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# **Methodological Approach for Designing Training Courses Tutoring Tools, Analogies with HMI Design for Industrial Supervisory Control**

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## **Abstract**

*This paper presents an on-going work about the design of monitoring human-machine interfaces (HMI) in the domain of distance training course. The objective is to define interactive tools that facilitate the task of the on-line teacher. The teacher needs to see the path and the contributions of the learners in the Learning Management System (LMS). The hypothesis is that the approach has strong analogies with design of HMI for industrial supervisory control, where human operators perform supervisory and monitoring tasks concerning variables related to a dynamic process. In both cases, HMI plays a key role in the quality of the human-machine system. The paper presents a comparison between both areas (training monitoring and industrial supervisory control): problematics, task modelling, tools design. Perspectives concern a methodological framework for HMI design and evaluation in the context of supervisory control in distance course.*

**Keywords:** Distance training, monitoring, supervisory, human-machine interface, design methodology

## **1 Introduction**

Distance training platforms create complex and highly dynamic system where the on-line teacher faces difficulties to monitor learning activities of the participants. These difficulties are related to the position of distance working and to the lack of global perception of the individual situations. The tutors have to reconstitute for themselves the puzzle of the learners' activities through the information that the environment provides them. Thus, they need structured information about the learners' activities in order to bring them relevant and effective helps. The aim of the research is to aid teachers in distance training course to gain understanding of their learners and become aware of that what happening in the group they manage (Mazza and Dimitrova 2003).

Most of the works present the training scenario as a process that the teacher has to go along with and to regulate (Guéraud and Pernin 1999). So, the tutoring task is in fact a monitoring activity of the learning process. Our hypothesis is that the design of monitoring interfaces for distance training platforms may be guided by the results for 30 years in the field of industrial process supervision ; see the works of V. De Keyser, J.M. Hoc, M. Lind, P. Millot, N. Moray, J. Rasmussen, T.B. Sheridan, D.D. Woods, and so on. This paper proposes a comparative approach. First, we present the domain of the on-line tutoring through the characterization of the learning process, the tutoring task, and the interactive tools needed by the operators to perform these tasks. Then, we develop a comparative study using different criteria before to propose a set of research perspectives.

## **2 Training Courses Monitoring Activity**

The job of tutor applies in different contexts and to different levels. For example: to guide a group of learners during a synchronous activity during a couple of hours (Gueraud *et al.* 2004), to manage an on-line forum during several weeks (Georges 2004), or to help a learner along his or her personal path in a set of multimedia resources for several months (Gueye 2005). In all cases, the quality criteria of the monitoring tools concern the capacity to take into account the different user profiles: pedagogical tutors (Barros and Verdejo 2000), and also learners themselves for a reflexive point of view on learning path (Heraud *et al.* 2004), or designers, analysts and teaching trainees (May *et al.* 2007). This section presents different aspects of the tutoring domain: what is the object of supervisory, what are the tasks of the tutors and what are the Human-Machine Interfaces (HMI) needed to instrument these tasks?

### **2.1 Learning Process Modelling**

Training devices are often described at different levels of detail. For example, a training curriculum is composed of several modules, themselves described as sequences of courses and exercises. Thus, the learning situation observed by the tutor consists of several levels of data. Each level has its own character of evolution during the training session. The training model proposed by (Teutsch *et al.* 2004) organizes the learning situation of each learner in three stages of data: (1) the identity and the training context of the person (no significant evolution during the session); (2) the profile of the person, i.e. the disciplinary skills (level of knowledge rationally improving during the session), the control of the training device (experience to quickly acquire at the beginning of the session) and the “how to learn“ skills (that can be partially improved during the session); (3) the personal path into the device. This journey includes the planned way, the real path, declined in intermediate points and overall balance, and the local situation, expressed in contributions to the proposed activities. The profile corresponds to the representation built by the tutor concerning the level of the learner’s abilities.

The learning process can therefore be seen as a set of data of various kinds, relatively independent but inter-related. This data set is observed at different levels of focus: global training pathway, recent period of learning activity or current phase of exercise for example. Each view is characterized by its own dimensions of duration, content and actors, and is guided by its own objectives: observation and monitoring. For example, in

the case of foreign language learning, a grammatical error is not fatal if the purpose of the activity is to develop communication skills.

## 2.2 Pedagogical Monitoring Task Modelling

The pedagogical monitoring is divided into three parts according to (Després 2003): the perception of the learners' activity, the learners' support and the management of the activity of monitoring itself. The perception part requires to situate the individual activity inside the training device and inside the group. For that, the tutor has to take an interest in the learners' productions, in the exchanges between learners, and in the group dynamics (Laperrousz *et al.* 2004).

Nevertheless, the central task of the tutor is to observe each learner's learning path. The group is an element of the context, like the scenario or time constraints.

Learning Management Systems (LMS) usually keep a record of the students' activities in a distance course. LMS accumulate large logs of data of student activities and usually have built-in monitoring features that enable the instructors to view some statistical data such as the history of pages visited, the messages read or posted in discussions, marks achieves in quizzed, and so on (Mazza and Dimitrova 2003). This complex information is rarely used by teachers since it is predominantly in numerical or alphanumeric format, with a poor logical organization, and difficult to manage. For instance, Figure 1 shows a view on the logs captured by a LMS (Moodle): logs are simply listed in the structure of the course.

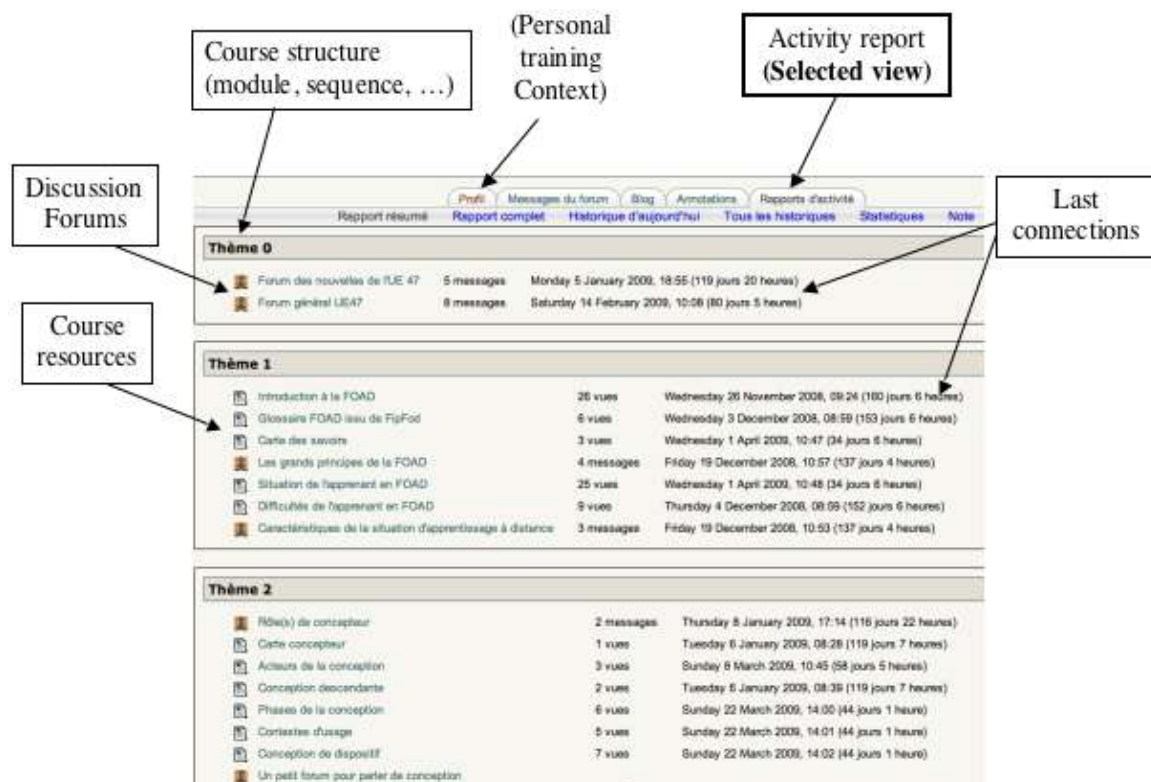


Figure 1. View on traced activities in a LMS (Moodle)

Generally, tutors are aware students' actions throw up three kinds of information: productions to assess, messages posted in forum or by email, and system notifications.

The tutor needs to be able to simultaneously guide substantial numbers of learners, each with a personal path, and with a period of reactivity not exceeding a few hours. These objectives require rapid identification of the learner's situation; not only a record of the learner's activity on the device, but also the articulation of this current situation with the history of the last few sessions, with the complete learning journey, or with paths and situations of the other learners.

### 2.3 Pedagogical Monitoring HMI Needs

LMS platforms allow access to the interactions between user and system, but don't propose synthetic views to the coaching teacher (France *et al.* 2007). This lack is a problem of designing and developing human-machine interfaces dedicated to the on-line tutor needs (Mazza and Dimitrova 2007).

We can include the project FORMID (Gueraud *et al.* 2004) that allows to monitor and to compare the progress of a group of learners (Figure 2). The system is based on a scenario and tracks both finely modeled.



Figure 2. Project FORMID: view on the learners' progress in the learning scenario (anonymized screenshot, Gueraud *et al.* 2004)

In practice, the tutor seeks to be informed of the progress of each learner in his/her learning path. This information may come directly from the system tracking: participation in activities, quality of quiz answers, exchanges on email or forum, and so

on. This information can also be built by the system in the form of alerts: delay in a post or blocking on an exercise for example. In any case, it is necessary to have links between each of these events and the learning context of the learner. The tutor may also need global views on the group of learners<sup>i</sup>, for example to highlight trends in the difficulty of some exercises at the global level in a topic. It is also important to note that the response times (individual or collective) can be relatively varied, while evolving over time, depending on the objectives, learning strategies or conditions of work of each. The experience of the tutor will be essential to better integrate them into its job.

Conceptually, a tutoring interface depends on three principles linked to the tutor's perception of the learner's situation: (1) Context of emergence. The tutor can access the emergency context of the solicitation, i.e. the activity page where the learner was at the moment of the solicitation (production, message or warning). (2) Articulation: for each learner, the tutor has to decide message priority; which messages, warnings or production to treat next. The answer can be in the story (recent or not) of the learner with the device. The tutor has to visualize the learner's work using a "zoom" on the learning situation. The levels of focus correspond to the levels of granularity of this situation. (3) Individual assessment: this is built according to the real journey and the solicitations coming from the learner and his activities.

For instance, CROISIÈRES is an online language learning system; it offers a set of structured resources in order to reach a threshold level in French (Gueye 2005). It is based on a modular structure: the learners can choose their learning activities in relation to their goals and learning strategies. Several monitoring instruments are available (Teutsch *et al.* 2004): dashboards, individual assessments and paths, detailed views on contributions.

The chronological view (Figure 3) presents a synthesis of the learner's journey (Principle 3, *individual assessment*). The time is divided into three periods: the past which represents (synthetically) the journey of the learner, the present which details recent learning activity, and the future which indicates the time available to the end of the course. The page shows three types of information: productions to assess, messages from learners, warning notifications generated by the system (the observation of the learner's work identifies long periods of inactivity, repeated failures in the same exercise, or excessive navigation between several modules). These different items can be related to each other (Principle 2, *articulation*). The tutor can access productions and the context of activity of the learner from each segment of the learning unit. (Principle 1, *context of emergence*).

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<sup>i</sup> In the case where members of the learning group interact with each other (communicate, exchange documents, motivate each other, develop autonomy), an analogy can be made with a system composed of agents (in terms of multi-agent systems, see for instance (Wooldridge 2009)). This allows us to consider other perspectives that are not described in this paper.

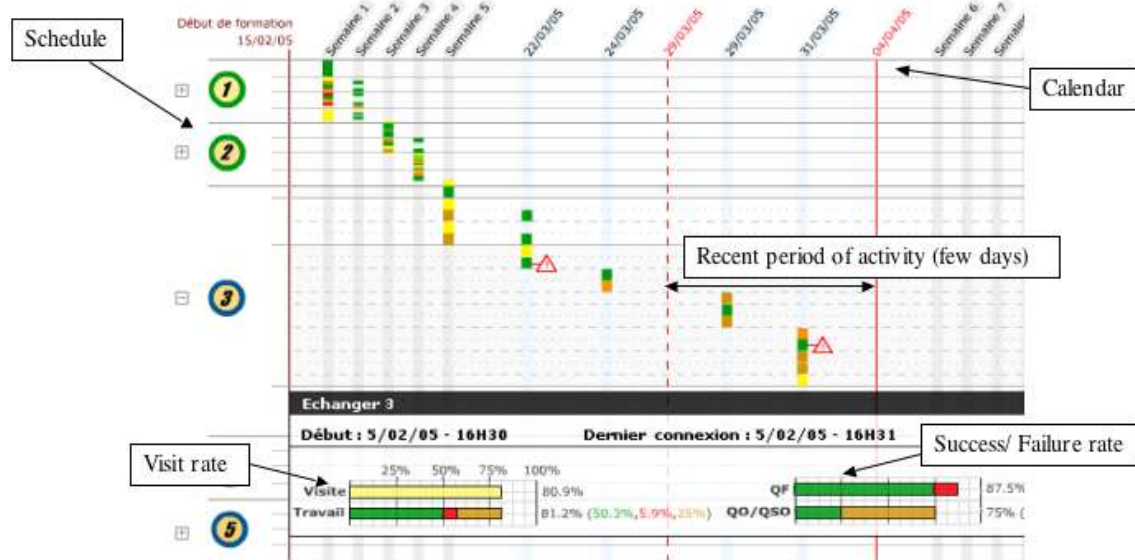


Figure 3. Project CROISIERES: overview of the learning path

### 3 Connection with Industrial Supervisory Control Domain

The goal is to make easier the tutor's task of perception of the learning activity. The means are to structure the organization of the training activity, and to define a model of monitoring of distance learning activity. The challenge that designers of web-based learning environments face is to process complex multi-dimensional data provided by LMS and to transform these data into appropriate representations that can be used by teachers in their practice. The problematic seems to be the same for HMI design for Industrial Supervisory Control. This section proposes a connection between both domains: training monitoring and industrial supervisory control.

#### 3.1 Brief recall concerning Industrial process monitoring

Control rooms exist in many industrial domains (chemical processes, transport, power plants...). Human operators have to perform cognitive tasks which cannot be performed by automatism (Hoc 1996; Moray 1997), relatively to dynamic processes composed by hundreds or even thousands of variables. Indeed the integrated automation of industrial processes allows system autonomy during certain normal situations; in these situations the human operators have to perform monitoring tasks, and to verify the production performance, quality and/or safety. In case of accident or incident, they have to intervene to correct, compensate or anticipate problems by using their individual skills (Rasmussen 1986; Stanton 1994). Certain situations are unusual, and the human work can be realized under temporal constraints which can generate stress and risks of human error (Reason 1990). Since many years, a particular attention is given to HMI design and evaluation; it is indeed very important to adapt them to the human tasks to perform and the operator profiles. One considers that the HMI play a central role in the global human-machine system efficiency (Milot 1988; Kolski 1997; Ezzedine and Kolski 2004; Sheridan 1992, 2002).

### 3.2 Global comparison and discussion

Apparently, training monitoring and industrial supervisory control do not share the same goals, and do not apply the same methods of intervention (Table 1).

|                          | <b>Training Monitoring</b>  | <b>Industrial Supervisory Control</b>  |
|--------------------------|---|--|
| <b>Domain</b>            | Human learning, shared device, personal path                                  | Industrial production of products or services  |
| <b>Objectives</b>        | Improvement of knowledge and skills   | Productivity, quality and safety   |
| <b>Process modeling</b>  | Difficult to modeling (variability of human behavior)                         | Many methods from Software Engineering and reliability domain are available for <i>a priori</i> process modeling |
| <b>Operator</b>          | Tutor, teacher, adviser, coach  | Human operator in control rooms  |
| <b>Interventions</b>     | Regulation of the learning process (educational, personal and social aspects) | Control, command, regulation of processes  |
| <b>Operator modeling</b> | No available formal models of tutoring and tutors' behavior                   | Several models available about human decisional behaviors  |

Table 1. Differences between the domains

However, these domains seem to share the same problematics concerning the instrumentation of the human operators (Table 2). The need of global design approach in the domain of training monitoring seems to find food for thought in the industrial supervisory control domain.

| <b>Training Monitoring</b>   | <b>Industrial Supervisory Control</b> |
|--|---------------------------------------|
| <ul style="list-style-type: none"> <li>- Process modeling using different abstraction levels and different points of view</li> <li>- Complex and heterogeneous nature of the variables implied in the various situations</li> <li>- Assistance needs concerning the identification of events and phenomena</li> <li>- Dynamic nature of the processes, monitoring of instantaneous values, patterns, histories</li> <li>- Central role of monitoring and control HMI in (1) the instrumentation and (2) the quality of supervisory control task</li> <li>- Assistance provided by the system concerning computing of indicators and alarm management</li> <li>- Effectiveness and efficiency criterion: performance of operator-instrumentation combination</li> </ul> |                                       |

Table 2. Similarities between the domains, focus on HMI design

This comparison emphasizes that monitored processes are not the same, but the real approximation concerns the situation of supervision. Whatever the process to oversee, the monitoring task is directly dependent on the tools in terms of HMI. In both cases, the HMI reifies the supervision approach: modeling supervised process, reporting (including risk statements), direct access to data, interaction with components (individual or at a higher level) of the process, assistance in decision-making.



Initial design recommendations can be highlighted. First, the experience of HMI design in industrial processes can help HMI design in training monitoring. Then, the condition of effectiveness is a distinction between, in one hand, the aspects of Domain Modeling, carrying significant differences (industrial supervising versus pedagogical monitoring) and, in other hand, the instrumentation approach, common to both supervision situations. Finally, this instrumentation approach focuses on modeling the process of supervision in terms of situation assessment and decision making (Hoc 1996) and on software architecture for integrating tools to support supervision. The process of HMI design can be based on the principle of triangulation (Mackay and Fayard 1997) between theoretical models, field practices and development of artifact. The evaluation phase of the artifacts is essential in the design process.

#### **4 Conclusion**

In both domains, training monitoring and industrial supervisory control, the process to monitor is essentially dynamic, and can be seen according to different abstraction levels. The modeling of supervisory tasks is essential to understand how to meet the needs of the human actors involved.

This paper was concerned by monitoring HMI in the domain of distance training course; a first overall comparison has been made with the industrial supervisory control domain. It seems that some concepts and needs are common, and that the first domain may benefit some progress and proposals from the second one. Many research perspectives can be identified. First it would be possible to work on a methodological framework for the design and evaluation of HMI for distance training monitoring. Stimulation could come from design methods thought for industrial supervisory control, or complex systems (cf. works around the U model, Lepreux *et al.* 2003), or more generally on HCI-enriched model (Kolski and Loslever 1998). It will be important to consider the contribution of analysis and modeling methods from the reliability domain (Villemeur 1992); indeed different situations (normal or abnormal) have to be taken into account. It would be also pertinent to examine the work about ecological HMI (Vicente and Rasmussen 1992; Burns and Hajdukiewicz 2004) to consider their benefits in the situation of distance training monitoring.

#### **5 Acknowledgement**

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