The Strategic Organization of the Observation in a TEL System
Studies and First Formalizations

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Abstract: The instructional designers may design learning sessions with tools offered by the Technology Enhanced Learning systems. Any learning situation is designed to follow specific learning objectives. Instructional designers examine the progress of these situations and evaluate the correlation between their deployment and the objectives through an observation activity. We present in this article theoretical and practical studies in order to understand the real needs of instructional designers in organizing their activity of observation. We also present the concept of Observation Strategy to answer the needs of instructional designers for organizing the observation of learning sessions deployed in the TEL systems.

1 INTRODUCTION

Our research activities focus on the observation of learning situations and the perception (such as visualization) of indicators when using a TEL system (*Technology Enhanced Learning system*). The observation is defined in (De Ketele, 1987) as a process to gather facts in order to analyze them. It is based on the processing of data collected during the deployment of learning situations within the TEL system.

We originally propose to consider the efficiency of an observation activity as related to the *a priori* definition and formalization of an *observation strategy*. This efficiency mainly relies on the relevance of various choices: the observation means implemented and/or used, the visual widgets selected for representing the calculated indicators, and so on.

This article aims at summarizing several objectives according to the following three points:

- To present and analyse the different studies we have done in order to explicit the needs and practices of instructional designers when specifying observations activities;
- To define and formalize the concept of observation strategy;
- To illustrate the proposition with a concrete example from past experiments about the observation in a TEL environment.

The organization of this paper was planned in such a way to meet these goals. After this introductory section, we focus on the observation in the TEL systems in order to show the actors concerned by this activity and their objectives related to the observation of learning situations. In the same section we present the context in which our research is carried out to show continuity with the research activity of our team and to summarize the goals of our work. In the next section, we discuss the theoretical and practical studies we have done to understand the real needs of instructional designers in terms of using pedagogical indicators. These two studies, with complementary objectives, respectively consist of a state of the art about the observation and perception of indicators and a field investigation to understand the needs of instructional designers. Once these needs are identified, we present the concept of observation strategy which is our answer for identified needs. The definition of this concept will be followed by its formalization as a meta-model. To better illustrate the concept introduced, we present a case study inspired by an experiment. The conceptualization of the case study will be in accordance with the proposed definition and the meta-model will be used to formalize this case study. To conclude, we present our current work.

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2 CONTEXT

2.1 Observation in a TEL System

Any process delivering TEL learning situations should include a specific phase about observation and uses analysis in order to notify instructional designers of the quality of the deployed situation (Choquet and Iksal, 2007). By interpreting the results of an observation, teachers, or tutors, can guide the learning activity by trying to encompass the potential dysfunctions related to the learning scenario designed (Settouti and al., 2007). They can then introduce personalized support and provide educational materials adapted to the different learners behaviours. An instructional designer can also exploit the observation traces and indicators in order to modify the learning scenario for upcoming deployments (reengineering). Many researches propose solutions requiring the intervention of an IT expert to assist teachers in defining their observation needs, or in the interpretation of the observation results (for example in order to improve the initial learning scenario (Pernin and Lejeune, 2006)). It could also be interesting to provide learners, during the learning session, with some specific visual tools for representing some relevant information about their progress or knowledge acquisition.

2.2 Current Research Context

Our research activity is part of an editorial chain supporting the observation within a TEL system proposed by (Iksal, 2011). In this context, the instructional designer is considered as the most appropriate actor to define and specify what is required to observe during the learning situation. This leads us to consider the design of the observation activity as a specific phase into the global instructional design process. To this aim, the instructional designer has first to make explicit his observation needs. Then, the learning scenario can be analyzed, driven by the observation needs, which are the description of what to observe, when observing it, how tracking and calculating it, how representing the result, for who and for what.

In previous team research works about the reengineering of TEL systems, we proposed a formal language for describing pedagogical indicators: the UTL Language (*Using Tracking Language*) (Choquet and Iksal, 2007). It allows the definition of observation needs, and the specification of indicators from raw data independently from the language used for the definition of the related learning scenario and independently from the tracks formats. Additionally, we proposed another language (Pham Thi Ngoc, 2011), DCL4UTL (*Data Combination Language for UTL*). It is an extension of UTL that adds the ability to formally specify the automated calculation methods to get the indicators from the collected tracks and observation needs previously expressed using UTL. Thanks to the formalization of indicators, they can then be reused for other observations; the DCL4UTL mappings between indicators and tracks provide designers, for a same TEL system, a reusable and calculable data.

Our specific research work aims at providing the actors of a learning system (especially the instructional designer), with a homogeneous set of tools for 1/ defining observation strategies, 2/ calculating and displaying observation results with an ergonomic and intuitive perception interface. These tools should be used *before, during* and/or *after* the learning session.

3 PRACTICAL AND THEORETICAL STUDIES ABOUT OBSERVATION PRACTICES AND TOOLS

3.1 Practical Study

3.1.1 Presentation of the Survey

In the context of our research, instructional designers are at the center of the observation activity. Our goal is to support them when organizing the observation in a strategic method by adapting it to their objectives and to the characteristics of their pedagogical scenarios. Instructional designers must have the ability to create observation strategies in order to capitalize them for sharing and reusing purposes. They must also have the ability to modify saved strategies for example by adding or removing some indicators. Our goal is also to provide instructional designers with some dedicated tools dealing with the restitution of the observation results, in an understandable and appropriate format to help their analyze. To meet these expectations, the next challenge relies on:

> Identifying instructional designers' needs and practices about the organization of observation activities.

We decided to conduct a confirmatory study

(Wilkinson, 1999) to validate our observations and hypotheses with instructional designers using the UMTice environment. It is an LMS (Learning Management System) based on the Moodle platform. It is used in the University of Maine (France) either for distant online courses or for blended learning in addition to presential courses. The confirmatory nature of our study does not prevent us from exploring other tracks (Le Roux and al., 2004) on the practices of instructional designers in terms of observation.

3.1.2 Assumptions

We stated different assumptions about the instructional designers' needs and practices for organizing the observation of their learning situations. These hypotheses stipulate that instructional designer's objectives could vary from one session to another. When designing the learning situation, he defines some indicators. During the deployment phase of the learning situation, he does not systematically use all the indicators previously defined. Set-up indicators may vary depending on the activities performed or according to some pedagogical aspects of the scenario that the instructional designer wants to evaluate or validate. These indicators can also depend on what he wants to confirm or not with a particular group of learners.

We have also assumed that instructional designers need to organize the observation according to the restitution of the calculated indicators (format): they have to be understood without being an expert in computer languages.

The survey presented in the following sections aims at verifying these hypotheses and highlighting the elements of an observation strategy.

3.1.3 Methodology

To verify and collect the instructional designers' needs concerning the observation of learning situations they develop with the platform, we initiate a process consisting of three steps. The first step of this investigation consists in the realization of individual interviews with instructional designers from the multimedia department of the Technology Institute of Laval, France. This step is motivated by the fact that we have instructional designers available to answer our questions and to give us their feedback on the observation during their use of the UMTice platform. This allows us to check, in a very first time, some elements of our hypothesis. The second step concerns the distribution of a questionnaire for all the instructional designers using UMTice. This questionnaire only proposes closed questions (Droesbeke et al., 1997), mainly because we aim to obtain some quantitative statistics to validate and confirm the conclusions derived from our previous interviews with a reduced community of instructional designers. The choice of the questionnaire is related to the availability of means to conduct such an investigation, the access to a target audience and the ability to have enough answers. Once the information about needs and practices in observation are collected from the first community of practitioners, we realize a simulation with the visualization prototype in which we simulate a concrete example of a learning situation with a strategic organization of observation and indicators visualization. We present this simulation to the instructional designers in order to check if our approach could satisfy their needs. This allows us to validate some aspects of the prototype and to collect some comments and criticisms to improve the functional and ergonomic aspects of the Human Machine Interface.

Figure 1 summarizes the different steps of the investigation with their related objectives:

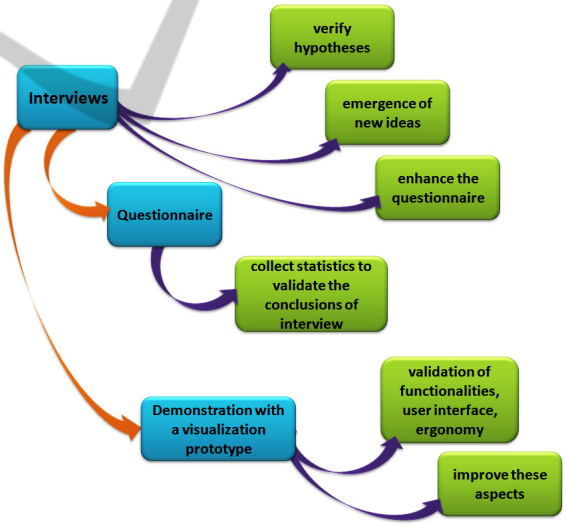

Figure 1: The investigation process.

3.1.4 The Interview Phase

Interview Process

The interviews we made took place individually. Each meeting spent about one hour. The interviews were introduced by the presentation of the research work within which the study takes place. Questions relating to the observation of learning situations were discussed. Instructional designers spoke about their observation activities. They presented the

observation tools that the platform proposes to them for monitoring the learning situations. Discussions focused on the needs of organizing observation (autonomy, choice of indicators, etc.), the way of restitution of the results (moment, format, etc.) the needs for broadcasting these results and the possibility of reusing the same organization from a pedagogical scenario execution (session) to another.

The interview has followed a roadmap to treat all the points related to our hypothesis placing the instructional designer at the center of the observation activity. The interviews were, also, an opportunity to test a first version of our questionnaire on the study of needs and practices in observation.

First Analysis of Interviews

The analysis of the interviews made with instructional designers of Multimedia Department of the Technology Institute of Laval allowed us to highlight three different categories of results:

a) Position Relatively to the Existing Devices

Regarding the existing tools, teachers we interviewed indicated that the platform UMTice of the University of Maine already provides tools to observe learning situations: the Moodle activity reports, histories, reports of participation or statistics on the purposes. These tools allow them mainly to identify the resources consulted, the users of a forum and the consultation rate per student of educational resources available online. Teachers said they used this information to get an idea of learners who show a real interest for resources to prepare activities that require the information contained in these resources. Due to poverty of visualization and indicators perception tools, some teachers tried to use an external tool to the platform UMTice, called Gismo (Mazza and Milani, 2004). Instructional designers find easier the analysis, understanding and use of graphics and color codes of Gismo. The teachers using Gismo do not say to be completely satisfied with this tool because they find the number of indicators viewed very small and these indicators focus on the visualization of relational behavior between learners (initiated discussions, participants, exchanged messages, etc.) and not on activities or productions made in solving exercises, for example. Some instructional designers proceed in a different way to consider indicators provided by UMTice. They export them to an Excel file and then analyze them. It appears that this additional activity is time consuming and therefore, after a while of using this method, they stopped to use it.

b) Desired Improvements

The improvements wanted by instructional designers interviewed are many and it is important to mention some of them. There is an unanimous wish to have more structured forms of indicators restitution, such as tables, graphs, and especially time lines and color codes. Teachers interviewed are convinced that the visualization of an indicator in different ways, through different visualization structures increase their understanding of the information carried by the indicator. Teachers expressed the need to identify the most active members through forums and who participate the most in collaborative learning. Some teachers have expressed their wish to go to a finer grain in the visualization of consultations of the resource base. They want, for example, to know the indexes of pages consulted, consultation time, current activity during the consultation, etc. Teachers have also expressed their desire to have an evolution in the time of the indicator values to verify that the interventions made on pedagogical scenarios have improved the learning activity.

c) Appreciation of the Proposed Solution

The analysis of the outcome of the interview also shows that instructional designers are favorable to the idea of having a tool that provides a rich choice of indicators to be displayed, depending on the activity carried out, and return them at the desired time and in a more accessible and understandable format without using an additional activity. It is important also to note that the teachers interviewed found interesting the possibility to use in their observation activity, an editor to define configurations of observation, to capitalize, share and reuse them. It should be noted, too, that the need for indicators in real time is not really expressed, insofar as they are not faced with such a situation in their use of the platform, but they find the idea interesting. Instructional designers showed a real interest in our proposal to provide them with a graphical editor of observation strategies whose use could be available to all teachers, whatever their level in computer science.

3.2 Outcomes from Theoretical Studies

Many research works dealt with some observation aspects. Some of them are focusing on the display of the observation results to the right recipients. They generally provide a set of visualization tools allowing a better understanding and interpretation of the results. The visualization of indicators can be achieved by means of different views, supporting the isolation of interesting phenomena, and allowing an intuitive vision of what happened (Dyke and al., 2009).

An overview of these works is presented in (Ouali and al., 2013). These works have developed specific tools for displaying the results of indicators. Some of these tools allow the monitoring of learning situations in real-time (France and al., 2006) (May, 2010). Other ones limit the visualization to the end of the learning session (Mazza and Dimitrova, 2004) (Heraud and al., 2005). Some tools combine several viewing format for a same indicator (Greenhalgh and al., 2007) (Morrison and al., 2006). Other works propose the indicators visualization thanks to a horizontal time axis (Van Diggelen and al., 2008), by the means of contingency graphs (Heraud and al., 2005), or by Chernoff Faces (France and al., 2006). The tools from (Greenhalgh and al., 2007) demonstrate the added value of a computer-assisted traces analysis but they focus on very specific data and require further developments to adapt their techniques to TEL systems. Some tools specifically address tutors in order to provide them with monitoring elements for supervising some learning sessions (Heraud and al., 2005). Most of calculated and visualized indicators are exploiting traces from communication activities between participants in a session (May, 2010) (Mazza and Milani, 2004). Some works are very TEL-system-dependent and only focus on specific generated traces. It does not allow the exploitation of their tools and techniques on other platforms (Mazza and Milani, 2004) (Mazza and Dimitrova, 2004). We also notice that the majority of existent tools focused the visualization of indicators on a very limited set of them, generally calculated from traces of message exchanges. It is also important to consider the lack of research works taking into account the context of the pedagogical scenario.

If we consider research activities in the field of observation particularly concerning learning situations and perception of educational indicators, we are able to present some facts related to the teacher or the instructional designer. The first concerns the lack of results directly designed and provided for the teacher: a majority of projects focused on learner support activities (Van Diggelen and al., 2008) and activities of researchers (Dyke and al., 2009). The specific needs of the teacher or the instructional designer, which may vary from one session to another, are not taken into account. We noticed, moreover, that the viewing covers on the same indicators whatever the scenario of the learning session. These indicators are often proposed directly by the learning platform; they are not defined at a sufficient abstract level that could improve the understanding and the observation setting up for instructional designers. So, it is not possible to decide neither indicators to display, nor the time of viewing, etc. We also notice that teachers often feel constrained by the complexity of the technical environment, so it is difficult for them to think about and design the observational process of the learning situation without technical considerations. In terms of indicators restitution, the visualization means available often require learning and training efforts to use them.

The state-of-art we performed has highlighted a real need for a strategic organization of the observation activity. Several questions remain:

> How to help the teacher or instructional designer to organize his activity of observation strategically? How to take into account the observation objectives of the teacher or the instructional designer? In what kind of form the results of the observation should be returned?

4 THE PROPOSAL

4.1 The Overview of an Observation Strategy

The concept of observation strategy is related to how the observation is organized. Indeed, this organization is concretely driven by various observation needs for different actors and different objectives. It is also intimately linked to how the learning situation is organized, the learning scenario,

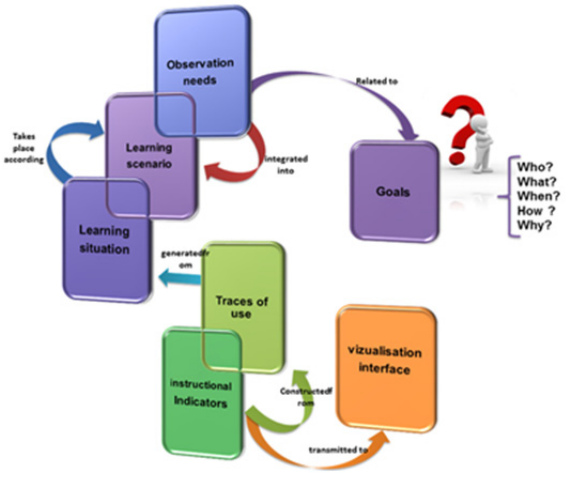

Figure 2: A general idea of our concept of observation strategy.

and its actors and pedagogical objectives. But for a same learning situation, various strategies can be defined according to the actors targeted; their observation needs, the considered tracks, the elicited indicators, the distribution and representations of the results, and so on. Figure 2 draws this general concept of observation strategy.

Such strategies should try to answer to these questions: does the right actor observe the right information? At the right time? With the right format? Does it correspond to his observation needs? Does the information presented (indicator) is at such an abstract level from the TEL environment tracks to be useful?

4.2 Definition of the Observation Strategy

The observation strategy consists of a set of indicators, their perception mechanisms (form of restitution of these indicators) and the recipients of these indicators. It is composed also of its context of use (in connection with the pedagogical scenarios), the objectives of the observation (learner assessment, adaptation of the pedagogical scenario, monitoring the learning session etc.) and time of observation (during the session, after the session, the completion of an action, etc.).

Although the strategy can evolve progressively with uses, it must nevertheless be considered ahead of the learning situation. It must be extensible by adding new indicators. It must be capitalizable to be reused. Observation Strategy must also be adaptive to the context of learning scenario.

4.3 Formalization of the Strategy

Figure 3 shows the meta-model of an observation strategy. In this meta-model, we find out the composition of an observation strategy including a specific context and multiple components. Defining the context requires the definition of four elements: the elements of the scenario, the groups of individuals to observe, the indicators to watch and the perception means available. The elements of the scenarios can be resources or activities. The groups are composed of individuals each having a specific role during the course of the learning situation. A monitoring component strategy consists of a set of triplets "indicator, individual perceiving means" and the time of observation. The triplet is set to be displayed by a particular recipient. For each indicator, at least one means of perception is associated with the possibility or not to change for each indicator the means by which it can be viewed. The observation time can be defined in two ways: by listing the elements of the educational scenario that must be observed or by defining a period indicating the activity by which the observation begins and the activity by which it ends.

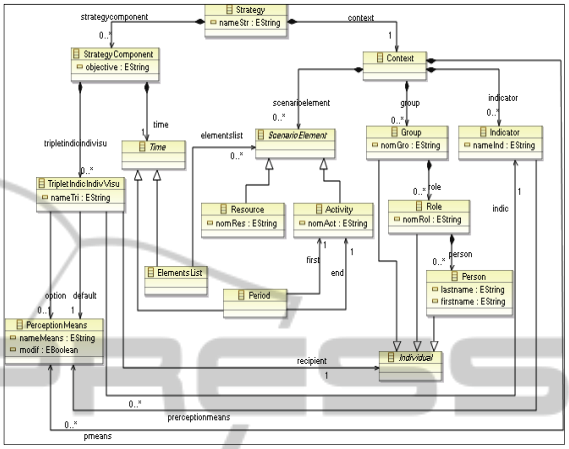

Figure 3: Meta-model of an observation strategy.

5 EXAMPLE OF DEFINING AN OBSERVATION STRATEGY

5.1 Description of the Learning Scenario

In this example, we want to illustrate the specification of an observation strategy by a teacher or instructional designer. The learning situation to consider in this example comes from an experiment performed in (Pham Thi Ngoc, 2011). This experiment was performed in the Multimedia department in the Laval Institute of Technology, France. It involved 90 students in the first year of DUT degree, over a practical session. These students were divided into six groups. The educational objective of the session is about object-oriented programming in Java in the course "Basics of object-oriented programming". For a period of three hours, the student must answer twelve questions through a programming environment called Hop3x (Lekira, 2011). Teachers have defined specific indicators for each of the 12 questions

5.2 Definition of the Observation Scenario

We want to observe the solving of the 12 questions by the students participating to the practical session.

The indicators to consider are the transverse ones for the 12 questions. To respond to observation objectives related to the designer, tutors and learners, the designer has defined the following elements:

- For each indicator, viewing default means are defined, and other means are available to the designer so that he can choose another way or other means for the same indicator.
- The designer defines the time of observation as the time spread over all activities of the scenario.
- Recipients of the observation are the designer, both tutors and 90 learners.
- The designer watches all the transverse indicators. Tutors observed the indicators 1 to 5. Learners observe the indicators 8 and 9.

With information relating to the experiment's progress, we can define the strategy described in Figure 4. In this figure, we find the defined triplets and the period for viewing. For the triplets, the individual considered is the designer, and for each of the indicators to visualize, a perception means is set by default. For some indicators, an optional means is associated. The moment of the indicators displaying is the end of processing each question, that is to say the time of transition to the next question because in Hop3x the calculation of the indicators s done in the move to next question.

Period	At the end of processing each of the 12 questions		
Target	Indicator	Displaying Tools	
		default	Optional
Designer	The frequency of manual compilation (per minute)	*rod graph*	*bar graph*
	The execution frequency (per minute)	*rod graph*	*bar graph*
	The rate of correction of errors in compiling	*bar graph*	*grouped column chart*
	The percentage of meaningful variable names	*grouped column chart*	*bar graph*
	The percentage of meaningful method names	*grouped column chart*	*bar graph*
	What is the average time spent per question for each student?	histogram	
	The number of compilations per question and per student	histogram	

Figure 4: Example of a specified observation strategy.

5.3 Formalization using the Meta-Model

Because we plan to use a homogeneous set of *Domain-Specific Modeling* tools (*Eclipse Modeling Framework and Graphical Modeling Framework* (EMF & GMF)) in order to drive the development of the observation strategy editor, we on purpose propose to formalize the previous example by using the Eclipse Metamodeling Framework. To this end, we formalize the observation strategy meta-model as an *ecore* meta-model and we use the tree-based editor generated by EMF to build a formalized instance of our example. Such approach certifies that this instance is conformed to our meta-model-conformance. It is also a relevant method to test the meta-model semantics. According to the meta-model, we have first to define all the elements composing the *context* and then, secondly, we can define the different triplets *indicator* /*individual* / *perception means* and *moments of observation*.

6 CONCLUSIONS

We presented in this paper, the problem of observation of learning situations and perception of pedagogical indicators. We discussed in the first instance, the notion of observation in a TEL environment. We are interested in a second time to the research context in which this work takes place. We have presented and discussed thereafter, an investigative process to understand the needs of instructional designers, related to the organization of the observation of learning situations. This investigation provides three different phases. The first one consisted in interviews with instructional designers. During these interviews, designers expressed their points of view on the observation devices provided by the platform they use. They were also able to express their expectations to improve the existing system and their appreciation for the functionalities we have presented them to organize their observation activities strategically. The next phases of the investigation will focus on the distribution of a questionnaire to a higher number of instructional designers to validate the results obtained in the interviews, and on the development of a demonstration with a visualization prototype in order to verify if it meets their expectations and improve it, taking into account their assessments. Thanks to that study, we identified the need for a strategic organization of observation. In response to this, we have proposed the concept of observation strategy which aims at performing the activity of observation effectively. This concept was described using a meta-model, and it was illustrated with an example of defining an observation strategy, applied to an

experiment. Currently we are working on developing a prototype of a graphical editor of observation strategies. The idea of this prototype comes from the desire to provide an interface allowing the definition of strategies by describing the context and the strategy components. We are also working on the development of a dashboard to display the indicators in accordance with the defined strategies.

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