The need for virtual information managers in education

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Abstract

In this paper, the authors analyse 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, 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 whether at secondary or university level. Finally, they propose a solution, which consists of naming a 'small virtual educational library' (SVEL), and they show how it works in Physics education context.

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1. 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 analyse, propose and describe Internet-based initiatives in education, which include computer courses, multimedia learning modules and virtual laboratories (Adelsberger, Collis, & Pawlowsky, 2002; Collis, 1999). There are areas, however, that we feel have been partially overlooked by certain
educational sectors. This paper will focus on one of these areas: the management of information as an educational resource.

There are a number of specialised papers that discuss the problem of classifying information on a large scale (Draft & Standard for Learning Objects Metadata, 2001; Graziano & Russo, 2001). 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” (Zurawska & Zurawski, 2001).

We have analysed the methods used by different secondary schools and university departments to manage and supply students with the information 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 real 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 paper, we analyse requirements for the small-scale management of information on networks used for educational purposes. By small scale we understand, among other aspects, that the users have a specific profile, that the content manager is suitably fragmented and that the request of the user is therefore fairly detailed (fine metainformation). 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 in1 (Bohigas, Jaén, & Novell, 1998).

The paper is organised as follows. In Section 2, we have analysed the features of currently existing virtual educational libraries. In Section 3, we have analysed different types of information management and the ways in which these work. Finally, Section 4 is devoted to our proposal for a SVEL.

2. Currently existing virtual educational libraries

We have analysed 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. These schools' websites may be found in2 We have also studied the information management systems of university departments and other units, although in these cases it is more difficult to distinguish between external educational use addressed at students and internal research use by scientists.

Some of these libraries offer services for finding information both on the Internet and in their own document collections. One can thus access lists of links to journal collections, book lists, other libraries, etc.

1 Web address: http://baldufa.upc.es.
Searching for information on the Internet is performed using the habitual search engines. Searching for information within the library’s own collection is normally performed by means of pages with lists of links to other pages that are in fact alphabetical lists. Large libraries may have local search engines, which allow users to search for books by title, author or subject. The result of a search usually gives all the information in the book record and tells the user where to find the book. Local search engines also show whether the library is subscribed to any journals.

None of the sites consulted allows users to carry out a more refined search than this. They give rough metainformation of the documents managed, in line with the degree of fragmentation of the existing documentation. One may be able to find a book of mechanics problems, but not fine metainformation, such as problems involving centres of mass whose level of difficulty corresponds to the first year of a degree and that have been included in a final examination.

The basic unit of metainformation is the book record. Users search for books through these records, whose format is generally not very flexible.

Most lecturers and students are already aware of a large part of the rough metainformation that they normally need, but it would be very useful for them to access fine metainformation.

The study carried out on existing virtual educational libraries can be summarised as follows:

- The various items of information tend to be classified as a list of links on a web page.
- Popular search engines\(^3\) are commonly used, and additional, complimentary and/or explanatory guidelines on their use are given.
- Higher education centres 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. In other words, rough metainformation on documents with little fragmentation is offered.
- Large libraries tend to have a local search engine for rough metainformation. Fine metainformation is not considered.

Our aim is to set up an information manager or SVEL that works on a small scale and offers fine metainformation on documents that are suitably fragmented that matches users’ requests. On a large scale, large libraries do not consider fine metainformation. On a small scale, there are no information managers or they are not used.

### 3. Information managers

The aim of this section is to analyse the various types of existing virtual information managers (IM) so that we can position our proposal of a SVEL as an IM with its own specifications. 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. An 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 classed as VIMs, as are software help files, although it is not the help files themselves that are classed as VIMs but rather the information managers that they contain (Microsoft®, 2000; Wolfram, 1999). 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 (arXiv.org, 2003).

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 (Lien & Peng, 1999). 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.

3.1. Search engines

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

3.1.1. 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 (Introna & Nissebaum, 2000) analyses 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 their <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. Several problems may occur when employing this procedure:
The information provided by the most important <TAGS>, such as the title, might not be correct. 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.

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?

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. 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.

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 (Van Thong et al., 2002).

3.1.2. 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:

- 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.).
- 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 (Rushkoff, 1996). 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. 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:

- 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.
- 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 is also considered. Google, for example, uses PageRank (Rogers, 2002), 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 specialised or bibliographic searches. There are interesting alternatives, however (Goldman, Langer, & Rosenschein, 1997). The authors propose a system called MUSAG, which consists in 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.

3.2. 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:

- Standard Windows programs (Microsoft®, 2000) 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 who 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.

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• 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 (Wolfram, 1999). A number of words, organised 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.

4. A small virtual education library

Having analysed 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 centre 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 educational establishments. It manages a virtual library and adapts to requirements, as opposed to simply providing a list of links. In general, with respect to the analysis performed in the previous section, both the interface chosen, the fine metainformation required and the volume of content managed are similar to those of computer software help files. However, in terms of versatility (accessibility, document format, entering and removing content), they are more similar to search engines. We propose that a SVEL should fulfil the following criteria:

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 design of the SVEL interface must fulfil usability criteria for educational environment.
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 (Blanco, Bohigas, Jaén, & Novell, 2000; Bohigas et al., 1998). The SVEL we have designed (see Fig. 1) is able to manage the fine metainformation of 10,000 documents, although we have classified 1500 so far, with a very high degree of fragmentation (if we classify problems we do them one by one rather than by collections).
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:

4.1. 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 constitutes 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.

4.2. The documents must be classified by keywords and Conceptual Sets of Keywords

Bearing in mind the study we performed in Section 3.1. and the specific field of application that we wish the SVEL to have, we are inclined to adopt a system of classification by keyword. A simple structure of keywords is not sufficient to generate an efficient system to support searching. We therefore introduced CSKs. To the best of our knowledge, the idea and use of CSKs is an original contribution made by this paper.

The keywords must be stated in advance. In doing so, they are stated in their private form, which is for internal use, and public form, which is shown to users. This allows any character to be used (ú, à, &, $, UPC, etc.) in order to make a keyword intelligible. It also allows the search engine to be configured for use in any language. Simple keywords may be used in conjunction to form a CSK. An example of a CSK might be [law, newton]. This is significant, because if users wish to find a particular Ampere's law relating to electromagnetism, the keywords they might
employ would be organised thus: [law, ampere], electromagnetism. In this manner, the SVEL recognises the fact that the user is looking for the Ampere law, as opposed to all electromagnetic 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 recognise that the CSK comprises several simple keywords.

We may define two types of keywords: basic and non-basic. The first tend to be keywords 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.). The remaining are non-basic. See Fig. 2.

4.3. 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, or all the CSKs related to law if the subject area is not made explicit.

If students enter, for example, the keyword energy, and the SVEL suggests several options to complete the CSK, such as potential or mechanics, when they select potential it suggests further options, such as gravitational, electrostatic, etc. See Fig. 3. 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 realise the broad sense of the concepts and the general nature of the definitions. We believe that our SVEL addresses these issues.

Fig. 2. The panel for entering search terms. The basic keywords appear in the drop-down menus in the column on the left. The other keywords appear in the adjacent columns. If a student selects ‘centre of mass’, only the keywords associated with documents that are compatible with this selection will be shown.

Fig. 3. This figure shows the process of selecting a CSK. A student has selected ‘energy’ as the keyword. The SVEL indicates that this keyword is part of various CSKs and shows the options that are available. The student selects ‘potential’. The SVEL shows the student that he or she can continue to build the CSK or leave it as it is.
The results of a search are a list of URLs that are related to the user’s CSK request. See Fig. 4. 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. In our particular design, in addition to this information, the CSK structure is used to show the keywords that complete the CSKs in relation to the user’s request. For example, if one is looking for a law within the field of electromagnetism, one enters (with the help of the SVEL) law, electromagnetism. 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.

4.4. The design of the SVEL interface must fulfil usability criteria for educational environment

The SVEL interface must be designed in keeping with general usability criteria for educational environment (Mayer, 2001) and particularly the Parallel Instruction Theory (Min, Yu, Spenkelink, & Vos, 2004). This theory studies how information should be organised on the screen for it to be efficiently used. 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 screen, without ever losing sight of any of the essential elements of the process as described above. See Fig. 5.

The SVEL interface acts in a similar way to the help file for the Mathematica program (Wolfram, 1999), which prompts the user with keywords. The user does not have to guess the keywords, but instead selects them from ones listed in panels that are organised by subject.

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

If one selects a keyword, the lists that appear on the right suggest only those keywords that pertain to documents that also contain the keyword selected. 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 keywords selected belongs to a CSK, the SVEL suggests keywords to complete the CSK.
4.5. Humans must intervene in the selection and classification of documents

Human intervention in the selection and classification process provides several advantages, some of which have already been discussed in the analysis of the VIM in Section 3. We might add:

- Educational institutions already carry out a manual process of selecting documents, which they save as lists of links on simple web pages.
- The introduction, by (Ip, Morrison, Curie, & Mason, 2000), 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.
- 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 decentralised, so that it allows a resource to be defined according to its relevance to the place where it is likely to be used.

The SVEL may meet the needs of an educational institution, which we think would require anywhere from 100 to 10,000 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 selec-
tion 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.

We envisage that teachers will carry out the selection and classification 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 (University Libraries at Virginia Tech, 2003) and the specific characteristics of the site that maintains the SVEL. 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:

- Ensure that the URL’s content is relevant.
- Verify that the URL is stable and that it is not likely to disappear from the Internet.
- Describe the document briefly, including details of the author, institution and language, if this information is available.
- 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.

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Fig. 6. Fragment of the categories file. The keywords that will be used to classify the documents are entered here. On the left, we see the private version and on the right the public version. Each keyword is assigned a label, in this case 040, which indicates in which column it will appear in the search engine interface. The column of empty cells indicates that the keywords will appear in the default order, i.e. in alphabetical order.
The keywords that the SVEL will employ are stated in the categories file. Each keyword is assigned the following: (1) a private form; (2) the category to which it will belong; (3) the order in which it is to appear in the list, if not alphabetical; (4) a public form. See Fig. 6.

This file also states the hierarchical order of each category of keyword, which determines the column in which the keywords belonging to this category will be shown in the search engine interface.

URLs are classified in the URL file. This file comprises groups of three rows. See Fig. 7. The first row 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 keywords 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.

The process of classification can be performed directly by editing the URL file. Although we have tested several interfaces that aim to facilitate the task, the fact is that the efficiency of cut and paste was not improved on in this case. However, we do not rule out the possibility of designing a simple interface in the future that allows new documents to be entered not only by administrators but also by certain types of accredited users.

5. Conclusions

We have developed a tool for managing educational content on a small scale (SVEL). To achieve this, we first analysed the tools used in educational establishments and libraries, and the VIM provided on the Internet or in specific computer applications. As a result of this analysis, we were able to define a series of requirements that had to be met by an SVEL. We believe that we have met these requirements. In particular, the general design of the interface in which the search engine is located was not designed arbitrarily, but in accordance with well-established usability criteria for educational environment. Another novel feature is the fact that the classification and search includes the use of CSKs, which have proven to be very efficient. This allows the different keywords to be grouped together in a simple and intuitive manner at the moment when the documents are classified. The CSKs thus help the users in the search process and can offer them keywords related to their request through CSKs.

Our SVEL can be freely accessed from the “la baldufa” web page. It allows one to find a large number of pages with physics content at secondary and university level, some of them original and some external (Bohigas et al., 1998). The SVEL is habitually used by a group of 10 lecturers at our department who are collaborating in the project. It has proven to be a very useful tool for search-
ing for and selecting documents on a given subject and thus for preparing classes, assignments and support materials for the subjects that are taught. These selections can subsequently be accessed from the personal pages of the lecturers by means of links. We have not carried out a detailed analysis of the server traffic because, as previously stated, access is completely free and the access log files are not very reliable for this type of study. A future objective could be to provide the SVEL with some mechanism for recording activity that would allow us to continue to improve its performance.

In order to analyse the design of the interface used and separate the difficulties that can be attributed to the content (in our case physics), we made a personalised version for non-expert users. To this end, we made a browsable CD to be used by primary school children aged 12. The material on the CD is mainly composed of a large number of images, documents in text format, sounds and animations; the need to present the material in an ordered manner led us to consider the possibility of applying our SVEL as a tool for locating the documents. A CD was handed to each child and they were asked to use it in their school’s computer room under the observation of the authors of this article. From the first attempts, the children used the SVEL skillfully. After a few minutes, they were handling the SVEL very efficiently. This experience showed that the design of the interface of the SVEL is indeed sufficiently simple and intuitive, regardless of the content that is classified.

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