Monitoring Virtual Classroom: Visualization Techniques to Observe Student Activities in an e-Learning System.

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Abstract

In this paper, we propose an approach based on visualization to support the teacher to observe the students' activities. After comparing the teaching in classical rooms and in e-learning systems, we present some visualization techniques used in various domains. The paper then focuses on visualization techniques in order to help the teacher to better interpret what happens during the learning session.

***Keywords**. Visualization tools, e-learning systems.*

1. Introduction

Most teachers would agree that teaching in traditional classrooms and via e-learning systems is not the same job. Usages are modified or even new ones are induced in the latter, for instance, some virtual communities can be created, or the observation of the students' behaviour is restricted. Hence, the perception of what happens and of relationships between users has to be totally reconsidered.

To face these new usages, various supports may help the teacher. During an experiment we performed in 2004 at the Graduate Business School of Chambéry in France, we envisaged several supports to observe student behavior within a Web-based learning system. A first support was provided by trace annotation to better interpret the students' traces recorded during the session [1]. A second support was proposed thanks to the preparation of an observed experiment by selecting and structuring the relevant observable factors [2]. Finally, a third support was proposed via different visualizations to compare data representing the learners' activity against a recommended learning scenario, in order to help the interpretation of the learners' behavior [3]. These supports help the teacher to interpret the students' behaviors, but can also furnish a feedback on the session, feedback helpful for further teaching scenario improvement.

Beyond the teaching scenarios' aspect, we have to deal with a framework where a certain number of activities have to be achieved. Learning platforms present the advantage of allowing students to evolve in the class at their own speed. Therefore, there is a real possibility of flexibility for the teacher who can constitute with leisure groups of levels (as many as necessary) which is not the case in a "true life" class.

This richness related to flexibility must go along with a need for awareness of what occurs: need for observation but with immediate graphic translation thanks to visual artefacts easy to interpret. We propose in this paper a subset of these graphic artefacts.

Within the framework of this paper, we present the way a teacher can observe in a classical classroom and in an e-learning system. We then describe some visualization techniques. The main part of this paper focuses on the visualization system we propose to help the teacher to follow the students' activities. Finally, we discuss our approach and draw conclusions.

2. How to watch like a teacher

In this section, we want to capture how a teacher uses her/his vision in a traditional classroom in order to find out which metaphors can be adapted to an e-learning system.

2.1 From reactivity in traditional classrooms…

How does it work in a traditional classroom? The teacher is continuously aware to make her/his own analysis of the classroom: s/he has a global perception of the classroom and according to some signs, s/he adapts the lesson. For instance, while the teacher is observing the classroom, s/he can notice a student in difficulties and then decide to approach her/him.

During the learning session, the teacher must be particularly vigilant to the following situations: When a student calls for help; when a student is too slow; when a student gets angry; when a student spends too much time doing the same thing; when a student does nothing (linked to the course); when students speak together which generates too much "noise" …

On the other hand, the teacher may be willing to be aware of other particular facts, thanks to polls and counts of hands up, such as: How many students succeeded exercise 1? How many students read the supplementary help file? Who is currently performing the evaluation test? Who did not reach exercise 3 yet?

2.2 … To flexibility in e-learning systems

The difference induced by e-learning systems comes from the fact that there is less feedback. On the contrary, there is more freedom for reorganizing the classroom in a virtual way all along the session. By consequence, this flexibility generates a need for increased awareness.

Initially, the teacher can wish to have an overall view of the classroom. Later on, s/he can decide on a strategy, for example, to isolate the good students from those in difficulties; in the latter group, to separate the students who performed lots of exercises which proved to be false from students who were stuck to the first activities; or to focus on which exercises came out to be the most difficult. At some other point, the teacher may decide to get a chronological view of the activities, namely a historic, for a particular student, in order to know if the student carried out the exercise once, twice or more, if s/he did something else before coming back to it. Finally, the teacher may be willing to switch from a view to another view.

Our idea is to supply the teacher with a support for awareness purpose. Visualization tools can help from different points of view, for instance: general view of the classroom; view of the activity of a particular exercise; view of a particular student. We aim at proposing various visualization tools and a system to navigate between these complementary tools.

In the following section, we present the different visualization techniques for the follow-up of students.

3. Various visualization techniques

In many domains, data is used to identify relevant information, interesting patterns, hidden relationships, in order to improve analysis and decision-makings. While the amount of data continuously increases, data visualization tools evolve to transform these data into meaningful visual representations. The visualization tools can render large quantities of data from basic charts to graphical indicators, from scorecards to dashboards, from advanced visualizations to virtual reality. Finally, the visualization aims at rapidly identifying the key variables, discovering meaningful patterns, helping to detect the root causes of problems among millions of logs. A survey of such techniques is beyond the scope of this paper (see [4,5] for more examples of techniques). We focus here on some graphic representation that should meet our purpose.

Basic charting consists of pie, bar and line charts that contribute towards the identification of general upward and downward tendencies, the display of relative values to see how data relates to other data.

Advanced data visualizations provide sophisticated graphical representations that allow multiple dimension data to be displayed, such as multidimensional charts, scatter plots, constellation graphs, and spatial images. For instance, parallel coordinates [6] represents multidimensional data using lines; Hyperslices [7] consists of a matrix of k^2 slices through k dimensions of initial data. Interesting advanced data visualization concerns the **icon-based or glyph-based techniques**. Certain features of the glyph or icon are mapped to certain dimensions of an n-dimensional data point. A popular technique consists of using Chernoff faces [8] which performs this by associating an attribute to a face characteristic (i.e. head shape, eye size, nose width). By using the most striking face features, it is possible to represent a dimension number of data higher than three. They benefit from the richness of our lived and from our capacity to reveal very light changes in the facial expressions. Another technique consists of using star glyphs [9], where the dimensions are represented as equal angular beams radiating from the circle center.

Animations lead to watching data changes over time, which gives a velocity and direction to the represented values.

Finally, **interaction** offers a deeper experience than the traditional visualization tools, as it allows the user to directly interact with a given representation: by rotating it or brushing it over to uncover context information about it, by filtering unwanted values or values with respect to certain thresholds or by zooming in to detail or out to get an overview. This leads to the possibility to study the underlying data and the discovery of new information. Another interactive means is to link information together to display elements via color coding and related context, and thus offering a richer comparative context, relating back and forth representations as the user makes different choices that affect the visual information. A further interactive means consists of launching another visualization tool by clicking on a chosen data.

In the following section, we present our visualization system based on these techniques.

4. The visualization system

The need for flexibility offered to the teacher guides the development of our system. At the beginning, we want to provide a global vision of the students, and then, depending on the teacher, we want to offer different possibilities to interact with the system, to switch among various views. First, the interest is to propose a visualization system of the whole class of students. Second, different means must allow the teacher to interact with the system to go further in the analysis process: the selection of a face, in order to analyze the matching student, which may yield a particular type of analysis; the selection of an activity to focus on it; etc.

4.1 The classroom view

In our system, a student is represented by a Chernoff face (cf. Figure 1), which evolves dynamically in time, according to what the student performs during the session. First, at the beginning, the organs are just points (a), and they grow until state (e) according to the number of logs recorded during the system use. Nevertheless, the nature of the activity is not considered here as it is complex to be determined.

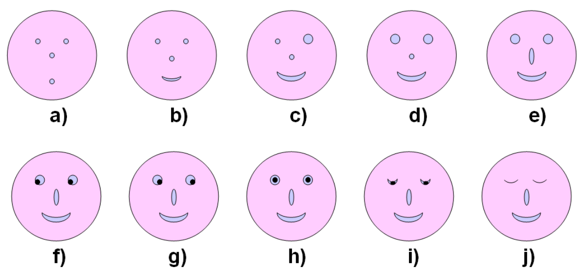

Fig. 1: Chernoff faces adapted

Second, we use the color of the face to represent the time spent by the student doing the current exercise: at the beginning of the exercise, the face is white, and the longer the student works on it, the darker the face becomes.

Third, we add some animation to the eyes, in order to represent the current activity of the student. This allows us to know if the student is really performing something or not. Indeed, if a student activity was observed (See Figure 1, (f) to (j)): during the last minute, the eyes are moving ((f) and (g)); between one and two minutes, the eyes are staring (h); between two and three minutes, the eyelids are falling (i); afterward, the eyes are closed (j).

Next, we want to represent visually the whole class of students in 2D. Unfortunately, it is not interesting to match the classroom topology, because first we are not able to situate the students geographically, and second, in the case of distant learning, students are not obligatory in the same room. On the contrary, we can use other dimensions that may bring further indications on the activity.

Therefore, we propose to group the students by activities, and to represent each activity by a bubble (cf. Figure 2). Initially, there is no a priori knowledge about the relationships between activities, all the bubbles are randomly placed, and progressively, the bubbles move to minimize the distance between the successive activities done by students. The purpose of this representation choice is to rapidly visualize who is doing what.

A first consequence of this representation is that it helps us to determine which activities are more likely to be performed before a given activity. A second consequence allows us to distinguish rapidly students working solely (isolated) and those working in cooperation/parallel (cf. Figure 2, (a) for a lonely student, (b) for a working group).

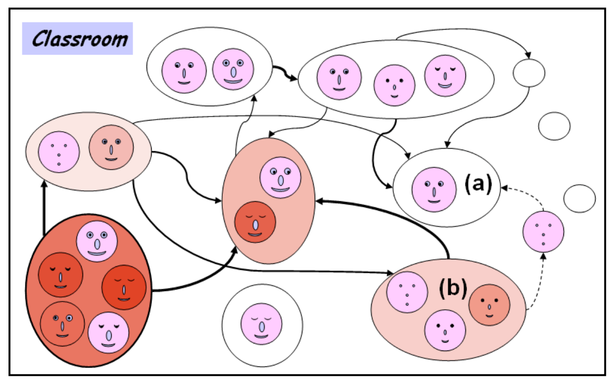

Fig. 2: Classroom view

In a bubble/activity, we choose to represent two types of information: a first one is the background color of the bubble which saturation corresponds to the relative delay of the students implied in this activity compared to the average time required (by usage) (cf. section 4.3); a second one is the quantity of implied students represented by Chernoff faces. A problem may appear if too many students are engaged in the same activity: the Chernoff faces may overlap or be reduced to fit in the bubble, inducing information loss. We propose to dynamically change the size of each bubble with respect to the number of students it contains.

4.2 The student view

From the classroom view, the teacher can select a student by clicking on the corresponding Chernoff face. As a matter of fact, the teacher can be interested in knowing how long the student takes to complete an activity and her/his activity rate along the training session. Therefore, in the student view (cf. Figure 3), we visualize the time spent by the student for each activity, represented on the X-axis. We use the line **t=t0** to show the current instant and the past is on the left side of this line. We add another dimension with the Y-axis that represents the cumulated logs generated per minute.

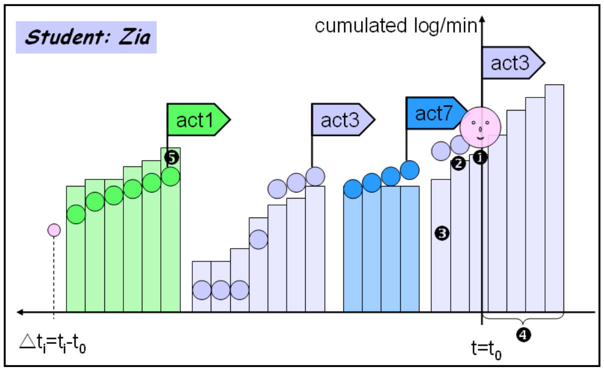

Fig. 3: Student view

We then place the Chernoff face of the student on the Y-axis ❶ so that it corresponds to the number of logs generated by this student since the beginning of the current activity. At each minute, the graph is shifted of one unit to the left and a new dot then appears to replace the Chernoff face ❷ (we just want to remember the number of logs generated, not the status of the student). Furthermore, we compare this value to the average value of prior students by adding a histogram bar behind with the appropriate height ❸. We also display, for the current activity, all the histogram bars predicted ❹ (by consequence, on the right side of the line t=t0), in order to inform the teacher of the forthcoming quantity of presumed logs. Besides, to distinguish the different activities of the student, we use different colors for each activity, and we place a flag labeled with the activity number above the Chernoff face. When the student ends an activity, the flag remains on the last dot ❺.

4.3 The activity view

From the classroom view, the teacher can select an activity by clicking on the corresponding bubble. Indeed, the teacher can be interested in knowing how long students take to perform an activity. Therefore, in this activity view (cf. Figure 4), we visualize the time spent by the students for this activity, represented on the X-axis. We use the line $\mathbf{t=t_0}$ to show the current instant and the past is on the left side of this line. We add another dimension with the Y-axis that ranges from 0 to 2 times the average time spent by the previous students to complete the exercise. When a new student starts this activity, her/his Chernoff face in positioned on the Y-axis at the height corresponding to her/his average time relative to the classroom average time of doing exercises. For instance, on Figure 4, the Chernoff face ❶ is an average student starting the activity, while the Chernoff face ❷ is a student that is relatively slow.

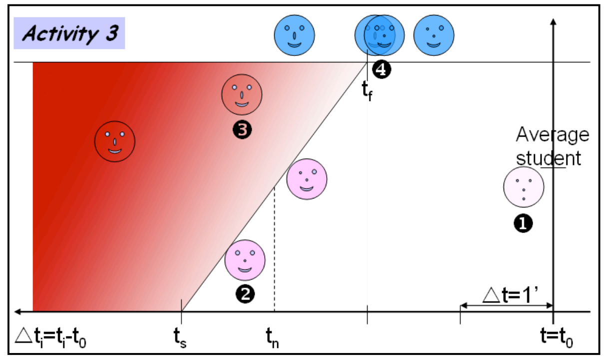

Fig. 4: Activity view

We define other values that allow us to categorize the students. t_n corresponds to the normal duration to complete this activity for an average student; t_s corresponds to $(1+\alpha)*t_n$ (with $0<\alpha<1$) and represents a duration for a slow student, while t_f corresponds to $(1-\alpha)*t_n$ and represents a duration for a fast student. The line (t_s,t_f) separates the space into two zones, the right zone being the regular zone, whereas the left one represents the danger zone, since there, the students are taking too much time to perform the activity, which suggests that they are in difficulties. For instance, the Chernoff face ❷ is “normally” slow, while the Chernoff face ❸ exceeds her/his predicted time. As the time goes by and the line $\mathbf{t=t_0}$ stands still, all the Chernoff faces move backwards. For instance, in thirty seconds, the Chernoff face ❷ will enter the danger zone.

Lastly, when a student finishes the activity, her/his Chernoff face comes up to the surface line and her/his time freezes. For instance, the Chernoff face ❹ stands for a student that ended the activity in 2 minutes, and as the time goes by, this value remains the same.

5. Discussion

We made some choices about the visualization techniques, with a desire of simplicity, to avoid any cognitive overload of the teacher, and intuition, to facilitate the switch of a representation to another.

The selected representations rely on two main metrics: the time spent to make activities and the logs’ quantity that should represent the activity density. We could adapt these representations to other metrics which can be very different according to the criterion sought in observation. For example, we can imagine the rate of co-operation between students in a group.

Finally, the fact that the tools are only handled by the teacher is naturally a simplification for the clearness of our talk. We could use them as well for other purposes: meta-cognition for the student to understand how s/he learns; awareness to situate one-self compared to the classroom; or awareness to situate one-self compared to her/his training in what is awaited within an activity and to preserve this profile for later drawing conclusions on the way s/he learned.

These graphic modes are multi-criteria and we can add supplementary information in a simple way. For example, for Chernoff faces, we did not take into account the shape, the size and the relative position of the organs. An obvious extension could consist in attaching a semantic to these attributes, for instance an emotion could be related to the shape and the size of the mouth. We used only one color for the Chernoff faces, but we could extend to several colors related to attributes, and switch between them thanks to a filter.

However, too much information can lead to cognitive overload. We thus have to do experiments to validate our interfaces with teachers within the framework of teaching activities on computers.

6. Conclusion

The work presented in this paper proposes an approach based on visualization to support the teacher to observe the students' behaviors. The advantage of the flexibility in e-learning systems corresponds to new usages, and thus requires more awareness for the non familiarized user.

Various perspectives can be envisaged. Dashboards can be used as powerful analytical tools since they offer means to help users to understand not only what is happening, but also why it is happening. However, the analytic goal must guide the visualization selection: the visual representation and by consequence the visualization tools have to be appropriately chosen, otherwise, they will not provide the meaningful information the user could have hoped. Smart authoring wizards may then help the user to choose the suitable tool.

Another perspective for our visualization system is to provide some help for the detection of not done activities, unforeseen activities, or what was planned but performed in unpredicted way. This detection is particularly useful for the designers who define learning scenario with languages such as IMS-LD [10], or LDL [11] because these languages do not provide observations facilities yet. We already proposed some visualization tools to represent the traces in order to compare them to a learning scenario in [1].

Finally, more advanced visualization techniques may go further in the analysis. Immersive visualizations act as virtual reality games by immersing the user into virtual environments that contain 3D representations of data. The visualization can also enable to dynamically evaluate alternative scenarios.

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