A process oriented approach for modelling on line Learning Environments

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Abstract:
In this paper we describe the modelling approach used in an on going project bringing together partners from the academic world and from a company. The two main features of this approach are the following. Firstly, it starts from the production model recommended by ISO for modelling any production activity in industry and then it refines and specialises this general cycle to on-line learning production. Secondly, it takes a reverse engineering perspective as it starts from an existing set of software services, which are currently tailored to customers'needs by the company engineers. The general model includes three complementary views: a process oriented-view, a life cycle oriented view and a data flow oriented view. We compare this model with some models previously proposed or currently in use. Then we give an overview of SERPOLET; the kernel set of services which is included in all the on line learning delivery environments currently provided by the company. We show how the existing components can be split throughout the models.
Finally, we show our perspectives for anticipating forthcoming needs.

Keywords: LMS models, distance learning life cycle, learning systems delivery platforms, instructional engineering models

Introduction

Web-based learning environments are very complex systems that could be described only by several models, which bring complementary views of the system. Many models have already been proposed for learning design and delivery platforms, but we believe that new Learning Management Systems (LMS) should be based on new models, which allow taking into account the whole cycle of on-line learning design, production and management. Moreover one of the main challenges in building such new models is that they not only satisfy today's industry and academic requirements but also anticipate those of the future.
In this paper we describe the modelling approach used in an on going project bringing together partners from the academic world and from a company. The two main features of this approach are the following. Firstly, it starts from the production model recommended by ISO for modelling any production activity in industry and then it refines and specialises this general cycle to on-line learning production. Secondly, it takes a reverse engineering perspective as it starts from an existing set of software services, which are currently tailored to customers'needs by the company engineers.
In the next section we describe our general model including three complementary views: a process oriented-view, a life cycle oriented view and a data flow oriented view. Then we compare this model with some models previously proposed or currently in use. In section 4, we give an overview of SERPOLET, the kernel set of services which is included in all the on line learning delivery environments currently provided by the company. We show how the existing components can be split throughout the models.
Finally, we show our perspectives for anticipating forthcoming needs.

1. A three views model for on line learning design, production and management

Many models have already been proposed in the field of distance education and of on line learning delivery. Most of these models take a partial view of the activity or are focused on a given category of actors. Our goal is to build a model, which takes into account the whole life cycle of the production process from a SME perspective. For that purpose, we start from general models that reflect industrial production processes.

2.1 The ISO production process model

The general model recommended by ISO [1]for the production of any industrial activity can be considered as a commonly agreed synthesis of existing production process models. Therefore we take it as a starting reference. The general principles on which ISO9000 standards are based are the following:
Each industrial activity relies on a process. A process is defined as a set of interactive and interrelated activities, which transform input elements into output elements. So, each process is firstly described by its input data and its output data, the result of the process. Several processes may occur in a product lifecycle, all together they describe the means and activities, which performs the transformation of input data into output data (ISO 8402). A process itself is composed of a set of transformations, which adds value to the input data. These transformations are depending of and relying on external factors and resources,

[1] http://www.iso.ch

namely performances, material resources and human resources.

2.2 The process oriented view

From these definitions we derive a process-oriented view of on line learning production.

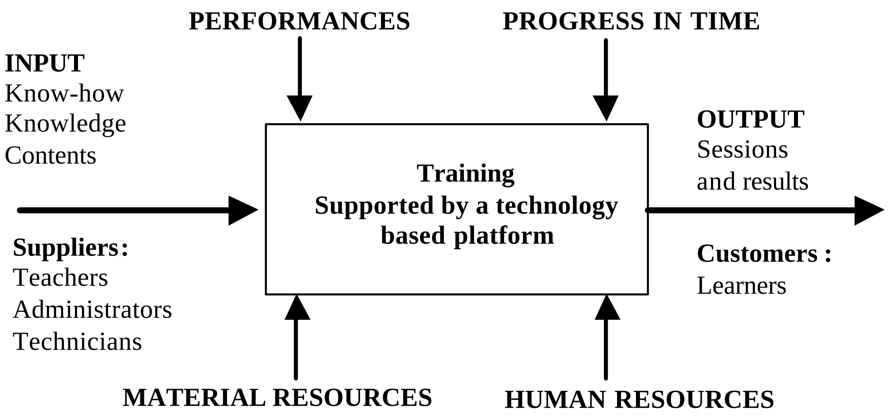

Fig.1 Open and Distance Learning Production Process

For open and distance learning production input data include knowledge, know-how, and curricula. Data suppliers are teachers, trainers, training resources designers, technicians, administrators and other domain specialists. Output data include training sessions, evaluation and testing modules, scores and other learner information. The main customers for these data are the learners. The global process is enabled by external factors such as material resources (equipment, computer-based services) and human resources (teachers, tutors, training administrative staff). Other constraints or success criteria are described under the performance (financial cost, quality management, success criteria) and progress (duration, calendar constraints) items.
It is very important to start from a process oriented approach to allow considering producing a training activity in the same framework as any other production process in a company. However, we need complementary views to focus our attention of the way in which sub-processes are scheduled over time and on the support these sub-processes are given or are not given by existing services. Moreover a distance learning platform is said to be completed if it follows the complete life cycle training production process. So in the next paragraph we present a life-cycle view of the process.

2.3 The life-cycle view

As showed by the diagram in fig. 2, we propose to describe the complete cycle of a formation through five main phases: creation phase, orientation phase, training phase, follow-up and evaluation phase and management phase.

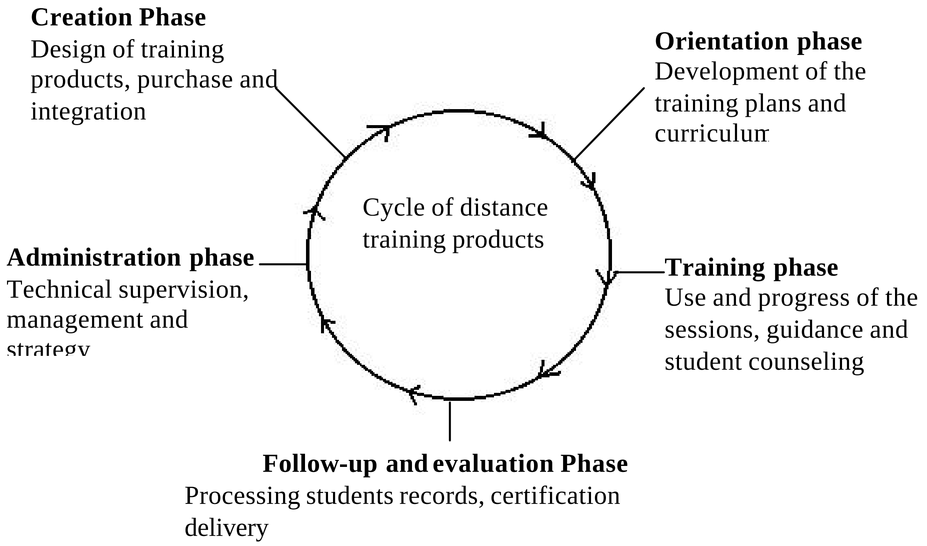

Fig. 2 The life-cycle of a distance training production

2.3.1 Creation phase

In this phase the author creates educational material while using an authoring tool available on the platform. He can also integrate other external modules. The different educational components that can be aggregated are of variable format such as HTML or any document produced with common word-processing or presentation packages.

2.3.2 Orientation phase

This phase allows the adaptation of the available courses to the learner's or group of learners' needs. The training adviser defines in this phase the sequence of the different elements of formation that is going to be integrated in the learner's process.
Every sequence takes account on one hand of educational data on the users (learners, groups, subgroup) such as the objectives and the levels, and on the other hand of the information on the available educational elements (educational modules, training plans, degree course, booklet…).

2.3.3 Training phase

In this phase, the learner consults his electronic booklet and can follow his educational modules. He performs evaluation activities and he collaborates with the other actors of the platform (teachers and other learners).
The communication tools used in this phase vary from a platform to another one (forum, chats, white board…).
According to the needs and the means, some feedback is provided to tutors for exploitation in the next sessions.

2.3.4 Follow-up and evaluation phase

The follow-up of the learner and his evaluation are key elements in the cycle of training products. They serve during a session is being processed and at the end of every session of training. Indeed, the educational follow-up allows the teachers to know the activities done by the learner during his training and to record data on these activities in order to analyse them.

The tests of the evaluation allow the teachers to measure the level reached by the learners and to compare it with the learning objectives. They can also be exploited for the future sessions of training.

Besides the follow up of the learner, there is also a need for product evaluation, experience feedback in order to further improve learning material and module sequencing.

2.3.5 Administration phase

In this phase, the teachers (administrators of the training) manage the educational and administrative aspects of the training.

The educational aspects are: the management of the learners, the management of the groups, the management of the degree courses, the certification delivery, the experience feedback management.

The administrative aspects include: the management of the users, the management of the rights of access and the management of payment, invoices issuing, links with other information systems.

2.4 The data oriented view

After having described a training product through a process view completed by a life-cycle view, we need to focus our analysis on the data exchanged among the various entities taking part in the process. Being standards compliant for all data exchanges is a key for interoperability of components within a given LMS and from one LMS to another one. Moreover this will ensure reusability of the produced materials and give to the whole process an industrial approach.

As there are many kinds of data to describe, we propose to organise them along four levels: pedagogy, didactics, media, and data processing. This categorisation is activity and profession oriented, we start from the training activity and the data exchanged during the activity is in progress. Then we shift to data related to content which are more general than data related to the media used for scenarising these contents and only finally we take into account more technical data.

At the pedagogical level we describe data related to the learner/teacher relation and exchanges and more general data such as learning objectives.

At the didactic level, we describe data related to the teaching and learning of a given domain or know-how.

At the media level, we consider data related to the media used to present learning content to the learner

At the technical data processing level we take into account technical and physical data such as data and metadata format (RDF, XML).

Each level could be in turn refined through several views including a modelling perspective (either object-oriented or functional oriented) and an implementation perspective. The data oriented view is not yet completed, but it already shows on which levels standard recommendations do exist as exemplified in fig.3.

Data level	Data examples and existing or expected standards
Pedagogy	Learning scenarios (EML description)
Didactics	Didactic bricks (domain related languages expected)
Media	Media object
Informatics	Learning objects Metadata (LOM, SCORM), learner data (SCORM 2.0)

Fig. 3 A four level data view for a learning product

We intend to use these models all together to link existing services implemented in software modules to one phase of the process as described in section 4. Before that we compare these models to the main attempts currently available in learning design and learning production modelling.

3. A short overview of existing models

Many models have been proposed for IT based training design and software platforms implementations. Most of them are focused on a given service or on a given category of actors or on a given step in the whole process. Indeed these focussed models are useful in the scope for which they have been designed, but they cannot act as general models. Besides these partial models, there are also comparison studies based on a set of existing functions or roles or actors. Such approaches do not allow a global view of existing and forthcoming actors, roles and services. The ideal model should act as a framework for describing and comparing a wide range of existing and forthcoming systems.
In the following paragraphs of this section, we present either local models or general models and we shortly compare them with our approach.

3.1 The MISA model and method

MISA[2] is proposed by the LICEF[3], the tele-university research centre, Quebec. It provides the most complete and sophisticated model that has been proposed up to now. MISA [1] is an instructional engineering method supporting 35 main tasks and processes, it is strongly based on knowledge modelling and takes into account all the components of a learning system, relying on the solid experience gained by its authors in designing distance learning events over time. One progresses into the method through 6 phases and along 4 axes. MISA is supported by powerful tools such as MOT[4], its object-oriented knowledge model editor allowing to build a graphic representation of knowledge as well as a formal one. It uses XML technologies, is linked with the Explor@ platform.
Let us give an overview of the four axes. The first one is about content design, it allows modelling knowledge and skills. The second one is about pedagogical design, scenarios, activities and related issues. Support to new learning material production is brought through the third axis. Delivery planning is described through the last axis.
Even if the many views are not identical, (more tasks are supported in MISA, a different

[2] MISA: Méthode d’Ingénierie pour les Systèmes d’Apprentissage (for engineering method for learning systems)
[3] LICEF: Laboratoire d’Informatique Cognitive et d’Environnements de Formation, télé-université, Montréal.
[4] MOT: Modélisation par Objets Typés (for modelling using typed objects)

order is proposed for the phases), the steps and axes can be compared to the views and the steps in our life cycle model.
As far as SME needs are concerned, MISA is very much focused on design and supports quite well training delivery. But the described versions remain weaker for other services such as competencies management and trainers follow up, quality criteria, maintenance and updating, invoicing and other links for instance with accountancy services for to-day deployment in SMEs.

3.2 IEEE LTSC architecture

The Learning Technology Standard Committee (LTSC) of the IEEE Computer Society aims at proposing standards for Information Technology-based Education and Training systems [2]. Among other contributions, they provide a Learning Technology System Architecture (LTSA) which aims at being a framework for designing and comparing a wide range of systems over time. The architecture is first presented as a five layers model. According to LTSA draft 9, these refinement layers are described as follows from highest to lowest levels:

- Learner and Environment Interactions (informative): Concerns the learner's acquisition, transfer, exchange, formulation, discovery, etc. of knowledge and/or information through interaction with the environment.
- Learner-Related Design Features (informative): Concerns the effect learners have on the design of learning technology systems.
- System Components (normative): Describes the component-based architecture, as identified in human-centred and pervasive features.
- Implementation Perspectives and Priorities (informative) : Describes learning technology systems from a variety of perspectives by reference to subsets of the system components layer
- Operational Components and Interoperability coding, APIs, protocols (informative): Describes the generic "plug-n-play" (interoperable) components and interfaces of an information technology-based learning technology architecture, as identified in the stakeholder perspectives.

They further develop layer n°3 for the system components as shown in figure 4

Component organisation

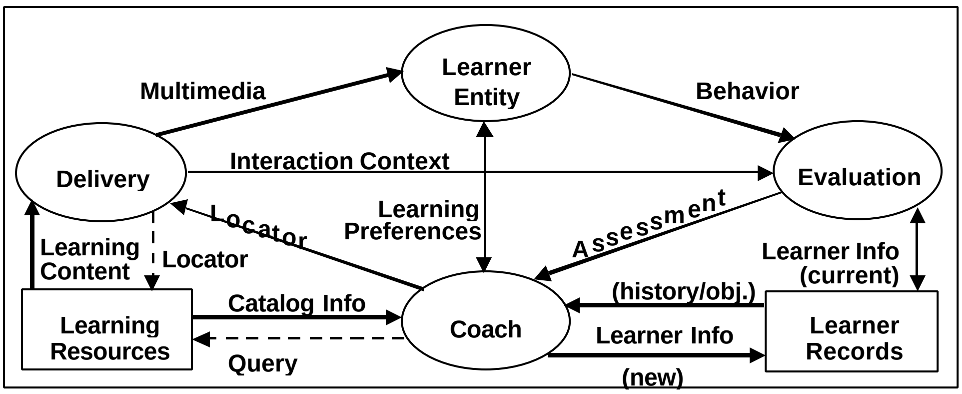

Fig. 4 The LTSA system components.

The LTSA system components are:

- Processes: learner entity, evaluation, coach, and delivery.
- Stores: learner records, learning resources.
- Flows: learning preferences, behaviour, assessment information, learner information (three times), query, catalogue info, locator (twice), learning content, multimedia and interaction context.

Compared with our aims and needs, the LTSA focuses on processes which are also taken into account in our models, on stores which are taken into account through shared resources and flows to which we also give a particular attention through our data flows. The whole product life cycle is not well focused.

3.3 EML and SCORM

Many key players in the field of Web-based learning content issues are joining their efforts under the leadership of ADL[5]. They aim at forging alliances in strategic technical areas in order to accelerate the pace of adopting standards and allowing Web-based contents to be widely reusable. The result of their efforts is SCORM, a Sharable Content Object Reference Model [3]. SCORM was built for vendors and toolmakers, not for designers. It deals with content aggregation and run-time environment, how to run content and to track learner, how to manage learner's data exchanges between the delivery place and the LMS. SCORM actors define a LMS as a server-based environment to control the delivery of learning content to the student. They intend to be LMS neutral.

As this model was built, many educational designers pointed out that describing content was useless, without describing learning objectives, pedagogical scenarios in which learner and tutors activities and their interactions are organised. Several educational modelling languages (EML) [4] have been designed in order to fulfil this need. An EML is a semantic information model and binding, describing the content and process within a "unit of learning" from a pedagogical perspective in order to support reuse and interoperability of the given unit. EML from the NL Open University has been recently incorporated into SCORM. Similarly, the IMS[6] Global Consortium develops open technical specifications to support distributed learning [5]. Examples include Digital Repositories, Learner Information package, etc…

Clearly, SCORM, EML and IMS actors are not yet providing a global view of the whole learning delivery process.

3.4 Leroux model

In his doctoral dissertation, P. Leroux proposes a generic model for the design of an interactive learning environment [6] [7]. General models in research and technological development inspired him. The entry point is a training problem to be solved (a customer's request). The model includes several components that are not often listed in existing surveys. One is the context of learning delivery (isolated learners, or pupils in a school or low qualified adults), a second one deals with the learning theories and practices on which

[5] ADL: Advanced Distributed Learning, trademark.
[6] IMS: Non profit organization supported by members of a World wide consortium

the training relies (collaborative learning, learning by doing, etc.), a third one is the learning situation that has to be set up (distributed project, individual problem solving. Then there is a focus on an iterative prototype design including teachers and trainers in the design loop.
P. Leroux has successfully used his model to describe and compare several existing learning environments that have been designed so far. Again, although the model includes very interesting features, it does not aim at covering the whole production and delivery lifecycle.

4. Describing a distance learning platform from the three views of the model

4.1. Using the models for a reverse engineering process

In order to reflect the complete model of a formation process described in section 2, we now use the model as a reference framework for describing a teaching platform called SERPOLET. SERPOLET originates in the research project SEVE conducted within the Bull group and then in a private company during the eighties and nineties [8] and [9]. During the past decade, it was partially reshaped, several times recoded and substantially completed and it gave birth to several commercial products designed to fulfill customers needs. Examples include:
- *SATAAR*: multilingual platform deployed for the Algerian National Ministry of Education,
- *KIOSQUE FORMATION*, a training platform with secured by fleas cards deployed in a national telecom-training institute
- *OMETIC*: collaborative platform for project management deployed in a national distance learning institute.

Within the company SERPOLET acts as a kernel set of services that are completed by additional modules in order to customize learning delivery platforms to users needs.
Main technical requirements for SERPOLET based environments are the following:
- SERPOLET functions under the Windows technology
- It uses IIS web server.
- It requires no installation in the user station.

We use a reverse engineering process. So our goal is to obtain a set of SERPOLET modules specifications and to organize them according to the three views of the model. With this approach we aim at getting an exact view of each available service in the global process, at pointing out steps, activities or actors that are not yet well supported. Finally with the data oriented view we aim at getting a detailed view of the data exchanged in order to become standard compliant as soon as recommendations are provided by international bodies for a given category of data. We also expect an easier updating of existing services within the global picture.

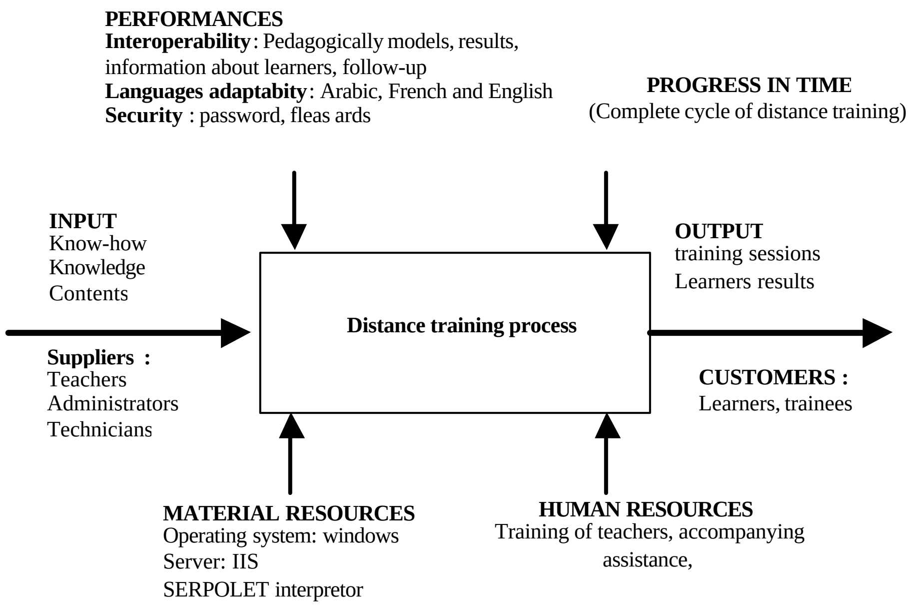

Fig. 5. Distance Learning Process

4.2 The process oriented view

The diagram in fig. 5 represents services provided by SERPOLET according to the distance learning process.
To the entry of the process, the teachers, the educational designers, the administrators and the technicians rely on their knowledge and their know-how to create and integrate their educational materials. They define the kind of follow-up that they want during the learning activities. To the exit of the process, the learners or the trainees work in their universes of training and give back some returns on their training sessions.
The educational supports are provided either on line or on CD-ROM.
For the human resources part, the SERPOLET educational team puts at the disposal of the teaching authors training sessions on the main functionality of the authoring system SERPOLET. First applications are built under the guidance of instructors, then a technical support is assured by the technical team SERPOLET.
The main performance features of the platform SERPOLET are the following: Firstly SERPOLET is a multi-language platform, secondly it ensures data and modules interoperability including learner data and learner records exchange and reuse. We detail the progress of training sessions in the next paragraph according to the five phases of the complete cycle of the formation.

4.3 The life cycle oriented view:

The diagram below shows the first classification of services available on the platform SERPOLET following the five phases of distance cycle of training products:

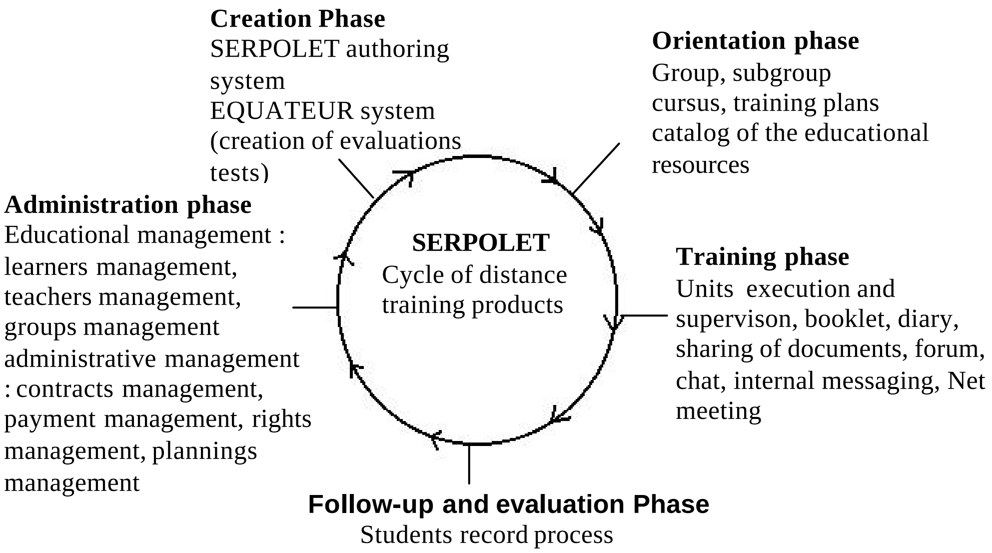

Fig. 6. SERPOLET: Cycle of distance training products

As the diagram shows on fig.6, in the creation phase, the platform offers a authoring system who allows the teaching authors to create educational modules in a format that integrates a lot of existing formats (text, pictures, video…). The authoring language allows the processing of learners'results and feebacks. It also integrates the EQUATEUR system that permits to create the evaluation tests.

The authors also have the possibility to integrate educational modules created with external tools.

In the orientation phase, the platform puts at the disposal of the teaching advisers a set of services that permit them to put the learners in the adequate groups or subgroups of training, to elaborate the personal training plans and to personalise the degree courses for a learner or a group of learners.

In the training phase, the learning environment allows each learner: to follow his educational modules, to consult his training booklet and to work in collaboration with the other actors of the platform.

The collaborative work tools used in the platform are tools for asynchronous communication (electronic mail, forum of discussion) and tools for synchronous communication (on line meeting, chat, sharing of applications and documents).

In the follow-up and evaluation phase, the teacher follows the learning behaviour of the learner in their sessions of training, they determine the level reached, and assess knowledge and skills acquired. The results will be exploited in the next sessions of training.

In the management phase, the platform SERPOLET provides the administrators of the formation with two types of functionality, the educational functionality and the administrative functionality.

The educational functionality includes definition of the groups, definition of the learners, exploitation of the data, definition of the formation plans, definition of the degree courses...

The administrative functionality includes management of the contracts, management of the rights, management of payment, management of the planning...

4.4. Where are we now and how do we use it?

The reverse engineering process is not yet achieved, so all the existing components and services are not yet posted on the diagrams. However it is already possible to show some benefits from the approach. Let us provide two examples. Firstly, if we look at the most recently required services, we can observe that they are related to invoice and accountancy management, to competencies management and to language adaptation. Secondly, if we look at the various diagrams in terms of service coverage per item, we can notice that the "performance" item in the process-oriented view is nearly empty. However it is a main issue for industrial production, so attention should certainly be beard on it in the coming years.

5. Conclusion

In this paper we have described a process-oriented approach to build models for Information Technology-based training and for software environments supporting the related training processes and activities. We propose a model including a process oriented view, a life cycle oriented view and a data flow oriented view. With a process oriented view we intend to put the focus on the training process and to tailor software components that support all the steps of the process. With a life-cycle view we aim at taking into account all the phases of a project, from the very beginning of the design to the maintenance and updating services for the customers. With a data flow view and a specification of data exchanged we aim at ensuring the highest level of interoperability and reusability of components. By combining these three views and by mapping them to customers'requests we aim at capturing nearly all the activities played by the many actors involved. Moreover, each view is completely open, new items can be added in the process view, new actors or new phases can be added in the life cycle view, so the model itself is open for future evolutions.
Finally, by being process oriented as recommended by ISO we aim at building models that could be used by industry and that remain compliant with forthcoming ISO production certifications. Also from a usability perspective, our reverse engineering approach allows us to focus on existing software components and to wrap them up them in news architectures rather than rebuilding all from scratch.

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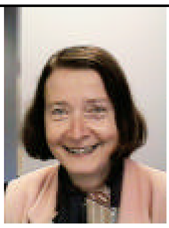
Monique Grandbastien is professor in Computer Science at the university Henri Poincaré in Nancy (France). From 1989 to 2000 she was the head of a research team on the applications of computers in Education. She supervised 10 PhD students on the topic and authored or co-authored many papers. She is currently involved in the AIDA virtual multidisciplinary research team. Her interests focus on knowledge representation for learning systems. She is the chief editor of the French scientific journal for Computers in Education and co-editor of a new journal on Distance learning. She is a member of the French normalisation body on ICT for learning, teaching and training and of the ISO/JTC1/SC36/WG1 working group on the same topic.	
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