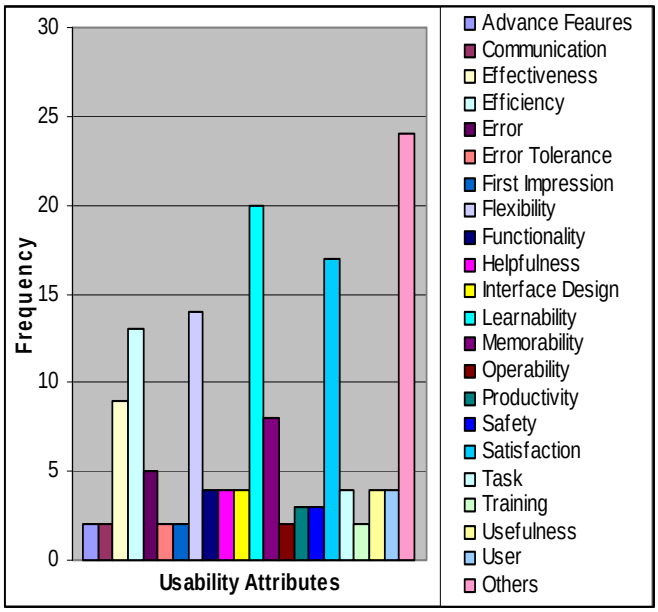

Figure 2: Analytical view of usability attributes

6. Conclusion and Future Scope

This paper believe that since different users have different priorities during the usage of system, therefore, we need to consider final usability attributes to decide whether the particular software system being developed is acceptable overall or not by them. For system designers, developers and users, this paper provides a detailed analytical comparison of the various attributes, to achieve a more thorough view of the usability strengths and weaknesses. So they can get help in decision making and avoid costly mistakes when choosing software systems and/or applications. The attributes learnability, satisfaction, flexibility efficiency, effectiveness and memorability have more impact on usability of software system. Therefore this paper recommends a combination of these attributes into consideration of usability decision making for software system. In future, research will be to model the relationship among usability attributes and its impact on usability of system in different environment. For example, software system may be use in technical environment or in social environment, and then different usability attributes may have different impact on the system.

7. References

[1] Abran, A., Khelifi, A. and Suryn W. (2003): Usability meanings and interpretations in ISO standards, Software Quality Journal, Vol. 11, pp. 325–338.
[2] Alred, G. J., Brusaw, C.T., and Oliu, W.E. (2003): Business writer's handbook, 7th edition, Macmillan, NY.
[3] Arms, William Y. (2000): Digital libraries, Cambridge, Massachusetts, MIT Press.

[4] Bass, L. and John, B. E. (2003): Linking usability to software architecture patterns through general scenarios, Journal of Systems and Software, Vol. 66(3), pp. 187-197.
[5] Battleson, B., Booth, A., & Weintrop, J. (2001): Usability testing of an academic library Web site: A case study, The Journal of Academic Librarianship, Vol. 27(3), pp. 188-198.
[6] Bevan N. (2009): International Standards for Usability Should Be More Widely Used, Journal of Usability Studies, Vol. 4(3), pp. 106-113.
[7] Bevan, N., Kirakowaski, J. and Maisal, J. (1991): Proceeding of 4th International Conference on HCI, Stuttgart.
[8] Blandford, A., and Buchanan G. (2002): Usability for digital libraries, Proceedings of the Second ACM/IEEE-CS Joint Conference on Digital Libraries, 424, New York, ACM Press.
[9] Booth, P. (1989): An introduction to human-computer interaction. Hillsdale, USA, Lawrence Erlbaum Associates Publishers.
[10] Brinck, T., Gergle D. and Wood S. D. (2002): Designing Web sites that work: Usability for the Web, San Francisco, Morgan Kaufmann.
[11] Butler, K. (1985): Connecting Theory and Practice: A Case Study of Achieving Usability Goals, In Proceedings of CHI 85, ACM, New York, pp. 85-88.
[12] Campbell, K., and Aucoin, R. (2003): Value-based design of learning portals as new academic spaces, In: Jafari, A. and M. Sheehan (Eds.), Designing Portals: Opportunities and Challenges, Hershey, PA, IRM Press, pp. 162–185
[13] Clairmont, M., Dickstein R. and Mills V. (1999): Testing of usability in the design of a new information gateway. http://www.library.arizona.edu/library/teams/access9798 (accessed July 7, 2010).
[14] Constantine, L. and Lockwood. L. A. D. (1999): Software for Use: A Practical Guide to the Models and Methods of Usage-Centered Design, Addison-Wesley, New York, NY.
[15] Dix, A., Finley, J., Abowd, G. and Beale, R. (1998): Human-Computer Interaction, 2nd edition, Prentice-Hall.
[16] Donyaee, M. and Seffah, A. (2001): QUIM: An Integrated Model for Specifying and Measuring Quality in Use, Eighth IFIP Conference on Human Computer Interaction, Tokyo, Japan.
[17] Dumas, Joseph. S. and Redish Janice C. (1993): A practical guide to usability testing, Norwood, NJ, Ablex Publishing Co.
[18] Eason (1984): Towards the experimental study of usability, Behaviour and Information Technology, Vol. 3(2), pp. 133-143.
[19] Frojkaer, E., Hertzum, M. and Hornbaek, K. (2000): Measuring Usability: Are Effectiveness, Efficiency, and Satisfaction Really Correlated, In CHI'00, New York, ACM Press, pp. 345-352.
[20] Gardner-Bonneau, D. (2010): Is Technology Becoming More Usable or Less and With What Consequences, Journal of Usability Studies, Vol. 5(2), pp. 46-49.
[21] Gluck, M. (1997): A descriptive study of the usability of geospatial metadata, Annual Review of OCLC Research. http://www.oclc.org/research/ publications/arr/1997/gluck/gluck_frameset.htm
[22] Goodwin, N. (1987): Functionality and Usability, In Communications of the ACM, Vol. 30(3), pp. 229-233.
[23] Gould, J. D. (1988): How to design usable systems, In Handbook of Human Computer Interaction, ed. Martin Helander, New York, Elsevier, pp. 757–89
[24] Grady, R. B. (1992): Practical Software Metrics for Project Management and Process Improvement, Prentice Hall, Englewood Cliffs, NJ, USA.
[25] Head, A. (1999): Web redemption and the promise of usability, Online, Vol. 23(6), pp. 20-32.
[26] Hix, D. and Hartson H. R. (1993): Developing user interfaces: Ensuring usability through product & process. New York, John Wiley.
[27] Holocomb, R. and Tharp A. (1991): Users, a software usability model and product evaluation, Interacting with computers, Butterworth-Heinemann, Oxford, UK, Vol. 3(2), pp. 155-166.
[28] Hornbæk, K. (2006): Current Practice in Measuring Usability: Challenges to Usability Studies and Research, International Journal of Human-Computer Studies, Vol. 64 (2), pp. 79-102.
[29] IEEE Std. 1061. (1992): IEEE standard for a software quality metrics methodology, New York, IEEE Computer Society Press.
[30] ISO 9126 (1991): Information Technology-Software Product Evaluation-Quality Characteristics and Guidelines for their Use. Geneva.
[31] ISO 9126-1(2001): Software engineering- Product Quality – Part 1, Quality model.
[32] ISO 9241-11 (1998): Ergonomic requirements for office work with visual display terminals (VDTs) Part 11: Guidance on usability.
[33] Jeng, J. (2005): What is usability in the context of the digital library and how can it be measured, Information Technology and Libraries, Vol. 24(2), pp. 47-56.
[34] Juristo, N., Moreno, A.M. and Sanchez-Sequra, M-I (2007): Analyzing the Impact of Usability on Software Design, The Journal of Systems and Software, pp. 1506-1516.
[35] Kengeri, Rekha, Cheryl D. Seals, Hope D. Harley, Himabindu P. Reddy, and Edward A. Fox. (1999): Usability study of digital libraries: ACM, IEEE-CS, NCSTRL, NDLTD, International Journal on Digital Libraries, Vol. 2, pp. 157–69.
[36] Kim, K. (2002): A model of digital library information seeking process (DLISP model) as a frame for classifying usability problems, Ph.D. dissertation, Rutgers University.
[37] Krug, S. (2006): Don't make me think: A common sense approach to Web usability, Berkeley, CA, New Riders Publishing.
[38] Lecerof, A., & Paterno, F. (1998): Automatic Support for Usability Evaluation, IEEE Transactions on Software Engineering, 24(10), pp. 863-888.
[39] Lewis, J. R. (1995): IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use, International Journal of Human Computer Interaction, Vol. 7, No. 1, pp 57-78.
[40] Löwgren, J. (1993): Human-computer interaction, Student literature, Lund, Sweden.
[41] Makoid, L., Forte, C., and Perry, J. (1985): An Empirical Model for Usability Evaluation Based on the Dynamics of the Human-Computer Interface, Technical Report TR-85-15, North Carolina State University.
[42] McCall, J. A., Richards, P. K. and Walters, G. F. (1977): Factors in Software Quality, Springfield, VA, National Technical Information Service.
[43] Nielsen, J. (1993): Usability Engineering, Academic Press.
[44] Oulanov, A. and Edmund F. Y. P. (2002): CUNY+ Web: Usability study of the Web-based GUI version of the bibliographic database of the City University of New York (CUNY), The Electronic Library, Vol. 20 (6), pp. 481–87.
[45] Pack, T. (2003): Fiddling with the Internet dials: Understanding usability, Online, 27 (2), pp. 36-38.
[46] Porteous, M., Kirakowsky, J. & Corbett, M. (1993): SUMI user handbook, Human Factors Research Group, University College Cork.
[47] Preece, J. Y. Rogers, H. Sharp, D. Benyon, S. Holland, T. Carey, Human-Computer Interaction, Addison Wesley, 1994.
[48] Reed, P. (1986): Usability Testing in the Real World. In Proceedings of CHI 86, ACM, Boston, 212.
[49] Rubin, J. (1994): Handbook of usability testing: How to plan, design, and conduct effective tests, New York, Wiley.

[50] Sauro, J. & Lewis J.R. (2009): Correlations among Prototypical Usability Metrics: Evidence for the Construct of Usability, proceedings of the conference in Human Factors in Computing Systems (CHI 2009) Boston, MA.
[51] Seffah, A. (2008): A Low-Cost Test Environment for Usability Studies of Head-Mounted Virtual Reality Systems, Journal of Usability Studies, Vol. 3, No. 2, pp. 60-73.
[52] Seffah, A., Donyaee, M., Kline, R.B. and Padda, H.K. (2006): Usability measurement and metrics: A consolidated model, Software Quality Control, Vol. 14, No. 2, pp. 159–178.
[53] Shackel, B. (1981): The concept of usability. Proceedings of IBM Software and Information Usability Symposium, Poughkeepsie, NY, September 15–18, 1–30; and in J. L. Bennett, D. Case, J. Sandelin, and M. Smith eds. 1984. Visual Display Terminals: Usability Issues and Health Concerns, Englewood Cliffs, NJ: Prentice-Hall, pp. 45–88.
[54] Shackel, B. (1986): Ergonomics in design for usability. In Harrison, M. D. and Monk, A. F., editors, People and computers, Proc. second conf. of the BCS HCI specialist group, pp. 45–64, Cambridge, Cambridge University Press.
[55] Shackel, B. (1991): Usability – Context, framework, definition, design and evaluation. In Human Factors for Informatics Usability, ed. Brian Shackel and Simon J. Richardson, 21–37. New York, Cambridge University Press.
[56] Shneiderman, B. and Plaisant, C. (2005): Designing the User Interface: Strategies for Effective Human-Computer Interaction, Addison Wesley, Boston, MA.
[57] Wixon, D. and Wilson C. (1997): The usability Engineering Framework for Product Design and Evaluation, Handbook of Human-Computer Interaction, pp. 653-688, Edited by M. G. Helander *et al*.