

ACCESSIBILITY AND USABILITY OF A COLLABORATIVE E-LEARNING APPLICATION

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Abstract: VisualPedia is a collaborative environment proposed to facilitate the development of *educational objects* thought for *all students*, including students with different forms of disability. In this paper we briefly introduce VisualPedia and then report on the experience in the evaluation of accessibility and usability of the system prototype we have developed so far. We also discuss possible future improvements that have become evident after the experimentation with end users.

1 INTRODUCTION

The knowledge life-cycle has radically changed with the advent of Web 2.0 technologies: the user in fact has become active (*prosumer*) in the process of building knowledge. The network is no longer a mere tool for content distribution but it is rather a facilitator for the interaction among the participants involved in the educational process, and the literature clearly states that collaborative learning is superior to individual learning. Wim Veen, for instance, describes adolescents (Veen, 2009) as the generation of “*Homo Zappiens (who) lives in human and technical networks that provide new opportunities to act experiment and learn. Homo Zappiens learns within social networks where content is distributed and discontinuous. As a consequence, future learning will be based on concepts of aggregation, externalization, collective knowledge creation and immersion . . .*”

Active participation is one of the main ingredient of our software prototype, named VisualPedia. The second important ingredient is personalization since we think that the delivery of content tailored to the user is particularly relevant in the school educational context where students with different needs coexist.

Personalization in this context does not mean that the system automatically selects different learning paths based on the learner’s profile. This is typical of Adaptive Hypermedia Systems which are generally more complex than our software prototype; for a brief survey on different views of personalization see for instance (Verpoorten et al., 2009). In VisualPe-

dia personalization means that the same content can be delivered in different format depending on users’ visualization preferences. The prototype, in fact, is a wiki-based application developed to offer an initial response to some school needs towards the standardization of e-learning content for students with different forms of disability (visual, ranging from blind to high levels of visual disorders, cognitive and verbal).

VisualPedia stakeholders are of two different types: school teachers and students. Teachers from different classes and, possibly, from different schools, are encouraged to collaboratively produce learning material that students can access in different formats, depending on their profiles. The model is still traditional in some sense: teachers are the producers of the educational content. However, they can perform this task in collaboration with other colleagues (i.e. with peers), and no longer in isolation.

The aim of this work is the evaluation of the accessibility and usability of the developed system. Key point of the paper is the comparison of the evaluation of usability performed by heuristic experts and end-users with disabilities. We remark that this is particularly important because the end-user perspectives can be quite different from those of experts since they use assistive tools to access the system. The evaluation opens up discussions and proposals of enhancements along several directions that will be discussed.

The paper is organized as follows. Section 2 briefly introduces related work and Section 3 describes the main characteristics of VisualPedia. Sections 4 and 5 discuss the experience on the evaluation

of the accessibility and usability of such environment. Future developments are reported in Section 6.

2 RELATED WORK

The literature on e-learning is huge, ranging from the description of innovative learning management systems (proprietary or open source) to the proposal of different pedagogical models, to the description of case studies involving real users, and so on.

Here we concentrate on e-learning softwares developed having in mind Web 2.0 suggestions that call for promoting online collaboration among teachers and students, without any software barrier, in the pure spirit of the *design for all* philosophy. Therefore, our work takes advantage of experiences gained in the areas of accessibility and usability, software for people with disabilities and wiki systems.

Accessibility. This is a big issue in the development of online content and services. Quoting Tim Berners-Lee: “*The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect*” and several activities have been promoted since 1997 by the W3C to define technical guidelines to produce accessible digital resources.

Indeed, there are several ongoing discussions on this topic. Some authors (Kelly et al., 2007) suggest that the focus on technical guidelines can be counter-productive and they elaborate on the term Accessibility 2.0 for the development of accessible Web sites and/or e-learning resources that address users needs rather than compliance with technical guidelines. Moreover, since finished and perfect solutions are generally not available, they suggest an incremental process with successive refinement and development involving a wider range of stakeholders (the *always-beta* metaphor).

Accessibility experts are also suggesting to relax some of the guidelines since it seems these are encouraging common mistakes instead of facilitating the access. As an example, they claim the use of access keys is contradictory since these can override keyboard shortcuts for screen readers (Moss, 2008).

Usability. Usability evaluation is one of the most important cornerstones of the interaction systems design (Dix et al., 2003). Beyond its perceived usefulness, any software tool is really accepted by a large community of users if it is also easy-to-use.

In order to assess and test a system several evaluation methods can be adopted to measure or predict how effective, efficient and satisfying it would be when the user interacts with it in her/his context of

use. These methods range from inspection techniques to tests with end-users.

Results from some studies (Thompson and Kemp, 2009; Silva and Dix, 2007) have highlighted how conventional usability evaluation methods like heuristic evaluation (Nielsen, 1995) and even exploratory methods like the cognitive walkthrough (Cathleen et al., 1994), are not appropriate to analyze Web 2.0 or social networking sites. These studies argue that the adopted inspection methods do not reflect the opinions of the users. For example in (Silva and Dix, 2007) the authors found that YouTube failed when tested using heuristic evaluation although it is one of the most popular Web applications. Moreover, (Greenberg and Buxton, 2008) presents a thesis according to which, in some cases, focusing on the usability can be harmful.

This is because usability methods tend to put the lens on the usability bugs and not on the whole usefulness of an application. Innovative ideas, such as those at the base of the Web 2.0 on social networking sites, could be discouraged by negative results and give up on plans that might otherwise bear good fruits.

(Petrie and Kheir, 2007) presents the results of a test with end-users (blind and sighted people) to investigate the accessibility of two Web sites, discussing the issue of the relationship between accessibility and usability. The authors show that usability and accessibility problems do not belong to two distinct, non-intersecting sets, but they can be seen as two overlapping sets including “pure accessibility” problems, “pure usability” problems, and “universal usability” problems (Shneiderman, 2000) that affect both disabled and not-disabled people.

Special Softwares. Several software tools for people with disabilities have been proposed. As an example, the software platform Edushare (Sauvain and Szilas, 2009) is a Web-based learning environment designed for autistic children who are exposed to simple and repetitive tasks. Different users can access Edushare covering five different roles. Autistic children are the *learners* and they are helped by *accompaniers* during the execution of their learning sessions. *Developers* create new exercises outside the platform, the *program director* is responsible of the progress of the children, and *distant analysts* evaluate the proposed exercises, typically by analysing the log files collected by the software platform.

The main difference between VisualPedia and Edushare is that the latter is specifically built for autistic children while we aim at an online virtual place where digital resources should be inclusive of everyone. Moreover, in the paper it is not explicit whether developers can collaboratively build new exercises.

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- <educationalObject>
  <name type="IMG" altimg="Tower of Pisa">Tower of Pisa</name>
  <objCtxAnnotation>Pisa.jpg|center|thumb|100px|</objCtxAnnotation>
  <source>http://en.wikipedia.org/wiki/Leaning_Tower_of_Pisa</source>
  - <descriptions>
    - <description title="Tower of Pisa" level="complete">
      <vocalDescription/>
      - <txtDescription>
        The Tower of Pisa is the campanile, or freestanding bell tower, of the cathedral of the Italian city of Pisa. It is situated behind the Cathedral and is the third oldest structure in Pisa Cathedral Square after the Cathedral and the Baptistery. Although intended to stand vertically, the tower began leaning to the southeast soon after the onset of construction in 1173 due to a poorly laid foundation and loose substrate that has allowed the foundation to shift direction. The tower presently leans to the southwest. ...
      </txtDescription>
    </description>
    + <description title="Tower of Pisa" level="summary"></description>
    + <description title="Tower of Pisa" level="simplified"></description>
  </descriptions>
</educationalObject>

```

Figure 1: XML representation of the Tower of Pisa.

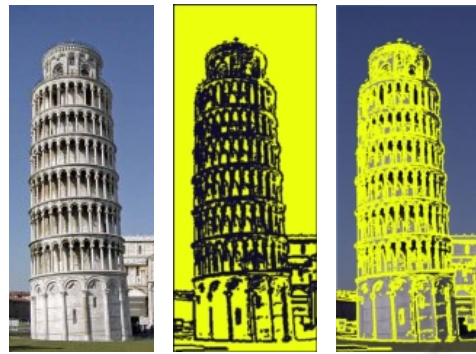


Figure 2: Simplification of the Leaning Tower of Pisa.

Wiki Systems. Many wiki systems do exist, as witnessed by the long list displayed at <http://www.wikimatrix.org/> where different wikis can be selected and compared. However, as discussed in (Taras et al., 2008), not much research has been devoted to the analysis of their accessibility. The authors underline that accessibility is not an issue for many wiki developers and suggest some improvements that could be added to wiki systems to refine their level of accessibility. We mention here the need of adequate presentations for different visual disabilities since this is one of the issues considered in VisualPedia, as discussed in next section.

3 VISUALPEDIA FACILITIES

The main goal of VisualPedia is that of offering a repository of e-learning content, called *educational objects*, that can be presented to users (students) according to their profiles. Educational objects can be described at different levels of complexity and images can be delivered in their original format or in a simplified version which is thought for users with visual impairments.

The overall motivations, architecture and characteristics of VisualPedia have been already described in (Bocacci et al., 2009), and we briefly present here only its main features. VisualPedia is built on the top of MediaWiki, which has been selected as our starting point because of its popularity, facility of use, and large community of developers. In the remainder of the section, we discuss how educational objects are handled, stored, and retrieved in the system. Moreover, we describe the image simplification process and the modification on the MediaWiki system to make it accessible.

Educational Objects. Educational objects describe notions represented through different media: text, image, sound. Each object can be described at different

levels of complexity: *complete*, *summary* and *simplified* text. The last level preserves essential concepts that are described with a simplified structure of the sentences and a controlled vocabulary, and are devoted to students with cognitive disabilities.

Educational objects are uploaded into VisualPedia thanks to an extended user interface: school teachers can collaboratively upload new objects and describe them at different levels of detail. Descriptions can be initially incomplete and afterwards extended by collaborating peers.

Educational objects are internally stored in the text attribute of the MediaWiki Page table as XML documents with different tags, one for each description level plus the bibliography reference and optional links to vocal descriptions. Figure 1 reports a fragment of the XML document for the Tower of Pisa.

Images and sounds are stored in the MediaWiki Image table. Tags are introduced in the XML document to distinguish the role (an object or part of a description) of the image/sound within the educational object. Moreover, in the Image table the values of longDesc and alt attributes required for image accessibility are also included.

Image Simplification. The images stored in VisualPedia can be delivered in a simplified form trying to mask many irrelevant details, which are discarded without even noticing by normal user, while, on the other hand, capturing such details wastes much effort for visually impaired ones. Moreover, the use of many bright colours intended to capture the attention, can be perceived as confusing by disabled users, who would most appreciate a line drawing with strong contrasting background and no further details.

Therefore simplification algorithms, based on the Canny method (Canny, 1986), have been developed so that any colour or grey scale image can be converted, automatically and relying on the user profile, into another simplified one.

Figure 2 shows an image of the Leaning Tower

of Pisa and two simplified versions that can be obtained by applying the algorithms. Only the original image is stored, the simplified versions are computed on the fly. Simplified images can also be printed with a Braille printer thus offering to blind users some information of the shape of the educational object itself.

MediaWiki Engine Modifications. The MediaWiki PHP code has been modified in several aspects. First, for creating, handling and visualizing educational objects. Moreover, in order to guarantee the accessibility of pages, the generated HTML code has been checked and parsers for checking and sanitizing the content introduced by the users have been added.

Users profiles containing information about the users' visualization preferences as well as the level of details of the descriptions of educational objects have been integrated in the standard MediaWiki user profile. This information is used both for the visualization and retrieval of educational objects.

Finally, retrieval facilities that take the user's profile into account to rank and return educational objects have been introduced. For each educational object all the available descriptions are returned, sorted according to the resulting ranking. The snippet associated with each link contains also the type of the description (*complete, summary, simplified*), a qualitative assessment of the result (*good, discrete, sufficient*), and the percentage rank value. As an example of the search results see Figure 3.

4 ACCESSIBILITY EVALUATION

VisualPedia needs to deliver educational contents compliant to the technical accessibility requirements as specified in the Italian Law n. 4/2004 (Legge Stanca, 2004). Therefore we have updated the MediaWiki output functions to meet the Italian requirements and - when possibile - also WCAG 1.0 (W3C, 1999).

Technical accessibility tests have been performed asking a group of experts to analyze VisualPedia. They used CSE Validator (<http://www.htmlvalidator.com/>) to check the HTML code and analysed the contrast between the background and the text by inspecting the CSS files.

A report has been written highlighting some technical mistakes that have been corrected in the current version of the system. The lack of alternative text (`alt` tag) for some images or the lack of back buttons in some pages are examples of the identified mistakes. In addition, two small parts of the interface did not show enough contrast between the background and the foreground.

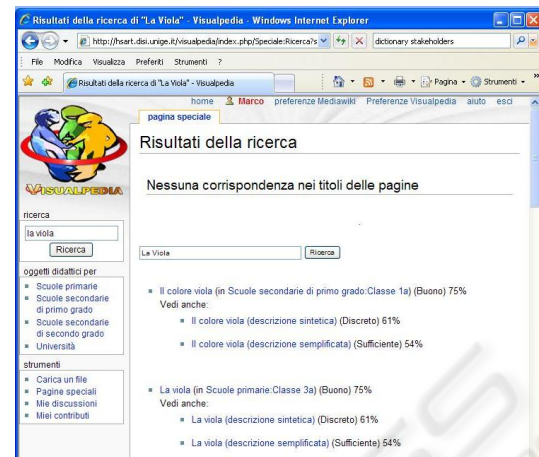


Figure 3: Search results.

The general (and informal) comment was that, apart from minor mistakes, the accessibility of the pages is generally good at least from a technical point of view, i.e. when considering the "quality" of the output HTML code. However, they also observed that the real problem will move to the production and upload of the educational objects. Indeed, even if the framework is perfectly accessible, the contents within stored could not be accessible. Therefore, data entry is the critical phase that could possibly vanishing the development of an accessible framework.

Unfortunately, as we know from the literature, the conformance to the technical accessibility guidelines does not necessary mean that a Web site is usable or that "websites that achieve higher conformance to WCAG are also more usable by people with disabilities..." (Petrie and Kheir, 2007).

5 USABILITY EVALUATION

In this section we present an usability study obtained from a combination of two methods: an evaluation of the user interface according to general purpose heuristic principles and a test with end-users. They will lead to some reflections on the validity of VisualPedia. The experimental test is designed in order to involve different communities of users, in particular disabled users, to check the software and the assumptions on image simplification.

The final goal of this usability study is to contribute to the discussion on evaluation of Web applications to support communities of practice using Web 2.0 approach. The main aim is to determine whether the results of the heuristic evaluation accurately reflected the user's expectations and needs and whether,

Table 1: Heuristic principles applied in this first test.

1	Visibility of system status
2	Match between the system and the real world
3	User control and freedom
4	Consistency and standards
5	Recognition rather than recall
6	Flexibility and efficiency of use
7	Display all but needed information
8	Error prevention
9	Help users recognize, diagnose, recover from errors
10	Help and documentation

in spite of poor usability, VisualPedia can be considered an innovative e-learning system for disseminating educational matters, which future releases might bring good results.

5.1 Test with Experts

Participants. The heuristic evaluation was conducted by five evaluators with experiences in HCI and was designed according to the conventional practice (Nielsen, 1995). This heuristic evaluation strategy followed an approach without observers and adopted the Nielsen heuristics as evaluation grid (Table 1).

Tasks. According to the Nielsen principles no specific task should be assigned to the evaluators. Each one can choose a user profile for which her analysis would be performed. Then, she can move on the system as she prefers in order to check the system.

Procedure. The five evaluators examined VisualPedia according to a specific user profile and each one performed one analysis session and wrote a report describing the identified usability problems. A debriefing session among all the evaluators followed in which the problems detected by each of the evaluators have been collected and organized into categories.

Results. Table 2 was built relying on the results of this first test with experts. The table reports only the main usability bugs discovered. For each bug a first column describes the problem, a second column presents the heuristics that have been violated and finally in the last column the number of evaluators that have discovered that problem is reported.

Preliminary Considerations. According to the results of the heuristic evaluation, the diagram in Figure 4 reports the number of heuristics that have been violated. This diagram highlights that seven out of the ten heuristic principles were violated while the other were supported in a satisfying degree but not fully (except for principle 9).

In addition to the previous result, the evaluators carried out a qualitative analysis of the data collected

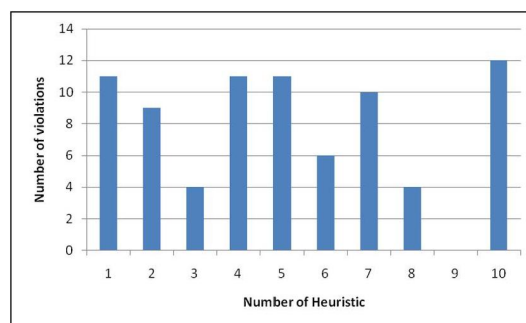


Figure 4: Distribution of the violated principles.

using a methodology that adopts six main categories in evaluating usability of Web-based systems (Polillo, 2004). These categories are: accessibility, architecture, content, communication, functionality, management and usability. The methodology is based on the attribution of a score (from 0 to 4) for each category by each evaluator. By exploiting these scores it is possible to draw another diagram reporting the qualitative analysis of VisualPedia (Figure 5). The diagram points out a low evaluation along the different categories with the exception of the accessibility category. By a discussion with them, we identified that the low scores were due to the lack of content within VisualPedia, that did not encourage their evaluation of the characteristics of the system. In the concluding section, we will propose countermeasures for this issue.

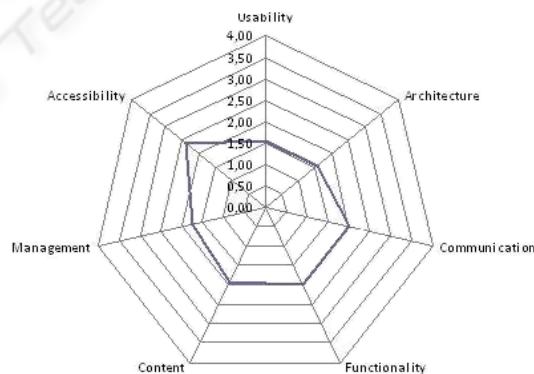


Figure 5: Qualitative analysis of VisualPedia.

5.2 Test with End-users

Participants. The test with end-users was conducted with a group of 25 students with different forms of disability, different ages (the majority being over 14), different education (ranging from primary to high schools), and different skills in the use of the computer and/or assistive tools. The majority (22) hold a computer at home and use it mainly for studying and Web browsing. They use Internet to search

Table 2: Main result of the test where experts were asked to conduct a heuristic evaluation study.

Problems	Heuristic violated	N. of evaluators
Some links point to pages of Web site maintenance	2	2
Log page is too detailed. All users can see the other users' activities	3	1
In some tables the formatting is not correct and some XML code appears	8	3
The search function finds only exact matches	6	3
Poor information on how to search	10	5
The home page has too many items and the list is too complex	5,7	3
In the first page the educational object is called page	4	1
Poor information about VisualPedia functions	10	5
The menu appears even when not needed	7	3
Poor information about the menu containing the MediaWiki preferences	2,10	2
Image visualization and simplification take too long	1	2
Some borders of the object inhibit the content understanding	1	2
How to come back is not clear	1,4,5, 6,7,10	5
It is very difficult to understand where I am	5,6,10	1
Some technical terms are not clear	2	1
In some cases the menu on the left mysteriously changes	1,4,5,7	1
Some pages contain HTML code in clear	2	1
No help available	10	5

contents for their homeworks (14), exchange e-mails (12), communicate via forums and/or social networks (9). In the following we report for each category of users the assistive technologies employed for the experiments and/or the preferences set in their profiles.

- 7 users (3 male, 4 female) were totally blind: they all used the screen reader software Jaws (a product developed and distributed by Freedom Scientific <http://www.freedomscientific.com>); in addition to Jaws, two students also used the Braille display at the same time.
- 10 users (5 male, 5 female) were visually impaired: five of them used magnifier softwares, four used the enlarger tools provided by the operating system (Windows Vista), and one enlarged font size using the VisualPedia personalization.
- Finally, 8 users (5 male, 3 female) were affected by down syndrome with intelligence quotient lower than 45. Two of the users were also affected by visual impairment. They used VisualPedia preferences: text was shown in upper-case and surrounded by thick lines (see Figure 6) to focus their attention.

Tasks. Individual half-hour sessions have been organized in which every single user has been asked to perform really simple tasks:

1. *login* to the system,
2. *browsing*, i.e. finding an educational object following the available links, and
3. *searching*, i.e. finding the same educational object using the internal searching facility.

Short questionnaires have been delivered before and after the execution of these tasks.

Procedure. All participants performed their tasks in front of two evaluators (selected among the authors of this paper) but they were assured that the evaluation was on the VisualPedia software, not on their abilities on the use of the browser and/or assistive tools. In some cases, parents were also present during the test, without interfering during the execution of tasks.

Results. All the users performed successfully their tasks. Some needed more time and/or some help but this was mainly due to their inexperience in the use of the computer. Visually impaired users did not have any problem, blind students had some troubles with the screen reader, especially for those pages with extra information (we realized that it could be easily omitted since it does not add real value to the page).

The post-test questionnaires pointed out that VisualPedia is generally easy to use. Specifically, Figure 7 shows that the execution of the three tasks (login, browsing, searching) did not pose any real problem to the majority of them.

Preliminary Considerations. Running the tests with this group of end-users has been particularly emotional. Students really tried hard to do their best, also those with difficulties in the use of computer and/or assistive tools. We realized they really felt as part of the project, trying to provide their help, each one according to her/his capacities.

Moreover, these tests highlighted some problems that were not detected during the heuristic evaluation. As an example, in the second task – browsing to find some content – the interface displays a combo box to

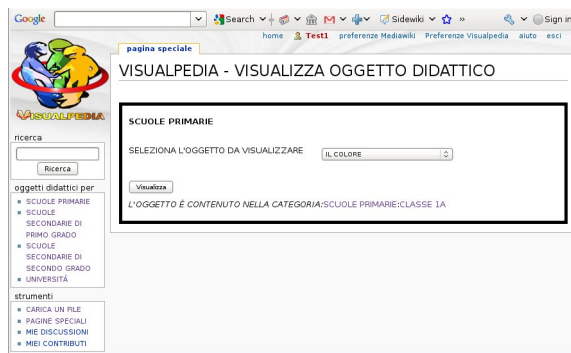


Figure 6: VisualPedia personalization.

select the educational object (see Figure 6). While the combo box is generally easy to interact with, those users which were not particularly expert in the use of assistive tools had more difficulties in finding and interacting with this element of the Web page.

As another example, consider the third task: finding content using the internal search engine. For each object matching the query, VisualPedia returns three different descriptions (if available) plus some additional details. This abundance of information has been indicated as useless during the heuristic evaluation and, even worst, resulted annoying for some of the blind students. Jaws, in fact, started reading every single word, causing confusion and disorientation.

6 FUTURE DEVELOPMENTS

We have reported the experiences gained in the evaluation of accessibility and usability of the VisualPedia system, a collaborative wiki-based system for the management of educational objects tailored also for students with special needs.

The evaluation results highlight several problems that need to be fixed in the next version of VisualPedia. Moreover, further improvements are required for what concern the management of XML data and the knowledge base of VisualPedia. We conclude the paper with considerations on these aspects that open to future research activities.

Usability. Innovative systems like VisualPedia radically change the way in which users participate to the creation process of the knowledge at the base of a system. (Bruns, 2008) shows how in the collaborative content creation environments like Wikipedia what is emerging is no longer just a new form of content production, but a “*new process for the continuous creation and extension of knowledge and art by collaborative communities: produsage*”. The usability evaluations presented in this paper are devoted not only to

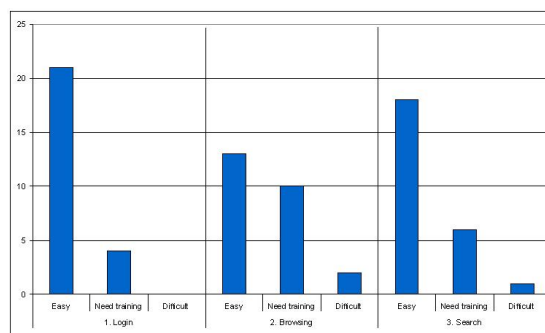


Figure 7: Post-test results.

find simple usability bugs but to understand the usefulness and acceptance of an application like VisualPedia even if, as discussed in Section 2, in some cases, focusing on the usability can be harmful. We think that the innovative ideas at the base of VisualPedia should not be discouraged by some negative results of the heuristic evaluation when they are balanced by the genuine enthusiasm demonstrated during the test with end-users. For this, starting from the current poor usability, it is necessary to design new improvements, following a star cycle of software development, able to bring to the definition of an innovative e-learning system for disseminating educational matters reflecting the user’s expectations and needs.

XML Representation of Educational Objects.

The representation of educational objects as XML documents has many relevant implications both for what concerns accessibility of the content and effective organization and retrieval of information. Indeed, one of the crucial aspects of Web-content accessibility is the organization of the data according to HTML tags that lead to documents that are not accessible. The possibility to organize information using XML allows the separation of information representation from its logical organization. Therefore, specific representations depending on the user profiles can be tailored and thus overcoming the current limitations (e.g. tables that are usually poorly accessible can be structured in XML and specific layout based on div tags can be obtained for visual impaired users through XSL transformations). Moreover, XML based representations of mathematical formulas (e.g. through Math-ML) can be integrated in the educational object representation. This can facilitate the access of mathematical formulas through screen readers and Braille displays. Finally, in the spirit of semantic Wikipedia (Krötzsch and Vrandečić, 2009), ontological organization of educational objects can be provided and exploited for searching facilities within the VisualPedia repository.

VisualPedia Knowledge Base. As pointed out also from the heuristic analysis, the number of educational objects currently stored within VisualPedia is too low (around 30 objects). Despite our great efforts in pushing the teachers to provide a certain number of educational objects, they end up with a really small number. This is due, from the one hand, to the high working load in the teaching activities and, to the other hand, to a lack of motivation in participating to the project.

In order to face this problem we need to move along different directions. First, we plan to consider mash-up technologies for gathering educational materials from the Web (e.g. WikiPedia) and then tailoring the materials to the user with disabilities. In this way, the original information can be left in the original source and only a view of it can be stored within VisualPedia with modifications necessary to face the user difficulties. The second direction is to directly involve the students in the production of educational objects under the teacher supervision. By integrating in VisualPedia tools like WikiDashboard (<http://wikidashboard.parc.com/>), teachers can check the students' activities and identify those that effectively worked on their homeworks. Last but not least, we should work on teachers' motivation, trying to understand how to involve them in the development of new educational objects in the same spirit of authors of user-generated content (Nov, 2007).

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