Evaluating the Library 2.0 Services via Computing with Words

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Abstract. Web 2.0 tools have changed the relationship between users and libraries by improving the involvement of users in the libraries activities. To use such tools efficiently, it is essential to know if they are meeting user requirements and expectations, and how they could be improved to increase user satisfaction. The aim of this paper is to present a model to evaluate the quality of the Library 2.0 services. To do so, the quality assessments are defined using user's perceptions on the quality of the Library 2.0 services provided though the websites of the libraries. We assume a fuzzy linguistic modeling to represent the user's perceptions and apply tools of fuzzy computing with words based on the LOWA and LWA operators to compute the quality assessments of the Library 2.0 services. In addition, the model uses the LibQUAL+ methodology, allowing for the identification of specific 2.0 services in need of improvement and of those outstandingly satisfied by the library.

Keywords: Library 2.0, quality, computing with words, LibQUAL+.

1 Introduction

Libraries play a notable role in the educational progress, enabling and facilitating the exchange and growth of information, knowledge and culture among teachers, students and the general public. This purpose is nowadays enhanced and facilitated by the use of technology and, in recent times, by the so-called Web 2.0 [1, 2].

The term Web 2.0 was coined by O'Reilly [3] to describe the trends and business models that survived the technology sector market crash of the 1990s.

He noted that the companies which had survived the collapse were collaborative in nature, interactive, dynamic, and users created the content in these sites as much as they consumed it [2]. A Web 2.0 site may allow users to interact and collaborate with each other in a social media dialogue as creators of user-generated content in a virtual community, in contrast to websites where people are limited to the passive viewing of content. Developing the idea of Web 2.0 in the library context, the concept of Library 2.0 emerges.

Library 2.0 is a model for a modernized form of library service that reflects a transition within the library world in the way that services are delivered to users. The focus is on user-centered change and participation in the creation of content and community. Library 2.0 has multiple facets reflecting the typical means of user participation that Web 2.0 enables. These facets include blogging, tagging, social bookmarking, social networking, podcasting and so on.

As libraries are service institutions, better service will be provided if the nature and needs of users are known. As the Library 2.0 model enables and encourages participation of the user/client not only in the use of the service but also in its management, the evaluation of the Library 2.0 services needs to be judged by its users. According to user comments, observed weaknesses and strengths can be understood and, in order to eliminate defects and develop strengths, proposals can be provided to this end. Furthermore, focusing on users in the libraries and the efforts to resolve their expectations, it makes the academic libraries more dynamic [4].

Different quality evaluation models of digital libraries based on user perception have been proposed [5]. However, these models have not taken into account the new dimension of the libraries, i.e, the impact of Web 2.0 on library websites.

The aim of this paper is to propose a quality evaluation model of the Library 2.0 services. We present a model measuring the quality level of the Library 2.0 services offered by libraries through their websites according to the users' perceptions. Conventional measurement tools used by users to express their opinions are devised on numerical values, but, as the natural language is the standard representation of those concepts that humans use for communication, it seems natural that they use words (linguistic terms) instead of numerical values to provide their opinions. The use of words or sentences rather than numbers is, in general, less specific, more flexible, direct, realistic, and adequate form to express perceptions. These characteristics indicate the applicability of fuzzy set theory [6] in capturing the user's perceptions, which aids in measuring the ambiguity of concepts that are associated with human beings subjective judgment. Since the evaluation is resulted from the different evaluator's view of linguistic variables, its evaluation must therefore be conducted in an uncertain, fuzzy environment. For this reason, we use an ordinal fuzzy linguistic modeling [7] to represent user's perceptions and tools of fuzzy computing with words to compute the quality assessments. Furthermore, it is important to note that using the LibQUAL+ methodology [8], the model is able to identify both the Library 2.0 services in which the service levels should be improved and the Library 2.0 services satisfied outstandingly by the library.

The rest of this paper is set out as follows. Section 2 presents the fuzzy linguistic approach for computing with words and the LibQUAL+ methodology. Section 3 describes in detail the model we propose. Finally, Section 4 presents some conclusions.

2 Preliminaries

In this section, the LibQUAL+ methodology for quality evaluation of libraries is described and the fuzzy linguistic approach for computing with words, which is used to design our quality evaluation model of Library 2.0 services, is presented.

2.1 LibQUAL+ Methodology

In 1999, a major project to develop a standardized measure of library service quality was undertaken by the Association of Research Libraries (ARL) in collaboration with Texas A&M University. The result of this project was LibQUAL+ [8], which is an extension of the SERVQUAL (for SERVice QUALity) tool [9]. SERVQUAL has been carefully tested and widely accepted after a dozen years of application in the private sector and elsewhere. Grounded in the gap theory of service quality, the singular percept of SERVQUAL is that "only customers judge quality; all other judgments are essentially irrelevant" [10]. According to the gap model, service quality is the gap between customer's expectations and perceptions. When experiences exceed expectations, the quality of the service is high, and vice versa. Service quality is conceptualized as a gap between customers' minimum/desired expectations of service quality and their perceptions of the service quality actually received. A positive gap indicates that the service performance has exceeded customers' expectations, whereas a negative gap indicates that the service performance has fallen short of the expected service.

Following that idea, LibQUAL+ is a survey administered by the ARL to measure library user's perception of library service quality and to help libraries identify service areas needing improvement [8]. To do so, the LibQUAL+ survey is composed of 22 core questions that measure perceptions concerning three dimensions of library service quality. For each question, respondents are asked to indicate their minimum acceptable service level, their desired service level, and the perception of the actual service provided by the library by giving a score from one to nine. The minimum service level and the desired service level reflect the importance of that service to the user: a low level means that it is not considered very important, and vice versa – when the minimum or desired service level receive high scores, the issue is important. An adequacy gap (the perceived quality in relation to the accepted minimum level) and a superiority gap (the perceived quality in relation to the desired service) are determined based on the answers.

2.2 A Fuzzy Linguistic Approach for Computing with Words

Many problems present vague and imprecise aspects [11]. In such problems, the information cannot be assessed precisely in a quantitative form, but it may be done in a qualitative one, and thus, the use of a linguistic approach is necessary. For example, when attempting to qualify phenomena related to human perception, we are often led to use words in natural language instead of numerical values. The fuzzy linguistic approach is an approximate technique appropriate to deal with vague and imprecise aspects of problems. It models linguistic information by means of linguistic terms supported by linguistic variables [12], whose values are not numbers but words or sentences in a natural or artificial language. A linguistic variable is defined by means of a syntactic rule and a semantic rule.

The ordinal fuzzy linguistic approach is a very useful kind of fuzzy linguistic approach used for modeling the linguistic aspects in problems [7]. It facilitates the fuzzy linguistic modeling very much because it simplifies the definition of the semantic and syntactic rules. It is defined by considering a finite and totally ordered label set $S = \{s_i\}$, $i \in \{0, \ldots, \mathcal{T}\}$, in the usual sense, i.e., $s_i \geq s_j$ if $i \geq j$, and with odd cardinality. Typical values of cardinality used in the linguistic models are odd values, such as 7 or 9, with an upper limit of granularity of 11 or no more than 13, where the mid term represents an assessment of "approximately 0.5", and the rest of the terms being placed symmetrically around it. The semantics of the linguistic term set is established from the ordered structure of the label set by considering that each linguistic term for the pair $(s_i, s_{\mathcal{T}-i})$ is equally informative. For example, we can use the following set of nine labels to provide the user evaluations: $\{N = None, EL = Extremely\ Low, VL = Very\ Low, L = Low, M = Medium, H = High, VH = Very\ High, EH = Extremely\ High, T = Total\}$.

An advantage of the ordinal fuzzy linguistic approach is the simplicity and quickness of its computational model. It is based on the symbolic computation [7, 13] and acts by direct computation on labels by taking into account the order of such linguistic assessments in the ordered structure of linguistic terms. This symbolic tool seems natural when using the fuzzy linguistic approach, because the linguistic assessments are simply approximations which are given and handled when it is impossible or unnecessary to obtain more accurate values. Usually, the ordinal fuzzy linguistic model for computing with words is defined by establishing (i) a negation operator, $Neg(s_i) = s_j \mid j = \mathcal{T} - i$, (ii) comparison operators based on the ordered structure of linguistic terms: Maximization operator: $MAX(s_i, s_j) = s_i$ if $s_i \geq s_j$; and Minimization operator: $MIN(s_i, s_j) = s_i$ if $s_i \leq s_j$, and (iii) adequate aggregation operators. In the following, we present two aggregation operators based on symbolic computation to complete the ordinal fuzzy linguistic computational model.

The LOWA operator. An important aggregation operator of ordinal linguistic values based on symbolic computation is the LOWA operator [7]. The *Linguistic Ordered Weighted Averaging* (LOWA) is an operator used to aggregate non-weighted ordinal linguistic information, i.e., linguistic information values with equal importance [7].

Definition 1. *Let $A = \{a_1, \ldots, a_m\}$ be a set of labels to be aggregated, then the LOWA operator, ϕ, is defined as:*

$$\begin{aligned}\phi(a_1, \ldots, a_m) &= W \cdot B^T = \mathcal{C}^m\{w_k,\ b_k,\ k = 1, \ldots, m\} \\ &= w_1 \odot b_1 \oplus (1 - w_1) \odot \mathcal{C}^{m-1}\{\beta_h,\ b_h,\ h = 2, \ldots, m\}\ ,\end{aligned} \tag{1}$$

where $W = [w_1, \ldots, w_m]$ is a weighting vector, such that, $w_i \in [0, 1]$ and $\Sigma_i w_i = 1$. $\beta_h = w_h / \Sigma_2^m w_k$, $h = 2, \ldots, m$, and $B = \{b_1, \ldots, b_m\}$ is a vector associated to A, such that, $B = \sigma(A) = \{a_{\sigma(1)}, \ldots, a_{\sigma(m)}\}$, where, $a_{\sigma(j)} \leq a_{\sigma(i)}\ \forall\ i \leq j$, with σ being a permutation over the set of labels A. $\mathcal{C}^m$ is the convex combination operator of m labels and if $m = 2$, then it is defined as:

$$\mathcal{C}^2\{w_i,\ b_i,\ i = 1, 2\} = w_1 \odot s_j \oplus (1 - w_1) \odot s_i = s_k\ , \tag{2}$$

such that, $k = min\{\mathcal{T},\ i + round(w_1 \cdot (j - i))\}$, $s_j, s_i \in S$, $(j \geq i)$, where "round" *is the usual round operation, and $b_1 = s_j$, $b_2 = s_i$. If $w_j = 1$ and $w_i = 0$, with $i \neq j$, $\forall i$, then the convex combination is defined as: $\mathcal{C}^m\{w_i,\ b_i,\ i = 1, \ldots, m\} = b_j$.*

The LOWA operator is an "or-and" operator [7] and its behavior can be controlled by means of W. In order to classify OWA operators with regards to their localization between "or" and "and", Yager [14] introduced a measure of *orness*, associated with any vector W : $orness(W) = \frac{1}{m-1} \sum_{i=1}^{m} (m - i) w_i$. This measure characterizes the degree to which the aggregation is like an "or" (MAX) operation. Note that an OWA operator with $orness(W) \geq 0.5$ will be an *orlike*, and with $orness(W) < 0.5$ will be an *andlike* operator.

An important question of the LOWA operator is the determination of the weighting vector W. In [14], it was defined an expression to obtain W that allows to represent the concept of fuzzy majority [15] by means of a fuzzy linguistic nondecreasing quantifier Q [16]:

$$w_i = Q(i/n) - Q((i - 1)/n),\ i = 1, \ldots, n\ . \tag{3}$$

When a fuzzy linguistic quantifier Q is used to compute the weights of LOWA operator ϕ, it is symbolized by ϕ_Q.

The LWA operator. Another important aggregation operator of ordinal linguistic values is the *Linguistic Weighted Averaging* (LWA) operator [13]. It is based on the LOWA operator and is defined to aggregate weighted ordinal fuzzy linguistic information, i.e., linguistic information values with not equal importance.

Definition 2. *The aggregation of a set of weighted linguistic opinions, $\{(c_1, a_1), \ldots, (c_m, a_m,)\}$, $c_i, a_i \in S$, according to the LWA operator, Φ, is defined as:*

$$\Phi[(c_1, a_1), \ldots, (c_m, a_m)] = \phi(h(c_1, a_1), \ldots, h(c_m, a_m))\ , \tag{4}$$

where a_i represents the weighted opinion, c_i the importance degree of a_i, and h is the transformation function defined depending on the weighting vector W used for the LOWA operator ϕ, such that, $h = MIN(c_i, a_i)$ if $orness(W) \geq 0.5$, and $h = MAX(Neg(c_i), a_i)$ if $orness(W) < 0.5$.

We have chosen the LOWA and the LWA operators as the basis of our evalution model due to the following reasons: (i) both operators are complementary (the LWA operator is defined from the LOWA operator) and this simplifies the design of the evaluation model, (ii) both operators act by symbolic computation and, therefore, linguistic approximation processes are unnecessary and this simplifies the processes of computing with words, and (iii) the concept of fuzzy majority represented by linguistic quantifiers plays a role in the computation process and so, the assessments on Library 2.0 services are obtained according to the majority of evaluations provided by the users.

3 A Model to Evaluate the Quality of Library 2.0 Services using Tools of Computing With Words

In this section, we present a model using tools of fuzzy computing with words to evaluate the quality of the Library 2.0 services. The main characteristics of the model are: (i) it presents a set of subjective criteria related to the Library 2.0 services, (ii) the quality level of the Library 2.0 services offered by the library through its website is measured using user's perceptions on those services, (iii) it uses the ordinal fuzzy linguistic modeling [7] to represent the users' perceptions and performs computing with words based on the linguistic aggregation operators LOWA [7] and LWA [13] to compute the quality assessments, and (iv) it uses the LibQUAL+ methodology in order to identify both the Library 2.0 services in which the service levels should be improved and the Library 2.0 services already satisfied by the library.

The quality evaluation model presens two elements: (i) an evaluation scheme that contains the subjective criteria, and (ii) a computation method to generate quality assessments of Library 2.0 services.

3.1 Evaluation Scheme

To elicit user opinion regarding the quality of Library 2.0 services, we adapt the Linh's checklist [17], which is a questionnaire with 95 *yes–or–no* questions. In [17], Linh analyzes what types of Web 2.0 technologies have been applied in Australasian university libraries, as well as their purposes and features. Linh uses a checklist that includes features and criteria that emerged from the content analysis of literature on Web 2.0 in libraries. The checklist is based primarily on the usability evaluation of library websites and the list of checkpoints for web content accessibility guidelines 1.0. However, as this number of questions is excessive, we are going to define a low number of subjective criteria being easily understandable by the users in order to avoid user rejection.

We propose the evaluation scheme shown in Figure 1, which is composed of twenty four subjective criteria about the Web 2.0 tools commonly used in the libraries. Furthermore, as we are interested in obtaining the quality level of the 2.0 services offered by the library, for all of its twenty four items (subjective criteria), users are asked to indicate the minimum level of service that they would

***Category 1 – Use of RSS*:**

1. RSS usefulness to inform you about library news and events
2. RSS usefulness to inform you about new books, journals and e-resources databases
3. Adequacy of instructions on how to use RSS
4. Adequacy of links on library's web site/pages to download RSS
5. Usability of RSS items (e.g., items in RSS are searchable and classified into topics)

***Category 2 – Use of Blogs*:**

6. Blog usefulness to inform you about library news and events
7. Blog usefulness to inform you about new books, journals and e-resources databases
8. Blog usefulness to publish book and journal reviews/discussions
9. Blog usefulness for information literacy
10. Adequacy of instructions on how to use Blogs
11. Blog recentness (i.e., how recent are the latest postings)
12. Adequacy of blog links (i.e., they point to relevant Internet resources, to similar blogs, etc)
13. Blog usability (e.g., entries are searchable by keywords, entries are browsable by topics or by date, etc)

***Category 3 – Use of Podcasts*:**

14. Podcast usefulness to inform you about library news and events
15. Podcast usefulness to inform you about new books, journals and e-resources databases
16. Podcast usefulness to provide guidance to use resources and other library facilities
17. Podcast usefulness for information literacy
18. Adequacy of instructions on how to use Podcasts
19. Podcast usability (e.g., a transcript accompanies each podcast, podcasts are searchable by keywords, podcasts are browsable by topics, etc)

***Category 4 – Use of Wikis*:**

20. Wiki usefulness as subject guides
21. Wiki usefulness to provide resource listings
22. Adequacy of instructions on how to use Wikis
23. Wiki editability (e.g., users can create new pages, edit an existing page, upload files, etc)
24. Wiki usability (e.g., it provides a link to the library home page, a keyword search engine, etc)

Fig. 1. Evaluation scheme to assess the quality of Library 2.0 services.

find acceptable, the desired service level they expect, and their perceived service level (i.e., its formulation is similar to the LibQUAL+ survey). In this way, we are able to identify both the 2.0 services in which the service levels should be improved and the 2.0 services satisfied outstandingly by the library.

3.2 Computation Method

We have designed a computation method to generate quality assessment in academic libraries that has two main characteristics:

- *It is a user-centered computation method.* The quality assessment is obtained from individual linguistic judgments provided by their users rather than from assessments obtained objectively by means of the direct observation of the Library 2.0 services.
- *It is a majority guided computation method.* The quality assessments are values representative of the majority of individual judgments provided by the users of the Library 2.0 functionalities. The aggregation to compute the quality assessments is developed by means of the LOWA and LWA operators.

The computation method is composed of the following steps:

1. Users express their opinion by filling the questionnaire described in Subsection 3.1. To do so, the linguistic term set presented in Section 2.2 can be used. As a result, for each one of the users $u_j \in \{u_1, u_2, \ldots, u_n\}$ and each questionnaire item $i_k \in \{i_1, i_2, \ldots, i_{24}\}$, there is a tuple ($\mathrm{MSL}_{jk}$, DSL_{jk}, PPL_{jk}), that encodes the minimum service level, the desired service level, and the perceived performance level, provided by the user u_j on the item i_k, respectively.
2. To get the global user opinion regarding each item i_k, (MSL_k, DSL_k, PPL_k), the LWA operator is used. The users of the library do not play equal roles in measuring Library 2.0 service quality: i.e., some users should be more influential than others in some questionnaire items as it is not always valid that all group of users have equal importance with respect to the decision being made. This is because the degree of relevancy, knowledge, and experience may not be equal among them. Therefore, it is assigned a relative linguistic importance degree, $\mathrm{UI}(u_j, i_k) \in S$, for each user, u_j, on each questionnaire item, i_k. This importance degree could be obtained from a set of experts or the staff members of the library and it may be different for each library. Then, for each item i_k, its correspondent tuple (MSL_k, DSL_k, PPL_k) is computed using the LWA operator as:
$$\begin{aligned} \mathrm{MSL}_k &= \Phi_Q((\mathrm{UI}(u_1, i_k), \mathrm{MSL}_{1k}), \ldots, (\mathrm{UI}(u_n, i_k), \mathrm{MSL}_{nk})), \\ \mathrm{DSL}_k &= \Phi_Q((\mathrm{UI}(u_1, i_k), \mathrm{DSL}_{1k}), \ldots, (\mathrm{UI}(u_n, i_k), \mathrm{DSL}_{nk})), \\ \mathrm{PPL}_k &= \Phi_Q((\mathrm{UI}(u_1, i_k), \mathrm{PPL}_{1k}), \ldots, (\mathrm{UI}(u_n, i_k), \mathrm{PPL}_{nk})), \end{aligned} \tag{5}$$
where MSL_k, DSL_k and PPL_k are the linguistic measures that represents the minimum service level, the desired service level and the perceived performance level, respectively, of the library with respect to item i_k, according to the majority (represented by the fuzzy linguistic quantifier Q) of linguistic evaluation judgments provided by the group of users.
3. To get the global user opinion regarding all items, (MSL, DSL, PPL), the LOWA operator is use. Tuple (MSL, DSL, PPL) is computed using the

LOWA operator as:

$$\begin{aligned} \mathrm{MSL} &= \phi_Q(\mathrm{MSL}_1, \ldots, \mathrm{MSL}_{24}), \\ \mathrm{DSL} &= \phi_Q(\mathrm{DSL}_1, \ldots, \mathrm{DSL}_{24}), \\ \mathrm{PPL} &= \phi_Q(\mathrm{PPL}_1, \ldots, \mathrm{PPL}_{24}), \end{aligned} \tag{6}$$

where MSL, DSL and PPL are the linguistic measures that represents the global minimum service level, the global desired service level and the global perceived performance level, respectively, achieved for the library, according to the majority (represented by the fuzzy linguistic quantifier Q) of linguistic evaluation judgments provided by the group of users about all items.

4. Gap analysis is done for each item. According to LibQUAL+, the minimum and the desired scores establish the boundaries of a *zone of tolerance* within which the perceived scores should desirably float. The difference between the perceived and minimum scores is called the *Service Adequacy* (SA) gap, and the difference between the desired and perceived scores is called the *Service Superiority* (SS) gap. The computation of SA and SS relies on the *linguistic distance* defined as:

$$D(s_i, s_j) = s_k \ , \ \text{where } k = \begin{cases} i - j \text{ if } \ i > j \\ j - i \text{ otherwise} \end{cases} \tag{7}$$

So, for each item i_k, SA_k and SS_k are computed as:

$$\begin{aligned} \mathrm{SA}_k &= D(\mathrm{PSL}_k, \mathrm{MSL}_k) \\ \mathrm{SS}_k &= D(\mathrm{DSL}_k, \mathrm{PSL}_k) \end{aligned} \tag{8}$$

The cases when the perceived level of service falls out of the zone of tolerance are denoted as SA^- and SS^+. SA^- means that the library is not meeting its users' minimum expectations, i.e., the perceived score is lower than the minimum one. Likewise, SS^+ means that the library is exceeding its users' desired expectations, i.e., the perceived score is higher than the desired one. Therefore, SA^- can be used to identify Library 2.0 services needing improvement, whereas SS^+ is an indicator of the extent to which Library 2.0 services are exceeding the desired expectations of the users.

4 Conclusions

In this paper we have proposed an evaluation model of Library 2.0 services that provides quality assessment according to users opinions. Considerable use has been made of fuzzy set technology to provide the ability to describe the information by using linguistic label in a way that is particularly user friendly. Furthermore, we have applied automatic tools of fuzzy computing with words based on the LOWA and LWA operators to compute quality assessments of academic libraries. In addition, using the LibQUAL+ methodology, the proposed model is able to identify Library 2.0 services which should be improved and Library 2.0 services satisfied outstandingly by the library.

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