

Virtual Information Managers in Physics Education Context

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ABSTRACT: In this article, the authors analyze how educational institutions behave in relation with the contents available through the web. They also reflect on the features of the currently available information managers (IMs), from an educational point of view. They found there is a lack of tools for information management at low scale when it has to be used as a resource for teaching and learning. Finally, they propose a solution, which consists of naming a “small virtual educational library” (SVEL), and they show how it works in a physics education context. © 2006 Wiley Periodicals, Inc. *Comput Appl Eng Educ* 14: 291–299, 2006; Published online in Wiley InterScience (www.interscience.wiley.com); DOI 10.1002/cae.20090

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INTRODUCTION

The significance of the Internet phenomenon is beyond question. Its influence in education, whether desirable or otherwise, is clearly evident. There are numerous projects that analyze, propose, and describe Internet-based initiatives in education, which include computer courses, multimedia learning modules, and virtual laboratories [1,2]. There are areas, however, that we feel have been partially overlooked by certain educational sectors. This article will focus on one of

these areas: the management of information as an educational resource.

There are a number of specialized papers that discuss the problem of classifying information on a large scale [3,4]. Teachers, however, do not seem to be particularly aware of this problem, even though they are the protagonists of many of the proposals mentioned in the previous paragraph. Several precedents do exist, and they support our viewpoint: “There is a lack of papers describing the process of their creation, the problem faced during preparation of didactic materials, construction of virtual libraries, and experiences in their usage in education” [5].

We have analyzed the methods used by different university departments and secondary schools to manage and supply students with the information

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available on the Internet. Every one of these institutions provides this information as a list of links. They also provide instructions on how to use the most popular search engines. None of them, however, has a system for managing online information. There is a disparity between this and the services that a local or school library can provide. There, students encounter staff who provide assistance and tools that they can employ to find the information they are looking for. What, then, is the virtual equivalent of this support?

In this article, we analyze requirements for the small-scale management of information on networks used for educational purposes. Subsequently, we have outlined a proposal for the design and construction of a small virtual educational library (SVEL). One of the configurations of our SVEL can be found in the web address <http://baldufa.upc.es> [6].

In following section, we have analyzed the features of currently existing virtual educational libraries. In section Information Managers, we have provided definitions of different types of information management and the ways in which these work. In section The Problem of Classification, we have considered the problems that classification may entail in the field of information management, and section Small Virtual Library for Education is devoted to our proposal for a SVEL.

CURRENTLY EXISTING VIRTUAL EDUCATIONAL LIBRARIES

We have studied the information management systems of university departments and other units, although in these cases it is difficult to distinguish between external educational use addressed at students and internal research use by scientists.

We have also analyzed the way virtual libraries operate in secondary schools in Australia and Canada, because these countries have been using the Internet for educational purposes for many years.

Nonetheless, we have observed a number of common traits, as outlined below.

- The various items of information tend to be classified as a list of links on a web page.
- Popular search engines (<http://www.google.com/>, <http://www.yahoo.com/>) are commonly used, and additional, complimentary, and/or explanatory guidelines on their use are given.
- Higher education centers occasionally provide their own search engines.
- Many of the links provided tend to be institutional or generic in nature. Websites are therefore not explored in any depth.

INFORMATION MANAGERS

To describe a small virtual library for education (SVEL), we must first define what we mean by an information manager (IM), of which our SVEL is a particular type.

An IM is a device that may or may not require human intervention. By means of an established protocol, the IM selects and classifies information and provides access to it at the user's request. A IM might be used by a real library to select and classify books, journals, articles, etc. Nevertheless, we are concerned with IMs that work with the virtual information held in computer files on the Internet or on a specific computer, so in order to distinguish these in particular we will refer to them as virtual information managers (VIMs). The essential difference between conventional IMs and VIMs is the format of the information they manage. The VIMs' functions may be partially automatic or they may not require human intervention at all, even in the process of selecting and classifying information; this is what differentiates VIMs from other IMs.

Internet search engines are classified as VIMs, as software help files, although it is not the help files themselves that are classified as VIMs but rather the IMs that they contain [7,8]. There are also bibliographic VIMs, which are used to search for books and articles in online journals and libraries. These generally contain previously selected documents in specific formats, so that the user is able to search for these documents by title, author, subject, etc. A good example of this is Reference 9.

A VIM is based on *potential information*. For an Internet VIM, this potential information would be all the information available online, although VIMs are not generally able to manage the total sum of potential information. The relationship between the quality of the management and the quantity of information processed is one of the parameters that may be used to define the effectiveness of a VIM [10]. In this regard, the accessibility of the potential information should not be confused with the success rate of the search for information. It is relatively easy for an Internet VIM to access a large quantity of information, but classifying this information so that users obtain a high success rate when they perform a search is not quite as straightforward.

In the following two sections, we have briefly described how search engines and software help files function.

Search Engines

Search engines are VIMs that work on the Internet. Their functions may be divided into two areas:

(A) *Tasks that are not requested by the user.* With varying frequency, a search engine accesses documents on the Internet and records their characteristics. It classifies each document in terms of these characteristics, thus generating a database. The problems encountered by a search engine at this stage are related to the quantity of documents and the wide variety of formats. Millions of documents may be accessed on the Internet and it therefore seems reasonable to take a sample of those that are likely to be classified and to ignore those that are irrelevant. The selection process must be mostly automatic, due to the amount of information to be processed. A recent study [11] analyzes the lack of impartiality of these automatic devices, whether for strictly technical reasons or for other reasons that might not be admitted to quite as readily. The retrieval of these documents' characteristics depends on their format. In the case of HTML files, the search engine retrieves the text contained in its <TAGS>. The relative importance of the text found depends on the <TAG> that contains it (e.g., title, subtitle, meta keyword tags, etc.). Other types of files (PDF, DOC) are processed in a similar way.

In the case of images, the search engine detects the format of the image file as well as other characteristics that allow the image to be viewed.

Music files are processed in a similar fashion. In the particular case of vocal sound files, recent studies have focused on the retrieval of information directly from them by means of voice recognition, as opposed to the context in which they are called up [12].

How reliably these documents' characteristics can be retrieved may be affected by their authors' level of competence and desire to have their work featured on popular search engines.

(B) *Tasks requested by the user.* The search engine receives the user's request through an appropriate interface. This request is filtered and codified according to established criteria. The relationship between the user's request and the request as filtered by the search engine may be affected by:

- (1) The distinction (or absence thereof) between upper and lower case, the order and number of words used, the acceptance (or otherwise) of certain conjunctions and signs (the, a, and, or, by, for, ? & % \$ [] {} , ; : etc.).
- (2) The acceptance (or otherwise) of differences in number, gender, and others.

Once the search engine has filtered the request, it retrieves all the related files from the database. Finally, depending on the number of documents it finds, they are listed for the user in a certain order (i.e., by specific criteria, in blocks of 10, to a maximum number, according to a success or reliability rate, etc.). Each reference to a document is usually accompanied by a fragment of the text, in which the keyword(s) requested has been highlighted. The user is then able to discern whether the keyword appears in the desired context before opening the document.

This basic procedure is used by the default search interface, which is generally a text field in which users type their requests. This type of interface is representative of what we might call the *click culture* [13]: Type in what you require, *click!* and the results appear. Search engine designers are conscious of the fact that this type of search may not be enough and hence offer users other, more sophisticated search interfaces, which allow the use of logical conjunctions (AND, OR), phrases ("My house," "UPC," etc.), and other alternatives that may enhance the results of a search. To make the most of these options, it will generally be necessary for the user to gain basic skills that go beyond those habitually employed in the aforementioned *click culture*.

In addition to allowing users to carry out searches directly, search engines compile information sources in lists of URLs that are selected and ordered thematically (see http://directory.google.com/Top/Science/Educational_Resources/). Users visit the site that features the subject they are interested in and access the relevant list directly. The selection may follow two sets of criteria:

- (1) By human intervention, with the collaboration of specialists in the subject in question. The choice of information is based on criteria such as quality and relevance.
- (2) Automatically, on the basis of how often a specific URL is accessed by users. The quantity and quality of the external links that lead to the URL are also considered. Google, for example, uses PageRank [14], a URL ranking system with which it compiles its thematic lists.

The disadvantage of employing these criteria is that they assume a generic user profile. They are of no use in carrying out specialized or bibliographic searches. There are interesting alternatives, however [15]. The authors propose the automated compilation of a dictionary for each user, which would serve to place the keywords that he or she employs in context. The dictionary would be fed with the words that appear in the documents effectively accessed by the user from the results of a keyword search. This type of procedure may be very effective in creating automatic search processes in which the search terms are highly defined and there is a close relationship between the whole document and the part of it in which the keyword appears. This is not the case, however, in less standard searches or searches for diverse subjects. MUSAG may then act as a bottleneck, holding back relevant documents.

Computer Software Help Files

Computer software help files are VIMs that manage the information content of computer software manuals. They are not the manuals themselves.

There are two basic types:

- (1) Standard Windows programs [7] include a VIM that functions externally in a similar way to those employed by search engines, although in general they search for information contained in the program manual, located on the computer. They search for the words entered in a text field and also provide information classified by subject. As opposed to Internet VIMs, these may offer a single list of words or concepts, ordered alphabetically. Some of them employ an assistant or guide which attempts to detect the problem or difficulty that the user has encountered and then offers relevant help. This assistant may be of use to users who have little experience with the program. These are generally able to detect the standard problems users may encounter, but not their real aim when using the program.
- (2) Other types of help files opt for classifying possible search terms by subject. A good example of this is the help file of the Mathematica program [8]. A number of words, organized into categories, are featured in dynamic columns. These words are filtered from left to right as the user selects search items from general concepts to specific subjects. This method for accessing information has a number of advantages over those

previously mentioned. It enables users to see what the help file has to offer whilst they are carrying out their search. The VIM displays increasingly specific terms as users state their request more and more explicitly. There is therefore a collaboration between the user, who decides which term is of greater relevance, and the VIM. In addition, this type of VIM displays the results of the search in the same interface as the terms that make up the user's initial request.

THE PROBLEM OF CLASSIFICATION

In our discussion of Internet VIMs, we have explained that they attempt to determine the actual content of documents. In the case of HTML files, the text contained in the document's <TAGS> is analyzed. Several problems, some of which have been mentioned previously, may occur when employing this procedure:

- (1) The information provided by the most important <TAGS>, such as the title, might not be correct.
- (2) It might even be the case that the title is held, for aesthetic reasons, within an image file. As a result, the search engine will not be able to detect it.
- (3) The author of the document may enter text to *deceive* the VIM, in order to attract the attention of potential clients. Some time ago, it was standard practice to enter text in the same colour as the background. The text was not visible to the user, although the VIM was able to detect it and, as a consequence, classified the document incorrectly.
- (4) A single document may be made up of various linked HTML files. How can the VIM guarantee the correct classification of this document and the links contained in it? How can the VIM discern which file is the *master file* that is linked to all the document's contents?

These types of problems, which occur as a result of the automation of the process of classification, are exacerbated in the context of education. Awareness of these problems has led to great efforts to describe online content with a higher degree of human intervention. To this end, what are known as *metadata* [3,4], which we might define as information that

describes information, have been developed. The aim of these metadata is to “facilitate the search for, evaluation, acquisition and use” of resources [3]. With reference to education, we might add “to facilitate the common use and exchange of educational content (learning objects) by developing catalogues and inventories that account for cultural diversity and the linguistic context in which this educational content and metadata are to be used” [3].

Therefore, metadata represent a convergence in the description of educational content online. To date, the following categories have been defined:

- (1) General
- (2) Lifecycle
- (3) Meta-metadata
- (4) Technical
- (5) Educational
- (6) Rights
- (7) Relations
- (8) Annotations
- (9) Classification

Other categories that are in several aspects more suited to education have been proposed. In education, it is useful to be provided with a description of the document’s content, but perhaps more so of its usefulness as an educational resource. The introduction, by Ip et al. [16], of the concept of “non-educationally focused” (NEF) documents is significant. This concept is directly linked to the fact that the origins or authors of documents that are relevant to education are not necessarily educators or cultural promoters themselves, but might be companies, factories, travel agents, writers, journalists, etc. They propose a mechanism to reveal NEF documents, which is compatible with currently existing metadata.

SMALL VIRTUAL LIBRARY FOR EDUCATION

Having analyzed the different parts and procedures that constitute a VIM, we need to assess how VIMs might be adapted to educational requirements. We envisage the management of a limited amount of information with the aim of satisfying the requirements of an educational institution with a small number of teachers (less than 100), such as a secondary school, a university department, or a resource center that gathers specialists in a specific subject from a specific area. The SVEL manages a previously classified selection of the information available online. Therefore, when the user makes a request to

the SVEL, the SVEL works with a number of documents that contain information that is highly relevant from an educational perspective and that fulfils teaching criteria.

A SVEL is a VIM that manages the online information required by secondary schools or similar educational establishments. It manages a virtual library and adapts to requirements, as opposed to simply providing a list of links.

As a result of the above analysis of VIMs, we propose that VIMs and SVELs in particular should fulfil the following criteria, whilst we also target the document classification problems that metadata are unable to solve:

- (A) The format of the document must not affect its relevance as an educational resource.
- (B) The documents must be classified by keywords and conceptual sets of keywords (CSKs).
- (C) The process of searching must in itself be a learning activity.
- (D) The SVEL interface must fulfil educational criteria [17].
- (E) Humans must intervene in the selection and classification of documents.

On the basis of these requisites, we have developed a SVEL that is currently being used for the management of educational documents in the field of physics [6,18]. Due to its design and the way it is used, we consider this SVEL to be potentially effective in the management of documents relating to learning in other subjects. The following are details of its characteristics:

- (A) *The format of the document must not affect its relevance as an educational resource.*

The documents searched for may have a variety of formats. Their educational relevance does not generally depend on these technical characteristics.

The group of files that constitute a thematic unit may also vary considerably. For example, the statement of a physics problem may be one document to be classified, and a whole course may be another.

- (B) *The documents must be classified by keywords and CSKs.*

The metadata’s classification by category demonstrates their generic character. A SVEL, which we may assume will show a relatively high degree of specialization, at least with respect to the generic

nature of metadata, will practically use one sole category from the list presented, the *General* category, where the keywords subcategory is located. The procedure used in our SVEL analyzes the structure of the keywords used in the classification of documents in depth. It enables new documents to be classified and new keywords to be entered. The keywords may also be private or public, for internal use or for the user. This allows any character to be used (ü, à, &, \$, UPC, etc.) in order to make a word intelligible.

However, we believe that it is not sufficient to use keywords alone. Simple keywords may be used in conjunction to form a conceptual set of keywords (CSK). An example of a CSK might be [law, ampere]. This is significant, because if users wish to find a particular Ampere's law relating to electromagnetism, the keywords they might employ would be organized thus: [law, ampere], electromagnetism. In this manner, the SVEL recognizes the fact that the user is looking for the Ampere law, as opposed to all other Ampere's laws or all the things that Ampere has done in electromagnetism. The CSK [law, ampere] is not a concept that may be divided into separate parts, nor is it a string of text. The SVEL is able to recognize that the CSK comprises several simple keywords.

For the purposes of this discussion, we may define two types of keywords: exclusive and non-exclusive. The first tend to be categories that are used to classify the basic features of the document (level of difficulty, problem, theory, activity, etc.) and the general area of knowledge that it falls into (mechanics, thermodynamics, electromagnetism, etc.).

(C) *The process of searching must in itself be a learning activity.*

Searching for information does not necessarily have to respond to the precepts of the click culture; it should be a more thoughtful exercise. In fact, the search itself should be an act of learning.

This means that the SVEL interface should in some way include the keywords that the user might need. The SVEL designed prompts the user to employ CSKs wherever possible. Therefore, when the user enters the word law, the SVEL suggests the possible CSKs: [law, newton], [law,...]... [law, ampere], according to the field specified by the user, such as mechanics or electromagnetism, all the CSKs related to law if the subject area is not made explicit.

If students enter, for example, the word energy, and the SVEL suggests several options to complete the phrase, such as potential or kinetic, when they select potential it suggests further options, such as

gravitational, electrostatic, etc. As a result, students become aware of the fact that there are different types of potential energy within the field they have selected. It is important for students to realize the broad sense of the concepts and the general nature of the definitions. We believe that our SVEL addresses these issues.

The results of a search are a list of URLs that are related to the user's CSK request. Some of the information contained in the URL may be extracted directly from the URL or otherwise, depending on each case. Conventional Internet VIMs display the first paragraph in which the requested keywords appear. This may not always provide information on the site or document in question, as a paragraph in a book may not provide exhaustive information on its contents. The SVEL must also, or instead, relay the brief information (author, institution, country, language, a summary of the content, teachers' comments, etc.) that was entered during the classification process. Our particular design, in addition to this information, provides further keywords to create a CSK and thus complete the user's request. For example, if one is looking for a law within the field of electrostatics, one enters (with the help of the SVEL) law, electrostatic. If the SVEL finds a document that has been classified as, among other things [law, coulomb], this information will be provided alongside the resulting URL. In other words, the SVEL is able to correlate one's request with the supplementary information provided in the result.

(D) *The SVEL interface must fulfil educational criteria.*

The SVEL interface, in which the user carries out a search, acts in a similar way to the help file for the Mathematica program [8], which prompts the user with keywords. The user does not have to use the keywords the program suggests, but instead selects them from ones listed in panels that are organized by subject. The fact that the information managed by a SVEL is subject to change must be taken into account.

The SVEL interface must conform to a design that is in keeping with educational criteria.

This is a complex issue due to the lack of knowledge of the educational criteria that an interactive application must subscribe to in order to aid learning [19] provides several guidelines to follow when content is presented as text or images. In our case, we have ensured that the entire search process (choosing the keywords, entering the request, viewing the list of results that contain new information relating to the request, viewing the content of the documents returned, etc.) may be carried out in the same

interface, without ever losing sight of any of the essential elements of the process as described above.

The interface that we have designed occupies an optimized area of the screen. It appears in the lower half of the browser window and may be viewed at the same time as the documents visited.

Users may refer to the documents found in their searches without losing sight of the results or the keywords chosen.

In the upper half of the SVEL interface, there is a text field where the user enters the keywords. The keyboard is not employed to enter these keywords. The user selects them from a variety of dynamic lists in which they are grouped by subject.

Keywords that fall into exclusive categories may be accessed from the scroll-down menus that are located to the left of the SVEL interface.

Once the exclusive keywords have been selected, the SVEL goes on to suggest, from other categories, those keywords that are found in documents that also contain the exclusive keywords. Furthermore, the search will only return those documents that have been classified using the exclusive keywords.

The non-exclusive dynamic lists of words are ordered from left to right and follow a hierarchy previously established by the SVEL administrator.

If one highlights a word, the lists that appear on the right suggest only those keywords that pertain to documents that also contain the highlighted word. This mechanism facilitates the choice of keywords by the user, allowing the SVEL to use a large number of keywords if necessary.

If one of the words selected belongs to a CSK, the SVEL automatically opens one or more columns in which it suggests keywords to complete the CSK.

(E) *Humans must intervene in the selection and classification of documents.*

The uses that educational resources may serve may change over time, although not their content. Their classification must therefore be dynamic and adaptable over time. This means that the management of information must be highly decentralized, so that it allows a resource to be defined according to its relevance to the place where it is likely to be used.

Educational websites need to manage information. For this reason, they feature lists of links that have been classified in some way. However, something else is needed if the aim is to manage information that is too extensive to be displayed as a list of links. This explains the need for human intervention in the process of classification.

A SVEL may meet the needs of an educational institution, which we think would require anywhere from 100 to 100,000 documents to be classified, and not millions! In the case of web pages that are of no interest to the school or that may even mislead students, we simply do not classify them. It may be claimed that this undermines the freedom of the student in some way; we, however, feel that this is not the case. The student can and should continue to access the Internet in its entirety. The SVEL complements conventional Internet VIMs, providing the student with a selection of content chosen by teachers, which may be compared with other Web content. Clearly, the process of selecting the documents undertaken by the teachers will involve conventional Internet VIMs.

As previously explained, the process of selecting and classifying the documents that are to be administered by the SVEL requires human intervention. We envisage that teachers will carry out this process. Any valid Internet URL may be selected. Typically, teachers will accumulate URLs recommended by third parties (other teachers, students, etc.) or that they have found through conventional Internet VIMs. The teachers are responsible for selecting documents that meet the standards of quality and relevance dictated by their educational requirements [20] and the specific characteristics of the site that maintains the SVEL. This is the process of selecting information that the SVEL must manage. The amount of information will generally increase over time, so a continuous process of classification and revision must be anticipated.

The following steps must be taken when classifying a URL:

- (1) Ensure that the URL content is relevant.
- (2) Verify that the URL is stable and that it is not likely to disappear from the Internet.
- (3) Describe the document briefly, including details of the author, institution, and language, if this information is available.
- (4) Assign keywords and CSKs.

Internally, the SVEL is basically configured by means of two files, which we will refer to as the *categories file* and the *URL file*.

The keywords that the SVEL will employ are stated in the *categories file*. Each keyword is assigned the following: (1) a public form; (2) a private form; (3) the category to which it will belong, and (4) the order in which it is to appear in the list, if not alphabetical.

This file also states the type (exclusive or non-exclusive) and the hierarchical order of each category of keyword.

URLs are classified in the *URL file*. This file comprises groups of three columns. The first column contains the URL of the document to be classified, the second the description of the document that will be displayed in the search results, and the third the list of words and CSK assigned to the document. The keywords used in the description will be effective if they have been previously stated in the *categories file*.

CONCLUSIONS

The VIM developed meets the requirements of a SVEL as discussed above. It has proved to be very effective in the classification by keywords: on one hand, it guides users when they are unsure of how to define what they are looking for and, on the other, it allows a more flexible classification by subject. For example, to classify a document that contains the subject of *potential energy* it is not necessary to define a new keyword, *potentialenergy*. Instead, two existing words are used, giving, however, a different value to the accumulation of the words that make up the whole phrase or string of text “potential energy.”

The documents’ classification process may seem, at first sight, somewhat involved, because it is carried out manually. While it is certainly true that it takes time to classify the initial documents and that this process is not free of errors, once this first stage has been completed, the classification process becomes a lot easier.

The main SVEL interface is where most of its problems are found. When we take full advantage of the SVEL possibilities and we offer the user a great number of options to define the search for information, there are too many buttons, pop-up menus, and lists, which may disorientate the non-expert user. There is also an unsolved problem in the sizes assigned to the SVEL interface within the page. We have tested the option of having a new window exclusively for the IM but having various windows open may also confuse the user. It may also give rise to communication problems between the pages, which would not occur if the SVEL were incorporated into a sole HTML page. The problem of organizing the information presented in an educational project has not yet been solved, but it does constitute an interesting area of educational research.

The automatic detection of the user’s profile (e.g., if the user is a secondary school student) and the subsequent presentation of information that has

already been filtered might be a way to solve several of these problems. For the present design, students must indicate whether they only wish to view information of a certain level of difficulty. In order to simplify the SVEL interface, in this case, once the user had been identified as a secondary school student, it would only offer the information requested that corresponded to that educational level, thus eliminating the need for pre-selection.

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BIOGRAPHIES



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