Observe and react: interactive indicators for monitoring pedagogical sessions

Jean-Charles Marty*
Liris Lab, UMR 5205,
Université de Lyon,
Batiment Blaise Pascal, 7, Ave Jean Capelle,
69621 Villeurbanne Cedex, France
Fax: +33-479-75-86-90
E-mail: jean-charles.marty@liris.cnrs.fr
*Corresponding author

Thibault Carron
Lip6 Lab, UMR 7606,
Université Pierre et Marie Curie,
Paris VI, Equipe MOCAH-LIP6,
Campus Jussieu, 4 place Jussieu,
75252 Paris cedex 05, France
Fax: +33-144-27-70-00
E-mail: thibault.carron@lip6.fr

Philippe Pernelle
Disp Lab,
Université de Lyon,
Lyon 1 IUT Villeurbanne Gratte-ciel, France
E-mail: philippe.pernelle@univ-lyon1.fr

Abstract: The use of learning games implies they can provide the teachers with an answer to the lack of awareness often reported for such systems. The monitoring of the activity is indeed a central task for teachers that can be carried out only if key elements related to an ongoing pedagogical activity are reported. In this paper, we propose a solution based on the users’ traces that are transformed and displayed for the teacher through indicators. We also discuss how the monitoring actions are in a sense connected with these indicators. The approach is illustrated through three use cases, paying particular attention to the teachers’ needs and to collaborative aspects.

Keywords: monitoring; traces; indicators; game-based learning; collaborative learning; regulation; learning environments; learning technology.

1 Introduction

Recent years have seen a rise in learning with computer-based learning environments. These are now seen as a powerful instructional tool that can be used in various contexts. Although these environments provide functionalities that are recognised as being valuable, students tend to consider them as unexciting (Prensky, 2001). Nevertheless, learning games can be seen as an attractive evolution of these computer-based learning environments taking into account the new hobbies of the so-called digital natives (Galarneau and Zibit, 2007; Dondlinger, 2007). Indeed, as Prensky observed, today’s students are able to multitask, are used to process new information fast and from several sources, and prefer to use hypertext media systems like the internet. This new way of learning changes habits, offers new opportunities to let the students organise their learning activities, applying their own strategies according to what they know from their academic strengths and weaknesses (Squire, 2003). This way of self-regulating (Zimmerman, 1990) their activity can be supported in such environments. More generally, videogames are even seen as providing a new form of rhetoric thanks to their basic ‘representational mode of procedurality’ (Bogost, 2007) and may be a means by which to envisage programming or computation with a brand new view (Matheas, 2005). Moreover, when these game-based learning environments are multi-players, another central issue concerns the collaborative learning aspects. The use of collaborative tools is increasing, allowing the students to co-construct knowledge efficiently (Lou et al., 2000).

Nevertheless, as a result from the teacher’s point of view, the monitoring of the ongoing activity is much more difficult (Hong and Koh, 2002). Indeed, in such
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educational platforms, and especially in game-based learning environments, the teacher would like to have the same possibility as in a teacher-directed environment, to actually be aware of what is going on in the classroom, in order to react in an appropriate way. Of course, s/he cannot have the same feedback from the students, since s/he lacks human contacts.

The general objective of this paper is thus to provide the teacher with support in facing the difficulties for the monitoring task. We explain how this feedback is made possible by exploiting the activity traces that the users leave on the computers while performing their activity (Hijon and Carlos, 2006).

We first describe three concrete cases, putting the focus on the teachers’ needs from a monitoring point of view. We then explain a way of obtaining the relevant indicators from the users’ actions in order to make this monitoring easier. We finally describe how to interact with the environment through some indicators elaborated from traces.

2 Description of examples

We would like to begin our paper by presenting three concrete examples coming from three experiments that we have performed recently. The first one provides the teacher with an overall view of the ongoing (non-collaborative) activity. The others are related to the monitoring of collaborative learning sessions, one focusing on the monitoring of the production of the activity, the other one centred on the organisation of the activity.

2.1 Monitoring individual activities in a classroom

2.1.1 Description of the experiment

The experiment proceeded with an audience of first year students at the Institute of Technology of Chambéry (France). It lasted two hours. There were eleven students, and a teacher, all located in the same room. During this session, the students had to solve four independent problems, linked with their programming lesson. The teacher did not mention any order, although an optimal path existed (the resolution of some exercises can ease the resolution of others). All the necessary resources (lesson documents, text of the problem) were available on the experimentation platform. The proposed activities were purely individual ones. There was thus no need for communication between students. A student could change the exercise s/he was doing when s/he wanted. S/he was able to come back to a previous (not finished) exercise as often as needed. The only requirement was to signal these changes through an interface that uploaded the associated resources. Before the beginning of the activity, the teacher defines an average time to spend on each exercise, according to the level of difficulty of each exercise.

2.1.2 Learning subject

The exercises were related to Java Programming Language. The students were expected to provide a solution to several small programming exercises. All the exercises are independent, but the resolution of a given exercise can ease resolving another one. In that sense there is a preferred order for solving these small problems.
2.1.3 What data related to the activity of the students does the teacher need to access during the session?

We had a quick interview with the teacher to identify his needs. It came out that a few features were mandatory to monitor the activity. First of all, he required knowing who was doing what (which exercise) at any time. He also needed to know who was having trouble (who was spending too much time on a particular exercise). He wanted to see who was active on the given activities and who was sleeping (doing something else). He wished additional features, such as seeing the historical path all along the exercises from a student. Finally, he needed more general information to reengineer the pedagogical session after the activity: which problems were too hard to solve for this specific audience in the proposed time, which path between the problems did the students favour?

2.1.4 Actions needed to monitor the session

Not much was needed to monitor the activity. The teacher insisted on the need for advising the students to change the exercise when they have spent too much time on a particular exercise.

2.2 Monitoring the balance of participation in a collaborative activity

In this part, we describe an experiment where students were immersed in a Game-Based Learning Environment that we have developed. Learning Adventure (LA) is a game-based learning system representing a 3D environment where the learning session takes place [see Marty and Carron (2011) for details on this environment]. The environment is generic in the sense that it is not dedicated to a particular teaching domain. With the help from a pedagogical engineer, the teacher adapts the environment before the session by setting pre-requisites between sub activities and by providing different resources (documents, videos, and quizzes) linked to the course. The map topology represents the overall scenario of the learning session, i.e., the sequencing between activities. Similar models that link pedagogical issues with game elements can be found with a more general point of view in Amory et al. (1999) and more precisely concerning this approach in Carron et al. (2008). LA is based on a role-play approach (Baptista and Vaz de Carvalho, 2008). Players (students or teachers), possibly represented by their own avatars, can move through the environment, performing a sequence of sub activities in order to acquire knowledge. Activities can be carried out in a personal or collaborative way [see Dillenbourg (1999) for a list of collaboration abilities]: one can access knowledge through objects available in the world, via help from the teachers, or from working with other students. In order to communicate with other players a chat tool is available. It is more complex to construct group knowledge with specific tools. If we want to address collaborative learning properly, we need to offer adequate tools. For instance, we have designed a collaborative tool called the post-it wall (see Figure 1). The purpose of the tool is quite simple. It allows the same features than a board in a meeting room with post-it notes. People can stick post-it notes on a wall and move them to rearrange the ideas. Of course, when someone moves a note, all the people involved in the activity notice the change. All the participants in a ‘post-it wall’ activity
have the same view of the wall at any moment. The collaborative activity is well supported by the tool since a real discussion takes place between the students to construct the class diagram. The tool supports well the different propositions and the visualisation of the current status of the group knowledge.

**Figure 1** The post-it wall in learning adventure (see online version for colours)

2.2.1 Description of the experiment

This experiment was carried out in 2010 in our university with six groups of 15 students with their teacher. The students were 18 years old and familiar with computer use. Each student accessed the virtual environment through his/her workstation, and had a personal (adapted) view on the world. These students used the environment for approximately two hours and a half. They were explicitly allowed to communicate through the chat tool provided with the system and were warned that they would be observed concerning the use of the system. The students were free to refuse this observation (the same practical work was available outside the learning environment), but everyone agreed to follow the proposed protocol.

2.2.2 Learning subject

The aim of the session (role playing game) was to assess the knowledge and know-how of the students about object-oriented concepts. A story guided the knowledge quest thanks to metaphors. The challenge is encouraged through non-playing characters (NPCs) who propose a coherent contest. Indeed, in one of the activities for learning one of these concepts in this environment, the students were asked to use this post-it wall to provide the class diagram of an ecosystem whose components were present in the game. The solution had to be the result of the common thinking from a group of 15 students. The final objective was to obtain a correct diagram displayed on the post-it wall.
2.2.3 What data related to the activity of the students does the teacher need to access during the session?

In this part of the experiment (i.e., the collaborative activity), the teacher was mainly concerned by the goal of keeping a balance between the learners’ contributions. He wanted to know if there were active participants in the activity.

2.2.4 Actions needed to monitor the session

In order to keep the group homogeneous regarding the level of activity, the teacher needed to inform the participants about their level of contribution, and in some cases to slow down a particular student (change of rights, change of moving speed, additional quest) to let the others participate.

2.3 Monitoring the group organisation in a collaborative activity

Designing new sessions for students with LA reveals new needs, especially when collaboration is addressed. The ‘post-it wall’ was a first simple example, but more complicated tools are also emerging. For instance, the co-edition of document is very often required in collective knowledge acquisition, especially in the reformulation phase, when the group explains the path followed to reach an objective. For that purpose, we have designed in LA a new collaborative tool: the collaborative outline drawer. This tool aims at helping a small group of people (five to eight) to provide an outline of a document. Every member of the group takes place in front of a free board (see left part of Figure 2). Clicking on the board gives access to the collaborative session.

Figure 2 General view of the collaborative feather (left) and personal and collaborative spaces in the feather tool (right) (see online version for colours)

One must understand that there are three different spaces used in this tool:

- Each participant has his/her personal space. A rough notebook is a good metaphor for this space. One can scribble ideas in this space before proposing an idea to the rest of the group. This space is displayed in the lower right part of Figure 2.
- A collaborative workspace. The ideas proposed to the group appear in this space. Discussions around these ideas can be stimulated through actions available in the
space menu. One can ask for explanations on the idea, provide a positive or a negative comment (the colour of the feather changes). Only the ideas are displayed on the board, but one can see the discussions around an idea by clicking on it. Vertical lines are displayed on this space in order to classify the ideas and construct the outline of the document in a hierarchical manner. As in the post-it wall, the users are able to move the ideas and to align them with others, to re-order them. The ideas aligned on the same line are at the same level in the outline (chapter/subchapter/subchapter). This space is displayed in the higher right part of Figure 2.

- A ‘marble space’ where the ideas validated by the whole group are engraved. This space is not a collaborative one. It contains the decisions of the group (from a vote on the collaborative space) and the history of all the discussions of the ideas. Hopefully, the marble space contains an outline of the document at the end.

2.3.1 Description of the experiment

This experiment was carried out in 2011 in our university with co-located settings. The conditions and methodology were almost the same than the one described before. The main difference lies on the fact that three groups of five students were created at the beginning of the session and maintained all along the experiment as justified in Gress et al. (2010).

2.3.2 Learning subject

The pedagogical objective of the session was the initial step for designing complex software from simple items. Organisational issues are also addressed in this session. Each group of students was asked to produce an outline of a document proposing a new game. Each student must first discover a game brick [part of the game bricks classification (Djaouti et al., 2011)] that was hidden in the game (see Figure 3). Then the group had to design a game based on these different bricks acquired by each member. The collaboration for this design was effective through the collaborative outline drawer. The interactions between students took place in the collaborative workspace of the tool (see Figure 2), each member proposing new ideas, commenting others’ ideas, asking questions on new propositions, proposing a vote. The result of this phase is a common thinking of a group of five students, expressed by a document outline (displayed on the marble space).

**Figure 3** Searching and finding game bricks (see online version for colours)
2.3.3 What data related to the activity of the students does the teacher need to access during the session?

In this experiment, the teacher was interested in having a global view of the profile of each participant: Is s/he a leader? Is s/he a creative actor? Is s/he an organiser?

2.3.4 Actions needed to monitor the session

Two kinds of actions were discussed with the teacher.

The first one concerns actions to be done at the end of the collaborative outline drawer activity. The idea is to use the rough profiles (calculated from the actions performed during the collaborative activity) in order to allocate new roles (and associated rights) to students for the following activities (e.g., group leader, and group organiser). These new roles will be used during the same learning session, but in the following activities. These activities were linked to Software Engineering in our scenario, since the students needed to evaluate the different tasks to construct the game, using the Scrum methodology (Schwaber and Beedle, 2008). The description of these activities is outside the scope of this paper.

The second kind of actions is connected with the need for motivating or stimulating students during the collaborative feather activity. The teacher would like to allow a particular student to view his/her own profile (through a diagram summarising the main characteristics of his/her contribution).

3 Observe at the right level

The three experiments described in the previous section put emphasis on the need for obtaining accurate information on the ongoing activities. In this second section, we explain how to achieve such a goal through users’ traces and trace-based systems (TBS). We illustrate it by providing solutions to the teachers’ expectations listed in “What data related to the activity of the students does the teacher need to access during the session?” for the three experiments.

The tracing activity is an appropriate way to reflect in depth details of the activity and to reveal very accurate hints for the teacher. For instance, many e-learning platforms or learning systems are based on web servers (Zaïane and Luo, 2001; Burton and Walther, 2001). These servers easily supply logs (information concerning the connections on this server) stored in specialised files. Working from these logs immediately reveals two main problems: the information collected from thousands of users is huge; and the information is too low-level to give interesting pedagogical information concerning the students. For instance, a data provided in the SQUID format by a web server, such as 193.48.120.76 22/04/2003 04:25:31 POST TCP_MISS/200 http://www.univ-savoie.fr:443/Portal/logged_inFIRST_PARENT_MISS/www3-ssl2.univ-savoie.fr text/html is not directly interpretable. It should be transformed, rewritten, in order to ease its comprehension.

Traces are thus objects containing rich information but remaining very difficult to manage and understand. Very often, an ad-hoc treatment of the traces (e.g., logs) leads to their visualisation, easier to understand for the teacher. Carron et al. (2006) and France
et al. (2006) have already proposed some trace visualisations as a solution to specific observation problems. The purpose here is to be more general and offer observation features on any pedagogical tool.

3.1 Trace-based systems

We propose a methodological approach to the traces exploitation by separating different phases linked to the observation lifecycle. We ground our work on a model elaborated by Settouti et al. (2009) in collaboration with the SILEX team of the LIRIS laboratory. This model called TBS defines the different modules associated with these different phases.

A general process for taking the traces into account in a learning system is given in Figure 4. The different phases for the traces lifecycle are presented in the left part of the figure. In order to offer observation features at an understandable level of abstraction, we need to collect the traces and transform them. As this paper focuses on monitoring, the analysis of the traces must be done in real time directly by the teacher and we propose a visualisation to help him/her perform this task.

Figure 4 Process for a TBS model (see online version for colours)

3.1.1 Collecting phase

The collecting phase is prepared before using the TBS and consists of gathering the traces generated in the e-learning platform. Trace collecting is a complex computer science problem, due to the large volume of rough traces that one can possibly collect. This collection can be made through instrumented software according to the observers’
intentions (Talbot and Courtin, 2008) or through files generated by the operating system, or through dedicated spy software, such as key loggers. Another issue related to the trace collection is the heterogeneity of rough traces. Choquet and Iksal (2007) proposed a way to model them, in order to facilitate their use.

**Table 1**  List of awareness indicators

<table>
<thead>
<tr>
<th>Probe name</th>
<th>Parameters</th>
<th>Awareness category</th>
</tr>
</thead>
<tbody>
<tr>
<td>WorkshopArriving</td>
<td>&lt;UserName&gt;, &lt;WorkshopName&gt;</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>WorkshopLeaving</td>
<td>&lt;UserName&gt;, &lt;WorkshopName&gt;</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>WorkshopAnswering</td>
<td>&lt;UserName&gt;, &lt;WorkshopName&gt;</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>WorkshopAnsweringWithContent</td>
<td>&lt;UserName&gt;, &lt;WorkshopName&gt;, &lt;AnswerContent&gt;</td>
<td>Social awareness</td>
</tr>
<tr>
<td>WorkshopTeacherValidating</td>
<td>&lt;UserName&gt;, &lt;WorkshopName&gt;, &lt;TeacherName&gt;</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>WorkshopTeacherValidatingWithContent</td>
<td>&lt;UserName&gt;, &lt;WorkshopName&gt;, &lt;TeacherName&gt;, &lt;Comment&gt;</td>
<td>Social awareness</td>
</tr>
<tr>
<td>WorkshopCorrectlyAnswering</td>
<td>&lt;UserName&gt;, &lt;WorkshopName&gt;, &lt;Boolean&gt;</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>StudentConnecting</td>
<td>&lt;UserName&gt;</td>
<td>Informal awareness</td>
</tr>
<tr>
<td>HelpConsulting</td>
<td>&lt;UserName&gt;, &lt;HelpName&gt;</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>Chatting</td>
<td>&lt;UserName&gt;, &lt;ChannelName&gt;</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>ChatContentListening</td>
<td>&lt;UserName&gt;, &lt;ChannelName&gt;, &lt;SentMessage&gt;</td>
<td>Social awareness</td>
</tr>
<tr>
<td>GroupCreating</td>
<td>&lt;GroupName&gt;, &lt;GroupType&gt;, &lt;Username1&gt;, &lt;Username2&gt;, ...</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>GroupSplitting</td>
<td>&lt;GroupName&gt;, &lt;GroupType&gt;, &lt;Username1&gt;, &lt;Username2&gt;, ...</td>
<td>Group-structural awareness</td>
</tr>
<tr>
<td>StudentDeconnecting</td>
<td>&lt;UserName&gt;</td>
<td>Informal awareness</td>
</tr>
<tr>
<td>TeacherConnecting</td>
<td>&lt;TeacherName&gt;</td>
<td>Informal awareness</td>
</tr>
<tr>
<td>TeacherDeconnecting</td>
<td>&lt;TeacherName&gt;</td>
<td>Informal awareness</td>
</tr>
<tr>
<td>TeacherHelpCalling</td>
<td>&lt;UserName&gt;, &lt;TeacherName&gt;</td>
<td>Social awareness</td>
</tr>
</tbody>
</table>

The collecting phase should be viewed as a means for gathering useful information on the platform exploited by the users. The users work with a certain number of tools in a given environment. The idea is to equip any application with a tracing possibility. For each tool, we must decide a priori which features of the tool should be observed. This leads to defining an observation application programming interface (API) for every tool that is involved in the observation that the teacher wants to obtain. For instance, if we consider the second use case presented in the previous section, we need to consider an API for the game-based environment. We defined 17 elementary probes that may be flagged at any
moment by any client of our application. As seen in Table 1, each probe contains some parameters and has a particular aim in order to complete a specific category of awareness, which is not often addressed. Pinelle et al. (2003) provided us with a complete definition of awareness. As the users will additionally use a collaborative tool (the post-it wall), we also need to add an observation API for this tool (basic actions to be observed: add a post-it note, move a post-it note, delete a post-it note).

3.1.2 Transformation phase

For a teacher, the expectations concerning the perception through the system are somewhat difficult to express. The level of what needs to be perceived may vary, as is also the case in traditional teaching: a teacher may want to observe basic facts (e.g., who starts a new activity) or more abstract facts (e.g., who regularly cooperates before answering a quiz properly). The API provides the users with elementary probes. They are thus useful for observing basic facts. However, they may not be helpful enough when the level of abstraction needed is higher (Laflaquière et al., 2006). For instance, being aware only of a student consulting a help file can be not very meaningful. But if the same observation occurs just after s/he has given a wrong answer and then followed that with a success in the same activity, the teacher may be reassured as to the usefulness of the help file related to the activity. The combination of these three indicators (simple probes) allows to create a complex probe and thus to provide a higher-level explanation about the ongoing activity.

Figure 5 How to build up indicators from these traces (see online version for colours)

In order to combine elementary probes obtained from the collect phase, three operators have been proposed: AND, OR, THEN. All these indicators may be combined with each other to define new complex probes and their representation. Figure 5 shows an example of such a definition with the administration tool. The new indicator is available in the educational platform, with the same properties as the basic probes. In particular, the new
ones can be reused to create a more complex probe or indicator. Thanks to this mechanism, the set of indicators naturally increases with the help of the users, guided by the needs of observation in the platform.

3.1.3 Visualisation phase

Visualisation techniques are used in order to reveal the semantic from the traces, making it easier to understand and help an analysis from a particular viewpoint. The phase is aiming at facilitating the interpretation of the ongoing activity from a non-specialist.

The visualisation phase consists of making requests among traces and of visualising traces. We decide to situate the visualisation and the request system out of the TBS, since these tools do not fit the definition of trace manipulation as defined by Laflaquière et al. (2006). Indeed, visualisation techniques produce results that are not traces. Visualisation consists of elaborating a graphical representation, adapted to the analyst objective, from traces contained in the TBS. This representation can take many forms, such as a temporal 2D visualisation of a trace (France et al., 2006), of several traces (Mazza and Milani, 2005), or a spatial 3D visualisation (Cugini and Scholtz, 1999). The visualisation system relies strongly on the analyst objective. For instance, the visualisation system must be able to provide the analyst with a real time visualisation of the enactment of the users activities, and particularly to detect and show the users in trouble.

The idea is thus to provide specific indicators giving meaningful information to the teacher after several steps (collection, selection, abstraction, aggregation of different traces). The strong point of this approach is that the traces are not ‘hidden’ in the different software included in the platform. They are objects that can be manipulated independently from the educational platform. For instance, traces coming from different ‘sources’ (a collaborative tool, a chat) can be merged to obtain more general information. Trace modelling allows us to propose solution to user support, to adaptation to the student, to usage analysis. Furthermore, the transformations of the traces feed dynamically the indicators and allow the teachers to react during the learning session, what is hardly ever the case in most learning environments.

We now illustrate this trace-based approach with the three case studies that we have described in the first section.

3.2 Illustration with the three case studies

According to the teachers’ needs expressed in the different case studies, we propose in this section to show which indicators were implemented to meet these requirements and how there were obtained from traces.

3.2.1 Case study 1

In order to design an awareness tool appropriate for the teacher, we first looked at the probes that were available in the environment. One of them concerned the change of activity. It was possible to see as a basic action who was changing from an activity A to an activity B and when (Probe name: Change Activity; Parameters: <User>, <PrevAct>, <NextAct>). All the actions that could be performed in the different activities by a user were also stored (e.g., reply to an exercise, and consult a help document).
We noticed that the requirements were quite global, and we decided to represent most of the indicators in a same board (see Figure 6). The interest was to propose a visualisation system of the whole class of students. We use the representation introduced by Chernoff (1973) to represent the students (see Figure 6). Each Chernoff face evolves dynamically in time, according to the probes associated with the change of exercises. We use the colour 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 (Figure 6 – bubble A). 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. Next, we want to represent visually the whole class of students in 2D. Therefore, we propose to group the students by activities, and to represent each activity by a bubble. When a student changes the activity, the associated face moves from a bubble to another one (Figure 6 – path D). The purpose of this representation choice is to rapidly visualise who is doing what. By clicking on a Chernoff face, one can see the history of the pedagogical path followed by the associated student (Figure 6 – graph G). In a bubble/activity, we choose to represent with the background colour of the bubble which saturation corresponds to the relative delay of the students implied in this activity compared to the average time required (Figure 6 – bubble A). This information is useful to reengineer the pedagogical session after the activity, by changing the proposed time associated with each exercise, thus refined for a given audience. Finally, the thickness of the links between bubbles is proportional to the number of students that have followed this path (Figure 6 – path E) is a frequent path while (Figure 6 – path F is not).

Figure 6  Screenshot of the visualisation tool for the teacher (see online version for colours)
It was straightforward to update all these indicators from the probes that we acquired. For instance, a face can move from a bubble to another when a probe showing a change of exercise is active. The eyes of a face are activated as soon as an activity is detected for a particular user (P1 or P2 or … or Pn where the parameter ‘actor’ matches this particular user). The time features are easy to tackle since every probe is stamped with a time marker.

Figure 7  Learners’ participation to the post-it wall activity (see online version for colours)

3.2.2 Case studies 2 and 3

These experiments took place in LA and as we already mentioned it, this environment was equipped with 17 probes. Furthermore, some collaborative tools have been integrated in the LA environment (the post-it wall for the second case study and the collaborative feather for the third one). These tools had also been equipped with probes to observe it (add, move, delete a post-it note for the post-it wall; propose a new idea, add a positive comment, add a negative comment, ask for explanation, remove an idea, move an idea, structure the ideas, and propose a vote for the collaborative feather). In order to meet the teachers’ expectations linked with the second use case, we have set up one main indicator of collaboration in the environment. It deals with the balance between the learners’ contributions. We display a pie chart (see Figure 7) indicating what the contributions of each member of the group were. This chart is obtained from the probes associated with the post-it wall. It consists in summing up actions performed on this tool by each user. Many other indicators also existed in this environment (e.g., progression of students), but we only wanted to present the collaborative aspects in this second case study. Concerning the third case study, the teacher wanted a global view of the profile of each participant. We introduced two orthogonal indicators: one showing the characteristics of a particular participant, summarised on a Kiviat diagram (Figure 8) and one showing the participants
corresponding most to a given characteristic (Figure 9). These diagrams are directly issued from the probes associated with the collaborative feather, matching a user in case of Figure 8, and a name probe in the case of Figure 9.

**Figure 8** Individual view of user’s actions in the learning environment (see online version for colours)

![Feather activity diagram](image)

**Figure 9** Collective view of users’ participation to a kind of action (see online version for colours)

![Pie charts](image)

In this part, we have explained how to transform traces in order to obtain information useful to understand the activity. We have also illustrated our approach on the three case studies presented before, providing the teachers with solutions to their expectations.
4 Monitor

If we want to reengineer the sessions before setting up new experiments, using such indicators is adequate. The improvements that should be done are listed during the session and the modifications are carried out later. But if we want to react and change the environment while the session is going on, we need a way to manage these changes. That is the purpose of the next part of the paper.

4.1 Interactive indicators

There are many situations where reacting dynamically during the session is useful. Indeed, the teachers often wish to adapt the session according to the learners’ skills and knowledge. As explained above, the indicators can provide the teachers with this information. The teacher is therefore able to give more explanation or an additional resource to a student in trouble or to propose more challenging quizzes to students progressing (too) quickly. Indicators also provide valuable information to form groups. According to his/her pedagogical aim, the teacher can form groups with students having the same knowledge or on the contrary having complementary skills. The teacher can also use indicators providing behavioural aspects to prevent conflicts in the group. When a student is too active in a group, this can be a problem and the teacher is free to remove some rights to this student or to provide him/her with another ‘mission’. Finally, the teacher can use the indicators to give rewards to some students demonstrating good skills in a particular domain. S/he can thus give a particular role (with particular rights) to this student for the continuation of the quest. These special skills will be a benefit for the whole group. How can we associate these monitoring actions with the indicators?

The first idea we had in mind for controlling the environment was basically to have a list of actions that one can activate and that have immediate effect on the learning session (e.g., add a document in a room, change some participants’ access rights). We tried to adopt this approach in previous experiments. It turned out that it was very difficult for the teacher to monitor the activity. Indeed, he was involved in the collaborative activity with the students, answering questions, chatting with them in the game. When the indicators draw attention to a potential problem in the activity (student’s difficulty, group odd behaviour), he was obliged to change his focus of attention, concentrating on the user interface containing the monitoring actions. This loss of immersion implied a lower involvement in the activities. He told us that this was very difficult to manage.

For that reason, we have decided to change our way of activating monitoring actions. When an indicator displays information, the user’s focus of attention is on the indicator, and it is therefore better to be able to activate a monitoring action through the indicator. The indicator therefore becomes an interactive object, both providing the teacher with data linked to the learning activity and allowing him/her to activate correcting actions within the learning activity.

Let’s take as a simple example the first case study. The regulation action required was to be able to communicate with a student who was spending too much time on a particular activity. For that purpose we have transformed the indicator displayed on Figure 6. When a particular Chernoff face turned out to be darker, it became possible for the teacher to select this icon and to drag and drop it in another bubble. This simple teacher’s action activated a message post to the associated student indicating that the
teacher recommended him/her to change his/her current activity and to concentrate on the one linked with the destination bubble.

In the second and the third case studies, there is a need to inform the users about their level of contribution, mainly for motivation or awareness reasons. The teacher should be able to make the different indicators (Figures 7 and 8) visible to several participants. This action is activated through a simple flag on the indicator, in order not to change the teacher’s focus of attention. The third case study also refers to allocation of new roles for players according to the kind of actions that have done during the previous stages. In this particular case, the teacher’s change of focus is not a problem anymore, since this allocation can be done at the end of an identified step in the game (a kind of mini-reengineering of the following of the session).

5 Conclusions

The use of learning systems and particularly of game-based learning environments calls for awareness tools. From the teachers’ point of view, there is a strong need for having an understandable feedback on the ongoing learning activities. In this paper, we have presented a solution based on the activity traces. These traces are collected, transformed and displayed in order to provide the teachers with accurate information. This information is then used to monitor the (collaborative) activity according to the teachers’ pedagogical goals.

This approach was used in the three use cases described in the paper and in other experiments not described here. We conducted semi directed interviews with the teachers after the experiments. Basically, they all agree to state that they recovered awareness with the proposed tools. They feel that they were immersed again in the learning activity (and not only observers of how the students used the environment). However, they are one major criticism that was mentioned almost every time. The problem is that they must decide what to observe when designing their learning session, in order to have a set of indicators (developed by a pedagogical engineer) available. There is no way to introduce new indicators during the session. This is a problem because some observation needs appear during the session, especially when an expected event occurs. We will need to take this tough problem into account in the future for acceptability reasons.

5.1 Future work

Currently, our studies mainly address the monitoring problems, i.e., the possibility for the teacher to adapt the group activity in order to obtain better results. In our view, the approach is also valid for new pedagogical approaches, where students are asked to organise themselves in order to resolve a specific problem. In that case, the collaborative learning aspects increase because students need to use collaborative tools to co-construct knowledge effectively (Lou et al., 2000). It is often difficult for users to know how to use these tools effectively, especially because the interactions take place in a social context. The learners themselves can regulate the activity, instead of a monitoring done by the teacher alone. Self-regulation, co-regulation and socially-shared regulation are precisely described in Hadwin et al. (2010). In all these cases, the same needs for awareness tools are necessary in order to guide this regulation and the same approach can be applied. Some experiments dealing with socially shared regulation are scheduled for end of 2012.
Another enrichment of our work is to better categorise the monitoring (or regulation) actions. In the three case studies that we have described in this paper, the monitoring actions were associated in some ways to the indicators. The possibility of linking observation features and regulation actions in a pedagogical activity can probably be formalised. It is possible to describe the pedagogical scenarios with the IMS-LD standard (Koper and Olivier, 2003) and to situate the possible actions, e.g., act at the highest level of the scenario by changing the sequencing of the actions, or adapt the pedagogical resources at a lower level. With this formalisation, the objective is to associate indicators thresholds with associated formalised actions. The regulation actions (calculated according to the current value of an indicator) will therefore be immediately accessible from the indicator, which is smart for immersion reasons as explained earlier.

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References


Notes

1 For us collaborative learning is linked with the idea of grouping students to achieve a specific academic goal. The exchange of ideas increases interest and allows constructing group knowledge.

2 http://www.liris.cnrs.fr/equipes/?id=44&onglet=resume