Jointly published by Akadémiai Kiadó, Budapest and Springer, Dordrecht

Scientometrics, Vol. 65, No. 1 (2005) 67–93

Quality assessment of Spanish universities' web sites focused on the European Research Area

MARIA PINTO,[a] JOSÉ LUIS ALONSO BERROCAL,[b] JOSÉ ANTONIO CORDÓN GARCÍA,[b] VIVIANA FERNÁNDEZ MARCIAL,[c] CARLOS GARCÍA FIGUEROLA,[b] JAVIER GARCÍA MARCO,[d] CARMEN GÓMEZ CAMARERO,[e] ÁNGEL F. ZAZO RODRÍGUEZ[b]

[a] *University of Granada, Faculty Library and Information Science, Granada (Spain)*
[b] *University of Salamanca, Salamanca (Spain)*
[c] *University of San Pablo CEU, Madrid (Spain)*
[d] *University of Zaragoza, Zaragoza (Spain)*
[e] *University of Málaga, Málaga (Spain)*

This work has analyzed and evaluated the dissemination of research done at Spanish universities through the World Wide Web (WWW) in order to obtain a map of the visibility of the information available on this research and to propose measures for improving the quality of this diffusion, all within the social and institutional context of the European Area for Higher Education. The methodology applied in the study has used both qualitative and quantitative research methods to obtain some quality indicators on the dissemination of university research. The object of study consists of a sample of 19 Spanish universities, chosen according to their representativeness by Autonomous Community and their administrative and scientific weight. The process of defining indicators, both qualitative and quantitative, as well as the collection and analysis of data, are explained. The results give us a detailed panorama of the state of the art of the visibility of information on research in the web pages of selected universities. This has allowed us to make certain proposals for improvement that can contribute to the excellence of its dissemination.

Introduction

The European Union's commitment to the society of knowledge is centered around three scenarios: the Information Society, the European Area for Higher Education and the European Area for Research. Universities play a fundamental role in all of these, above all in the last two (COMMISSION OF THE EUROPEAN COMMUNITIES, 2003). The Society of Knowledge has its pillars in continuing education, the dissemination of research and the use of information and communication technologies, in which quality is one of the key objectives of the process. Quality is also a key element in competitiveness, and the primary responsibility for this in education falls upon each university institution.

Received April 19, 2005

Address for correspondence:
MARIA PINTO
University of Granada, Faculty Library and Information Science, Granada, Spain
E-mail: mpinto@ugr.es

0138–9130/US $ 20.00

Throughout the last decade, the information services using the web as a channel of communication have become a fundamental instrument for institutional information, owing to the undeniable advantages they offer for the development of higher education and research, activities that are based on the transfer of information (GARCÍA MARCO, 1997). The dissemination of information on the web is one of the strategic pillars of the internal and external processes of communication that are the substance of university life and it is, without doubt, a contributing aspect in policies of transparency, responsibility and quality.

Given the importance of university web information services, and, in particular, of the dissemination of research, the aim of the present work was to assess, from both a qualitative and a quantitative point of view, the availability and access to information in the virtual spaces of Spanish universities as regards research management. It is not, therefore, an evaluation of the research carried out at universities, but rather of its dissemination on the web. The key result we were looking for was to create a set of quality standards for the design of the web pages of Spanish universities, specifically in the sphere of research, in order to optimize the visibility of and the access to research results and management of Spanish universities as a whole within the current context of the society of knowledge

Although there are other initiatives in the publishing of information on research – carried out by agents as diverse as the authorities responsible for higher education and research at a European, state and autonomous community* level, and within the universities themselves through the Offices for the Transfer of Research Results (OTRI), the Vice-Rectorships of Research, Ph.D Commissions, etc. – the information available covers unevenly the different aspects related to university research. Furthermore, in general, this information is not integrated, much less made available in a homogeneous way throughout the country.

The present work centers on the role of web information and documentation services in the dissemination of research done at Spanish universities through the concept of *visibility* and the analysis of the conditions that make this visibility possible. As a first step we should specify the concepts of visibility and university information on research that will be used in this article. Visibility is defined on three levels. First, as regards *presence*, i.e. the extent to which the information is available on the web site of a given institution. Second, as regards quality, i.e. the degree to which such information is complete, multi-media, true, and up to date, at the same time being duly authorized. And third, as regards usability, i.e. the extent to which the information is presented to the prospective users in such a way that it is "usable".

Moreover, information on research is understood as that which is related to three aspects: preconditions (financing, human resources, infrastructures), results

* Spain is made up of 17 autonomous communities.

(publications and patents, events, etc.) and institutional responsibility (reports and evaluations). Specifically, we have analyzed the availability of the information related to projects, subsidies and aid; research activities, such as courses, conferences, and workshops, among others; mobility of teaching and research personnel (professors, research fellows, etc.); research reports, as well as information from the different Departments on their research groups and results. Taking into account the organizational structure of Spanish universities, we also analyzed the web pages of Departments, OTRIs, and Vice-Rectorships of Research.

Once the scope of our study had been delimited, the following goals were set:

a) Definition of quantitative indicators and parameters on the accessibility of information in the area of Spanish university research.
b) Definition of quality indicators and parameters to evaluate the availability, suitability and accessibility of the web space devoted to university research.
c) Analysis of the web space based on the above criteria. In the case of the quantitative evaluation we used a cybermetric robot recently designed by the REINA* group of the University of Salamanca, which explores the net automatically and autonomously, collecting significant data as defined by the user.
d) Analysis and qualitative evaluation of the information based on pre-established criteria of quality.
e) Analysis and evaluation of information and data with a view to establishing points in common and points of differences in the accessibility of information on the Internet.
f) Establishment of criteria and indicators of excellence for the design of virtual spaces devoted to research in Spanish universities.

European university area

The integration of a university system in the European area involves the need for common norms and standards, and this obliges us to initiate convergent and homogeneous actions from each country in the European Union. The Spanish universities' commitment to the Internet as a privileged means of communication in teaching, research, extension and management is in turn part of a concerted movement at the European level for the reform and integration of universities, which runs parallel to the EU's commitment to the society of knowledge (EUROPEAN COMMISSION, 2002).

* REINA "REcuperación de Información Automatizada" (Recovery of Automated Information), http://reina.usal.es

This society of knowledge is arising precisely from the confluence of continuing education, generalization of research, and transfer of knowledge throughout the entire social and economic body, and the intensive and extensive use of information and communication technologies (COUNCIL OF EDUCATION, 2000). European policy towards the society of knowledge concentrates its actions specifically in three scenarios: The Society of Information, The European Area for Higher Education and the European Area for Research (EUROPEAN COMMISSION, 2000, 2001, 2002). In the last two in particular, European universities play a fundamental role (COMMISSION OF THE EUROPEAN COMMUNITIES, 2003).

Moreover, this dynamic is contemplated within a cycle of continuous improvement, in which quality constitutes a key objective of the process. Quality that is not only a moral ideal, but rather an unavoidable conditioning affected by the increasing globalization and world competition among educational systems and universities, that is, quality that is understood as a requirement for competitiveness. This idea is inseparable from the process of Bologna, and thus the European Area for Higher Education, which locates the primary responsibility for quality of education within each university. In this sense, the European Union has expressed explicit interest in the quality of the web information services of public services (COMMISSION OF THE EUROPEAN COMMUNITIES, 2002).

In fulfillment of these international agreements and centering now on the Spanish context, the Spanish Basic Law for Universities (Basic Law 6/2001) has made the commitment to improving quality the keystone of its national policy within the design of the European Area for Higher Education. It considers the creation of the National Agency for the Assessment of Quality and Accreditation (ANECA) as one of the most important instruments of this policy. Thanks to this, Spain has become one of the first countries in the EU to create an institution for assessment along the lines of the Bologna agreements. The creation of agencies of quality and accreditation was the final step in the institutional structuring of the pursuit of quality. The ANECA and the organs of assessment now being put into practice in the Autonomous Communities of Spain, according to their competences, are the visible machinery of a new dynamics of quality in the university system. This dynamics should reach fulfillment in 2010 with the actual emergence and putting into operation of the European Area for Higher Education. The publication of information on the web by all the agents of the university system is, without a doubt, a contributing aspect of these qualities of transparency, responsibility and quality.

State of the art

The quality of corporate information on the web has been studied from different perspectives and approaches. Below we present five of the main lines of research applicable to the case of web information on research carried out at universities.

First of all, we have descriptive, and subsequently comparative, studies on contents and information services. Obviously, one of the pre-conditions of the visibility of research information is that the information is available on the web. Therefore, a first criterion will be the presence or not of information on the Internet. Relevant information can be identified by comparison with other existing sources or often by comparison of the different web services and contents. These descriptive and comparative studies are in turn a precondition for the proposal of ontological models of contents, some of which – besides the logical empirical practice – already exist based on this type of prior, theoretically elaborated studies in the area of university information (MIDDLETON et al., 1999).

Once information becomes available, it should be accessible and usable. Thus, a second type of study refers to accessibility through search engines and general and specialized catalogues. Accessibility through search engines – the method most employed by users – is an important field of research, which has even merited the interest of the journal *Nature* (LAWRENCE & GILES, 1999).

Third, the debate on the quality of the information on the Internet has centered greatly in recent years on aspects related to user satisfaction, first from a qualitative point of view, by proposing models based on the theoretical development of batteries of practical advice (e. g. CODINA, 2000), and subsequently by looking for indicators susceptible to automatic evaluation. Within this first approach, the star theme of the turn of the century as regards web site design is turning out to be its so-called "usability" (BADRE, 2002; BAWA, 2001; BRINCK, 2002; CHANDLER, 2003; CLAUSON, 1999; DUSTIN,2002; GRAHAM, 2002; HOLMES, 2002; KRUG, 2000; MANDER, 2002; NIELSEN, 2000, 2002; NORLIN, 2002; PEARROW, 2002; SPOOL, 1999; WROBLEWSKI, 2002). NIELSEN (2000) defines it as a qualitative attribute that evaluates the degree of ease of use of an interface, and situates it proactively with the methods that can be used to improve this ease of use during the design process. Most qualitative studies of web sites follow the flag concept of usability, although there are others not inscribed directly in this trend. All have contributed decisively to the study of university web sites. Among them we can quote, for example, that of CORRY et al. (1997); that of the South Africans BANTJES & CRONJE (2000); that of the SPANIARDS MATEOS et al. (2001), of TÉRMENS et al. (2003) and of the project USABAIPO (ASOCIACIÓN INTERACCIÓN PERSONA ORDENADOR, 2004) on the usability of Spanish universities webs; and that of the Argentine researchers OLSINA ET al. (1999a, 1999b). The criteria chosen and the models of analysis will be studied below.

It should be pointed out that the analysis of qualitative indicators has opened the door to the analysis of quantitative indicators – susceptible to being collected by a search robot – that correlate well with measures of quality. This line of research, closely connected to the former, but which offers complementary advantages quite such as the extraction of data independent of human judgment or the breadth of the sample studies, is becoming very popular and will be presented in detail later.

Finally, there is also an important line of research that is connected with the bibliometrical tradition, and approaches the indirect estimation of the quality of web sites by means of the links that the source receives. The use of bibliometric methods for Internet assessment was foreseen by PAISLEY (1990) and there are now several studies applied to the field of university information on the web, from the one pioneered by ALMIND & INGWERSEN (1997) on Danish universities; to the most recent ones by SMITH & THELWALL (2002) on Australian universities; THELWALL (2002), PAYNE & THELWALL (2004), and THELWALL & WILKINSON (2004) on British universities; TANG & THELWALL (2004) on US universities; and VAUGHAN & THELWALL (2005) on Canadian universities. An study has been produced with this methodology on Spanish universities (THELWALL & AGUILLO, 2003; see also AGUILLO, 2000). These studies allow us to extract inferences on the impact of the scientific production of universities similar to that obtained in bibliometric studies.

Work methodology

Brief description of the methodology of the whole project

To develop the objectives of our study we decided to apply a diversified and complementary methodology that would allow us to analyze indicators of quality regarding the visibility of information on research in Spanish university web pages. With this in mind we developed two different research methodologies, one qualitative and the other quantitative, which were then applied to the same set of university web sites. To do this, a sample of 19 universities was selected from the total of 65 Spanish universities, both public and private,[*] chosen according to their representativeness on the national scene and their administrative and scientific weight. We selected one university for each Autonomous Community, except for Madrid and Catalonia, where two were selected from each, given the greater number of universities in those two regions. A non-random intentional sampling was then carried out, in an attempt to guarantee maximum representativeness. The consensus of all the researchers on the multivariate analysis allowed us to define the universities to be studied. They were the following:

[*] Information taken from http://www.rediris.es/recursos/centros/univ.es.html

uab: Autonomous University of Barcelona
ub: University of Barcelona
uc: University of Castilla la Mancha
ucm: Complutense University of Madrid
ugr: University of Granada
uib: University of the Illes Balears
ul: University of La Laguna
um: University of Murcia
un: University of Navarra
unex: University of Extremadura
unican: University of Cantabria
uniovi: University of Oviedo
upm: Polytechnic University of Madrid
upv: Polytechnic University of Valencia
uri: University of la Rioja
us: University of Santiago de Compostela
usal: University of Salamanca
uz: University of Zaragoza
ehu: University of the País Vasco

An extensive summary of the qualitative methodology, results and conclusions has been published in Spanish in the *Revista Española de Documentación Científica* (PINTO et al., 2004). This article presents mainly the quantitative methodology, results and conclusions, though a summary of the qualitative research follows to provide context.

The qualitative research consisted of five stages. First, 58 qualitative criteria, with two values – true or false – were defined and grouped in seven areas or categories, based on a major review of the bibliography and a series of group brainstorming sessions. Second, a couple of analysis tools were designed for the convenient standardization of the analysis process of each university. The main tool was a "Data Sheet" with the areas and criteria, the subtotals for each area, the total score, and an assessment column containing the subtotals by category, but using a scale of 1 to 5, according to the percentage reached in relation to the maximum possible score. Thus, each category was assessed as "not acceptable" (up to 20% of the maximum score), "middling" (up to 40%), "acceptable" (up to 60%), "good" (up to 80%) and "very good". The mean value was also calculated in order to have an overall view of the assessment of each university. The second work tool was a "University Report" in free text, stressing positive and negative aspects, that is strong and weak points, giving complementary information, illustrated with the necessary web page screens. Third, the definitive collection of data took place in 2003 from July to September. The overall results were summarized in a general table (Table 1 in the Appendix), containing the assessment of each criterion individualized by university, the mean value and the

standard deviation. Finally, the overall data was interpreted, systematizing best practices and suggesting recommendations. The categories, indicators and results can be appreciated in Table 1 and are carefully explained in the cited previous publication (PINTO et al., 2004).

Methodology of the quantitative research

Quantitative works on the web center around a recent discipline, Cybermetry, which has an important statistical basis and which requires the compilation of thousands of pages, which can only be treated and analyzed automatically, in order to complete its task (ALONSO, 2002).

The procedure for collecting information was carried out using an automatic robot, such that, once assigned a starting page, the robot analyzes it, extracts the links it has and connects with them automatically, allowing the successive collection of thousands of pages. All the information from the pages analyzed is stored in a data base and all the necessary indexes can be calculated. For this phase we worked with the robot called *Sacarino bot*[*] developed by the REINA group[**] of the University of Salamanca. It is a highly configurable robot that has allowed us to work suitably in all the cybermetric aspects of this work.

The initial starting point, for each of the domains analyzed, consisted of the page address with the "Research" anchor of each university. Since each case was different in each of the universities analyzed and with the objective of unifying the automatic access to contents, we decided, for each one of them, to manually create a web page containing exactly the links that that university had placed in the section "Research", although there were other links related to research found outside this section.

A restriction we placed on the robot was to limit the level of depth we wished to analyze. To do this, we set the depth level to a maximum of 6, the same for all the domains. The motivation was none other than to avoid going through the entire graph of each university. Once all the pages of all the domains were collected, we applied an automatic classifier, properly trained with several pages selected expressly for research topics, and we felt that this test was adequate for confirming that the data collected indeed dealt with the topic of our study. The information collected was stored in a relational data base and processed.

Page-oriented or simple indicators.

a) Evolution of types of files. One aspect to study in the evolution that has taken place on the web is the use of certain types of files. This will give us an indication of the

[*] Sacarino. **S**onda **A**utomáti**CA** para **R**ecuperación de **IN**formaci**Ó**n en el web (Automatic Probe for Information Recovery on the Web)

[**] Grupo REINA, **RE**cuperación **A**utomatizada de la **IN**formación. (Recovery of Automated Information), http://reina.usal.es

trends occurring at a given moment in the use of a specific type of format, which is sometimes a matter of a temporary trend and in some cases an indication of the introduction and success of a certain technology. We therefore studied the evolution of the following types:

– Compression Files	– Graphics Files
– Video Files	– Sound Files
– Use of Styles	– Web Formats
– Use of Multi-Media Elements	

b) Use of tags. We analyzed the use of certain tags, their evolution, and in some cases the options most used of some of them.

- Title tag.
- Several tags. We represented in an overall way the use of several tags in the different universities. The tags analyzed were: <B>, <BGSOUND, <BLINK>,
, <CENTER>, <DIR>, <DIV, <FONT, <H, <HR, <I>, <LI>, <MAP, <MARQUEE, <OL, <P>, <PRE>, <STYLE, <TABLE, <UL, STYLE=>
- Use of "description" in the META tags. Accessibility in metadata (we have centered on the META tag). We calculated the ratio between the number of pages and the times the tag-option appeared (best was the trend to 1). The correct use of this option in the META tags involves additional description work on the document on the part of the author of the information and can be an interesting element of study.

c) Dates of up-dating. The dates when documents are up-dated give us an idea of how current the information is, although not their degree of up-dating.

d) Erroneous links. The existence of erroneous links in a web design indicates a lack of up-dating in the design of the hypertext system, which makes access to information difficult and gives an indication of how long the pages have been there.

e) Size of the web. Within the page-oriented analysis we should include those related to the different web sizes, highlighting:

– *Single number of nodes (of pages)*. The number of nodes is considered by some authors to be a first order cybermetric indicator and offers a good estimation of the growth of the different sites, which allows us to assess whether the domains have strong growth or not.

– *Document size*. The document size, also considered a first order cybermetric indicator, allows us to compare the size in bytes of the different web pages. In principle, the greater the size the more contents offered. Unlike other collection processes, our

measurement is not biased by the presence of multimedia objects, since the size is the real size of the content, disregarding multimedia elements

Connectivity indicators. The analysis of the characteristics of the links, as an important part of hypertext and thus of the web, is essential for suitably knowing the different domains or sites that we are analyzing and is related to information and information flows originating in the web. As ALONSO et al. (1999) state, links give a page a peculiar character that differentiates it from the rest of the documents and allow us to approach information retrieval on the web, a fundamental aspect in document processing, as shown by FIGUEROLA et al. (1998).

a) Hypertextual analysis. Number of links. Here, the total number of internal links is reflected.

b) Hypertextual density. This is considered to be the arithmetic mean of the number of links that each domain or site has. It tells us the mean number of links of the domains, although logically we cannot assess whether the changes made in the links are important or not. This indicator is most useful when several data collections are carried out from the same space and on different dates because we can then make a comparison.

c) Hypertextual development index. ELLIS (1994) and PARUNAK (1989) suggest that a good measure in this sense is $\frac{\text{no. of nodes}}{\text{no. of links}}$ (without counting node self-links), which allows us to characterize the hypertext topology in such a way that the lowest values point to a better index of hypertextuality and thus a better connection overall.

d) Endogamy index. This index endeavors to analyze the quality of the hypertext system by assessing the internal links and offering a good measurement of whether the domains have basically internal referencing or, on the contrary, have a better level of connection with other domains. To do this we propose calculating the endogamy index in such a way that the lower this value, the less endogamic the domains.

e) Visibility. This term used by BRAY (1996), who defined it as the characteristic that tells us the site that receives the most links, has been redefined by other authors seeking to eliminate the biases that the Web Impact Factor (WIF) calculation can have.

$$\frac{\text{no. of pages that mention the site}}{\text{total no. of pages of the site evaluated}}$$

This redefinition is aimed at obtaining the domains that receive the most links, but in a standardized way, permitting the comparison between the different domains analyzed.

f) Web diameter. This measurement (ALBERT, 1999; FALOUTSOS, 1999) is the maximum distance it takes to reach a given document, and gives an idea of the difficulty that may exist in reaching certain documents.

Topological measurements. An aspect that we believe could be useful in the quantitative study, although rarely applied in studies of this type, is related to the topological aspects of the web structure. A good way of analyzing the evolution of web domains, which focuses fundamentally on its hypertextual nature, is to calculate a set of measurements that take into account the links that occur between the different documents that make up the corresponding domain, as justified by SMEATON (1995b); ELLIS (1994); and BOTAFOGO (1992). Other subsequent studies, such as those by KLEINBERG (1999), based on the above-mentioned works, have focused on the study of connectivity and the topological structure of the web. KLEINBERG (1999) even relates this kind of work to the analysis of quotations and to the impact factor. These measurements are based on the consideration of the web as a graph (BOTAFOGO, 1992; ELLIS, 1994; HAYES, 2000; BRODER, 2000) and the application of different techniques proper to this theory, which we shall analyze later.

Furthermore, these measurements have a very interesting nature, proposed by ELLIS (1994), which is that they can be considered as measurements of similarity for graphs. This consideration allows us, besides obtaining a single value for each of the graphs, to use this single value to make comparisons between the values of different domains, indicating, when these values coincide, that both graphs (and therefore, domains) are very similar from the point of view of the characteristic we are measuring at the time.

a) Study of the graph. When considering the web as a graph, the nodes are represented by the html pages and the links are represented by directed edges.

The analysis of the structure of the web graph has been used on occasion to improve the quality of web searches, as in KLEINBERG (1999). It has also been used to classify web pages on the basis of the topic of the pages to which a specific page points, as in CHAKRABARTI (1998b), etc.

The link structure of the web also contains information on the different web communities that can be created and that are reflected through the web topology; it also allows techniques of similarity to be applied, based on the links, to structure and visualize the web (ALONSO, 2002).

- *Compaction*. The compaction index of a graph is a measurement that is obtained based on the matrix of converted distance. A graph having a high value in its compaction index indicates that the different nodes pertaining to the graph can be reached or linked easily, and this suggests a large number of cross references or links between different nodes. The compaction index moves between a value of 0, which indicates that the site is totally unconnected, and a value of 1, which indicates that the site is totally connected. This index is independent of the size of the graph and is a measurement that is extremely sensitive to the slightest variation in the graph structure, thus making it possible to differentiate graphs with the same number of nodes and links, but whose structure varies.

- *Stratum.* This is an index that lets us know whether the hypertext has been designed in a linear, hierarchical form that induces the user to follow a specific order for obtaining information or whether, on the contrary, this hierarchical structure does not exist and there is no order pre-established by the designer of the site for obtaining information

The values that the stratum can reach range from a value of 1, indicating a hypertextual structure of the linear type, which is not interesting since it does not take advantage of the characteristics of hypertext, to a value of 0, which indicates a circular structure in which the node for beginning the reading of information cannot be distinguished.

Results*

Simple or page-oriented indicators

Evolution of file types.

- Compression files. The use of compression files in the research web pages of the domains analyzed was relatively low, with minimum impact. The University of Granada (ugr) stood out from the rest in this respect. The presence of compressed files can indicate information available for downloading. Among the formats analyzed, the ZIP format was clearly the most used.
- Graphics files. The use of graphics formats in the different domains is much more generalized, with the University of Zaragoza (unizar) clearly ahead of the rest. Of the formats analyzed, the GIF format stands out as the most used.
- Video files. The presence of video files in the domains analyzed is practically null, with the University of Granada (ugr) standing out from the rest. The format most used is MOV.
- Sound files. There was a minimum use of sound files, the most used being WAV.
- Use of styles. The use of style sheets was quite generalized, with the University of Oviedo (uniovi) at the head (see Figure 1).
- Use of multi-media elements. In the overall assessment of multi-media elements, the University of Zaragoza (unizar) stood out from the others in the use of these elements (see Figure 2).

* A summary can be found in Table 2 of the Appendix

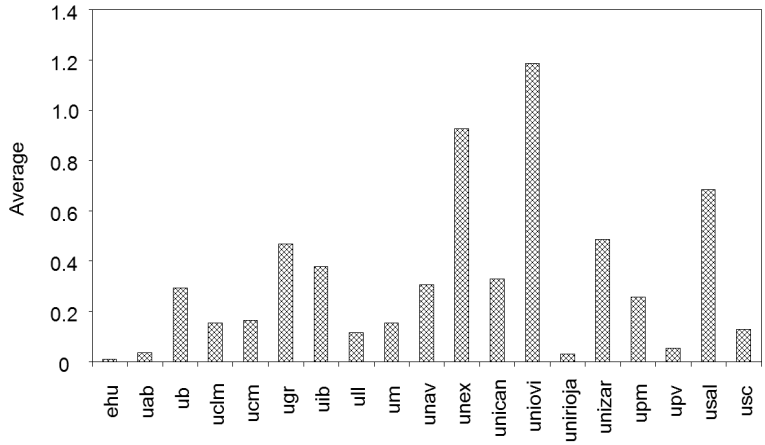

Figure 1. Use of style sheets

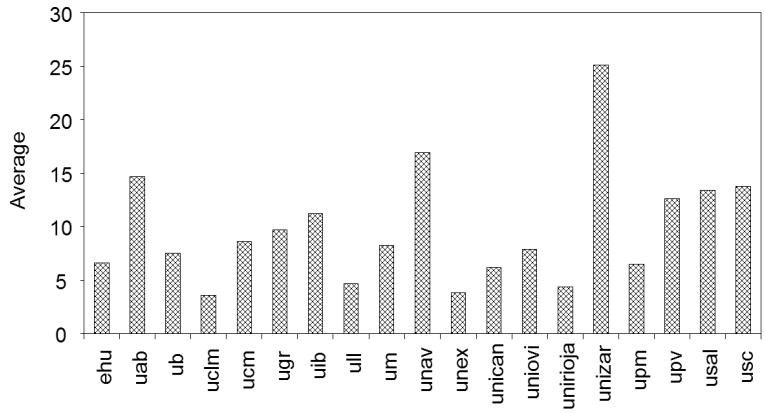

Figure 2. Use of multimedia elements

Use of tags.

- Title tag. It can clearly be seen that the domains have many pages without a title (taking into account that most editors assign it automatically nowadays) and some with values below 50%. The University of Extremadura (unex) stands out at 100%.

- Other tags. There was a minimum presence of tags such as BGSOUND (background sound), BLINK, PRE (text preformatting), MARQUEE, MAP (sensitive images). Of the two basic modalities for working with styles, the modality of working with reference to the (STYLE=) file clearly stands out with respect to incorporating the style to the page itself (<STYLE), and the university that most uses them is the University of Salamanca (usal) (such a high mean is due to the use of a STYLE= option applied to different tags).

There was a minimum use of lists, both ordered (OL) and unordered (UL) and a greater use of tables (TABLE), which seems to be a logical development.

The very generalized use of the FONT tag was notable in all the universities, as well as a quite generalized use of the DIV tag.

- Use of "description" in META tags. As can be seen, most of the domains studied lack the META tag with their description option. The University of Navarra stands out for its use of this (see Figure 3).

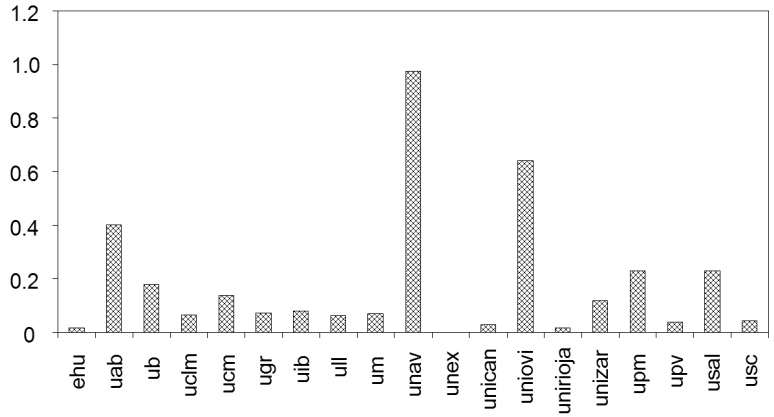

Figure 3. Use of description in META tags

Dates of updating. The number of universities that have pages with a date for the last updating in 2003 with percentages higher than 60% is only 7, the University of Murcia (um) (80%) and the University of Oviedo (uniovi) (91%) being most worthy of note. When the percentages for 2002 and 2003 were analyzed, all of them were above 60%, except for the University of Extremadura (unex), which had only 19% of pages updated in those years.

Erroneous links. It must be said that there was only one university with erroneous links, the University of the País Vasco, which had 10 erroneous links out of the 3263 links analyzed. There were no erroneous links in the rest of the universities.

Web size.

- *Absolute number of nodes (of pages).* Outstanding in size, with respect to the number of pages obtained, is the University of Granada (ugr), followed by the University of la Rioja (unirioja) (see Figure 4). As far as the small size of the research section is concerned, the University of Extremadura (unex), the University of the País Vasco (ehu), the University of Zaragoza (unizar) and the Autonomous University of Barcelona stand out. This piece of data could be assessed more precisely by knowing the total size of the domain of each university, and is an aspect to be taken into account in future work (one would work with the whole domain).

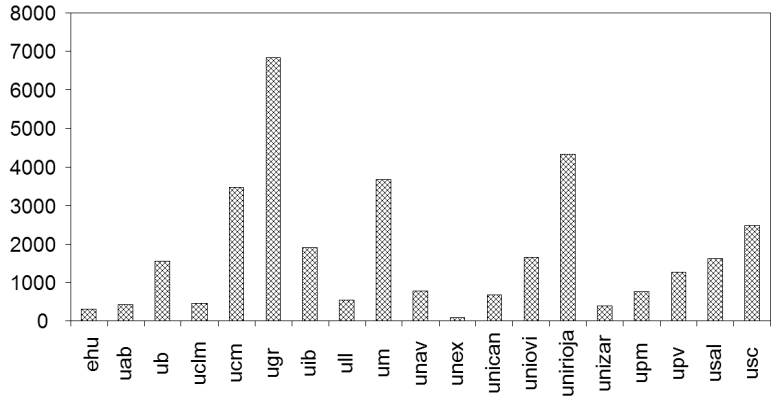

Figure 4. Number of nodes

- Size of the documents. The largest files were found at the University of Salamanca (usal), with the others having values closer to 10KB as opposed to the 50KB of usal (see Figure 5).

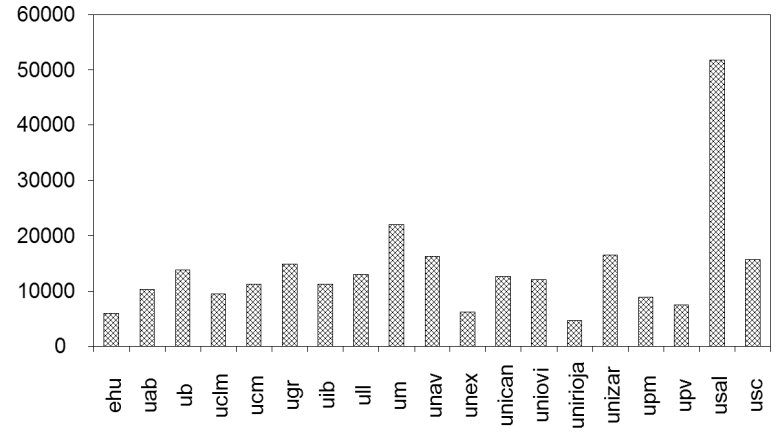

Figure 5. Average size (in bytes)

Indicators of connectivity

Hypertextual analysis. Number of links. The number of links follows the same trend as the number of nodes (as could not be otherwise). A priori, the more nodes, the more links. There are slight variations in the position of the universities according to the number of nodes and the number of links they have. We felt this was of scant significance (see Figure 6).

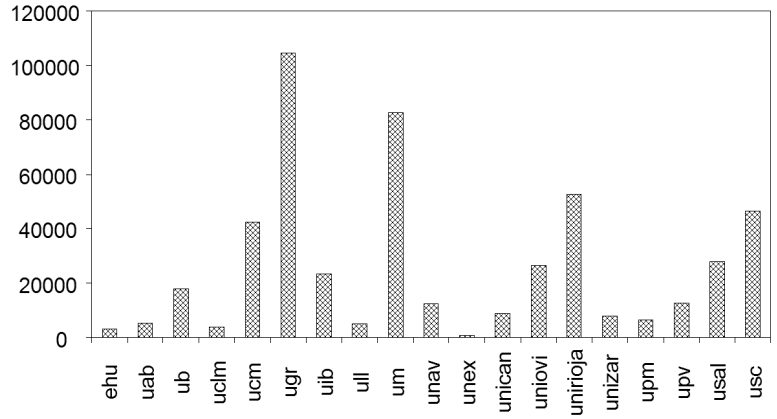

Figure 6. Number of links

*Hypertextual density.*This measurement specifies the data commented upon in number of links, relating the number of nodes and the number of links. In this aspect the University of Murcia (um), the University of Zaragoza (unizar), the University of Santiago de Compostela (usc) and the University of Salamanca (usal) stand out. The University of Granada (ugr) merits special mention, since it had the largest number of nodes and links and maintains a rather high density (see Figure 7).

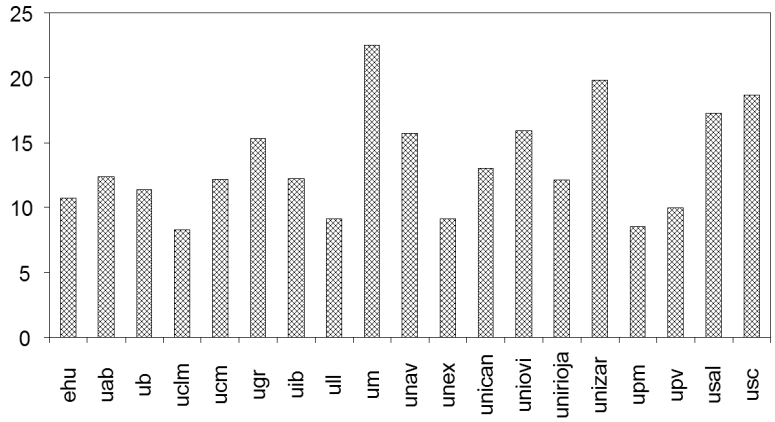

Figure 7. Hypertextual density

Index of hypertextual development. The best development of hypertext was found at the University of Castilla la Mancha (uclm), closely followed by the Polytechnic University of Madrid (upm). The good development of the University of Extremadura should also be mentioned (see Figure 8).

Index of Endogamy. The universities with the most internal page links (self-referencing pages) were the University of Navarra (unav) and the University of la Rioja (unirioja) (see Figure 9).

Visibility. The results of visibility (related to the hypertextual system and the links between one university and the research pages of the others) showed that the University of the Pais Vasco (ehu) was the most visible, followed by the University of Zaragoza (unizar) (see Figure 10).

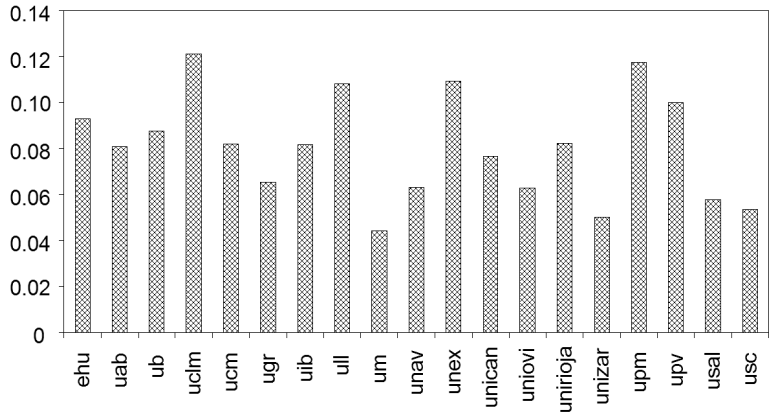

Figure 8. Hypertextual development

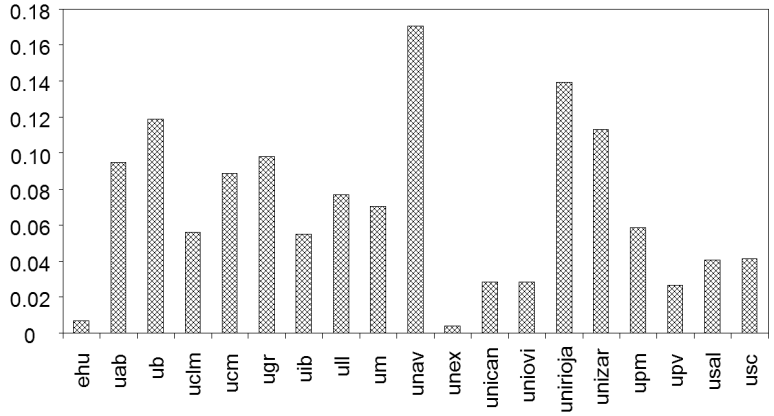

Figure 9. Endogamy

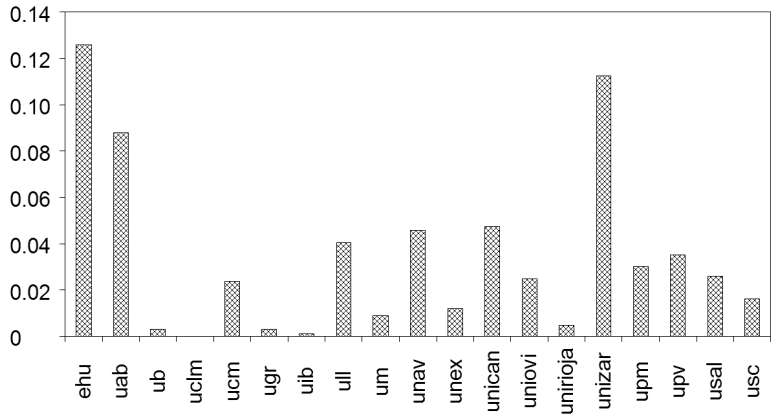

Figure 10. Visibility

Web diameter. In the case of diameter it must be taken into account that a smaller diameter means that it is easier to reach all the documents that form part of the collected space of information. Therefore a high value means that it is complicated to reach certain documents in the work space. The university with the largest diameter is the University of Barcelona (ub), followed by the University of the Pais Vasco (ehu) (see Figure 11).

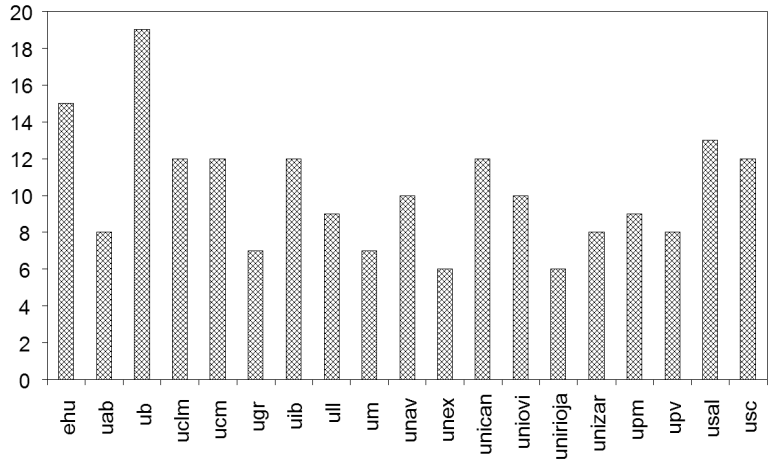

Figure 11. Diameter

If we take into account that the average web diameter of the Spanish domains is approximately 12 (ALONSO, 2002), only three universities have a larger one and 58% have a diameter under 10.

Topological measurements

Compaction. Thirty-seven percent (>0,7) of the universities were very well connected from the hypertextual point of view, the most outstanding being the University of la Rioja (unirioja), with a value close to 1. Thirty-two percent were badly connected, especially the Polytechnical University of Valencia, with a very poor score (see Figure 12).

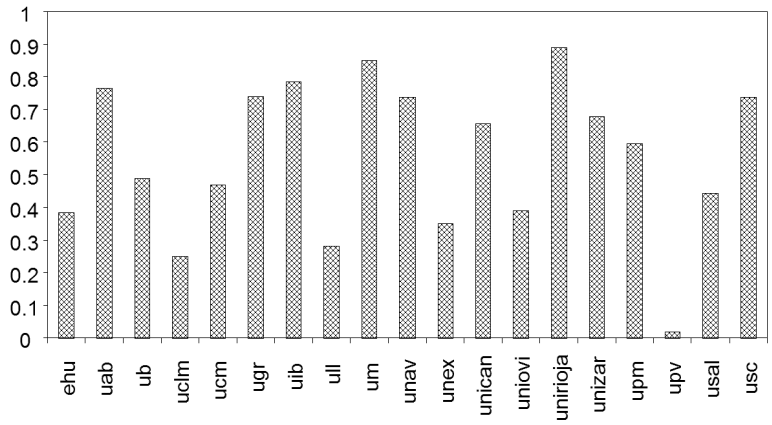

Figure 12. Compaction

Stratum. In general, the design of the university pages is circular, not linear or hierarchical. Users can choose the information they wish, without preset specific routes. The Polytechnical University of Madrid (upm) has the most hierarchical structure, but as we can see the value is around 0.11, which is very low. The Polytechnical University of Valencia (upv), with a value close to 0, has the most circular structure of all the universities (see Figure 13).

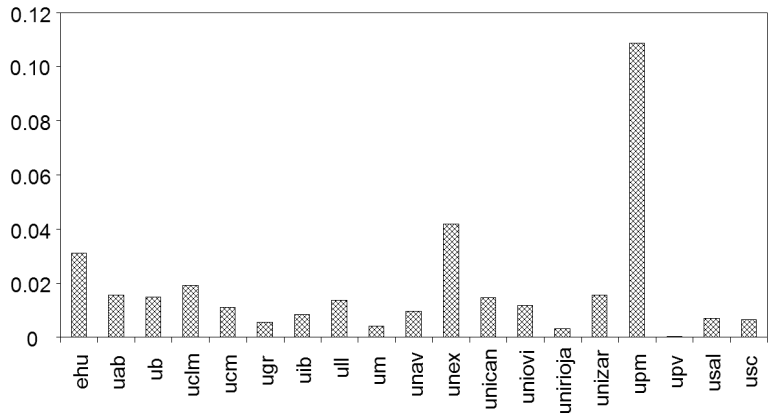

Figure 13. Stratum

Conclusions

The main conclusions – and implied recommendations – regarding the quantitative part of the study give information on the universities' research contents, currency, use of 'advanced' formatting standards, navigability, metadata and interrelations; and are consistent with the qualitative research conclusions and recommendations.

Referring to *contents*, there are conclusions regarding both the volume and type of information. The *volume* of information differs greatly among universities. Smaller size fields are preferred. Regarding the type of information, it is clear that universities give mainly textual and simple graphic information, and do not provide many documents for download. Much can be done to improve the multimedia dimensions of Spanish university webs.

The analysis of the *currency of information* suggests the presence of problems with the updating of information, but there are very few erroneous links.

Universities use advance formatting techniques, for example, they have widely adopted style files.

Regarding *navigability,* Universities do a good use of hypertext, with truly circular structures and generally acceptably connected pages.

But use of *metadata* is a weak point. Metadata are rare and even title tags are not consistently assigned. This problem connects with other accessibility issues detected in the qualitative study, for example, problems with positioning in search engines like Google.

Finally, and to a certain extent logically, due to the institutional character of the pages studied, *the relation among universities research pages* is low. Universities webs are mainly endogenous in the pages related to research institutional information.

As final words, it can be said that the research project assessed, both from the quantitative and the qualitative point of view, the availability of information of the results and management of research in a sample of nineteen Spanish universities. Starting from the perspective that the web is a space for the transmission and representation of vital information in the context of the society of knowledge, the absence or inadequate representation of information on research greatly reduces the accessibility of the rest of the scientific community and society in general, even the members of the same university community, to this information.

As has been mentioned previously, this work has not assessed university research itself, but rather the visibility of this research through its dissemination on the Internet. In fact, we have found that these two dimensions are not often correlated, which shows the need for establishing mechanisms of improvement which will permit the optimization of visibility and access to the information on research carried out in Spanish universities. This requires special attention on the part of those responsible for the area of university research.

*

This research was carried out with aid from the Spanish Programme for the Study and Analysis of Quality Improvement in Higher Education granted by the Spanish State Office for Universities, 2003. (Proyect EA2003-0012). Anne-Vinciane Doucet has participated as a research fellow.

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Appendix

Table 1. Summary of the results of the qualitative research. Legend of the assessment: NA: Unacceptable, R: Middling, A: Acceptable, B: Good, MB: Very Good

		UNIVERSITIES																			
	CRITERIA	UAB	UB	UC	UCM	UGR	UIB	UL	UM	UN	UNEX	UNICAN	UNIOVI	UPM	UPV	URI	US	USAL	UZ	EHU
1.	**Visibility**	10	11	12	7	8	11	9	8	8	5	6	8	7	10	6	9	8	6	8
1.1.	Entry main page	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	0	3
1.2.	Entry second level	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
1.3.	Site Map	2	2	2	0	0	2	2	0	0	0	0	2	0	2	0	0	0	2	0
1.4.	Table of Contents	2	3	3	3	2	3	1	2	1	2	2	0	2	2	1	3	3	2	2
1.5.	Search Engine	2	2	3	1	2	2	2	2	3	2	0	2	1	2	1	2	1	2	2
2.	**Authorship**	2	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	2	1
2.1.	Logo and university text	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2.2.	Webmaster	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0
3.	**Up-dating and Current Situation**	3	3	3	2	1	2	0	0	0	1	1	1	1	1	0	1	2	1	1
3.1.	Up-dating	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1
3.2.	Obsolete Links	2	2	2	2	0	2	0	0	0	1	1	1	0	1	0	1	2	0	0
4.	**Accessibility**	5	5	4	2	3	4	3	4	3	4	2	5	3	4	1	2	3	3	4
4.1	Compatible Navigators	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	1
4.2	WAI Standard	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.3	Printing	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1
4.4	Structural Help and Navigation	1	1	1	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0
4.5	Different Languages	1	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	2
5.	**Dissemination of Research**	23	15	23	3	9	19	6	6	8	10	6	12	4	13	8	20	8	15	8
5.1.	Search Engines	0	0	2	0	1	0	1	0	2	0	1	0	0	0	0	2	0	1	1
5.2.	Research Groups	3	3	3	0	2	3	1	2	0	1	0	2	0	3	0	3	1	3	3
5.3.	Conferences	3	3	2	0	0	3	0	0	0	0	0	2	0	3	1	3	0	2	0
5.4.	Projects	2	0	2	0	1	2	0	0	0	1	1	0	0	0	0	1	0	0	0
5.5.	Calls for Prizes	2	0	2	1	1	0	1	1	0	1	0	1	1	0	1	1	1	0	0
5.6.	Calls for Subsidies	2	2	2	2	2	2	1	0	2	1	2	2	1	2	1	1	1	2	1
5.7.	Calls for contests	2	2	2	0	0	2	0	0	0	1	0	0	1	2	1	2	1	2	2
5.8.	Relevant Info	1	1	1	0	1	1	0	0	1	1	0	1	0	1	1	1	1	0	0
5.9.	Researcher Directory	2	2	2	0	0	0	0	0	0	1	0	0	0	2	0	0	0	2	0
5.10.	Publications	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0
5.11.	Auxiliary Resources	1	1	2	2	1	1	1	1	2	1	0	1	0	0	0	2	1	1	1
5.12.	Research Reports	3	0	1	0	0	3	1	1	1	2	2	3	1	0	3	3	1	2	0
5.13.	Audience	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
6.	**Quality Assessment**	1	1	0	0	0	1	1	1	1	1	2	0	0	0	0	0	1	1	0
6.1.	Web Quality Policy Reflected	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
6.2.	Suggestion Box	1	1	0	0	0	1	1	1	1	1	1	0	0	0	0	0	1	1	0
6.3.	Questionnaire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.	**Navigability**	3	4	2	0	4	4	2	4	2	3	1	2	2	4	3	4	2	4	2
7.1.	Contents Menu always visible	2	2	1	0	2	2	1	2	1	2	0	0	0	2	2	2	1	2	0
7.2.	Consistent Terminology	0	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	0	1	1
7.3	Navigation buttons	1	1	0	0	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1
	MEAN SCORE	MB	B	B	R	A	B	R	A	R		R	A	R	A	R	B		A	A

Table 2. Summary of the results of the quantitative research

INDICATORS		UNIVERSITIES																		
		EHU	UAB	UB	UCLM	UCM	UGR	UIB	ULL	UM	UNAV	UNEX	UNICAN	UNIOVI	UNIRIOJA	UNIZAR	UPM	UPV	USAL	USC
Page-Oriented																				
File Types																				
	Compression	0	0	2	6	208	727	52	6	208	6	0	2	16	34	6	8	14	60	60
	Graphics	1995	6169	11754	1632	29918	66080	21220	2535	30217	13318	318	4179	13035	19014	9816	4926	16076	21703	34275
	Video	1	0	3	1	6	139	23	0	6	3	0	0	0	2	0	0	0	0	9
	Sound	1	0	0	0	30	30	3	1	30	5	0	1	2	1	4	1	2	1	0
	Style Sheets	3	15	458	71	569	3192	718	63	569	241	77	222	1968	129	191	195	69	1106	321
	Multimedia	1997	6169	11757	1634	29954	66249	21246	2536	30253	13326	318	4180	13037	19017	9820	4927	16078	21704	34284
	HTML	2141	2717	6407	1781	24343	48189	10267	2248	24343	6104	308	3408	14876	24782	4791	3195	3954	12650	23397
	Total	4244	9077	19260	3715	56381	1E+05	33262	5153	56879	20269	865	7965	31738	47655	15613	8843	20223	37084	58811
Use of Tags																				
	<TITLE>	144	284	1077	355	3100	5787	1551	420	3061	685	84	481	1412	3752	280	553	600	1379	2095
	META descrip	5	169	281	30	478	489	152	34	255	768	0	19	1064	76	46	175	51	370	107
Updating																				
	2003	45.34	49.28	39.26	36.36	44.24	35.70	72.39	31.66	80.33	57.42	6.41	73.95	91.61	70.59	67.37	52.18	69.50	56,37	47,52
	2002	28.81	22.12	29.48	32.73	24.54	34.99	10.63	34.56	13.92	18.41	12.82	8.75	2.93	29.41	21.75	27.33	16.22	24,23	28,13
	2001	15.25	13.70	24.16	24.24	10.64	21.98	7.28	13.51	3.97	4.48	15.38	9.13	2.27	0.00	7.16	17.59	4.83	6,955	16,57
	2000	9.75	13.94	3.81	4.55	9.34	4.07	2.61	15.06	0.65	16.50	65.38	3.04	1.40	0.00	2.92	0.87	7.20	9,663	4,143
	< 2000	0.85	0.96	3.28	2.12	11.25	3.26	7.09	5.21	1.13	3.20	0.00	5.13	1.80	0.00	0.80	2.03	2.26	2,78	3,63
Erroneous Links		10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Page Sizes		5.76	10.04	13.46	9.24	10.92	14.51	10.97	12.72	21.44	15.83	6.04	12.28	11.72	4.47	16.02	8.63	7.27	50,44	15,24
No. of Nodes		303.00	422	1565	461	3473	6827	1898	542	3665	787	84	675	1659	4333	392	759	1274	1617	2483
Connectivity																				
No. of Links		3263	5225	17887	3811	42398	1E+05	23241	5007	82559	12422	769	8812	26452	52650	7796	6468	12722	27984	46443
Hiper. Density		10.70	12.38	11.40	8.27	12.20	15.32	12.24	9.15	22.50	15.72	9.15	13.02	15.93	12.14	19.84	8.52	9.98	17,28	18,70
Hyper.Develop		0.0929	0.0808	0.0875	0.1210	0.0819	0.0652	0.0817	0.1082	0.0444	0.0634	0.1092	0.0766	0.0627	0.0823	0.0503	0.1173	0.1001	0,0578	0,0535
Endogamy		0.0070	0.0948	0.1189	0.0560	0.0887	0.0980	0.0552	0.0767	0.0702	0.1707	0.0039	0.0283	0.0285	0.1393	0.1129	0.0584	0.0265	0,0406	0,0412
Visibility		0.1258	0.0879	0.0032	0.0000	0.0239	0.0032	0.0011	0.0407	0.0090	0.0458	0.0120	0.0475	0.0247	0.0046	0.1125	0.0303	0.0353	0,0260	0,0161
Web Diameter		15	8.00	19	12	12	7.00	12	9	7	10	6	12	10	6	8	9	8	13	12
Topology																				
Compaction		0.3828	0.7658	0.4881	0.2487	0.4692	0.7383	0.7856	0.2822	0.8507	0.7369	0.3515	0.6558	0.3904	0.8900	0.6787	0.5951	0.0182	0,4434	0,7367
Stratum		0.0311	0.0157	0.0149	0.0193	0.0111	0.0055	0.0084	0.0139	0.0040	0.0097	0.0418	0.0148	0.0118	0.0031	0.0157	0.1088	0.0004	0,0070	0,0066