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Usability Definitions in a Dynamically Changing Information Environment

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abstract: The authors compared Web usability definitions, collected from library professionals at academic institutions of the Association of Research Libraries (ARL) through online surveys in 2007 and 2012, to determine whether library practitioners' perspectives had altered as information technologies evolved during this time. The authors applied three techniques of statistical data analysis— *t*-tests, cluster analyses, and the Mantel test—for comparisons. The results indicated significant increased emphases on the *Interface/Design* and *Effectiveness* attributes in the 2012 data set. This increase may be due to the rise in the use of mobile devices for information access, driving practitioners to place a stronger emphasis on these attributes.

Introduction

Over the last several decades, the proliferation of digital devices has reached almost every aspect of life, and members of almost every age group use these technologies heavily for work, education, and entertainment. Technological innovations have appeared at an exponential rate.[1] In addition, users increasingly access information via smaller technology devices, such as mobile phones and tablets. Due to the ubiquity of mobile devices, increased conversation about these new technologies has emerged in the library literature. The authors supported this observation by searching the *Library, Information Science & Technology Abstracts* (*LISTA*) database for the subjects *mobile application** or *mobile device** or *mobile technolog** or *cell* phone** or *smart phone** or *ipad** or *mobile phone** or *iphone** or *smart device** or *mobile application** or *handheld device** or *cellular phone**. Table 1 illustrates the trend in annual publication numbers on this topic indexed in *LISTA* from 2007 to 2012.

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Table 1.
Number of publications on mobile devices by year

Year	2007	2008	2009	2010	2011	2012
Number of publications	84	103	141	273	353	471

Issues relating to interface design are also changing at a staggering pace.[2] The introduction of novel devices, such as smartphones and tablets, has added a new dimension to interface design approaches and navigability.[3] Unlike personal computers or laptop monitors, which average between fifteen and nineteen inches, these smaller units have screens between two and eight inches. Libraries need to be particularly cognizant of the advantages and disadvantages of providing access to resources and services through devices with smaller screens.[4]

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As mobile phones and other handheld devices change and evolve, there is a need for usability experts to update, test, and revisit the standards set for these tools.[5] Design becomes a crucial component to provide the user with a quality experience across platforms. Limited space, in particular, necessitates different design strategies and compromises navigation, text input, and reading capabilities.[6]

With the changes in technologies, one would expect the definition of *Web usability* (hereafter referred to as *usability*) to take on new or additional meanings, or both. A succinct, authoritative definition of the usability construct will enable the production of robust systems.[7] In technical writing, it is imperative that the writer use clear and accurate definitions so that the reader can understand a product or product design.[8] Clarity with defining concepts and terms of a product is essential for identifying basic qualities.[9]

Initial research has been conducted in determining the comprehensiveness of usability definitions in library and information science. In a 2009 study, Yu-Hui Chen, Carol Anne Germain, and Abebe Rorissa undertook an analysis of usability definitions in the formally published literature of information science and computer science.[10] They expanded upon this research by comparing attributes emphasized in usability definitions found in the literature and those provided by library professionals at academic institutions of the Association of Research Libraries (ARL). The authors further analyzed the attributes by applying information behavior models, human-computer interaction (HCI), and usability frameworks. The results showed that formally published defini-

tions concentrated more on users, tasks, and environment, whereas library professionals focused more on content/resources and the system/technology. Based on the varying attributes derived from the study and the theoretical frameworks, the authors took a holistic approach and proposed a working definition of *usability*:

> Usability means that a system has visible working functionality familiar to its users, maximum reliability, and useful content that is supported by its environment and aligned with context of use. In addition, a usable system accommodates the cognitive capacity and various needs of its users, so that they can easily understand, effortlessly learn, and dynamically interact with the system as well as its content, resulting in a satisfactory experience with a high level of productivity.[11]

As noted earlier, information technologies have grown rapidly; one would expect that the value of usability would increase accordingly. The authors thought that practitioners would be more aware of the aspects and variables of usability, and that their definitions would reflect a more all-encompassing, holistic view. To determine whether there were changes in the way library practitioners define *usability*, the authors initiated the current study. At the end of 2011 and the beginning of 2012, they followed up with the library professionals at ARL academic institutions through an online questionnaire, which included the same open-ended question as in their 2007 survey asking for the participants' definitions of *usability*.[12] Following the research methods applied to their previous study, the authors compared the 2012 survey results with the earlier responses recorded in 2007.[13] The goal of this study is to examine whether there were discrepancies between the two data sets using the same information behavior models, as well as HCI and usability frameworks as theoretical foundations. Based on the findings, the authors explored whether a more holistic approach has emerged in how practitioners define *usability*. A broad, holistic view of usability will inform Web designers and developers of important considerations for the design process.

Literature Review

Usability plays a pivotal role in HCI, and it has gained significantly more attention after 1998 in the fields of computer science-information systems as well as library and information sciences.[14] Because usability is a multifaceted construct, researchers have defined *usability* from various perspectives. Seeing that usability is rooted in cognitive science, Philip Barnard, Nick Hammond, John Morton, John Brian Long, and I. A. Clark focused on users' cognitive aspects and mental models, suggesting that "to be truly 'usable,' a system must be compatible not only with the characteristics of human perception and action but, and more critically, also with users' cognitive skills in communication, understanding, memory and problem solving."[15] Following this thread, Alison Head defined usability as "how people perceive and process information through learning, the use of memory, and attention."[16] Nancy Goodwin and Raquel Benbunan-Fich indicated that usability involves the features of a website that impact the cognitive dimensions of its users when they interact with the site.[17] Benbunan-Fich further expressed the value of alignment between a system and a user's mental models for clear communication.[18]

Researchers in the field of usability engineering tend to define *usability* by enumerating measurable properties of this construct. Brian Shackel and Paul Booth considered usability from the perspectives of ease of use and task performance.[19] Shackel recognized the importance of system evaluation throughout the development life cycle and proposed that a usable system that allows its users to accomplish their tasks must meet the criteria of effectiveness, learnability, flexibility, and attitude. With the popularity of mobile technologies, it is especially important for a Web-based information system to be flexible, so it can offer its users multiple access points, platform compatibility, and ease of control. In addition to Shackel's operational viewpoint, Booth considered usefulness as fundamental to usability. Booth's notion of usefulness addressed the issue of meeting users' needs, which was echoed in the approach called *user-centered design* (UCD) advocated by Jeffrey Rubin.[20] Joseph Dumas and Janice Redish referred to usability as existing when "the people who use the product can do so quickly and easily to accomplish their own tasks."[21] Users, productivity, tasks, and ease of use are the focal points in their definition. Jakob Nielsen stressed that usability is a multidimensional concept that consists of five major quality components: easy to learn, efficient to use, easy to remember, low error rate, and user satisfaction.[22] Nielsen emphasized memorability, which related to the cognitive aspects mentioned by Barnard and his coauthors,[23] and highlighted error tolerance, an element that some authors neglected.

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Some researchers focused on the relationships between users and the Web technologies they utilize. Andreas Lecerof and Fabio Paternò's definition addressed the relevance of a system to the users' needs, efficiency, users' subjective feelings, learnability, and a system's safety features—for example, allowing users to undo previous actions to prevent potential errors.[24] Whitney Quesenbery accentuated user experience and affect by including engagement and pleasure in the contexts of information-seeking and online services.[25]

Many experts also regard information organization and structure as crucial usability elements. Jonathan Palmer emphasized website consistency, ease of reading, information organization, speed, and layout.[26] Steve Krug considered Web usability as intuitive websites through which most users can locate needed information without a struggle.[27] Krug's concept of intuitiveness stressed Jef Raskin's idea that familiarity is essential in designing Web-based information space.[28] Additionally, some researchers considered content as a core component of Web usability, asserting that a usable site should help its users successfully find, understand, and utilize needed information.[29] In this regard, both well-designed information architecture and useful information are critical dimensions of usability.

When researchers define *usability*, they have also taken into consideration the environment in which a particular system is used as well as the nature of tasks undertaken to achieve a user's goals. Shackel and other researchers emphasized the need to take

environment into account in relation to user support in fulfilling a specified range of tasks.[30] The definition put forth by the International Organization for Standardization (ISO) also addressed the element of environment, in addition to task performance and measurable attributes. ISO standard 9241-11 referred to 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."[31]

In a digital environment, information gathering involves interaction between human and information systems. This process encompasses interplay among a user's cognitive space, information objects, and the information retrieval system.[32] Additionally, this dynamic interaction includes a specific information environment. When a user engages with information, a cognitive process occurs. Informed by definitions and concepts in HCI research, Tefko Saracevic developed the stratified interactive information retrieval model in which "users (with a host of variables of their own) are related to a situation (task, problem-at-hand) within an environment, each having a number of characteristics and dynamics."[33]

Others have also introduced information-seeking models, including Nicholas Belkin's episode model, which consists of three components: the end user, the information objects, and intermediaries (such as humans, tools, or both) that facilitate the interaction between the user and the information objects. According to Belkin, the nature of interaction is subject to the user's goals, problems, and circumstances.[34] Another information-seeking behavior model proposed by Tom Wilson asserted the interrelation among cognitive, physiological, and affective needs. His model highlighted the environment factor, focusing on work, sociocultural, politico-economic, and physical aspects. Wilson noted that a user's social role in tandem with the environment would impact the user's needs.[35]

The models mentioned here are distinct in their perspectives on information behavior or the information-seeking process. Yet each reflects the constructs found in Shackel's usability framework, a model influenced by the HCI approaches of John Bennett and Ken Eason.[36] Shackel's usability model depicted the dynamic relationship of four key elements: user, task, tool, and environment. He emphasized that usability depends on the design of the information system and its respective users, tasks, and environments. Ping Zhang and Dennis Galletta highlighted similar aspects in their HCI framework, including human, technology, interaction, task, and context.[37] They indicated that humans use technology to complete tasks related to their work or personal lives based on specific settings or contexts. It is imperative to understand and respond to the complex interaction between humans and technology to achieve positive influences and outcome on system designs and usability issues.

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Chen, Germain, and Rorissa utilized those frameworks, in conjunction with analyzing *usability* definitions formally published in the literature of computer and information science and those provided by ARL library practitioners, to determine the characteristics

of those *usability* definitions. Based on the results, they proposed a working definition as presented in the introduction. This definition presents a holistic view by integrating the system, user, context, and user performance perspectives mentioned earlier. These elements are essential components contained in major behavioral models for information-seeking and also reflect key aspects of the human-computer interaction framework set forth by Shackel.[38]

Methods

Participants

For this study, the authors' goal was to explore changes over time in how *usability* is defined by library practitioners responsible for overseeing their libraries' Web portals. The authors compared the definitions provided by library practitioners of the academic members of ARL from a 2007 online questionnaire and a follow-up 2012 survey. The question about defining *usability* was identical in both instruments: "Please define Web usability in your own words." At the close of the 2007 survey, 67 (59 percent) participants answered this open-ended question. For the 2012 survey, 61 (54 percent) participants responded. Of the 61 ARL academic institutions that participated in the 2012 study, 37 also completed the 2007 questionnaire.

Content Analysis

In examining the 2007 data set, the authors applied Robert Philip Weber's standard content analysis procedures to analyze the definitions.[39] From this process, the authors identified concepts drawn from the key terms in each definition to form categories of usability attributes. For example, they categorized the terms *quickly*, *speed*, and *number of clicks* as *Efficiency*. The 67 definitions produced 445 terms. These terms could be grouped into eleven attribute categories, nine of which have been documented in the literature.[40] Several of these attributes, including *Memorability/Retainability*, *Low error rate/Error tolerance*, *Efficiency*, and *Interface/Design*, mirror Nielsen's usability heuristics: minimize user memory load, prevent errors, provide shortcuts, and have a consistent presentation, respectively.[41] The authors created two of the eleven attributes based on the content analysis: *User characteristics* (referring to type of user, level or experience of user, and demographic information) and *Context/Purpose* (referring to context in use, environment, and purpose of use). Table 2 lists the eleven attributes that served as part of the coding scheme. For the 2012 data set, the authors followed the same procedures, and the 61 definitions yielded 561 terms.

In the same manner that the 2007 data set was coded, all three authors coded the 561 terms in the 2012 data set in its entirety. The authors discussed any coding discrepancies until they reached 100 percent agreement. To ascertain coding reliability, the percentage of agreement was used to compare the authors' coding results and those of a graduate student blind to the purposes of this study. The computed value of this measure was above the often-cited threshold of 0.70.[42] Hence, the coding was deemed to be reliable.

Table 2.
The eleven attributes of usability

Attribute	Description
Attitude/Satisfaction	The system is pleasant to use so that users are subjectively satisfied when using it and like it.
Context/ Purpose	The system is supported by the environment within which it exists and aligns with the users' context and purpose for using it.
Control/ Flexibility	The system allows users to manipulate, adapt, customize, personalize, and access, using various devices and means; and it is compatible with varying applications.
Effectiveness	The system is functionally correct and helpful, allowing users to perform their tasks and achieve their goals.
Efficiency	The system is efficient to use so that once the user has learned the system, a high level of productivity is possible.
Interface/ Design	The system or website interface has an attractive and functional technical and visual design, including its design elements (for example, color, font, and images or icons), design consistency, navigation (its breadth and depth), information architecture, and task flow.
Learnability	The system is easy to learn, easy to use, and intuitive so that its user can rapidly start getting work done.
Low error rate/ Error tolerance	The system has a low error rate, so that users make few catastrophic errors during use, and if they do make errors, they can easily recover from them.
Memorability/ Retainability	The system is easy to remember so that the casual user can return to the system after not using it for some time without having to learn everything all over again.
Usefulness	Users find the content or information useful for their needs and tasks.
User characteristics	The system addresses users' cognition, information processing, mental model, level of knowledge or skill (novice, infrequent, advanced, or experienced), and demographic characteristics.

Statistical Analysis

To examine the distribution and percentage of the eleven attributes, the authors conducted a chi-square (χ^2) analysis to determine if the usability attributes emphasized in definitions and library ranking were dependent. Chi-square tests are a statistical technique used to compare observed data with the results expected. The larger the chi-square value, the

greater the probability that there is a significant difference. Then the authors applied hierarchical cluster analyses, first classifying observations to put similar ones into clusters, then arranging the clusters in a hierarchy, so that each cluster was more related to the ones nearby than to clusters farther away. To identify the differences and similarities between the two sets of definitions, the authors used three main statistical techniques to identify the differences and similarities between the two sets of definitions: the average linkage scheme, in which the distance between any two clusters is the average distance between elements of each cluster; chi-square (χ^2) analyses; and *t*-tests, a method of assessing the statistical significance of data.[43] Additionally, the authors examined if the 2012 survey participants took a more all-encompassing or holistic approach to defining *usability* by including more distinct attributes using a chi-square (χ^2) analysis.

To assess the holistic nature of definitions provided by the practitioners, the authors examined the similarities or differences between the tree diagrams for the eleven attributes— that is, treelike, branching diagrams representing hierarchies of categories based on their degree of similarity. The tree diagrams resulted from cluster analyses. For both groups of definitions, the authors applied the Mantel test, an analysis of the correlation between two sets of data, laid out in table form, using dissimilarity matrices, patterns that express the differences between the two data sets, with 10,000 randomizations. The authors used zt software, a free software tool that performs simple and partial Mantel tests.[44] The analysis requires the computation of several values of the Mantel test statistic, through multiple randomizations. In this way, the analysis tests whether the observed correlation, the extent to which two or more variables fluctuate together—or its corresponding Z-value, a measure of how far the score diverges from the most probable result—is significantly different from a random correlation (or from its Z-value).[45]

Human information interactions and usability involve some, if not all, of these five components: user, task, system, environment, and content.

To anchor our analyses in a more multidisciplinary theoretical framework, the authors categorized the eleven attributes into five broad categories or focal points (Table 3). Specifically, we utilized frameworks and models from a wide array of disciplines such as usability, HCI, and information behavior.[46] Although the emphasis of each framework and model differs slightly from the others, there is a common thread. That shared thread is that human information interactions and usability involve some, if not all, of these five components: user, task, system, environment, and content.

Results

As indicated earlier, the main goal of our current work was to compare the attributes of *Web usability* definitions as they evolve over time. Figure 1 presents the summary of the comparison of the eleven attributes between the 2007 and 2012 sets of definitions. Results from the 2007 survey revealed that the three most emphasized attributes were *User characteristics* (21.12 percent), *Learnability* (20.22 percent), and *Effectiveness* (15.51 percent). The top three most-emphasized attributes in 2012 were *Interface/Design* (23.35

Table 3.

Five focal points derived from widely accepted theoretical frameworks and models

Focal point	Attribute(s)
People / users	*User characteristics, Attitude/Satisfaction*
Tasks	*Effectiveness, Efficiency*
System / technology	*Learnability, Memorability/Retainability, Low error rate/Error tolerance, Interface/Design, Control/Flexibility*
Environment	*Context/Purpose*
Information objects / content / resources	*Usefulness*

percent), *Effectiveness* (17.83 percent), and *User characteristics* (17.65 percent). While both *User characteristics* and *Effectiveness* remained in the top three in the results for both sets of definitions, the order changed over the years. Even though *Learnability* (14.8 percent) fell from the top three in the 2012 survey responses, it came in a close fourth. Both *Low error rate/Error tolerance* (0.67 percent in 2007 and 1.25 percent in 2012) and *Memorability/Retainability* (0.67 percent in 2007 and 0.53 percent in 2012) were the two least-mentioned attributes by the participants in the 2007 and 2012 surveys.

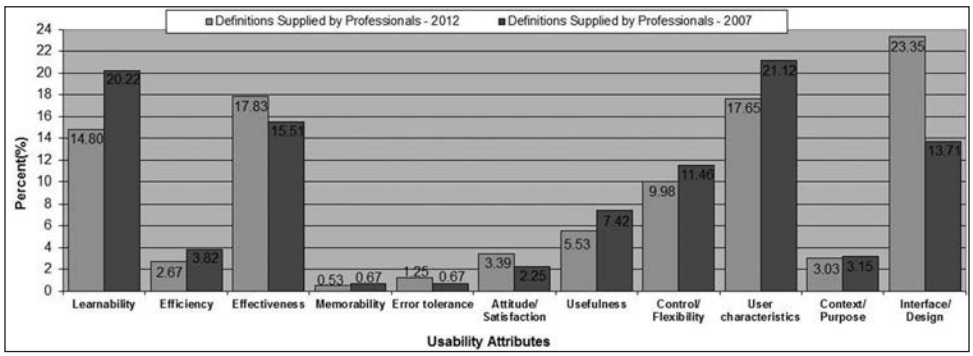

Figure 1. Percentage of terms used in definitions by usability attributes (2012 and 2007)

The top five attributes emphasized in 2007 and 2012 shared the same set of attributes, albeit with *Interface/Design* and *Effectiveness* attributes ranking higher in the list, while *User characteristics* and *Learnability* moved downward (Table 4).

Table 4.
The five most frequently mentioned attributes

2007	2012
1. *User characteristics*	1. *Interface/Design*
2. *Learnability*	2. *Effectiveness*
3. *Effectiveness*	3. *User characteristics*
4. *Interface/Design*	4. *Learnability*
5. *Control/Flexibility*	5. *Control/Flexibility*

To parse the results further, the authors analyzed the differences and similarities between the two sets of definitions using chi-square (χ^2) analyses and overlapping samples *t*-tests, a statistical analysis used when there are paired samples with data missing in one or the other sample.

All the key conditions for both tests were met. With respect to the chi-square test, only 13.64 percent (the recommended threshold is 20 percent) of the individual expected frequencies in the eleven attributes data set were lower than 5, and none were lower than 1. In regard to the five-category distribution, none of the expected frequencies were less than 5. For the overlapping samples *t*-test, assumptions regarding variability and sample size were met as well.[47]

Results of the chi-square analysis of the eleven attributes showed that a general shift had occurred over the five-year period. The results also indicated that usability definitions by library professionals and time are dependent: $\chi^2 = 23.66$; df (degrees of freedom, the number of pieces of information or values that are free to vary) = 10; and $p < 0.01$. That is, for the terms used in the definitions, professionals from the two samples emphasized different sets of usability attributes. On the face of it, results from the *t*-test of mean differences among the usability attributes showed only two attributes (*Interface/Design* and *Effectiveness*) with statistically significant differences between the two samples (Table 5). The largest mean difference occurred with the *Interface/Design* attribute (0.91 in 2007 versus 2.15 in 2012, an increase of about 136 percent).

When analyzing the 2007 data in their prior study, the authors found little evidence of a holistic approach to defining *usability*. To compare the scope of the 2007 and 2012 definitions, the authors analyzed the number and percentage of definitions and the number of distinct attributes within each definition. The percentage of the definitions in the 2012 data set indicates similar patterns to those of the 2007 data set, with more than 50 percent of the definitions containing four or fewer distinct attributes. The result of chi-square analysis showed no difference in terms of the level of holistic nature.

With respect to the five categories, Figure 2 is a depiction of the distribution of terms used in the definitions categorized by the five broad focal points. As observed in Table

Table 5.

Mean and standard deviation of number of terms from both sets of definitions by attribute

Usability attribute	2007 (N = 67) Mean	2007 (N = 67) Standard deviation	2012 (N = 61) Mean	2012 (N = 61) Standard deviation	*t*	Significance*
Attitude/Satisfaction	0.15	0.50	0.31	0.62	1.62	0.11
Context/Purpose	0.21	0.62	0.28	0.61	0.64	0.52
Control/Flexibility	0.76	0.99	0.92	1.31	0.76	0.45
Effectiveness	1.03	1.10	1.64	1.77	2.30	0.02‡
Efficiency	0.25	0.50	0.25	0.54	0.08	0.93
Interface/Design	0.91	1.37	2.15	2.80	3.09	0.00†
Learnability	1.34	1.53	1.36	1.35	0.07	0.95
Low error rate/ Error tolerance	0.04	0.27	0.11	0.41	1.12	0.26
Memorability/ Retainability	0.04	0.21	0.05	0.22	0.12	0.91
Usefulness	0.49	0.89	0.51	1.03	0.09	0.93
User characteristics	1.40	1.37	1.62	1.55	0.85	0.40

*Two-tailed. †$p < 0.01$, ‡ $p < 0.05$

7, only the categories of *Tasks* (t [126] = 2.06, $p = 0.04$) and *System/Technology* (t [126] = 2.43, $p = 0.02$) showed statistically significant differences, with about one and a half (1.47) more terms related to *System/Technology* supplied, on average, as part of the definitions in 2012 than in 2007. In other words, the 2012 participants used more language having to do with *System/Technology* than participants in 2007.

Similar to the analyses of the 2007 data set, the authors explored attributes emphasized by the practitioners based on the ARL ranking. Table 8 summarizes percentages of terms used in the definitions provided in 2007 and 2012, respectively, by usability attributes and grouped according to the ARL academic library ranking of their parent institutions. The three groups were Tier I libraries (ranked 1 through 38), Tier II (ranked 39 through 76), and Tier III (ranked 77 through 114). This breakdown does not seem to affect the order of the usability attributes emphasized by the participants from all three

Table 6.

Distribution of definitions by number of distinct attributes contained in each definition

Number of distinct attributes	2007 Number of definitions	2007 %	2012 Number of definitions	2012 %
1	1	1.5	6	9.5
2	11	16.4	4	6.3
3	16	23.9	12	19
4	17	25.4	13	20.6
5	10	14.9	12	19
6	7	10.4	9	14.3
7	5	7.5	4	6.3
8	0	0	2	3.2
9	0	0	1	1.6
10	0	0	0	0
11	0	0	0	0

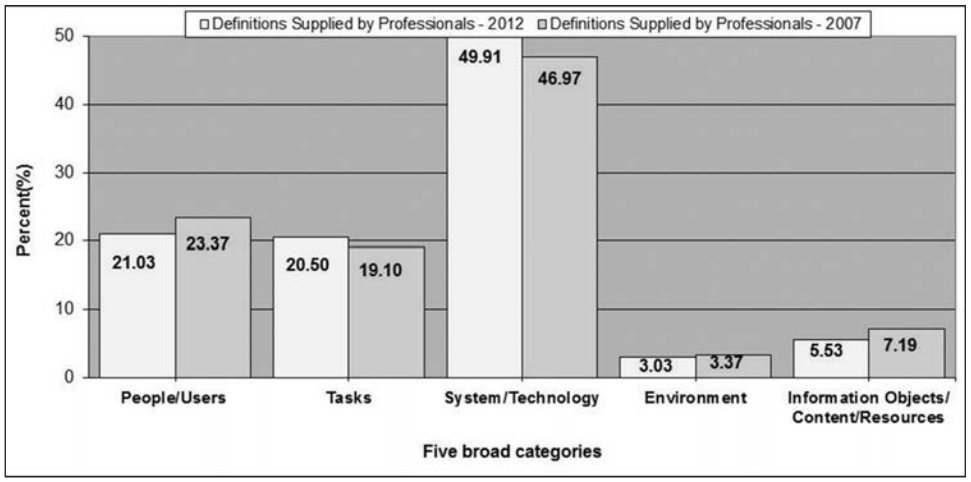

Figure 2. Percentage of terms used in definitions by the five broad categories (2012 and 2007)

Table 7.

Mean and standard deviation of number of terms from both sets of definitions by five categories

Five focal points/ categories	2007 (N = 67) Mean	2007 (N = 67) Standard deviation	2012 (N = 61) Mean	2012 (N = 61) Standard deviation	*t*-test	Significance*
People/Users	1.55	1.48	1.93	1.77	1.32	0.19
Tasks	1.27	1.35	1.89	1.94	2.06	0.04†
System/Technology	3.12	2.51	4.59	4.06	2.43	0.02†
Environment	0.22	0.62	0.28	0.61	0.50	0.62
Information objects/ Content/Resources	0.48	0.89	0.51	1.03	0.18	0.86

*Two-tailed. † $p < 0.05$

tiers of institutions as well as both samples. *Learnability* and *Effectiveness* were two of the top three attributes mentioned in the 2007 survey for all three groups of libraries. *Interface/Design* and *User characteristics* topped the lists of two out of the three groups in the 2012 survey. *Memorability/Retainability* and *Low error rate/Error tolerance* were among the consistently less-emphasized attributes by participants from both samples and all three groups of libraries.

The authors compared the mean number of terms from both data sets by attribute from the three tiers and found mixed results. In 2012, practitioners from two of the tiers (Tiers I and III) emphasized *Interface/Design* more than the other ten attributes, but the responses from Tier II put more stress on *Effectiveness*. For Tier I libraries, participants who provided the usability definitions in 2012 supplied more terms that fell into the *Interface/Design* category than those who provided the usability definitions in 2007. In other words, in 2012, the mean or average was 2.571, and the standard deviation—how tightly the values clustered around the mean—was 2.80. In the 2007 results, the mean was 0.85, the standard deviation was 1.20, t (46) equaled 2.55, and p was

Learnability and _Effectiveness_ were two of the top three attributes mentioned in the 2007 survey for all three groups of libraries. _Interface/Design_ and _User characteristics_ topped the lists of two out of the three groups in the 2012 survey.

Table 8.

Percentage of terms used in definitions by usability attributes and rank of Association of Research Libraries (ARL) academic libraries (2007 and 2012)

	Tier I		Tier II		Tier III	
Usability attribute	**2007 (N = 27)**	**2012 (N = 21)**	**2007 (N = 22)**	**2012 (N = 20)**	**2007 (N = 18)**	**2012 (N = 20)**
Attitude/Satisfaction	1.35	0.71	0.22	1.43	0.67	1.25
Context/Purpose	1.12	1.96	0.67	0.36	1.35	0.71
Control/Flexibility	4.27	2.14	3.60	3.03	3.60	4.81
Effectiveness	5.84	6.60	5.39	6.42	4.27	4.81
Efficiency	1.35	1.60	1.35	0.89	1.12	0.18
Interface/Design	5.17	9.63	5.39	5.70	3.15	8.02
Learnability	8.09	5.35	6.29	4.99	5.84	4.46
Low error rate/ Error tolerance	0.00	0.36	0.67	0.53	0.00	0.36
Memorability/ Retainability	0.00	0.18	0.45	0.18	0.22	0.18
Usefulness	4.72	2.67	0.45	1.25	2.25	1.60
User characteristics	11.46	7.66	4.94	4.99	4.72	4.99
Total	43.37	38.86	29.44	29.77	27.19	31.37

0.01. The Tier III library participants in the 2012 survey also supplied more language related to *Interface/Design*—mean = 2.25; standard deviation = 3.08—than participants in the 2007 survey—mean = 0.778, standard deviation = 0.88, t (36) = 2.01, and $p = 0.05$. What is more, the t-tests showed another set of mixed results with respect to the five categories. While participants from Tier I libraries, on average, supplied about two (1.79) more terms related to *System/Technology*—t (46) = 2.11, $p = 0.04$—in 2012 than in 2007, the trend was not consistent across the other two tiers. Although not statistically significant, those from Tier III libraries provided slightly more *System/Technology* terms—t (36) = 1.38, $p = 0.17$—in 2012 than in 2007.

Another method used for comparing the two sets of definitions and eleven attributes emphasized by both groups of participants was hierarchical cluster analysis, which examines how often the attributes occurred together. This analysis was conducted by means of an average linkage scheme, a study that computes the average distance between all pairs of items or objects from two clusters. Figures 3 and 4 are dendrograms or tree

diagrams generated for 2012 and 2007, respectively. One can observe some distinctions and similarities between the diagrams. The first distinction is that *Interface/Design* appears in the first cluster for the 2012 data set, whereas for the 2007 data set, it joined the first cluster (with three attributes) at a later stage, as shown by the distance. Secondly, the participants mentioned *User characteristics*, *Interface/Design*, and *Effectiveness* together more often in the 2012 definitions than the 2007 data set, where *Learnability*, *User characteristics*, and *Effectiveness* occurred together more frequently.

Furthermore, there was a high correlation ($r = 0.92$, $p < 0.0005$), using the Mantel test, between the two dissimilarity matrices generated to produce the dendrograms. This confirmed the similarity of the two sets with respect to the eleven attributes.[48]

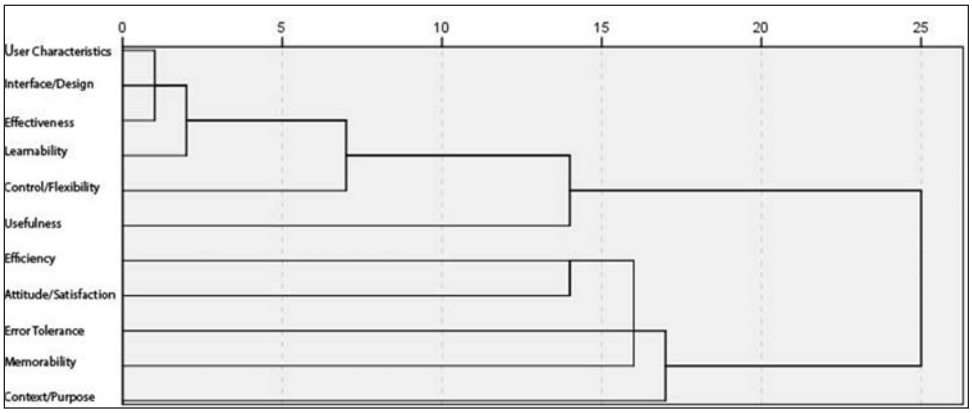

Figure 3. Clusters of attributes emphasized by participants in 2012

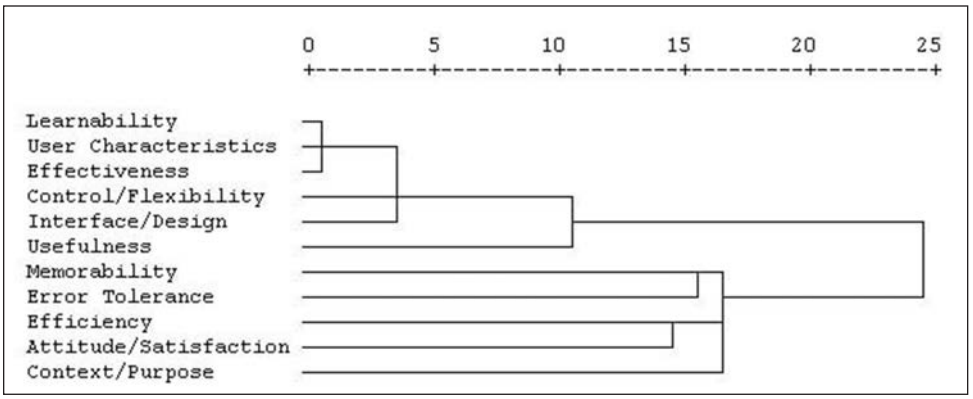

Figure 4. Clusters of attributes emphasized by participants in 2007

Discussion

In reviewing the survey results, the authors observed that the top five attributes emphasized in 2007 and 2012 shared the same set of attributes, though the *Interface/Design* and *Effectiveness* attributes ranked higher in the list, while *User characteristics* and *Learnability* moved downward (see Table 3). The orders of the five broad categories for the two data sets remained essentially the same ($\chi^2 = 2.49$, df = 4, $p > 0.05$). However, the 2012 results indicated a 3.00 percent increase in terms dealing with *System/Technology* and a 2.34 percent decrease in terms related to *People/Users* (Figure 2). *Control/Flexibility* was the only attribute that remained consistent. The shift of the top attribute from *User characteristics* in 2007 to *Interface/Design* in 2012 as well as the increase in the number of terms related to *System/Technology* should be no surprise with the evolution of technological developments. This implies that Web portal developers pay closer attention to *Interface/Design* issues as a result of the ubiquity of mobile devices. The authors speculate that this trend has influenced our participants in defining *Web usability* by using terms that reflected their thinking about interface or design, and they have become more cognizant of interface design as indicated in the comparison of the 2007 and 2012 definitions.

In addition, the chi-square analysis and paired *t*-tests of the eleven attributes and five categories revealed that in 2012, more definitions emphasized *Interface/Design* than stressed *User characteristics*. These results indicate that more practitioners are focusing on attributes related to *System/Technology* in their definitions of *usability*. This finding is consistent with the assertion made earlier that a shift is occurring, and this change may be due to the proliferation of mobile devices and increased use of such devices to access library Web portals, thus affecting professionals' thinking.

In the 2007 responses, there was a stronger emphasis in the attribute relating to user needs and their characteristics than the others.[49] Results of the 2012 survey indicated that the attribute *User characteristics* was still a main focus of professionals, yet there was increased attention to issues related to Web portal *Interface/Design*, in particular, and to the *System/Technology* category in general.

The authors compared the holistic nature of the two sets of definitions. Results showed that after five years, library practitioners did not include more attributes within their respective definitions. That is, in both sets there were four or fewer distinct attributes in over 50 percent of the definitions. This result indicates that in defining *Web usability*, library professionals have not adopted a broader or more holistic approach. The authors recognize the value of highlighting certain attributes (for example, *Interface/Design*), yet it is still important to take into account the other attributes (for example, *Context/Purpose*, *Memorability/Retainability*, and *Low error rate/Error tolerance*), which are crucial to fostering good user experiences. When attributes are overlooked, there are limitations in the end products. For example, when designing

The attribute *User characteristics* was still a main focus of professionals, yet there was increased attention to issues related to Web portal *Interface/Design*, in particular, and to the *System/Technology* category in general.

a website, stakeholders have to identify the context or purpose so the interface can be designed to address user needs.

While reviewing the results of cluster analyses, the authors observed that a common feature in both tree diagrams is the appearance of *User characteristics* and *Effectiveness* attributes in the same first cluster (Figures 3 and 4). Additionally, among the five broad categories, three—*People/Users*, *System/Technology*, and *Tasks*—appear more frequently in the first cluster of attributes for both sets of definitions. Furthermore, based on the Mantel test, there was a high correlation ($r = 0.92$, $p < 0.0005$) between the two dissimilarity matrices generated to produce the dendrograms.[58] This finding confirmed the similarity of the two sets of definitions with respect to the eleven attributes, indicating that while the participants emphasized more attributes dealing with *System/Technology* in 2012, they still considered users and their task effectiveness important aspects of usability. Both sets of definitions minimize the significance of *Context/Purpose* (or *Environment*), which was mentioned the least frequently with the other four focal points.

Conclusion

In a dynamically changing information environment, there are bound to be shifts in both the perception and key elements of *usability* definitions, albeit with varying degrees. These shifts may include changes in the basic components emphasized in defining core concepts. Due to new developments in information technology, the constant change in users' needs, and their evolving information behaviors, information science professionals need to redefine core concepts in their disciplines.[50] One core concept that requires redefinition is *usability*, a multidimensional concept. A well-rounded understanding of usability can facilitate the production of user-centered information systems. A critical analysis of *usability* definitions over time would provide insights into how the library community understands this concept.

A well-rounded understanding of usability can facilitate the production of user-centered information systems.

In this context, we initiated our two surveys on the nature of *usability* definitions provided by ARL professionals. Whereas the timespan between the surveys is a mere five years, there have been tremendous changes in technology, users' behaviors, and user attitudes during this time. In particular, there were rapid and dramatic advances in the capability and power of handheld devices. When the authors began the 2007 study, Apple Inc. had just introduced the first-generation iPhone. Users, for the most part, accessed Web pages using desktop computers with fairly large screens.[51] By 2011, the iPhone had gone through three iterations since its introduction, and the number of smartphones had surpassed that of PCs worldwide.[52] With respect to usability and Web interface or design, some of the characteristics that make handheld devices distinct from desktop computers are their small display screens, added interactivity through touchscreens, and portability. Designers of systems and applications (for example, Web portals) need to pay particular attention to their usability across multiple platforms.

The study results show that library practitioners are taking a stronger technology-centered stance in defining *usability* than in the past, and they have not lost sight of user

needs. On the other hand, attributes addressing users' cognitive capacity and attitude continue to receive little attention among ARL academic libraries across the ranks. This is an area of concern and needs to be addressed as libraries opt to use more off-the-shelf products, which impede usability testing opportunities prior to development and implementation.

The authors did not observe a significant difference between the 2007 and 2012 sets of definitions. A definition including concepts from HCI and information behavior could facilitate a better understanding of the multidimensional construct of Web usability. Web designers and developers need to take those essential aspects into consideration during the life cycle of the system development process. A holistic approach would enhance the usability of their products and would account for issues such as users' cognitive processes. As information technologies change at a fast pace, future research might monitor the shift of the Web usability attributes emphasized in library practitioners' definitions over a decade in a longitudinal study. This research would keep library professionals informed as to whether they are moving closer to a holistic, user-centered approach to usability or taking a more technology-driven direction.

Library practitioners are taking a stronger technology-centered stance in defining *usability* than in the past, and they have not lost sight of user needs.

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