

Visual Analysis of a Moodle-based Object Oriented Programming Course

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ABSTRACT

The literature in educational research has established that monitoring student learning is a crucial component of high quality education. When instructors and students are not in a face-to-face traditional environment, new forms of student monitoring must be explored. The effective use of CMS requires that instructors have been provided with appropriate means of diagnosing problems so that they can take immediate actions to prevent or overcome those situations. The aim of this paper is to present an analysis of an Object Oriented Programming course supported by a Moodle platform. Therefore, we have carried out the mining of an eLearning database and represented the more relevant results by depicting them a visualization based on the tag cloud visual representation.

General Terms

Visual analytics; Software Engineering, Object Oriented Programming; Visualization; Learning Management Systems.

Keywords

Object Oriented Programming, Visualization, eLearning, Timeline, Tagcloud, Moodle.

1. INTRODUCTION

Many Universities around the world, which deliver undergraduate programs in Science and Engineering, are currently incorporating virtual instruments as teaching measurement and analysis tools for student learning. Moodle (Modular Object-Oriented Dynamic Learning Environment - <http://moodle.org>) is a license free open-source software platform. Those involved with eLearning also call it as Learning Management System (LMS), or Virtual Learning Environment (VLE). Moodle is designed to help educators and content experts to create online courseware with opportunities for rich interaction. Its open source license and modular design allows content experts to develop additional functionality.

From the architectural point of view Moodle is based on a model-view-controller controller. The adoption of the Service Oriented Architectures (SOA) and its integration in Moodle require a deep knowledge of a system core library that is not particularly consistent. The core system is structured in modules, each of them providing a wide set of functions. Each module has a connection and access policy based on roles. This policy has to

be considered in the design of services. Extending Moodle to use Web Services (WS) gives more flexibility in controlling the connecting operation to obtain the optimal service, reduces the selection service by using accurate attributes of both consumer and service, is a friendly and easily accessible mechanism to discover and select of services and helps to build a high level of trust.

This API consists on a set of WS that encapsulate most of the services that an external (and even internal) application shall need from a Moodle server. In October 2008 this WS layer was integrated in the Moodle 1.9.3 and is going to be the standard interoperability subsystem for the future versions. This API is the base to develop a set of WS: Moodle-DFWSs. Moodle needs to be accessible using any transport protocol present or future. So it cannot depend on a concrete WS protocol, name it XML-RCP, SOAP, REST etc.

The SOA approach opens a new set of possible contexts of application: the retrieval and display of information from Moodle. This way our visualization tool it is the proof that it is possible to create alternative interfaces and clients, which permit extending the interactivity and interoperability of the eLearning environment.

According to Thomas and Cook [1], Visual Analytics supports analytical reasoning through interactive visual interfaces. This area has an important limitation towards their implementation within the LMS. The extraction of information from these systems is not trivial and in most cases means hardcoding the LMS and/or visualization tool. This approach involves establishing a link with the platform and, worse still, with its version. To accomplish this, different approaches arise, several of them based on SOA [2]. This article will use the Moodle web services layer [3] as a proxy to retrieval and exchange information.

The philosophy of Moodle includes a social constructionist approach towards education [4], emphasizing that both students and teachers can contribute to the educational experience in many ways. Moodle is also useful in an outcomes-based interactive classroom environment that could be continuously improved by analyzing the captured data of all activities such as 'views' and 'posts' for all the learning objects or components of a courseware hosted on a system. VLEs are defined as computer-based environments that are relatively open systems,

allowing interactions and knowledge sharing with other participants and teachers and providing access to a wide range of resources [5] hosted on the system. The value of a VLE is to fully enable "learning anywhere at any time" by providing an array of resources, opportunities for active participation, mastering content and self-learning.

In [6] the effects of motivational states on student performance in an eLearning scenario are analyzed, including measures of the correlation between the student interaction patterns with the VLE and his level of motivation. One of his results indicates that it is possible to predict deficits in autonomous and eLearning specific motivations by analyzing the interactions of the students with the VLE. The number of hits to read eLearning content, the number of hits to participate in forums, and a student's updating his or her profile have been positively correlated with autonomous and eLearning-specific motivations.

But in order to change and apply the new available tools, it is necessary to analyze the existing information based on experience. With this information we could determine what method or tool to apply and how and when we are going to do it. Also we may learn from previous errors discarding some elements or adapting them to better uses.

If we are working with Moodle as VLE for our subjects, its "Reports" subsystem is one such object that could be very useful in analyzing the level of interactivity between the instructor and students during the delivery of a courseware. Nevertheless, the interactivity reports become unusable when they represent great quantities of data. In this situation is where the visual analytics techniques, as the Tagclouds for example, are interesting to improve and allow the analysis of the huge quantities of data derived from the interaction activities in the VLE.

In typical usage, Tagclouds are created by mapping a dimension associated with a term in an underlying data to a dimension parameter determining how that term should be displayed. For example, the prevalence of a term in the set could be represented by its size. However, in Moodle the principal task of Tagclouds is Recognition/Matching. Tagclouds can evolve as the associated data source changes over time. However, while Tagclouds seem to invite exposure of their evolution over time, they do not explicitly represent them. This becomes a significant cognitive demand on people who want to understand how a Tagcloud evolved.

We are going to use a Temporal Tagcloud-based visualization tool applied to the information regarding to Object Oriented Programming subject in Computer Science degree at the University of Salamanca. With this tool we will be able to evaluate the strengths and weaknesses of the course and how to improve it. In addition, this type of analysis tools enables assessment of student activity in online environments.

The paper is organized as follows. In the Section 2 introduces the Temporal Words Clouds visualization technique; Section 3 presents the application of this visualization technique in the Object Oriented Programming Moodle-based course at the University of Salamanca. The Conclusions Sections closes the paper with the principal contributions and conclusions of the study.

2. TEMPORAL WORD CLOUDS VISUALIZATION TECHNIQUE

Visual representations help users to quickly perceive salient aspects of their data. Augmenting the cognitive reasoning process with perceptual reasoning through visual representations permits the analytical process to become faster and more focused. The main goal of the visualization is to provide a compact representation of the overall use of the forums' interaction on VLE, thus providing an overview of the eLearning platform interest, activities and its evolution over the time.

Usually, a tagcloud presents a certain number of most often used tags in a defined area of the user interface. Tag popularity is expressed by its font size (relative to the other tags) and is therefore easily recognized. Sometimes, further visual properties, such as the font color, intensity, or weight, are manipulated (for an overview see [7]). Next to their visualization function, tagclouds are also navigation interfaces as the tags are usually hyperlinks leading to a collection of items they are associated with. However, tagclouds are not only used to display tag sets but are also increasingly applied in other contexts and for various data sets, for instance, in the areas of information visualization or text summarization [8]. Furthermore, several layout variations emerged on the basic design principles of tag clouds. Most popular is the 'classic' rectangular tag arrangement with alphabetical sorting in a sequential line-by-line.

2.1 Tagcloud representation

The goal of the representation for each tag is to present not only how much it is highlighted, but also the evolution of this representativeness over the time.



Fig 1: Representation of a single tag on Temporal Tagcloud .

Figure 1 provides an overview of a tag with its three main components: the bar-graph, wave-graph representation and the tag. The bar-graph and wave-graph representation depict the significance of document content, represented by a word, over time. The size of the font word represents the meaningful of the word on forum activity of the VLE. The curves that shown in the Figure 1 present the significance of the word, which is depicted on background, extracted from a stream of forum posts. The thin lines, which grow up from the bottom of the word to the top, are the representation of the bar-graph. To further improving the meaning of the curves and the bars readability, they are assigned with different colors depending on their activity, green for update-post, red for read-post, and blue for add-post. The x-axis encodes the time and the y-axis encodes the significance of the word clouds.

The interactive visual tool can be used to analyze the usage of a CMS over time. Later, this view can be adapted to the user's requirements, so she can explore all the available discussions, forums, courses and users data, going from the overview to the

detail of a given person, course or discussion within a period of time.

2.2 Connection with Moodle

The connection between the visualization tool and Moodle is done using a web services layer.

It will conduct a series of steps:

- (1) User authentication is necessary to define whether or not the user could use web services;
- (2) Client invokes a service to retrieve the required information;
- (3) Depending on the user's capabilities different information will be returned;

- (4) Once the information is retrieved, this is preprocessed and formatted for display it properly through visualization tool.

2.3 System overview

The interactive visual tool can be used to analyze the usage of a Content Management System (a Learning Management System – Moodle – in the present case) over time. Also, shows the most relevant words from the forums activity. Here the user can chose, through the contextual menu interaction (see Fig. 2), to view about the keywords: the users, the courses, the discussions and the subjects of forum posts and the obtained from the analysis of all the semantic content of all forum posts exchanged in the platform.

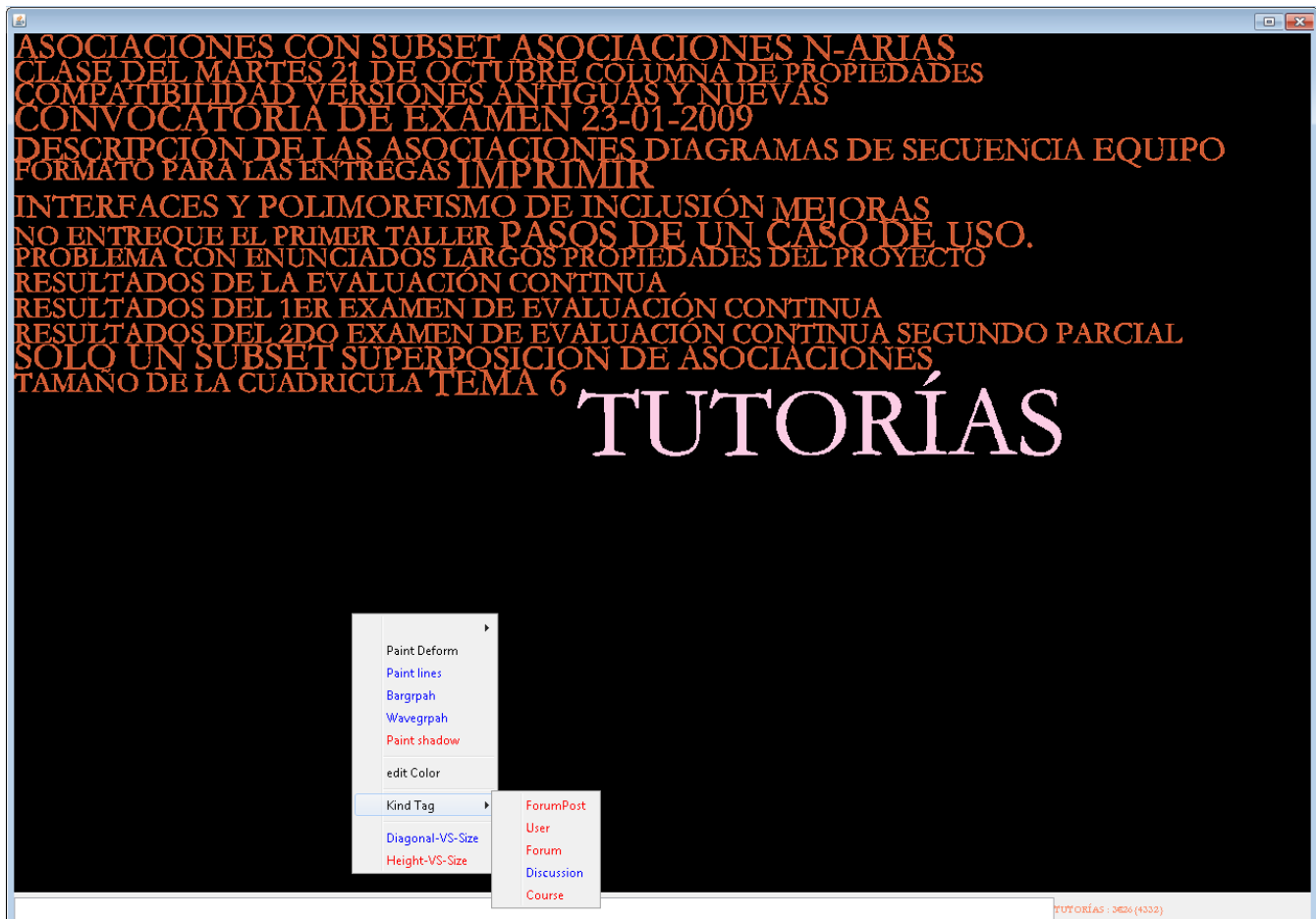


Fig 2: A visual analytic tool must allow users can interact with the data visualization in order to perform a dataset deeper analysis and make decisions in a more suitable way.

One of the interested visual analytic technic used on this work is the semantic zoom, which consists to balance the detail and context in data visualization, known as semantic zooming or multi-scale interfaces. A physical zoom, on the one hand, changes the size and visible detail of objects. A semantic zoom, on the other hand, changes the type and meaning of information displayed by the object [9]. The Temporal Tagcloud allows both types of zooming, but the emphasis is on the different shapes

that is formed depending on the chosen degree of detail, i.e., semantic zoom in the mouse double click interaction over the word, and thus the name of the tool.

When user uses the semantic zoom, depending on the context, the tool selects for analyzing the forum-posts related to the word zoomed. For example, if user makes double click over a course, forum or discussion, the tool uses for the analysis all the forum posts from that course or discussion or forum. If user makes a

The presentation of these topics emphasizes is focused from an object oriented design perspective instead using a more syntactical or language oriented orientation. This means this subject is a continuous of the Software Engineering subject, emphasizing concepts as object oriented design models (using UML [11, 12]) and design patterns [13, 14].

This way, it is easy to achieve a clear separation between object oriented model concepts and their underlined support by the chosen object oriented programming language(s) in lab hours.

The subject assessment is organized in three different examination activities, two for the theoretical part (a test and an oral presentation of a chosen topic related to the subject contents), and one for the practical part, which is based on solving a small programming project [15].

The Object Oriented Programming subject uses a Moodle-based VLE, so called Studium (<http://studium.usal.es>), which is the University of Salamanca institutional Virtual Campus, as subject web site for both resource repository and participants' interaction. The information gathered by this VLE has been exploited in order to discover necessities of the users, the students' behavior patterns, and new ways to improve the subject.

3.2 Scenarios

On a VLE the professors create, edit and fill different forums, discussions and posts. The following are two common scenarios that the professors have in a VLE:

- 1) Keeping track of different tagclouds from a course.
- 2) Monitoring a specific theme, forum, discussion or course.

3.2.1 Keeping track of different tagclouds from a course

Users, in a normally conversation or discussion, try to maintain the track of all discussions, forums and posts that they make. Forums are used as a support tools during Object Oriented Programming subject and tagclouds may be useful to obtain conclusions about how users use these tools.

Figure 4 shows the most used words in a bigger size. From this figure it is possible to obtain several conclusions related to how the forums are used:

- **Informative use.** The forum is used to inform students about events related to the subject, such as: announcements, schedule changes, dissertation defense, list of assignment submissions and so on. Following words must be highlighted in this sense: *Noticia, Aviso, Defensa, Convoca, Examen, Hora*, etc.; which in English means News, Notice, Defense, Summons, Review, and Time, respectively.
- **Subject related discussions.** Considering issues such as: *Reutilización, Desarrollo, Software, Composición, Aplicación, Generación, Híbrido*, etc.; which in English means Reutilization, Development, Software, Composition, Application, Generation and Hybrid respectively.
- **Doubts Resolution.** Using forums to answer questions relating to subject different areas. For example: *Proyecto, Asset, Biblioteca, IOStream*, etc.; which in English means Project, Asset, Library and IOStream, respectively.

It is evident that the most important words in forums are those related to the main important concepts in the subject.



Fig 4: Temporal Tagcloud of the more significant words in Object Oriented Programming subject.

3.2.2 Monitoring a specific theme, forum, discussion or course
Sometimes it is also useful to define how a concept is followed or when a user accesses to a certain data. Depending on that information different actions may be considered such as the introduction of new tools, changes on subject structure, and so on.

To do this also tagcloud visualization technique will be applied. In Figure 5, this phenomenon may be observed considering the word "Reutilización" which means "Reutilization".

Taking into consideration added posts (in blue) may be seen that "Reutilization" concept is introduced in the forum at the beginning of the subject and it has a medium frequency that

means that it could appear in more than one post. Taking into account updated posts (in green) may be observed that there are very few updates in “Reutilization” information. This information is not very relevant because possibly when it is introduced initially in a forum is not updated in the future; however, information about posts may be very representative. Regarding to these actions (in red) it is necessary to take into

account its rightward shift on the word, symbolizing that first appears midway through the subject and stands towards the end. This comes from the fact that the reutilization concept may be introduced in the beginning of the subject and may be specially commented at the end part when students have more knowledge about it and when they discover the concept meaning when they carry out their theoretical and practical projects.



Fig 5: The word reutilization in the tag-cloud.

Moreover, as a part of monitoring a specific theme, course, forum or discussion, may be useful to find and go directly to the most significant discussion. To do this also tagcloud visualization technique is used. The result is shown on Figure 6, where can be seen that the main important forum is NEWS

forum (in fact is so important than the other forums are not included in the image) and inside it (Figure 7) the main important discussion is that related to doubts resolution about an evaluation and tracking issue.



Fig 6: Semantic Zoom over main representative forums.

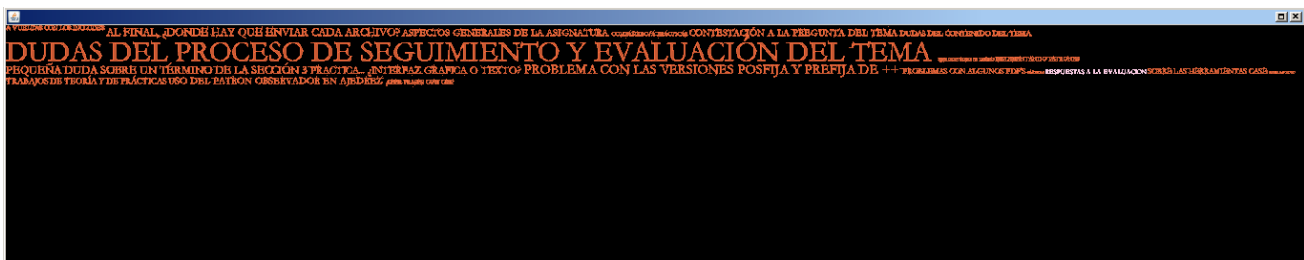


Fig 7: Semantic Zoom over main representative forums inside News forum.

4. CONCLUSIONS

Depending on the context, tagclouds can support user tasks ranging from locating specific items or groups of items,

providing an overview and general impression. Following is a list of tasks that temporal tagclouds can support:

- **Search.** Locating a specific term or one that represents a desired concept (or determining that it is not there), often as a means to navigate to underlying content.
- **Browsing.** Using tagclouds as a means to browse, often with no specific target item or topic in mind.
- **Awareness.** Looking at the tagcloud as a means to form a general impression of the underlying data set or entity associated with it. This impression can include awareness of the most prevalent topics, but also knowledge of those that appear less frequently.
- **Recognition/Matching.** Recognizing which of several sets of information or entities a tagcloud is likely to represent. For example, in social software sites, where the tagclouds can represent the terms assigned by or associated in other ways with a person, the tagclouds can provide an impression of that person and his interests and expertise [16].
- **Understanding evolution of the tag.** Understanding topic trends for two or more continuous time points.

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