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Checking an integrated model of web accessibility and usability evaluation for disabled people

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Abstract

A combined *objective-oriented* and *subjective-oriented* method for evaluating accessibility and usability of web pages for students with disability was tested. The *objective-oriented* approach is devoted to verifying the conformity of interfaces to standard rules stated by national and international organizations responsible for web technology standardization, such as W3C. Conversely, the *subjective-oriented* approach allows assessing how the final users interact with the artificial system, accessing levels of user satisfaction based on personal factors and environmental barriers. Five kinds of measurements were applied as *objective-oriented* and *subjective-oriented* tests. *Objective-oriented* evaluations were performed on the Help Desk web page for students with disability, included in the website of a large Italian state university. *Subjective-oriented* tests were administered to 19 students labeled as disabled on the basis of their own declaration at the University enrolment: 13 students were tested by means of the SUMI test and six students by means of the 'Cooperative evaluation'. *Objective-oriented* and *subjective-oriented* methods highlighted different and sometimes conflicting results. Both methods have pointed out much more consistency regarding levels of accessibility than of usability. Since usability is largely affected by individual differences in user's own (dis)abilities, *subjective-oriented* measures underscored the fact that blind students encountered much more web surfing difficulties.

Keywords: *Psychotechnologies, web accessibility and usability, user satisfaction, space and disability*

The theoretical model

The contrast between accessibility and usability is often reduced superficially to that of objectivity and subjectivity. This does not shed sufficient light on the complex interaction between technology and user [1 – 3]. According to this perspective, accessibility refers to the environmental characteristics of entrance/exit movements. Applying this view to user/computer systems, it therefore only concerns both hardware and software of the technological product. On the other hand, usability pertains to a system ability to perform the task for which it was designed, when it is utilized by a specific user [4]. Consequently, usability does not pertain at all to the technological aspects of a machine functioning, but to the cognitive aspects of the individual differences.

Defined in this bi-polar manner, accessibility might be established as the objective end of the user interaction while usability could be correlated to the subjective aspects, as determined by users' inherent individual differences. From this perspective, a technological product is reduced to a neutral entity that functions independently from its user in a neutral environment. As a result, a machine could be perfectly accessible but not usable.

In contrast, the *systemic-constructivist* perspective [5] proposes to overcome the false scientific dichotomous comparison between object and subject. Each entity is not considered separately from its observer

during the interpretative/reconstructive process because the entity is known by the subject only as an observed and perceived object.

From this viewpoint, accessibility and usability are not understood as characteristics regarding two separate interacting entities but rather as one system where both object and subject are just moments in a multiphase process of empirical observation. This prevents the existence of user-less technological products thereby guaranteeing that the accessibility of a machine always refers only to the possible entrance and exit of a signal needed to fulfill the task for which it was designed, and that it is in constant relation either to its designer or to its user. In this sense, a machine cannot be accessible and yet unusable at the same time.

According to this model, accessibility and usability do not refer to the objective and subjective factors of the user/technology rapport, but rather to a bidirectional way of observing the interaction. In effect, this represents two prospective points from which the one and only observed reality of the user/technology system is drawn. Accessibility of an environment is therefore defined based on how it allows the user to initiate and terminate the operation that completes the machine's task (*functioning construct*) while its usability is based on the user's perception of the user/technology interaction (*user performance*). The *functioning construct* of a machine is the basis for standard rules, (e.g., *Web Content Accessibility Guidelines Working* 1.0 [WCAG 1.0]) against which accessibility levels are controlled and assessed. The *user performance* in relation to *functioning construct* of a machine allows us to deduce scales (e.g., efficiency, satisfaction, cognitive load, helpfulness) of usability scores.

The *systemic-constructivist* model is compatible with a universal model of disability whereby ability/disability are viewed within a *continuum*. Using ability/disability to refer to an individual functioning in a real context can only have a theoretical interest since nobody has a complete absence of disability or complete absence of ability [6–8]. Therefore, ability/disability are referred to by the activities performed by an individual, originating from the environment and valued by a predetermined *functioning construct*. These activities can change the topology of an environment, and the construct with respect to the process and measure expected of its functioning.

Experimental plan

Our experimental design was drawn in such a way that data regarding accessibility and usability dimensions assess the disabled-user/web-interface entire system. This system is a help desk web page 'Servizio Handicap' (SH), part of the official website of a large Italian public university. In order to reach this aim,

the experimental design was based on an integration of *objective-oriented* and *subjective-oriented* methods applied to the observed system.

The *objective-oriented* method was utilized in order to verify the compliance of the interface SH with the *standard rules* issued by the *Web Content Accessibility Guidelines Working Group*. The method was applied through semi-automatic analytic and empirical tests onto HTML web page developing code and the SH functioning, using different internet browsers. Since this method was principally applied to the SH-interface features of the observed system, we propose this as the system's accessibility parameter.

The *subjective-oriented* method was utilized in order to assess how the end user interacts with the artificial system. It was performed through psychometric analytical tests and empirical proofs of observation of behaviour. Since this method was principally aimed to observe the user behaviour in the system, measuring the satisfaction levels, we propose these as usability levels of the student-disabled/SH-interface system.

The two methods were applied to the observed system during two experimental Phases, A and B, through five kinds of measures:

A *Objective-oriented tests*
1. Preliminary evaluation of the compliance with the W3C's WCAG 1.0 using *Watchfire® Bobby*™.
2. Accessibility by means of graphic browser *Microsoft Internet Explorer 5*.
3. Accessibility by means of textual browser *Lynx 2.8.4*.

B *Subjective-oriented tests*
4. Submission of standardized psychometric tool: (*Software Usability Measurement Inventory*) developed by the 'Human Factors Research Group' of the University College, Cork, with the collaboration of the 'MUSiCproject'.
5. Direct observation of the user's behavior by the 'Cooperative evaluation' test.

The two methodologies required multidisciplinary expertise in psychotechnologies in order to utilize measures and data score. Phase A was led by a group of engineers with computer science expertise and Phase B was led by a group of psychologists with psychotechnology expertise.

Phase A: Objective-oriented tests

Specific aims

The specific aims were as follows:

1. To identify the principal kinds of barriers in the website SH.
2. To assess the compliance with the W3C's WCAG 1.0.

These Phase A goals were reached using the SH home page as the starting point. The path from the University home page toward the SH web site was not tested.

Tools and methods

Accessibility evaluation was performed according to the WCAG 1.0 by W3C. This document comprises 14 *guidelines* each consisting of various *checkpoints*. A *priority* level is associated to each checkpoint.

The three *priority* levels are defined as follows:

1. *Priority 1*: A web content developer *must* satisfy the checkpoint as a basic requirement for accessibility.
2. *Priority 2*: A web content developer *should* satisfy the checkpoint in order to remove significant barriers to access information in the document.
3. *Priority 3*: A web content developer *may* address this checkpoint so as to improve access to web document for a larger user population.

The 14 WCAG are reported here as identified by the WAI:

1. Provide equivalent alternatives to auditory and visual content.
2. Don't rely on color alone.
3. Use markup and style sheets and do so properly.
4. Clarify natural language usage.
5. Create tables that transform gracefully.
6. Ensure that pages featuring new technologies transform gracefully.
7. Ensure user control of time-sensitive content changes.
8. Ensure direct accessibility of embedded user interfaces.
9. Design for device-independence.
10. Use interim solutions.
11. Use W3C technologies and guidelines.
12. Provide context and orientation information.
13. Provide clear navigation mechanisms.
14. Ensure that documents are clear and simple.

Guidelines 1–11 are mainly focused on elegant transformation. Following these guidelines the web page developer guarantees user content comprehension regardless of page layout, access devices, or user operating context. These guidelines primarily affect the code development for web pages.

Guidelines 12–14, on the other hand, assess the basic principles of understandable and navigable web content design, such as: Using clear language, and providing simple navigation mechanisms. These accessibility and usability issues are more related to website design rather than to code development.

The *Watchfire*® *Bobby*^TM *4.01* testing software was used in order to verify the SH's conformance to the WCAG checkpoints. It automatically points out barriers to accessibility, detected in the code, and highlights crucial page elements that the analyzer successively has to check manually.

Since accessibility evaluation by automatic tools cannot identify all accessibility issues, a human review was performed as follows:

A Evaluating accessibility through a graphical user interface browser (*Microsoft Internet Explorer 5*):
  1. Turning off images in the browser in order to verify that the text-equivalent was appropriate and informative with respect to the image content.
  2. Testing with different screen resolution to verify that the content was always perceivable and that a graceful transformation was guaranteed. The resolutions, considered most frequently used by the statistical data provided by Web Counter (http://counter.-search.bg), are 1024 × 768, 800 × 600, 1280 × 1024, 640 × 480.
  3. Turning off the *Cascading Style Sheets (CSS)* in the browser to make sure that the content remained understandable.
  4. Verifying that color combinations and text-background contrast were adequate.
B Examining the website by means of the text-based browser *Lynx* in order to assess whether the content is understandable when the page layout is ignored.

Phase A: Objective-oriented tests

Semi-automatic validation through software Bobby^TM

WCAG 1.0 rules discourage web developers using table elements in HTML since some older *screen-readers* may not handle side-by-side text correctly. In the SH, the page layout is designed with nested tables which make content comprehension complex for those using textual browser where a linearization of tables occurs.

The *priority 1* checkpoint is not satisfied only in one case: for one image the text equivalent is not provided. That image was used for decorative and not informative purpose, thus the alternative text was not a fundamental element. However, it is worth noting that when a user employs a *screen-reader* a

synthetic voice always alerts him that an image is present, thus useless visual elements should be avoided so as not to reduce content understanding.

Priority 2 checkpoints results show that form controls are not provided with *labels*: these elements indicate the purpose of a specific control and, thereby, facilitate blind user in orienting themselves throughout the page.

Among *priority 3* checkpoints the one dealing with table *summary* is not satisfied. The *summary* attribute furnishes information about table content in few words. This technical expedient describes the content to *screen-reader* users and improves understanding and navigability. *Summary* is particularly useful when employed to distinguish between mere layout tables and data tables.

Manual accessibility evaluation

Several documents are provided in *pdf* downloadable format by the SH site. To date, the *pdf* format is not automatically recognized by the *screen-reader*. It is only possible upon the installation of a plug-in or use of an on-line converter which are not available for a lot of users. To supply the same document in another format, the textual (.doc, .rtf, .txt, etc.) is one solution. In particular, this solution ought to be supplied for the file 'directory tape library.pdf' present in the support section for blind students.

Moreover, some *ambiguities* regarding names and links are present:

1. Some textual links are associated to the same page.
2. Different links point to the same page.

Graphical browser – Microsoft Internet Explorer

A. Viewing without images
Viewing SH site without images is not compromised. The textual equivalents of images are properly provided.

B. Viewing at different resolutions
Priority 2 **–** In the SH site, tables and cells dimensions are not always expressed as percentages. Hardcoded table dimensions set in absolute values can cause undesirable transformations in the page when users set windows and monitor resolution different from those of the software developer in the latter's attempt at achieving optimal layout.

C. View without CSS
CSS use is partial: Elements such as colours and text connected to the page format are hardcoded in HTML code. This mix limits the usefulness of CSS which utilizes format-related defined settings found in a single file. This readily allows the user to override the developer-supplied values with his own

style sheet, based on his preference or/and needs and to substitute the CSS defined by the developer. Since different style sheets are not interpreted by browser in the same way, it is necessary to underline the importance of the code homogeneity.
Priority 1 – The contrast between the link and the background is low when the CSS are not loaded.

D. Colour use test
Contrasts between text and background are appropriate. In the SH site no information is relayed by colours alone, so that contents are accessible to all users even if a person cannot see colours.

Textual browser text

The critical element in the web page transformation is the effect caused by tables linearization. In a textual browser, the table content will appear following the cell order (from left to right, from top to down). In a textual browser, it is not possible to align the columns. These aspects should be taken into account to allow better understanding of a web page. Regarding the SH site table linearization does not diminish text comprehension.

Reading by screen-reader

Using the *screen-reader* with both browsers created some problems. The list of links on the web page left side contains links with different labels that point to the same page. This problem diminishes link comprehension because of the confusion generated from arriving at the same page via different link names. One figure was not properly inserted in the text page which made it difficult to understand the content when it is read by a *screen-reader*.

Results of Phase A: Objective-oriented test

Based on the WCAG 1.0 and our analysis, it is possible to confirm that the website conforms well to *priority 1*: in fact it missed just one textual equivalence of an image. An image incorrectly positioned within the SH home page text compromised the comprehension when the page was read by mean of *screen-reader*.

Regarding *priority 2,* several problems were found:

1. Some links are not clearly and uniquely identified (links with different names point to the same page) making the navigation confusing.
2. Although some style sheets are used for page setup, they are only used partially and combined with HTML code, thus limiting their usefulness.

The visualization by graphical browsers is adequate, with respect to 'elegant transformation' encouraged by WAI guidelines.

Priority 3 requirements are not examined in the present analysis. Given the nature of the SH site's targeted users, we stress the importance of supplying documentation in different formats in order to meet different users' needs. In particular, the use of *pdf* format should be limited since it requires the user to take extra steps as discussed above.

Phase B: Subjective-oriented tests

SPECIFIC AIMS

The aims of the *subjective-oriented* tests were as follows:

1. To assess the satisfaction levels of disabled university students in their interaction with SH.
2. To identify the principal issues of usability and cognitive accessibility through the empirical observation of the user's behavior.
3. To assess web content usability.

These Phase B goals were achieved by examining the user's behavior in their internet navigation from the university website. It was through this starting point that the cognitive accessibility levels of the SH website's contents were evaluated.

Tools and methods

Two kinds of tools were applied in order to survey the SH usability and accessibility from a *subjective-oriented* perspective:

1. Analytic proof – user satisfaction assessing by means of the test SUMI administered to disabled students.
2. Empirical proof – user's behaviour observation by the *Cooperative Evaluation* test, performed by six disabled students in order to evaluate the outcomes of interaction between them and the SH.

SUMI

SUMI is a questionnaire for measuring user satisfaction. It is designed to be filled out by end users of a software product being evaluated. It features 50 items, on three-points Likert scale of answer modality (1 = Agrees, 2 = Don't Know, 3 = Disagrees). SUMI contains five sub-scales and a global scale: efficiency, affect, helpfulness, control, and learnability. It was administered to 13 subjects, enrolled at the University as disabled: 6 with motor disability, 6 with visual disability, and 1 with both motor and visual disability.

Cooperative evaluation

The 'Cooperative evaluation' is a procedure for eliciting usability feedback from users while they use a software product [9]. It is a variant of 'Thinking aloud', in which the user is encouraged to see himself as a collaborator in the evaluation rather than just a subject.

As well as getting the user to think aloud, the evaluator can ask such questions as 'Why?' and 'What if?'; likewise, the user can ask the evaluator for clarification if problems arise. This more relaxed approach has a number of advantages. It is less constrained and therefore easier for the evaluator, who is not forced to sit in solemn silence; the user is encouraged to actively criticize the system rather than simply quietly suffering through it; and the evaluator can clarify points of confusion, thus maximizing the effectiveness of the approach.

Six subjects were evaluated: two students with motor disability, four students with visual disability (one blind students and three with diminished vision).

Figure 1 shows the map of the where the *Cooperative Evaluation* was conducted:

1. The student sat on chair marked number 1;
2. The observers sat on chairs marked number 2;
3. The evaluator, interacting with the student, sat next to him;
4. The supervisor sat on chair marked number 2 behind the observer;
5. At the number 3 there are the two video cameras.

During the testing, subjects were surfing on a *Compaq Presario 2800* laptop, set with external speakers, *Microsoft*® *Windows*® *XP Professional* operating system, *LCD 15-inch* external monitor, and *Logitech* cordless keyboard and mouse. In order to browse on internet, subjects could choose among the software: *Microsoft Internet Explorer 6*; *Netscape Navigator 7*; *Opera 7* (free version); *Mozilla 1.5*; *Loupe 5* demo; *IBM Home Page Reader 3* demo; *Jaws 5* demo.

As soon as the subject sat down, the observer read him a short explanatory sheet regarding the goal and the modality of the test. Subjects were asked to comment out aloud and were informed that there was no time-limit imposed for the tests. They were also informed that it was not their behavior that was being evaluated but rather that of the SH-interface. The observer took notes on the steps used by the student as well as on the comments said aloud while making sure that no influence or disturbance was exerted on the user's behavior. The observer could only interrupt the user for the following reasons: to
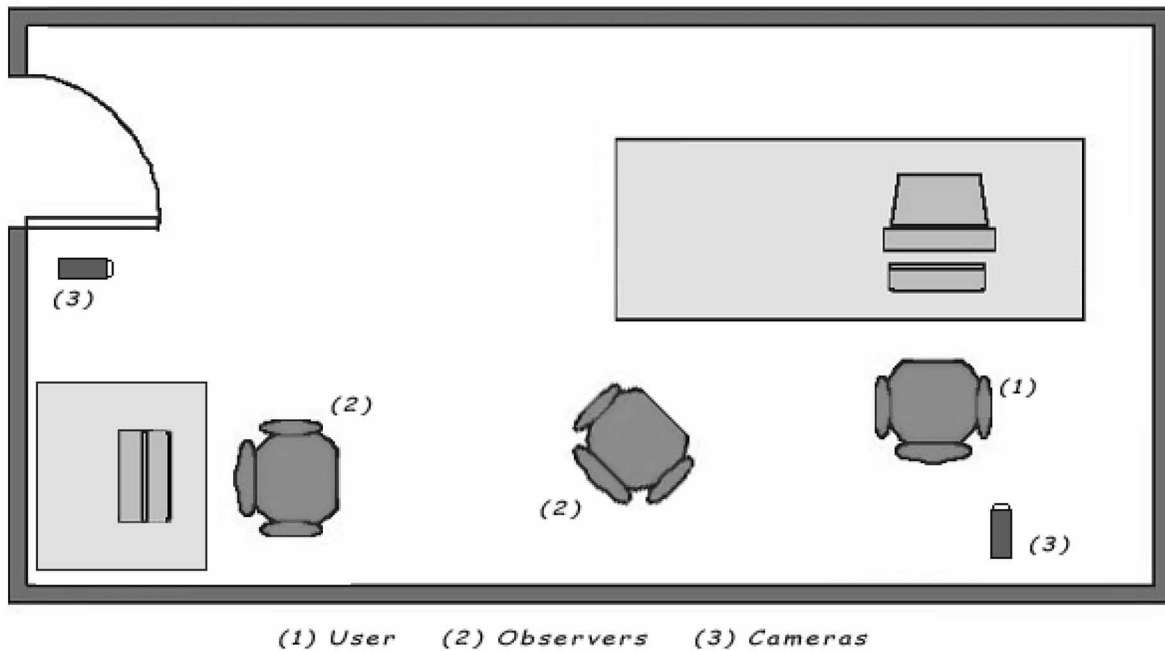
Figure 1. Cooperative Evaluation map setting.

obtain a better understanding of certain crucial browsing aspects or to elicit more comments about the student's actions. The average test time was about 30 minutes.

Results of Phase B: Subjective-oriented tests

SUMISCO data analysis

The data were analyzed by the SUMISCO computerized scoring program, following the SUMI User Handbook guidelines provided along with the questionnaire [10]. A standardized score is produced to be compared to the data. The output is standardized using the z-transform so that the statistical population mean score (or μ) is 50 and the population standard deviation (or σ) is 10. If some of the sub-scales are at or below 50 then they are *poor in usability* in that aspect. Sub-scale at or below 40 indicate the *need for remedial action*. *Good software* will achieve scores of 60 or more in most sub-scales (*ivi*, 33).

Table I shows the total scores of SUMIS six scales, and Figure 2 highlights the usability features of each scale.

The following explains the system usability characteristics of each scale from the data processed:

1. *Efficiency*: This refers to the user's perception of the software capacity to perform the task(s) in a quick, effective, and economical manner. The scale score is 48, which is slightly lower than the average, indicating that the scale has a rather

Table I. Total scores of SUMI's scales

Scale	UF	Ucl	Medn	Lcl	LF
1. *Efficiency*	79	55	48	41	19
2. *Affect*	86	64	58	52	26
3. *Helpfulness*	82	53	46	39	22
4. *Control*	72	50	44	38	24
5. *Learnability*	74	67	60	53	38
Global	76	60	54	48	26

UF = Upper Fences
Ucl = Upper Confidence Limits
Medn = Median
Lcl = Lower Confidence Limits

low efficiency. This could be because the software interface works in an inconsistent way and therefore does not allow the user to navigate effectively.
2. *Affect*: This is a psychological term for emotional feeling. In this context it refers to the user feeling mentally stimulated and pleasant or the opposite, as a result of interacting with the software. The scale score is 58, namely high: users enjoy their sessions with this software, they find it mentally stimulating to use; it is satisfying and attractive.
3. *Helpfulness*: This refers to the user's perceptions that the software communicates in a helpful way and assists in the resolution of operational problems. The scale score is 46, namely low: the web page is not very helpful as information is not seen consistently.
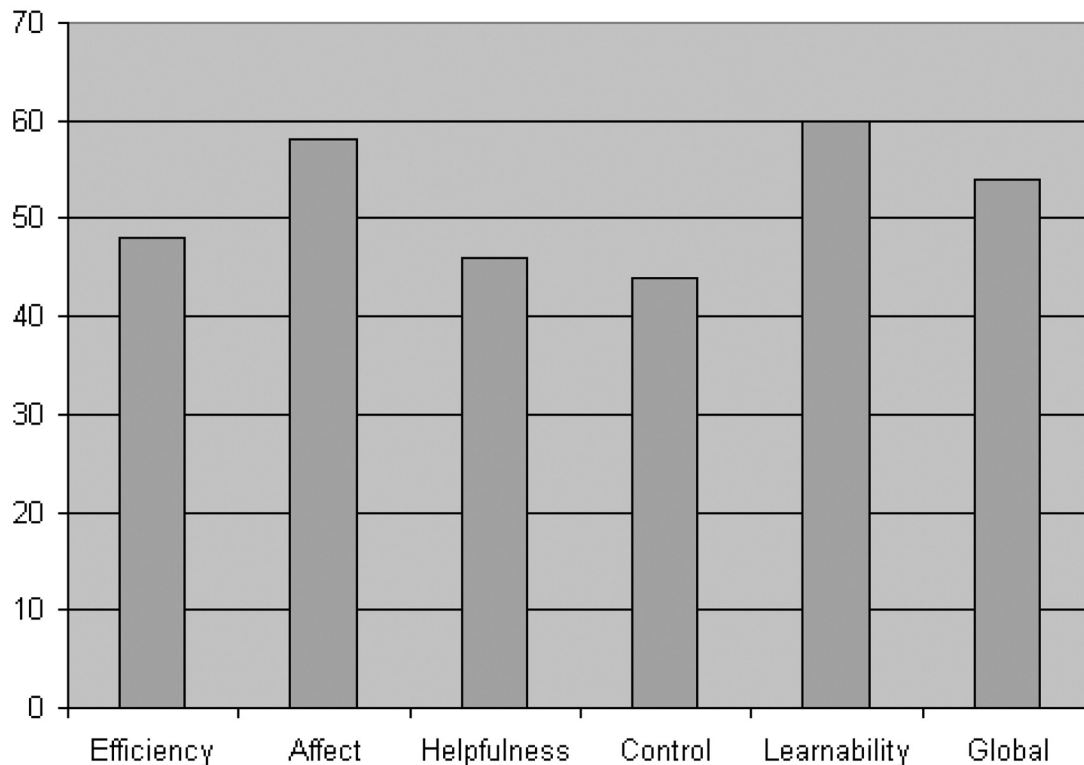
Usability features of SUMI's scales

Figure 2. Usability features of SUMI's scales.

4. *Control*: This sub-scale refers to the user's feeling that the software is responding in a normal and consistent way to inputs and commands. It is not difficult to make the software work, the user can get their work done with ease. The scale score is 44, namely low: users judge it to be unstable and unreliable since they do not always get an adequate response from deterministic actions.

5. *Learnability*: This sub-scale refers to the feeling that the user has – that it is relatively straightforward to become familiar with the software and that its tutorial interface, handbooks etc. are readable and instructive. The scale score is 60, namely high: the web page is easy to get into.

6. *Global scale*: It represents a general usability measure. The Global scale is a weighted sum of the most important usability items in the SUMI scale. The scale score is 54, namely almost high: the SH web page has a good usability level.

Cooperative evaluation results

Starting from the search engine *Google*[TM] home page (www.google.it), the subjects were invited to search

the help desk for students with disability of the University website. Five out of six subjects located the SH web page within the ten minutes allotted. It was not easy searching for the SH web page since the path preferred by the subjects starts from their respective Faculty home pages which do not always contain a link to the page in question.

Those subjects who used the *screen-reader* for browsing did not reach the SH web page from the University home page, since the text, provided as an equivalent alternative to the image link connecting to the student section, was evidently different from the graphic one and did not use conventional words. This resulted in confusion and thus led the blind students to discard it.

Moreover, the subjects met problems accessing several other sections from the University home page. This is because it is designed with *frames* which prevent one from easily jumping from one area to the next within the site. It must be mentioned that the use of *frames* is not even necessary since they are not utilized as content containers.

Once the subjects got to the SH site, they were interviewed in accordance with the evaluation protocols:

1. What they thought the name of this University web site section was;
2. What kind of resources they would have and would have wanted to find there.

Then, they were asked to navigate the site, and to decide freely when to stop. Once they had finished, the subjects were interviewed again about their experience with the SH interface. Afterwards, the two experimenters organized the data and watched the videotapes recorded during the experimental sections in order to gather information which may have been missed during the experimental setting.

The SH site is designed in four areas (see Figure 3): on the top there are two horizontal areas reaching the entire page width – Area 1 and 2 – and below that there is the real site divided in two vertical areas – Area 3 and 4.

1. *Area 1*: The University ID logo appears on the left side while the Help Desk's toll free number is a little bit to the right of the center.
2. *Area 2*: This contains five links: *Students*; *Home*; *Disability Help Desk* (SH); *Toll free number*; *Contacts*.
3. *Area 3*: This contains the navigation menu of the section which provides single click passages to almost all of the site contents, a slogan image, and three links to external resources.
4. *Area 4*: The principal area, bordered by a beveled-angle box, gathers all of the site contents.
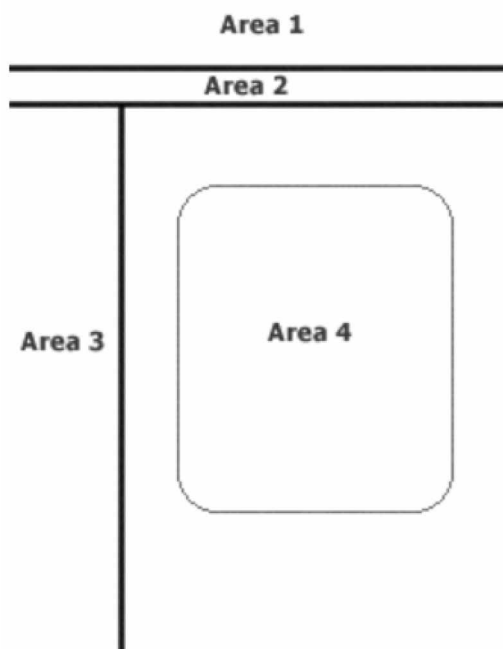

Figure 3. Layout of SH web page.

The Cooperative Evaluation results are divided into three categories:

1. User's behavior while browsing within the SH.
2. Browsing-specific problems.
3. User satisfaction with the SH contents.

The outcomes of the evaluation of the users' interaction with the SH point out that:

1. Students with motor disability did not show particular problems in navigation. Instead, they easily learned the navigation paths, accomplishing the committed tasks effortlessly.
2. On the other hand, students with visual disability, using a *screen-reader*, found barriers because of Areas 1 and 2. In particular, Area caused misunderstanding of the page identification because of the University title in the site ID. Moreover, the lack of a means to bypass Areas 1, 2, and 3 constrains the subjects to navigate through all the areas at all times and thus unreasonably delaying direct access of the contents in Area 4 (navigation goal of any link).

The identification of the browsing problems highlights these following points:

1. The page download and display speed is fast thus providing users with a feedback in a reasonable time, thanks to an economical use of graphic elements.
2. The font size is freely changeable (flexibility and efficiency in use). The home page width is adjustable, however the tables within the page do not automatically resize proportionally, rendering the layout not 'liquid'. Although we did not find this to be a problem in our setup: 15-inch monitor with a resolution of 1024×768 pixels and the highest color quality, the lack of liquid layout could cause problems for users with low resolution monitors, especially when reading contents of Area 4.
3. The design is minimalist. Three of the four sections contain a link and/or reference to the toll free number help desk: redundant information slows down web page scanning (particularly using *screen-reader*).
4. Using the *screen-reader*, scanning links of Area 3 is often interrupted by the link set on the graphic pointer, slowing down the browsing and delaying the presentation of the searched content.

The evaluation of the web-page contents shows us a low level of satisfaction:

1. Although the contents are easily reachable from the Area 3 menu, where titles are clear and self-evident, blind subjects must listen all the time to all the links of Areas 1, 2, and 3, before arriving at Area 4 for the demanded content.
2. Subjects showed a low level of satisfaction because of a generalization of the contents, a scarcity of information, and the constant referral to the help desk office or call center for further information.
3. Blind students expressed dissatisfaction because much of the contents are in *pdf* format, hence only readable through *Adobe Acrobat*© *Reader*. Moreover, several blind students remarked on the incoherence of the *pdf* format use for looking up the catalogue of the audiotape courses in the section regarding support for blind students.

Conclusion

The results of the two test phases are in accordance with the *systemic-constructivist* model adopted in this study regarding two aspects:

1. According to our experimental plan, both accessibility and usability were proposed as two distinguishably observable and assessable realities, measured in Phases A and B with different methods, because of the disciplinary expertise of different research groups. Nevertheless, results proved difficult to show that accessibility and usability are separated entities in interaction. Instead, they reveal a much more dynamic and complex reality that is attributable to the user/ technology rapport as discussed above.

   In both *objective-oriented* and *subjective-oriented* validation methods, problems found regarding accessibility and usability prevented us from cleanly segmenting the observed data into the two categories, *functioning construct* and *user performance*, which are theoretically and methodologically distinct. In both Phases of the analysis, we had to resort to the systemic interaction which revealed similar, if not identical, problems regarding accessibility, that is, the want of system functioning expected. Similar problems regarding accessibility surfaced during usability tests, of which specific examples are the difficulty encountered in navigating with the left-side menu of the SH, while testing user behavior via *Cooperative Evaluation*.
2. As a direct consequence of this previous point and as confirmed by the results, the integration of the *objective-oriented* and *subjective-oriented* approaches as well as the research groups' different disciplines and methodologies have proven to be

the appropriate choice for highlighting the observed system's complexity, disabled-students/SH-interface. This is true even if each approach has previously defined only one system parameter to be observed, such as the dependent variable of how the software works and the modality of the user's navigation. This demonstrates the difficulty of selecting (with accessibility and/or usability) only one system parameter without having to constantly refer back to the system in its entirety, such as the indispensable signifier of the observed parameter.

As seen from the *objective-oriented* and *subjective-oriented* test results, problems relating to the following were found: the use of a *screen-reader* (due to redundant links), the navigation (the side menu bars with unclear and/or redundant links), and the content availability in only one format (*pdf*). In both *objective-oriented* and *subjective-oriented* analyses, the obtained results would be attributable to both accessibility and usability, if according to current ergonomic definitions. Both analyses also show that the existence of disabled-student/SH-interface interaction problems cannot be attributed to only just one parameter. According to modern epistemology, the results force us to a ''reconstruction of the field of study based on new factors, a reconstruction which modifies some of the most fundamental theoretical generalizations of the field'' [11].

We therefore maintain that an integrated model for validating usability and accessibility of websites offer great opportunities for observing user/technology systems, even in situations where observed data are to be classified in only one of the two aforementioned categories. The formulation of web design standard rules (accessibility) could be accepted more universally when it takes better into account the different individual users' predispositions in their use of web technology (usability). We would like to point out that the law 9/04, recently promulgated by the Italian Parliament, regarding user-friendliness of software systems for disabled users, is in accordance with the ample vision of accessibility. Individual users' characteristics, disability issue in particular, are definitely included in the definition of the aforementioned law. The more restrictive definitions are found on the usability side. In fact, regarding accessibility, the legislation states that ''the capacity of the software systems must provide services and useful information, without discrimination, even for those who, due to their disabilities, need assistive technology or particular configurations''. (art. 2).

It is necessary to take into account the user entrance in the functioning construct of a machine, particularly in cases where individual functioning require use of assistive technologies. The usability of a technological product is very much tied to its capacity to neutralize and break down barriers that restrict users from accessing it in order to take advantage of it. Therefore, an integrated model of validation is the most suitable methodology when analyzing complex systems of user/technology interaction.

With regards to the functionality of the SH website, results show barriers in the form of both navigation and inaccessible content due to format. Moreover, the presented information is general and non-exhaustive. Overall, the site is only accessible on a superficial level in that some pertinent information remains hidden (please see results regarding compliance with the WAI Standard rules). This shows that the relationship between the functioning construct (how the site ought to work) and the user performance (visually and motor disabled students) contains numerous barriers.

The following steps must be undertaken in order to improve the accessibility and usability of the SH web site so as to increase students' level of satisfaction:

1. Eliminate Areas 1 and 2 and clean up links.
2. Allow a quicker way of getting the information requested (without the need to read the entire menu).
3. Use cascading links to improve the site's presentation and navigation.
4. Offer formats other than *pdf* for downloadable files.
5. Enrich the content with more information on services.

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