ASSESSMENT, EVALUATION AND MONITORING IN E-LEARNING SYSTEMS: A SURVEY FROM THE DPULS PROJECT

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Résumé : Dans les systèmes de e-learning la technologie permet d'enregistrer le processus en cours de réalisation. En fonction du contexte et du type de technologie utilisée, il est possible de garder une trace des différents éléments du système et d'en extraire indicateurs et données variés selon différents objectifs, qui peuvent aller de l'évaluation des étudiants, à la validation de l'expérience, et au monitorage. Le projet DPLUS, auquel ont participé 8 partenaires européens, a démontré que, même dans des environnements de e-learning radicalement différents, il était possible d'identifier des aspects communs aux méthodes d'évaluation, validation, et monitorage, et ceci dans le but de suggérer des hypothèses pour le transfert de savoir-faire dans ces secteurs.

Mots clés : e-learning, évaluation, validation, monitorage, indicateurs, données.

Summary : In e-learning systems the technology allows to record the events occurring during the learning process. Depending on the context and on the technology used, one may track different elements of the system and elaborate different kinds of indicators and data with different aims (i.e. assessing students' performance, evaluating the whole experience, monitoring the process). The European project DPULS, which involved 8 partners, enlightened that, even in a variety of e-learning systems, it is possible to identify some common aspects in the practice of monitoring the learning process, assessing individuals and evaluating the quality, with the aim of suggesting ideas for the transfer of know-how in such fields.

Keywords : e-learning, evaluation, assessment, validation, monitoring, tracking, indicators, data.

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1 - INTRODUCTION

One of the most significant consequences of the introduction of ICT in education consists in the opportunity given by technology to "record" and "maintain a history" of the events occurring during the learning process, with consequent possibilities of reflecting on the process itself, evaluating it and possibly improving it. Depending on the technology used, one may track different elements of the system and get different kinds of information; the elaboration and analysis of the obtained data may in turn have different aims.

The project "DPULS - Design patterns for recording and analysing usage of learning systems", carried out within Kaleidoscope, the European Network of Excellence (IST – 6° FP), aimed to develop Design Patterns containing the description of recurrent "tracking problems" in e-learning systems together with examples of possible "solutions". By "tracking problems" the consortium meant all those problems one faces while recording and analysing events in a technology-enhanced learning environment with the aim of gaining a better understanding of the learning situation.

The concept of "Design Patterns" has been recently borrowed by the architecture field [Alexander et al. (1977)] and widely experimented in many research projects[1]; Design Patterns are used to "describe a problem which occurs over and over again in an environment, and then describe the core of the solution to that problem, in such a way that you can use this solution a million times over" [Alexander et al. (1977)]. In other terms, Design Patterns are used in the educational field as a (semi-formal) way for describing design problems and sharing possible solutions.

Thus the main aim of the project was to develop Design Patterns in order to support the sharing and capitalization of know-how in the field of tracking. One of the preliminary step in the process of developing the Design Patterns, consisted in gathering the partners' experience concerning the most "typical" tracking problems faced in their e-learning systems. The project enlightened that, even if in a broad variety of e-learning contexts, it was possible to identify and describe a set of significant tracking problems and operative solutions. One of the first output in the process of gathering and analysing the most typical tracking problems, was a survey[2] that provides an interesting picture of the most recurrent problems in the evaluation of e-learning systems. In this paper the main results of such survey are presented: starting from the analysis of the problems and solutions presented by each partner, the consortium was able to identify four dimensions which may constitute the starting point for defining a model aimed at classifying problems and solutions in the field of tracking and evaluating e-learning systems.

2 - CONTEXT, FOCUS AND AIMS

The process of developing Design Patterns was a long and tricky one, because it required a great effort from the partners towards convergence and homogeneity. The project involved 8 European partners, each one having a specific context and coming from a particular experience. For this reason, at the beginning it was quite difficult to find a "common language" for describing and discussing the problems and it was necessary to define a

[1] Recent projects concerning the application of Design Patterns in the education are: E-LEN (http://www2.tisip.no/E-LEN/), Pedagogical Patterns (http://www.pedagogicalpatterns.org/), Design patterns for recording and analyzing usage of learning systems (http://www.noe-kaleidoscope.org/pub/activities/jeirp/activity.php?wp=33).

[2] The survey is contained in Pozzi F. (ed.), *Del. 32.4.1 - The set of recurrent problems and description of solutions* (deliverable produced within the JEIRP "Design patterns for recording and analysing usage of learning systems (WP 32)" of the Kaleidoscope Network of Excellence.

glossary addressing the terms mostly used by partners. The negotiation of terms turned out to be very useful, in that it supported a mutual understanding and allowed a first level of sharing and a dialogue among researchers.

The following step consisted in the enunciation by partners of the tracking problems they considered to be representative of their e-learning systems. In the following the list of problems indicated by the whole consortium is reported:

Table 1 – The list of the tracking problems addressed by partners

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Even if the problems stated at a first stage were quite specific and tightly intertwined with their original contexts, it was possible to start up a discussion about them. Furthermore, such discussion allowed to identify three dimensions that always characterize a problem and for this reason can be assumed as a basis for a classification.

In particular, one dimension which always characterizes a tracking problem, is the *context* where the problem typically occurs. The partners analysed their contexts and recognized that, even if specificities existed in the variety of the e-learning systems addressed, still it was possible to identify three main kinds of e-learning systems:

- systems for individual learning: in such contexts learning is usually the result of a student-computer interaction (with or without the support of a tutor or a teacher); communication facilities may be included, but are not the primary way to learn;
- Computer Supported Collaborative Learning (CSCL): these contexts are based on a socio-constructivist view of learning, where negotiation and discussion with other individuals is the primary way to learn, because it encourages critical thinking and, hence, understanding;
- Learning Management Systems (LMS): they are typically web-based environments, that usually rely mainly on a transmissive learning paradigm, even if communication facilities may be provided as well. Their main characteristic consists in that they support numerous teachers, students, courses, topics, resources, etc.

After having identified the main contexts of study, the consortium shifted the attention on the *tracking focus* usually addressed within the above mentioned systems. The result of the discussion enlightened that, broadly speaking, in the considered systems usually one (or more) of the following tracking focuses are addressed:

- the actors' behaviour and performance;
- the system;
- the resources.

Generally speaking, the actors' behaviour is the focus mostly addressed, independently from the kind of learning system. The tracking and analysis processes usually focus mostly on students' behaviour, but also on other actors' behaviour (i.e. tutors, teachers, etc.); the results of an analysis focusing on the actors' behaviour may be used either for the assessment of students (if the focus is the individual), or for validation purposes (if the analysis addresses the whole class). In particular, in individual learning systems the attention is usually devoted to the work performed by students on single exercises and on sets of exercises. The aim is to assess the correctness of students' answers, to get a general overview of the students' performance or progression across the exercises, to analyse links and relations among students' performances if existing, and finally to detect students' playing around with the system. As far as CSCL contexts, the analysis of the students' performances usually considers their level of participation (often in terms of sent messages, read messages, opened sessions, etc.), on the level of interactions (i.e. the level of consideration of each others' contributions) and, in same cases, on the kind of presence demonstrated (social, cognitive, teaching presence)[3]. Furthermore, in CSCL contexts, teachers' and tutors' behaviour is often taken into account, because their level of participation compared with that of the students and, more in general, the kind of interactions occurring among all the actors involved in the process, are of paramount importance to have a good understanding of

[3] The present classification of social, cognitive and teaching presence refers to the model of the Community of Inquiry recently developed by [Garrison, R., Anderson, T. (2003)].

the collaboration process. As far as the LMSs, students performance is often addressed either for assessment purposes or for evaluating the efficacy of the system (in terms of drops out). As a matter of fact, the very nature of the LMSs, that are usually meant for managing great numbers of students and courses, brings about the need of seriously evaluating the technology used and the resources offered. In particular, often the level of acceptance of the system by the population and the efficiency of the provided services are the focus of the analysis. Furthermore, resources, that may include materials, Learning Objects (LOs), documents, activities, etc. are often evaluated in LMSs, with a particular attention to their relevance and appropriateness to the learning context, the frequency of their use by students and teachers, etc.

Besides the context and the tracking focus, a third dimension emerged as characterizing the tracking problems of the DPULS consortium, i.e. the *aims of the tracking action*. One of the key idea that emerged from that survey is that, generally speaking, tracking and analysis in e-learning systems may have three main aims:
- the monitoring of the learning experience *in itinere*, usually for regulation purposes;
- the assessment of individuals' performance;
- the validation of the learning experience.

Depending on the aims of the tracking action, the gathering and analysis of data may take place at different time: validation and assessment usually occur at the end of the learning process, while monitoring usually takes place at run time. The tracking purpose affects the kind of analysis as well, in that it may turn out to be complex and time consuming, if it is carried out with validation and assessment purposes, while it is typically more superficial and based on data of a quantitative nature when the purpose is monitoring and regulation. Furthermore, the actors involved in the tracking action may change according to the aim: it is usually the designer who carries out the validation of the learning environment, while it is the teacher who is mostly interested in the results of the individual assessment and the tutor (and/or again the teacher) who monitors the process during its enactment phase.
The three dimensions identified by the consortium (context, tracking focus and aims) are probably not exhaustive. Still, as it will be shown later on, they may help in describing a tracking problem and may support in understanding its very nature.

3 - CLASSIFYING DATA

In order to face evaluation problems within e-learning systems, you need to elaborate solutions which usually envisage a double-phase process, including the gathering and the analysis of data. The data used for implementing such solutions typically include:
- raw data (typically automatically tracked by the system);
- subjective data (obtained through questionnaires, interviews and in general via content analysis);
- additional data (any other contextual or predictive data linked to the learning situation).

Usually, in systems devoted to individual learning, data are gathered through the automatic recording of log files and exercise answers (raw data); this means that each action performed by the student (e.g.: entering the system, browsing the exercises, choosing one exercise, performing that exercise, making mistakes, going to the next exercise, playing around with the system) is tracked, so that it is possible to be continuously informed about the time spent by each student on the system and on each exercise, his/her learning path, the number of mistakes done, the kind of mistakes, etc. Furthermore, the results obtained during the exams, the analysis of questionnaires and sometimes the video recording of the learning situation (subjective data) are often used in such contexts.
In different contexts, such as the CSCL, great emphasis is given on the process of discussion and negotiation among participants. In order to monitor the process, assess individuals or even evaluate the quality of the environment, it is essential to gain a deep understanding of the interactions occurring among people, which are typically recorded by the system in form of log files and/or histories (raw data) and are able to provide information about the participants' active participation (number of sent messages, number of downloaded documents, number of attended chats, number of session in time units, etc.) and about their passive participation (number of read messages, number of downloaded documents, etc.). These data have an intrinsically quantitative nature and may easily be

processed by means of statistical methods and tools [Wang (2004)]. However, other important information may be determined by qualitative analysis of textual data [Chi (1997)], such as the analysis of products collaboratively elaborated by students, of questionnaires and interviews submitted to students, or by the content analysis of messages exchanged among the participants during the process (subjective data); furthermore, the design documentation often provides information about the context and the target population (additional data).

In LMS, high numbers often characterize the context; for this reason the data used are mainly quantitative and include: raw data (log files, exercise answers, communication), but also subjective data (such as the analysis of the exam results and the evaluation of products).

Summing up the results of the negotiation concerning the data, it emerged that the following were the most used in the considered e-learning systems:

Table 2 – The most recurrent data

Within the DPULS project all these data were referred to as "primary data", in that they are not processed. Even if primary data can provide useful information about the learning process, often far more significant information may come from the elaboration of these data in meaningful aggregations ("derived data"). In other words, derived data are those obtained from other data; they may include calculated data (data which do not exist at primary level and are obtained by processing raw data – examples include: an average, a sum, etc.) and/or aggregated data (data presented with semantic links; examples: tables joined by a relation, a matrix, graphs, etc.) Such elaborations are potentially unlimited and derive strictly from the aims of the analysis.

Starting from the analysis of the data mostly used by the consortium, it was also possible to define a number of common indicators. In particular, data referring to the session distribution or duration by students (but also by teachers and tutors) and – where this is applicable – the number of written /read postings, the number of up/downloaded documents, the number of documents produced, etc., could all be clustered under a common indicator, which was called "actors' participation". Data addressing the results of students' work (in terms of mistakes and marks) may be included under the "student(s)' performance" indicator. To be noticed that, when used for assessment purposes, data referring to participation and student performance usually refer to individuals. When their purpose is the evaluation of the whole process, it is useful to consider averages and distribution measures across the whole student population, or a subset of it, so to neutralize (as far as possible) individual dependencies. Data referring to the usage (or reuse) of resources, which are typically summative against the dimension of participants, were labelled under the indicator "resource use". Finally, the number of people and courses in the system, the number of drop outs, the recall rates, refer to an "organizational" indicator.

The classifications provided for *data* (primary/ derived data; raw/ subjective/ additional data; calculated/aggregated data) and for *indicators* (actors' participation/ resource usage/ organizational) were used by partners as a fourth dimension for describing the solutions proposed, as it will be illustrated in the following.

4 - TOWARDS A MAP OF PROBLEMS AND SOLUTIONS

The survey carried out within the DPULS project has enlightened that tracking problems may be very heterogeneous and that specificities exist in each particular learning context, that often determine customized solutions. Still, within the DPULS consortium, starting from a deep analysis of problems, it was possible to use the four dimensions described above for classifying them and their solutions: in particular, each problem was classified according to its context of application, its focus and the aims of tracking. Furthermore, solutions were described in terms of the above mentioned data and indicators. This allowed the creation of a "problem/solution map"[4] where all the

[4] The problem/solution map has been produced within Tasks T32.6 and T.32.7 of the JEIRP "Design patterns for recording and analysing usage

problems addressed by the consortium and the adopted solutions could be placed.

Figure 1 – A screenshot of the problem/solution map

The obtained map turned out to be very useful, in that it supported a better, mutual understanding of the nature of the problems at hand, helped in finding out points of contacts and differences among problems and enhanced the discussion among partners concerning the kind of adopted solutions.

To be noticed that – thanks to the map, which allowed to collocate in the same virtual space problems even very different one from the other - a positive contamination took place not only among problems that may appeared similar at a first sight, but also a mutual enrichment was possible among problems that were initially considered very distant one from the other.

In particular, thanks to their collocation along the four dimensions, it was possible to join problems which were initially stated differently because of their authors' background and this highlighted that – even in different contexts – sometimes similar problems occur and similar indicators and data are used to solve them. For example, the evaluation of the collaborative production of documents is based on the number and on the type of documents produced by students both within the Learning Management Systems and in CSCL environments. An opposite but fruitful example is provided by those problems that are of the same nature, but adopt different solutions. For example, the problem of how to evaluate the level of interactions in communication forums was described by three different partners using different e-learning systems. Despite the similarity in the nature of their problems, the partners identified solutions that were surprisingly very different: even if in the three cases it is the quantitative dimension that dominates – in LMSs the indicators and data were very basic and provide very general information, while in CSCL contexts a deeper analysis was proposed, with the use of complex aggregations of data. The exchange of solutions between the three partners, enriched them and suggested ideas for new solutions. Another example of contamination was provided by those partners who addressed the evaluation of students' participation: even if this problem was recognized as crucial in all the contexts, often the proposed solutions varied a lot and a reciprocal nurturing took place.

The experience gained during the project demonstrated that the process of highlighting points of contacts among problems and solutions is quite complex. Nonetheless, the efforts of defining dimensions able to classify them, turned out to be very fruitful, in that it allowed the discussion and consequently the transfer of know-how. Even if the four dimensions should be refined, they may represent a starting point for classifying problems and solutions in the field.

5 – CONCLUSIONS

In this paper the key ideas of a survey carried out within the DPULS European project have been presented. The main aim of the paper was to show that, even if in a variety of e-learning systems, some aspects concerning the evaluation processes are quite common.

During the project, the effort of highlighting points of contacts among the partners' practices turned out to be quite complex, because it required a deep understanding of all the partners' contexts and, at the same time, a very high perspective on the aims of the project itself. The process was tricky and critical, because a great effort towards convergence, generalization and transferability was required. In order to share their experience, the partners defined four dimensions (context, tracking focus, aim of tracking and indicators and data) which were used for classifying problems and solutions, thus allowing the construction of a problem/solution map.

Even if further work should be done in order to achieve a fully consistent classification model, still the map turned out to be very useful. From the author's point of view, it is in this effort that the real value of the survey can be found, because it demonstrates that a certain

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of learning systems (WP 32)" of the Kaleidoscope Network of Excellence.

transferability of know-how is possible and that a common way can be found in the field of tracking and evaluating e-learning systems.

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TABLE 1

THE LIST OF THE TRACKING PROBLEMS ADDRESSED BY PARTNERS

Analysing links among students' performances in a individual learning system for improving the course
Analysing the work of a student on a special exercise in an individual learning system or in a diagnosis system
Assessing the correctness of students' answers in an individual learning system or in a diagnosis system
Deciding how to deal with very difficult course topics in a LMS
Deciding how to deal with very easy course topics in a LMS
Detecting and improving inadequate assessment procedures in a LMS
Detecting correlations between the frequency of LO use and the students' scores on LOs
Detecting students' playing around with an individual learning system
Evaluating social, cognitive and teaching presence in CSCL
Evaluating students' appreciation of each others' contributions in CSCL
Evaluating students' participation to CSCL activities
Evaluating the adoption of social interactive spaces in a learning management system
Evaluating the appropriate sequence of tasks in an individual learning activity
Evaluating the collaborative production of documents in a learning management system
Evaluating the design of a collaborative workspace
Evaluating the learner's (or class) presence in an individual learning activity
Evaluating the learner's autonomy in an individual learning activity
Evaluating the learner's performance in an individual learning activity
Evaluating the learner's progression in an individual learning activity
Evaluating the level of teachers' adoption / acceptance of a learning management system
Evaluating the relevance of a practical activity in a LMS
Evaluating the self-consistency of contents in a learning management system
Getting a general overview of the student's performance across exercises
Grouping students according to their performance in individual problem solving activities
Identifying student's weaknesses and suitable supporting activities in a LMS.
Identifying students' communication problems in a LMS
Identifying the reasons for drop-outs in a LMS
Identifying unpredicted roles arising from learners' activity in CSCL
Leading a multidimensional automatic analysis from students' answers to a given exercise
Supporting tutor in monitoring students within an individual learning activity

TABLE 2

THE MOST RECURRENT DATA

The session duration and distribution in time
The number of postings sent and of timely replies
The number of documents uploaded and downloaded
The number of collaborative documents produced and downloaded
The number of postings read
The student marks
The number of successful exercises
The number of mistakes
The number of requests for help
The number of uses of a Learning Object / activity
The scores for Learning Objects
The sequence and duration of a Learning Object / activity / task / resource
The number of created, imported, exported Learning Objects / activities
The number of active links
The number of teachers in the system
The number of students in the system
The number of courses in the system
The dropout rate in the system
The recall rate in the system

FIGURE 1

A SCREENSHOT OF THE PROBLEM/SOLUTION MAP