Critical Constructs of Digital Library Interaction

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Abstract

The perception of fundamental dimensions of digital library (DL) interaction requires the deep
exploration of interactive events. Interaction in DLs depends to a great degree on the content they
provide. The present study validates a theoretical framework for the usefulness-usability linking, based
on the areas of HCI and Information Behaviour. An online questionnaire survey was employed to elicit
DL users' opinions on the usefulness and usability of an Open Access system. Results demonstrate the
most crucial system and content evaluation attributes that can affect satisfaction on the usefulness and
usability of DLs.

Keywords: digital library evaluation, usefulness, usability, e-print archives

1. Introduction

Digital libraries (DL) handle information corpora, and support users to important work tasks,
such as authorship, education and research. Therefore many aspects of interaction rely on
their content. Researchers [Fuhr et. al. 2002; Borgman, 2003] underline the impact of content
in the DL usability. Content defines in a significant degree the context of DLs and not any
geographic or demographic variables, as in the case of other applications.

Evaluation is regarded a pivotal process in the DL development cycle, affecting the
acceptance of these systems. Furthermore, DL evaluation is considered a multifaceted process,
which draws knowledge and experience from many disciplines, such as computer science and
information science. One of its crucial areas is usability evaluation, which during the last
years undergoes a merging process with issues from the information behaviour domain.

The present study attempts to highlight, through sound statistical indicators, the need to
evaluate in a unified way DL's usefulness and usability. In particular the paper focuses on
Open Access (OA) systems, which are envisaged as the new form of digital libraries,
supporting information provision democratization. OA systems have a rich morphology and
cover applications from freely accessible scientific journals to institutional or subject oriented
repositories. For the present paper, E-LIS (*http://eprints.rclis.org*) was used, which is an OA
system to deposit preprints, postprints and other documents in the field of library and
information science. The knowledge produced out of this study can be beneficial for the DL
stakeholders, as well as for usability evaluation experts, who would attempt to evaluate a DL.

2. Literature Review

The "digital library" domain is wide and multi-disciplinary and thus many interpretations are being used interchangeably in pursue of accurate description. DLs are often seen as collections of objects and associated services for the creation, storage and dissemination of information, but can also be seen as integrated systems that support the needs of a user community [Borgman, 1999]. Advances in DLs, such as self-archiving systems, have further enhanced the provided functionalities and services focusing on the creation of original content and exploitation of innovative publishing schemes for their delivery.

User centered DL evaluation requires the definition and study of interaction events and the deep exploration of the physical and digital environments. Previous approaches, such as the Technology Acceptance Model (TAM) and Delone/McLean Model, co-relate the concepts of usefulness and usability. TAM has a sound tradition in the prediction of use in Information Systems area and several research applications of this model have been in the field of information providing systems. In specific TAM uses the ideas of perceived usefulness and perceived ease of use as predicting indicators of users' intentions and actual usage.

In addition, the body of empirical studies in Information Systems acceptance has shown that system usage and user satisfaction is depended on the quality of both system and content (information) [Delone, McLean, 1992]. Delone and McLean validate the assumption that performance fluctuation is based, apart from external variables, on intrinsic properties of system and information.

However these approaches, do not address specific challenges of the DLs structure and context. For example, Hong et al. [2002] report that the attributes of a DL can influence users' perceived ease of use and usefulness. However it was found that the perceived usefulness depends primarily on the relevance of the content and not on any other system attribute. Moreover, TAM, as being a predictive model, investigates the impact of external variables on the formation of perceptions on ease of use and usefulness and the prediction of usage is based on the profile of the user. Therefore it concentrates only on one dimension (user) and doesn't investigate the effect of specific attributes in interaction.

P3 model [Dillon, Morris, 1999] addresses the need of investigating the technical abilities (the "power") of a given system, such as its functionalities, which can influence user's perceptual and behavioural reactions. In detail it merges the notions of usability engineering and IS acceptance and considers that power, perception and performance define one's ability and willingness to use a system. Concluding the need to examine the relative effects of the system's functionalities on usefulness and usability is of utmost importance.

It must be noted that during the last years the consciousness about the mutual similarities between the Human Computer Interaction and Information Behaviour areas, the scientific area that studies human activities during information seeking and handling processes, is increased. The first years of usability evaluation practicing in the DL domain were designated by an intense interest in task accomplishment parameters (time, error rate etc) and satisfaction with properties of usable systems [Kengeri et. Al., 1999; Zabed, McKnight,

Oppenheim, 2004]. However recently there is an attempt to merge these areas in one common field that can provide a panoramic understanding of interaction [Chowdhury, Landoni, Gibb, 2006].

Current evaluation endeavors of OA systems have not yet undergone a user-centered evaluation process that covers both usefulness and usability. Veiga e Silva, Gonçalves and Laender [in press] report on a usability evaluation of a self-archiving system and concluded that the properties of easiness of use, comfort and usefulness are vital elements for the sustainability of such DLs. Concerns about the usefulness and usability are expressed in the Citebase research study [Hitchcock et al. 2002]. Despite the very enlightening results of the study, especially in the areas of content coverage and navigation, the differentia in the examined service do not allow safe correspondence with DL systems.

3. Research setting

3.1 Setting the stage

Interaction Triptych Framework [Tsakonas, Papatheodorou, 2006] was employed in this study. ITF assumes, in a triangular synthesis, that the effective interaction depends on both system usability and information usefulness. Figure 1 depicts a typical interaction in the DL domain, where the user communicates with other two primary constructs, which are system and content, in a compound way. Upon the axes that are created between the constructs, ITF defines three evaluation categories, namely usefulness, usability and performance (the latter - although important- is not discussed here). These categories classify metrics, methods and tools and establish an evaluation rationale for the user interaction. According to recent theoretical approaches [Beaulieu, 2000] interaction with information-providing systems is structured on physical actions and cognitive models. On this dialectic each category of ITF aggregates a set of attributes presented in Table 1. Each one of the attributes may influence user interaction in many different ways. For instance aesthetic appearance might have an affective effect on the users, while coverage is related to the cognitive world of the user.
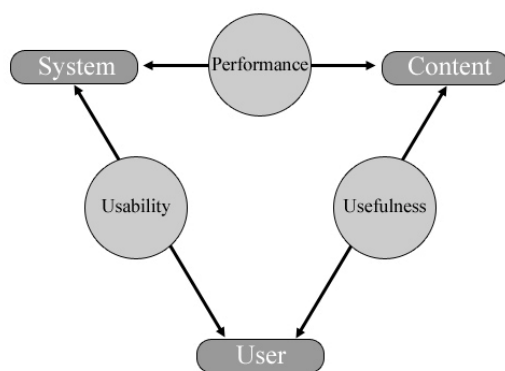

Figure 1. *Interaction Triptych Framework*

The essence of this structure has been previously met in the fields of information architecture and information behaviour analysis. Toms [2002] uses the same structure to analyze information interaction and discover critical points affecting information DL architecture, such as screen design elements (e.g. menu items). Järvelin and Ingwersen [2004] have used this triangular structure for the depiction of the cognitive models exchange process between the user, the content creator or provider and the system deliverer, which is realized by an interface.

3.2 Research questions

The present study attempts to respond to two research questions:

a) Which content and system evaluation attributes mostly affect DL interaction?
b) Which features and functionalities of E-LIS affect usefulness and usability?

Table 1. *Content and System Attributes*

Content attributes	
Relevance	The subject proximity of the resource to the information need.
Format	The availability of content in an information medium.
Reliability	The authoritative and credible dimensions of the resource.
Level	The division of resource information in sections, as citation, abstract or full-text.
Coverage	The temporal aspects of information resources in the DL.
System attributes	
Ease of use	The easiness to use system features and processes.
Aesthetic appearance	The graphical and structural elements of system.
Navigation	The ability to alter spatial states in an easy and uninterrupted way.
Terminology	The employment of proper terms and phrases for describing screen elements or information.
Learnability	The intuitiveness of a system in learning the user to operate it.

3.3 Methodology

A total of 131 of valid questionnaires were collected through an online questionnaire, which was active for a period of one month (May to June 2006). Although questionnaire surveys aren't considered as a principal method of usability evaluation, they have been used to elicit users' opinions [Koohang, Ondracek, 2005]. Furthermore this method was selected for its

ability to *"gather information about respondents' previous or current behaviors, attitudes, beliefs, and feelings"* [Covey, 2002], as well as due to its economy aspect and its ability to address to geographically dispersed audiences, like those of DLs.

The questionnaire consisted of thirty four (34) questions, divided in three parts (*http://dlib.ionio.gr/wp7/gtsak/elis_quest.htm*). The scope of the first part of the questionnaire was to collect the required information for participants' profile, in terms of familiarity with the system, usage, perceived significance for information seeking and willingness to spend time and effort. The second part focused on the participants' opinions for the significance of the usefulness, usability and performance attributes. In specific usefulness and usability subparts included six (6) questions, while the performance subpart included four (4). The last question of each subpart was administrating participants' overall satisfaction with the concepts. The final part was consisted of paired questions that examined the participants' views on usefulness and usability of the E-LIS functionalities and properties. The participants were asked to provide their agreement in a five-point Likert scale statement, from 1-"Disagree" to 5-"Agree". A Cronbach Alpha value for the reliability of the instrument was calculated for each of the questions of the second (usefulness subsection alpha .910, usability subsection alpha.939) and the third part (alpha .952) of the questionnaire that overcame the suggested thresholds (.70).

4. Results

The 131 participants represent various classes of users, such as registered (33.59%), unregistered (50.38%), editors (12.98%) and other classes (3.05%), including for example administrative staff. Participants reported a medium type of usage (M=2.98, S.D.=1.359) of the DL and significance (M=2.79, S.D.=1.183) in their regular information seeking activity. However they reported that they are quite willing to spend as much time (M=3.48, S.D.=1.159) and effort (M=3.59, S.D.=1.176) is required for the successful completion of their information tasks.

Participants declared their satisfaction with the content's format (M=3.85, S.D.=1.075) they find in E-LIS, as well as they believe that the various levels of information allow them to discover information more efficiently (M=3.79, S.D.=1.150). However they are not very satisfied with the content's coverage (M=3.43, S.D.=1.096). In the usability attributes, participants believe that E-LIS is an easy to learn (M=4.08, S.D.=0.966) and to use (M=4.06, S.D.=1.021) system, but possibly it could improve its look and feel (M=3.70, S.D.=1.021).

Table 2 presents the multiple regression analysis results on usefulness and usability. The general questions on usefulness and usability were regressed upon the factors that represent their respective attributes. Three attributes of usefulness produce the 65% of the observed variance: relevance (t(125)=4.697, p<.001), level (t(125)=3.956, p<.001) and coverage (t(125)=2.887, p<.01). Sixty three per cent of the variance is produced by four out of five usability attributes. Easiness of use (t(125)=2.354), aesthetic appearance (t(125)=1.734), terminology (t(125)=2.019) and learnability (t(125)=2.463) have a significant effect at p<.01.

Table 2. Multiple Regression Analysis - Attributes

Usefulness				
R^2 =0.653, adjusted R^2 = 0.639				
	r	b	S.E. b	β
- Relevance	.674	0.346	0.074	.338[*]
- Format	.608	0.053	0.090	.049
- Reliability	.653	0.034	0.102	.031
- Level	.723	0.342	0.086	.340
- Coverage	.623	0.220	0.076	.208[**]
Usability				
R^2 =0.634, adjusted R^2 = 0.622				
	r	b	S.E. b	β
- Easy to use	.732	0.245	0.091	.267[**]
- Aesthetic	.662	0.159	0.077	.173[**]
- Terminology	.700	0.187	0.087	.198[**]
- Learnability	.725	0.248	0.096	.256[**]
- Navigation[+]	.689	-	-	-
[*]p<.001, ** p<.01, [+]removed				

Similarly to the first regression model, usefulness and usability were regressed upon the variables representing E-LIS functionalities and properties (Table 3). However it must be noted that the term "useful" in the case of functionalities and properties possess a slightly different, yet important, meaning, that of *utility*. Significant equations were found in the regression case of usefulness (R^2=0.556, F=31.312, p<.001). However of the five factors, that were found to cause the 55.6 % of variance (browsing, search, personal account, services and OA), only two were found important to predict satisfaction. These were the peripheral services that E-LIS provides (t(125)=3.227, p<.05) and the OA nature of the e-print archive (t(125)=4.152, p<.001). The regression of the usability category produced equally important results. The same five factors were found responsible for the 57.9% of the variance, but by examining the t scores, the most important were found to be the OA nature of the archive (t(125)=2.878, p<.01) and the personal space in the DL (t(125)= 2.317, p<.05). In both cases the factor measuring the specific procedures in the DL (such as self-archiving for authors or editing for national editors) was excluded from the regression process.

Table 3. *Multiple Regression Analysis – E-LIS Functionalities*

	Usefulness				Usability			
	$R^2 = 0.556$, *Adjusted* $R^2 = 0.538$				$R^2 = 0.579$, *Adjusted* $R^2 = 0.562$			
	r	*b*	*S.E. b*	*β*	*r*	*b*	*S.E. b*	*β*
Retrieval functionalities								
- Browse	.594	.085	.153	.078	.663	.151	.115	.171
- Search	.626	.233	.155	.211	.682	.198	.118	.226
Enhanced functionalities								
- Personal Account	.535	.024	.076	.028	.614	.138	.060	.197[***]
- Peripheral Services	.629	.263	.081	.286[***]	.590	.109	.063	.144
Properties								
- Open Access	.605	.297	.071	.303[*]	.531	.154	.053	.197[**]
System Task								
- Procedures [+]	.617	-	-	-	.635	-	-	-
[*] *p*<.001, [**] *p*<.01, [***] *p*<.05, , [+] removed								

The experimentation with the time and effort the participants want to invest in finding proper information required the repetition of the regression model. This analysis was based on the assumption that time and effort are significant external variables that affect the efficient use of DLs. For users with no intention to spend time (n=25, R^2=.768) and effort (n=25, R^2=.792) the attributes format (Time *β* =.583, *p*<.01, Effort *β* =.642, *p*<.001) and relevance (Effort *β* =.331, *p*<.05) found to be significant factors for content usefulness, while users willing to dedicate time (n=63, R^2=.651) and effort (n=74, R^2=.705) perceived as more significant the attributes relevance (Time *β* =.415, *p*<.001, Effort *β* =.387, *p*<.001), reliability (Effort *β* =.370, *p*<.01) and level (Time *β* =.636, *p*<.001, Effort *β* =.253, *p*<.05).

In the case of usability, for the users with little or no intention to spend time (R^2=.881) and effort (R^2=.701) important predictors are the easiness to use (Time *β* =.366, *p*<.01) and aesthetics (Time *β* =.618, *p*<.001, Effort *β* =.568, *p*<.01). On the other hand users with strong intentions to spend time (R^2=.456) and effort (R^2=.632) appreciated much more the attributes easiness to use (Time *β* =.525, *p*<.001, Effort *β* =.281, *p*<.05), learnability (Time *β* =.231, *p*<.05) and navigation (Effort *β* =.251, *p*<.05).

In the E-LIS features question, participants with little or no intention to spend time (R^2=.735) and effort (R^2=.477) considered as important predictors for usefulness the attributes search (Time *β* =.781, *p*<.05), peripheral services (Time *β* =.435, *p*<.01) and OA (Effort *β* =.468, *p*<.01). Participants willing to invest time (R^2=.569) and effort (R^2=.542) found more significant services (Time *β* =.439, *p*<.001, Effort *β* =.283, *p*<.05) and OA (Time *β* =.366, *p*<.001, Effort *β* =.401, *p*<.001). Participants with decreased interest in spending time (R^2=.881) and effort (R^2=.758) found important predictors for usability search (Time *β* =.722,

$p<.001$, Effort $\boldsymbol{\beta}$ =.868, $p<.05$) and personal account (Time $\boldsymbol{\beta}$ =.245, $p<.05$, Effort $\boldsymbol{\beta}$ =.302, $p<.05$). Finally, for the participants with increased intention to spend time (R^2=.499) and effort (R^2=.502) personal account (Time $\boldsymbol{\beta}$ =.424, $p<.001$, Effort $\boldsymbol{\beta}$ =.372, $p<.001$) had significant effect.

5. Discussion - Conclusions

The present study investigated the usefulness and usability attributes of an OA DL. Participants of this study showed their preference to certain attributes that contribute to the usefulness and usability of E-LIS, such as the level and the format of the provided information, the easiness to use and the high level of learnability.

Beyond this, participants defined the most important attributes that can predict satisfaction. In the usefulness category we conclude that users desire to find information that serves their information needs and work tasks, in various levels that permit them to have an overview of the content and to access it in full-text, and wide enough to cover important time periods. At the same time the users appreciate the high levels of easiness of use, the aesthetically pleasant environment, the understandable terminology and the learnability. Breaking down these results into the willingness of participants to spend time and effort, it was found that users with decreased intentions would be satisfied if an easy to use and aesthetically adequate DL could provide them relevant content in their desired format. On the other hand, users with increased intentions would also like to operate an easy to use DL, with intrinsic learnability and enhanced navigation, in order to retrieve relevant and reliable in leveled formats.

Users also would consider a DL useful if they could support peripheral services, such as those provided by E-LIS (for instance content linking options when resources aren't available in full format), and they would find usable having their personal space, in order to manage their tasks more effectively, according to [Reyes-Farfán, Sánchez, 2003]. Moreover, the E-LIS OA nature is both useful and usable. While the first finding seems acceptable, the latter is an interesting finding and explanations may be found in the profile of the users. The registered users and the editorial crew can be regarded as supporters of the OA movement. Participants with decreased intentions to spend time and effort to retrieve information would appreciate an OA DL with search functionalities, peripheral services and personalized features, while users with increased intentions would prefer to use an OA system with supportive services and personalization options.

The findings of the current study reinforce previous studies' results, with alternative methodologies, such as on the time coverage, format, layout and search functionalities issues [Kengeri et al. 1999]. Furthermore, the findings concerning the easiness of use and learn are aligned with findings of the Veiga e Silva, Gonçalves and Laender study [in press] that clearly demonstrate that self-archiving DLs can be easy to learn and intuitive to use.

The main conclusion drawn by is study is the need of joint examination of usability and usefulness. In regard to these systems, usability evaluators are encouraged to investigate aspects of usefulness in parallel to acquire a holistic view of DL interaction.

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