How to integrate technology-enhanced learning with business process management

Nicola Capuano, Matteo Gaeta, Pierluigi Ritrovato and Saverio Salerno

Nicola Capuano, Matteo Gaeta, Pierluigi Ritrovato and Saverio Salerno are all based at the Università di Salerno, Fisciano, Italy.

Abstract

Purpose – *The purpose of this paper is to propose an innovative approach for providing an answer to the emerging trends on how to integrate e-learning efficiently in the business value chain in medium and large enterprises.*

Design/methodology/approach – *The proposed approach defines methodologies and technologies for integrating technology-enhanced learning with knowledge and human resources management based on a synergistic use of knowledge models, methods, technologies and approaches covering different steps of the knowledge life-cycle.*

Findings – *The proposed approach makes explicit and supports, from the methodological, technological and organizational points of view, mutual dependencies between the enterprise's organizational learning and the business processes, considering also their integration in order to allow the optimization of employees' learning plans with respect to business processes and taking into account competencies, skills, performances and knowledge available inside the organization.*

Practical implications – *This mutual dependency, bridging individual and organizational learning, enables an improvement loop to become a key aspect for successful business process improvement (BPI) and business process reengineering (BPR), enabling closure of, at the same time, the learning and knowledge loops at individual, group and organization levels.*

Originality/value – *The proposed improvements are relevant with respect to the state of the art and respond to a real need felt by enterprises and further commercial solutions and research projects on the theme.*

Keywords *Project management, Human resource management, Learning*

Paper type *Conceptual paper*

Introduction

The wealth of companies has progressively shifted from tangible assets (capital, resources, etc.) into intangible assets (knowledge, motivation, etc.), so, in order to raise the competitiveness of companies, it is extremely important to develop advanced workforce training solutions that are more adjusted to the continuous change in the competitive conditions in which companies are immersed. For this reason, technology-enhanced learning (TEL) is a primary need in modern enterprises.

Unfortunately the delay between the identification of an enterprise learning need and the actual learning purposed to fill the competency gap is still too large. According to Lindstaedt and Zimmerman (2006): ''right now most learning issues are dealt with by the human resources department, that's not necessarily the best department for this function [...] company-based learning needs to be embedded in business needs, so when a company changes its processes or procedures, the employee-training required to execute the changes develops in parallel''.

More generally speaking (Davenport, 2005) there is today a performance gap in TEL due to its limited capacity to be integrated within enterprise business processes. A better integration of TEL with business process management is in fact one of the greatest challenges for today's knowledge management. Also, according to Trondsen (2004)

enterprise learning should closely connect and align with work tasks specific to job roles and should relate to business objectives, processes, and workflows. The main advantages of this connection can be summarized in an improved productivity and business outcome, an improved relevance and use of learning content and resources, and a greater focus on learner and work context, improving worker satisfaction.

The fact that this lack of integration constitutes a big issue, especially at European level, can be also seen by looking at the IST priority of the 6th Framework Program (recently completed) and 7th Framework Program of the European Commission (EC). A focus of the strategic objective ''Technology-Enhanced Learning'' of the 2005-2006 Work Programme (European Commission, 2005) was in fact ''to explore interactions between the learning of the individual and that of the organisation in order to improve how current or emerging ICT can mutually enhance the learning processes for the individual and for the organisation''. The same objective in the 2007 Work Programme (European Commission, 2007) includes ''responsive environments for TEL [. . .] which can be embedded in the business processes and human resources management systems of organisations''.

To solve such issues, this paper presents EMBLEMA, a concept and an initiative that is currently under study and development at the University of Salerno, in cooperation with the Centre of Research in Pure and Applied Mathematics, proposing an innovative solution for TEL that integrates knowledge and human resources management features, tailored for organizations and based on a synergistic use of modern knowledge models, methodologies and technologies covering different steps of the knowledge lifecycle.

The key distinctive feature of the proposed solution is to make explicit mutual dependencies between enterprise and organizational learning with business processes and their integration in order to allow the optimization (tailoring and further personalization) of employees' learning plans with respect to the business processes (including competency development, skill gap shortening, etc.) and the optimization of business processes taking into account competencies, skills, performances and knowledge available inside the organization. This mutual dependency, bridging individual and organizational learning, also enables an improvement loop becoming a key aspect for successful business process improvement (BPI) and business process reengineering (BPR), enabling a closure, at the same time, of the learning and the knowledge loops at the individual, group and organization levels.

The paper is structured as follows: after a brief introduction of the state of the art the EMBLEMA initiative is presented, considering its objectives, technological components and starting point. Then advantages of the proposed solution with respect to the state of the art are reported, divided into three branches related to the training loop, the knowledge loop and the business improvement loop. Conclusions and references follow.

State of the art in the field

Enterprise resource planning systems (ERPs) are software solutions that integrate the data and processes of an organization into a unified system. ERPs typically attempt to cover all basic functions of an organization, regardless of the organization's business or charter. Several international ERP vendors are on the scene, but the main market shares are owned by SAP, with the SAP Business Suite, and by Oracle, with the Oracle e-Business Suite.

Main commercial ERPs (including those of SAP and Oracle) are able to manage and support several business processes like manufacturing (e.g. engineering, bills of materials, scheduling, workflow management, quality control, cost management, etc.), supply chain management (e.g. inventory, order entry, purchasing, supply chain planning, supplier scheduling, etc.), financial (general ledger, cash management, accounts payable and receivable, fixed assets, etc.), projects (costing, billing, time and expense, activity management, etc.), human resources (payroll, training, time and attendance, benefits, etc.) and customer relationship (sales and marketing, commissions, service, call centre support, etc).

Training in ERP is usually included in the human resource management (HRM) or human capital management (HCM) subsystems. Despite this, a limited level of integration of

> **"Enterprise resource planning systems typically attempt to cover all basic functions of an organization, regardless of the organization's business or charter."**

technology-enhanced learning components provided by ERPs within the other components is usually provided. This reflects on a lack of integration between learning and business processes, so hindering the fulfillment of higher performances both in terms of optimization of the learning loop at individual and organization level and in terms of optimization of enterprise knowledge processes, so constituting a huge barrier to business processes improvement.

By looking at SAP Human Capital Management and at Oracle Human Resource Management, it can be seen that they provide no tools for the automatic or assisted discovery of learning goals on the basis of business processes needs. This means that human resource managers must discover by themselves individual, group and enterprise business needs by interviewing project and function managers and trying to match each one's expectations, also taking into account the enterprise strategic objectives. This is a huge task that may be drastically simplified by applying automatic optimization techniques based on better integration between learning and ERP tools.

Moreover, the majority of the training tools integrated in ERPs are old-fashioned learning management systems providing static courses with little or no emphasis on individualization, collaboration, or the application of specific didactic models and methodologies. This results in stand-alone self-learning courses conforming to AICC CMI (Aviation Industry CBT Committee Computer Managed Instruction; Aviation Industry CBT Committee, 1998) or ADL SCORM (Advanced Distributed Learning Sharable Content Object Reference Model; ADL Technical Team, 2006) specifications with a limited degree of interaction that fails to motivate and engage learners. As an example, neither SAP nor Oracle training tools can deliver interactive multi-user collaborative experiences such as those obtainable with state-of-the-art languages and tools for learning (e.g. IMS Learning Design; IMS Global Learning Consortium, Inc., 2003).

The combination of these lacks results in a delay in the identification of learning goals at individual, group and organization levels once business process needs are identified and in a further delay in the bridging of competence gaps once learning goals are defined.

Some research projects dealing with these problems exist. As an example, the EC-funded integrated project PROLIX (see www.prolixproject.org) aims at aligning learning with business processes in order to enable organizations to improve their employees' competencies more quickly as business requirements change. To reach this goal, PROLIX is developing an open, integrated reference architecture for process-oriented learning and information exchange, supporting a complete learning process lifecycle that comprises:

- the analysis of complex business situations;
- the identification of individual and organizational learning goals;
- the analysis of competencies and matching them with individual skills;
- the definition of appropriate learning strategies and the simulation of competency-oriented processes;
- the execution of improved learning processes; and
- the monitoring of learners' performance according to the goals defined.

So PROLIX is already facing the problem of a faster and smarter closure of the training loop by better integrating it into HRM processes. It should be noted in addition that in the commercial ERPs examined, the impacts and side-effects of learning activities in other business processes are not considered. This lack of further integration produces delays in associated processes. As an example, considering knowledge management (KM) processes, it can be observed that neither knowledge elicitation features nor knowledge-sharing tools able to link the enterprise KM system to learning tools are currently provided. So, a lot of time elapses between the acquisition of a new knowledge, at individual or group level, and its formalization in a knowledge asset inside the enterprise KM system, and a lot of time also elapses between the formalization of a new knowledge asset inside the enterprise KM system and its exploitation in training activities.

As we will explain in the following paragraphs, EMBLEMA goes further. EMBLEMA considers the impact of learning on the KM process, as well as on other knowledge-based process, thus ensuring a deeper integration of leaning in businesses and a consequent higher synergy with the whole enterprise ecosystem, while closing not only the training loop but also the enterprise knowledge loop and the business improvement loop.

The EMBLEMA initiative

EMBLEMA stands for Embed Learning in Business Process Management. It is a concept and an initiative that is currently under development at the University of Salerno in cooperation with the Centre of Research in Pure and Applied Mathematics. The purpose of EMBLEMA is to define, develop and experiment models, methodologies and technologies aimed at tightly integrating individual learning with organizational business processes. State-of-the-art and innovative learning and knowledge representation models, methodologies and techniques are integrated to obtain individual and group learning experiences applying pedagogy-based approaches to motivate and engage each single learner according to his/her unique profile.

Planning and optimization algorithms, both deterministic and stochastic, are used in order to support human resource managers to monitor, assess and predict the evolution of knowledge, to discover individual and enterprise learning needs and to define training plans at the operational and strategic levels. Knowledge elicitation methodologies, based on collaborative learning approaches, are used and deployed in order to transform tacit knowledge owned by individuals and groups in knowledge assets reusable in learning activities and processes.

Objectives

EMBLEMA defines and applies methodologies and tools for knowledge elicitation in collaborative settings in order to elicit the tacit knowledge of workers exchanged during the interactions and make it reusable in future learning activities. Knowledge discovery and retrieval methods in asynchronous learning networks (ALNs) are integrated with algorithms capable of understanding the relevance of discussion threads inside collaborative tools, also based on the analysis of the learner models of the participants involved. The application of structured interactions – e.g. applying the SECI process (Nonaka, 1994) based on socialization, externalization, combination and internalization phases – and of simulation methodologies and tools to support the elicitation of knowledge are also explored.

EMBLEMA defines a knowledge-driven stochastic processes model and planning tool in order to represent organization business processes and related activities, resources, goals, roles and tasks. Stochastic models and simulation algorithms applying Markovian decision processes are introduced to model the intrinsic uncertainty of organizational processes. The model is specialized for the learning processes conceived as a specific business process. In such a context, the worker is represented not only with respect to the organization but also with respect to the learning process.

An optimized organization-aware learning processes planner tool is also defined and developed to automatically discover operational and strategic learning goals at the individual, group and organization levels and to define personalized and adaptive learning

plans covering such needs by applying optimization techniques. Such tools are able to assess and predict the evolution of knowledge, competencies and abilities by exploiting simulations of knowledge progression paths based on historical data, learning goals, plans and activities performed at each level, enabling in this way an iterative process for business process improvement.

EMBLEMA defines a goal-oriented competency/skill model that is able to represent the knowledge, competencies and skills connected with processes and related activities, resources, goals, roles and tasks as well as career progression paths among job roles. The competency/skill model provides the advantage that the employee can specify at a higher level the learning desiderata (e.g. by asking to acquire a specific competency or the ability to perform something) and the system, and using learning processes the planner arranges a personalized and suitable learning plan.

The model, together with the knowledge-driven stochastic processes model, is exploited both in the learning process planner and also in supporting other business tasks (through integration with human resource management systems) like the optimization of worker allocation on future activities and the automatic definition of possible improvements to business processes, maximizing the exploitation of knowledge assets spread inside the organization.

EMBLEMA defines an intelligent content structuring and creation tool to generalize the IWT knowledge model in order to support higher-level concepts and relations for representing different domains and contexts as well as low-level relations linking learning resources to represent mutual connections and cause-effect relationships. Sharing and harmonization tools, acting as a bridge between internal and external knowledge, are also defined to enable integration with external knowledge-based systems and tools.

EMBLEMA's starting point is an already existing e-learning platform named Intelligent Web Teacher (performed), which exploits experiences and know-how gained in several EC projects including, among others, InTraSys (Capuano *et al.*, 2001), Diogene (Capuano *et al.*, 2004), m-Learning (Capuano *et al.*, 2005) and ELeGI (Gaeta *et al.*, n.d.). IWT is a complete e-learning platform targeted to customize the learning experience on real learners' needs and preferences and to ensure extensibility and flexibility at the content, pedagogical approach and services levels. Among other things, IWT is able to formally represent knowledge about the teaching domain through an ontology-based knowledge model, to represent and apply different didactic methods and strategies, also based on advanced learning resources like simulations, and to generate adaptive learning experiences, starting from the knowledge model and the learner model by applying specific didactic methods. More details on IWT are given in below.

Theoretical and technological components

This section summarizes the theoretical and technological components of EMBLEMA. Five theoretical models are defined as specified below:

1. a stochastic business process model that is able to formally represent organization processes and related activities, resources, goals, roles and tasks, and also able to capture the intrinsic uncertainty embedded in organizational processes;
2. a stochastic learning process model that is able to formally represent learning processes as a specialization of business processes;
3. a generalized knowledge, competency and skill model that is able to formally represent the knowledge, competencies and skills connected with such processes and related activities, resources, goals, roles and tasks by generalizing, at the same time, the existing IWT knowledge model;
4. a knowledge mapping model that is able to formally represent links between knowledge models in order to move indexed entities easily among different contexts; and

5. a worker model that is able to formally represent the worker not only with respect to the organization (e.g. assigning him a role and a set of competencies, abilities, performances, etc.) but also with respect to the learning process (e.g. by assigning him a set of learning needs and a learning style).

Such models are used as the basis to define methodologies as specified below:

- an individual learning planning methodology that is able to automatically determine a worker's personal learning needs by performing a skill gap analysis taking into account their current and required knowledge, competencies and abilities with respect to tasks at hand and career progression paths;
- a group learning planning methodology that is able to automatically determine the group and the enterprise's learning needs at both the operational (dealing with the short-range of everyday activities) and strategic (dealing with the long-range development of its future activities) levels, taking into account constrains like people's workloads, proximities between workers owned and targeted knowledge, etc.;
- a learning process generation methodology that is able to automatically build learning processes satisfying individual, group and organisational learning needs, customized to individuals' profiles and preferred learning styles and applying formally defined learning methods and strategies;
- a business optimization methodology that is able to optimize the allocation of workers to activities and suggest possible improvements to business processes, maximizing the exploitation of knowledge assets spread inside the organization;
- a knowledge elicitation methodology that is able to elicit tacit knowledge owned by workers, also applying structured interactions in the collaborative environments in order to build knowledge assets and reuse such knowledge in the learning process; and
- a knowledge sharing methodology that is able to embed the learning environment in the organization's knowledge management process (and related software systems and tools) in order to facilitate the exploitation of the organization's knowledge in the learning process.

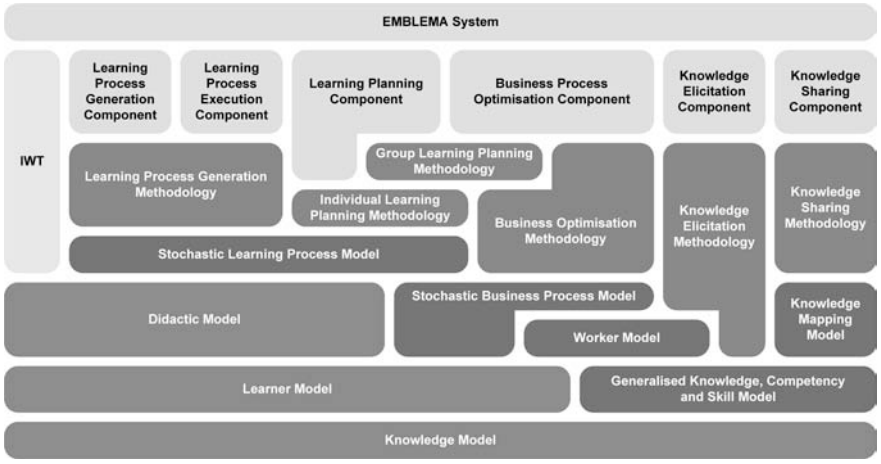
The models and methodologies mentioned above are used as the basis to define, design and develop software components that can be integrated in the reference platform as described below:

- a learning process generation component and a learning process execution component that are able to generate and execute learning processes exploiting the learning process generation methodology;
- a learning planning component that is able to generate individual, group and enterprise learning needs, exploiting individual and group learning planning methodologies;
- a business process optimization component that is able to monitor, assess and predict the evolution of knowledge, competencies and abilities at the individual, group and enterprise levels, and to suggest possible improvements to business processes exploiting the business optimization methodology;
- a knowledge elicitation component that is able to elicit tacit knowledge owned by workers applying the knowledge elicitation methodology; and
- a knowledge sharing component that is able to connect the learning environment with external knowledge management systems applying the knowledge sharing methodology.

Figure 1 organizes the models, methodologies and tools resulting from the project (dotted blocks refer to models and components already available in IWT) in a layered view, emphasizing the dependencies and connections among them. The resulting product is the EMBLEMA e-Learning, Knowledge and Human Resources Management system.

The application of well defined specifications and standards and the provision of knowledge-sharing and harmonization facilities as well as the adoption of technologies

Figure 1 EMBLEMA models, methodologies and components



specifically intended for interoperability (i.e. web services) allow for the integration of the technology-enhanced learning and working environment obtained with enterprise resource planning systems, knowledge management tools and/or integrated business solutions.

The starting point

As anticipated, EMBLEMA models and methodologies are used as a basis to develop prototype software components integrated in an already existing e-learning platform named IWT. Such integration results in a comprehensive environment for e-learning, human resource and knowledge management.

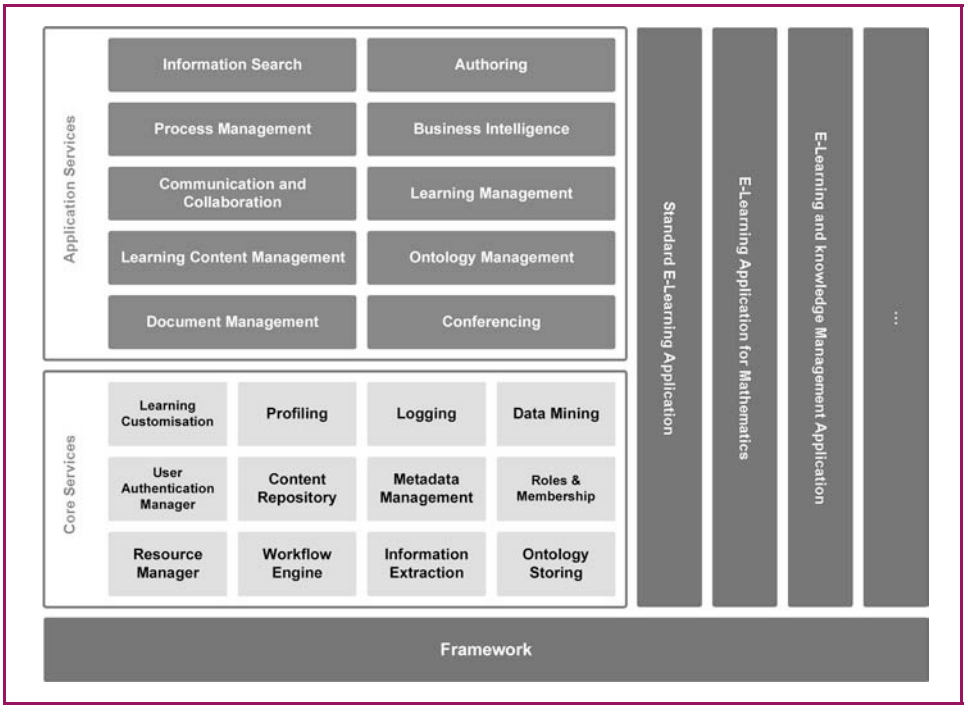
IWT stands for Intelligent Web Teacher (Capuano *et al.*, 2003a). It is a distance learning platform aimed at redressing the lack of support for flexibility and extensibility in existing e-learning systems. IWT arises from the consideration that every learning/training context requires its own specific e-learning solution. It is not realistic to use the same application for teaching, for instance, foreign languages in primary schools, mathematical analysis at universities, and marketing management to enterprise employees.

It should not only be the content that varies, but also the didactic model, the typology of the training modules to be used, the application layout and, overall, the connected tools. In practice, the need to introduce e-learning in a new learning/training context brings hard work for analysts, engineers and programmers. IWT solves this problem with a modular and extensible solution so as to become the foundation for building up a virtually infinite set of applications for either traditional or innovative e-learning. The IWT logical architecture is divided into three main layers, as shown in Figure 2.

The first layer at the bottom of the stack is the framework used by developers to design and implement core services, application services and learning applications. The second layer is composed of core services providing basic IWT features like resource management, workflow management, information extraction, ontology storing, user authentication, content storing, metadata management, role and membership management, learning customization, logging and profiling and data mining. Core services are used by application services and learning applications.

Application services are services used as building blocks to compose e-learning applications for specific domains. They include document management, conferencing, authoring, learning management, learning content management, ontology management, communication and collaboration, business intelligence, process management and information search services. Applications represent complex solutions covering specific learning scenario obtained as integration of application services.

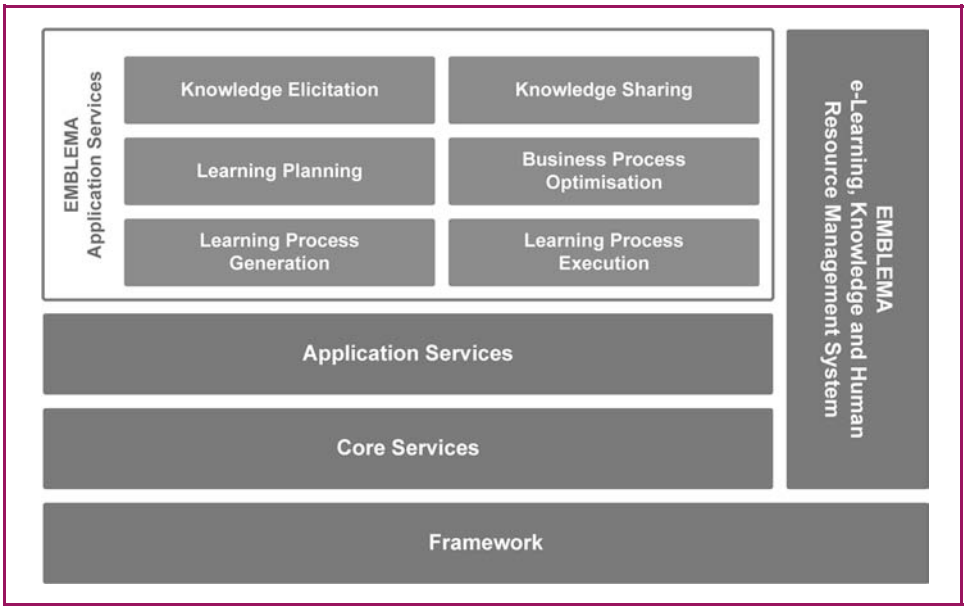
Figure 2 IWT logical architecture



The IWT architecture is modular enough to allow the deployment of solutions capable to cover application scenarios of different complexity and for different domains by composing service building blocks. Figure 3 shows how EMBLEMA fits the IWT architecture and contributes to build a comprehensive solution for e-learning, knowledge and human resource management.

Concerning standardization issues, it is important to note that EMBLEMA builds on and extend existing standards and specifications. In the business process arena, BPEL4WS –

Figure 3 EMBLEMA components inside the IWT architecture



i.e. Business Process Execution Language for Web Services (IBM, BEA Systems, Microsoft, SAP AG and Siebel Systems, 2002) – is used to model and deploy business processes coming from the planning process, while IMS RDCEO – i.e. Reusable Definition of Competency or Educational Objective – (IMS Global Learning Consortium, Inc., 2002) is exploited for competency modeling. Regarding learning technology, IEEE Learning Object Metadata (LOM; IEEE Learning Technology Standard Committee, 2002), ADL SCORM and IMS Learning Design, already adopted by core IWT services, are considered as vehicles for the delivery of learning activities and Web Ontology Language (OWL; W3C, 2004) as a base language to model knowledge structures like ontologies.

Advantages with respect to the state of the art

As mentioned previously, EMBLEMA defines and develops models, methodologies and software prototypes aimed at tightly integrating individual learning with organization business processes. As we have seen, some existing ERPs already provide the integration of learning and human resource management (HRM) processes but, in all cases, the degree of automation and optimization obtained is worse with respect to those foreseen in EMBLEMA, and less effective.

Some EC projects are already facing the problem of a faster and smarter closure of the training loop by better integrating it within HRM processes. It should be noted that, as in all commercial ERPs, impacts and side effects of learning activities in other business processes are not considered. In the following paragraphs EMBLEMA's main innovations are presented divided into three branches, the first related to the learning loop, the second related to the enterprise knowledge loop, and the third related to the business improvement loop.

Closure of the training loop

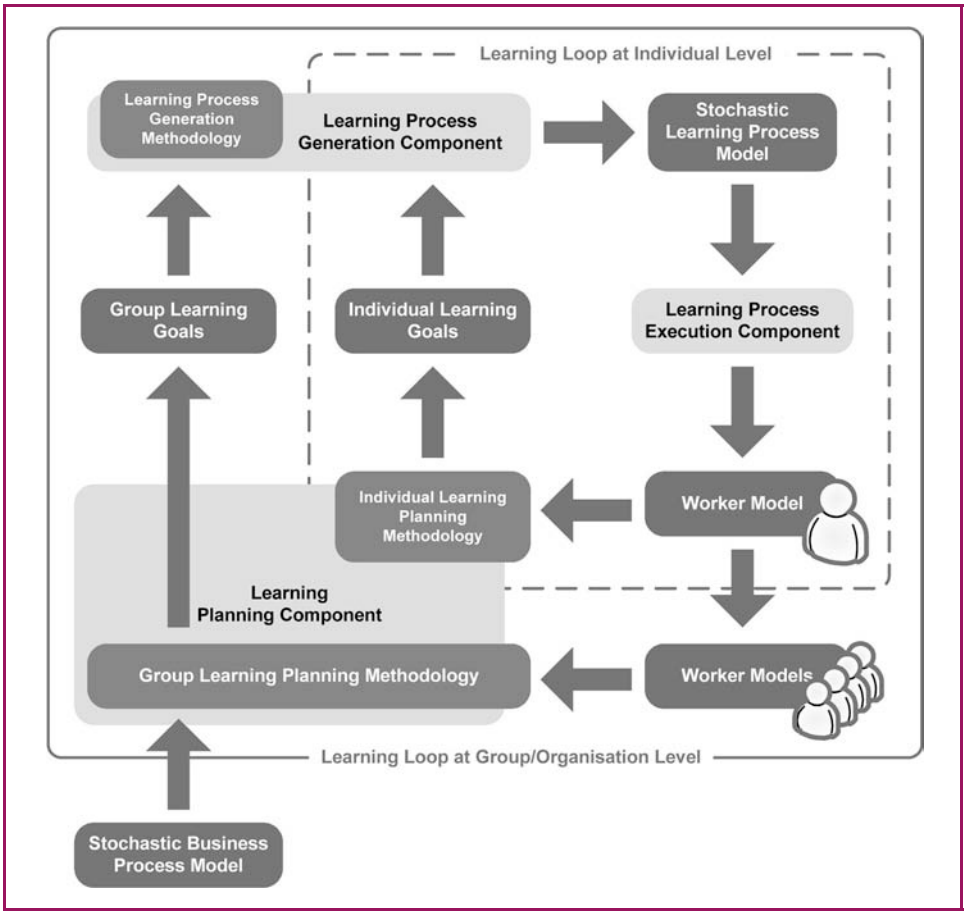
Figure 4 shows how EMBLEMA models, methodologies and components work together in order to close the learning loop at the individual and group/organization levels. A worker may use the learning planning component (exploiting the individual learning planning methodology) to find individual learning goals based on job role, current and required knowledge, competencies and abilities with respect to the tasks at hand, career progression paths, etc. Contemporarily, the project manager and the enterprise human resource manager use the same component (exploiting the group learning planning methodology) to find group and enterprise learning goals, based on other optimization variables like foreseen activities and projects, enterprise strategic goals, people's workloads, proximities between workers' owned and targeted knowledge, etc.

Individual and group learning goals are then exploited by the learning process generation component (using the learning process generation methodology) to build a stochastic learning process model taking into account, in this case, pedagogical constraints like learning preferences and learning styles and applying a specific learning strategy case by case. The resulting individual and group processes, defined according to the IMS Learning Design specification, duly extended in order to support the enterprise aspects, take into account, for each worker, individual, group and enterprise goals, and are executed through a learning process execution component. After the training activity the worker model (of each worker) is updated with respect to the new competencies acquired, and the learning loop can start again.

Thanks to the integration of processes at the innermost possible level (i.e. the level of knowledge), EMBLEMA allows a deeper integration of learning and organization processes with respect to traditional ERPs, resulting in a faster closure of the learning cycle with the consequent shortening of the time to individuate learning goals, to plan learning activities and to raise worker performances at all levels (individual, group, enterprise), also taking into account both operational and strategic goals.

Moreover, by exploiting optimization techniques, the process of goal definition also becomes faster and smarter with respect to traditional ERPs then being partially automated. Starting from traditional skill gap analysis methodologies (Wentling, 1992), advanced

Figure 4 The learning loop at individual, group and organization levels



enterprise-level training planning algorithms are defined. Such algorithms optimize the learning targets for each worker, taking into account global variables such as:

- skill gaps connected with job roles;
- competencies necessary to carry out new enterprise tasks at hand; and
- competency updates necessary to follow career progression paths, etc.

The application of a global optimization technique is possible thanks to the application of a common knowledge/competency model and to the integration of information about the working environment inside the learner models.

It is important to note that the learning process, being a human-driven activity like any other business process, has an intrinsic degree of uncertainty that should be taken into account to produce reliable plans for individual, group and enterprise skill development. As an example, if a profile needed for a particular activity, is not available then it can be created through training. Skill gap analysis finds the lack of competency with respect to the activity, and then the most suitable worker (the one with the nearest competency according to constraints) is found, a learning plan is generated according to the worker's learning preferences, and finally the worker is trained.

Given the intrinsic uncertainty, the training goal may be not reached on time satisfactorily for the target activity. To deal with this, EMBLEMA innovates training planning algorithms by introducing stochastic models and simulation algorithms applying Markovian decision processes to model learning and business processes. In this way plans are generated not only targeting objectives but also levels of probability to reach the targeted objectives. The

more strategic an objective is for the organization (or the group or the individual) the higher its targeted probability of achievement.

This is a completely innovative feature, not only with respect to traditional ERPs but also with respect to the main projects on the theme. Moreover, another innovation of EMBLEMA is related to tools that are able to assess and predict the evolution of knowledge, competencies and abilities by exploiting simulations of knowledge progression paths based on historical data, learning goals, plans and performed activities that are provided in order to support human resource managers in the settlement of probabilities of achievement for each found learning goal.

Further EMBLEMA innovations with respect to the learning cycle are a direct output of the integration of knowledge and learning methodologies and technologies. In particular, in the field of competency and worker modeling, EMBLEMA defines e-learning specific ontology models that are able to represent not only relations among domain concepts and between domain concepts and learning objects – as in several works on the theme such as Qin and Hernandez (2004) and Capuano *et al.* (2003b) – but also competencies and their connections with job roles and tasks in an organization as well as career progression paths among job roles.

EMBLEMA also defines rich models of worker representation that include the evaluation of the acquired knowledge and of preferred learning styles, by referring to several theories on the matter like Felder and Silvermann's learning and teaching styles (Felder, 1988) and Kolb's learning style inventory (Kolb and Fry, 1975). A good job in this sense has already been done in the context of the reference platform IWT. The main innovation carried out by EMBLEMA is the integration of e-learning driven information with enterprise-driven information such as job roles, career progression paths, etc.

Closure of the enterprise knowledge loop

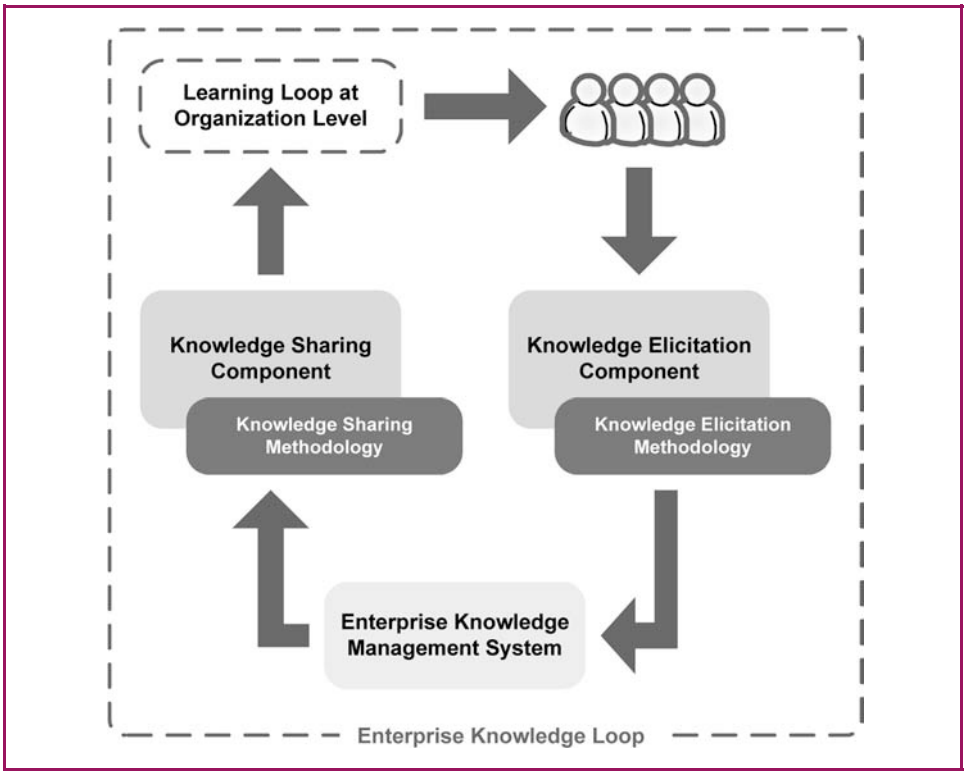
Figure 5 shows how developed models, methodologies and components work together in order to close the enterprise knowledge loop. Workers acquire competencies by getting involved in the learning loop; such competencies are improved by practicing in the working environment and produce new knowledge. Such knowledge (which may be retained at the individual or group level) is captured by the knowledge elicitation component (exploiting the knowledge elicitation methodology) and may be exploited directly in the learning loop as training material to train other people.

Moreover, the extracted knowledge can be imported into the enterprise knowledge management system in order to become a knowledge asset to be exploited inside the organization at every level. At the same time, the knowledge sharing component (exploiting the knowledge sharing methodology) is able to translate relevant enterprise knowledge assets, included in the enterprise knowledge management systems, in order to allow it be exploited in the learning loop.

Collaboration tools inside e-learning systems are widely recognized as a means to leverage human resources, competences and activities as well as to support learning communities purposed to promote the transfer of know-how between novices and experts. Negotiation,

"Planning and optimization algorithms, both deterministic and stochastic, are used in order to support human resources managers to monitor, access and predict the evolution of knowledge, to discover individual and enterprise learning needs, and to define training plans at operational and strategic levels."

Figure 5 The enterprise knowledge loop



validation and socialization phases that are developed during synchronous and asynchronous collaboration sessions allow learners to build their personal knowledge by presenting, discussing and negotiating it with other peers. Unfortunately, the knowledge generated in such sessions is usually lost after the sessions end and fails to become an asset that can be exploited at the enterprise level.

The knowledge elicitation tools introduced by EMBLEMA try to overcome this limitation by identifying relevant knowledge flows in group activities and formalizing them in semantically enriched knowledge assets to be stored in the enterprise knowledge management system and, eventually, reused in further training activities. From the methodological point of view, text mining and content analysis methods are considered in order to foster the process of knowledge discovery and elicitation. Text categorization techniques for session indexing are combined with heuristic methods for the approximate evaluation of the objective relevance of collaboration sessions and with collaborative recommendation methods (Balabanovic and Shoham, 1997) for the evaluation of its subjective relevance.

To support the elicitation process, innovative approaches like the SECI theory of knowledge creation are considered. According to (Nonaka, 1994), the key to knowledge creation lies in four (SECI) modes of knowledge conversion that occur when tacit and explicit knowledge interact:

1. socialization (the process of sharing experiences, thereby creating new tacit knowledge);
2. externalization (the process of articulation and conversion of tacit knowledge into explicit knowledge);
3. combination (the process of restructuring and aggregating explicit knowledge into new explicit knowledge); and
4. internalization (the process of reflecting on and embodying explicit knowledge into tacit knowledge).

Structured collaboration tools applying the SECI methodology, such as those suggested by Naeve *et al.* (2005) are considered to support knowledge elicitation.

EMBLEMA also defines knowledge sharing and harmonization methodologies and tools that are able to exploit enterprise knowledge embedded in KM systems e-learning activities. To do this, the most consolidated keyword-based indexing techniques (like vector space model) are enhanced to support ontology-based representation models. With respect to existing harmonization tools, which base their effectiveness on similarities among concept names only (pre-processed with thesauri), EMBLEMA also relies on the calculation of similarities among concept descriptions and already indexed documents. A further innovation is the exploitation of relevance feedback techniques (Ponte, 2000) to refine the extracted semantic information rather than to modify user models (the most common use).

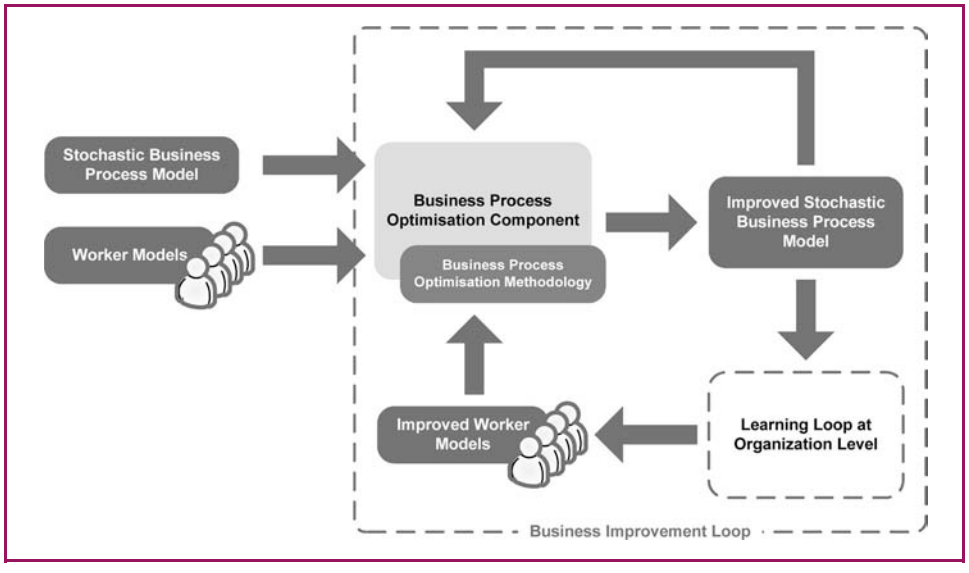
Closure of the business improvement loop

The EMBLEMA project focuses on optimization of the e-learning process and on maximizing its impacts on other organizational processes. As a side effect of this, EMBLEMA is also able to provide business improvement features. Figure 6 shows how models, methodologies and components work together in order to close the business improvement loop.

Starting from the formal description of organization's business processes and related activities, resources, goals, roles and tasks through a business process model and from a set of models describing workers with respect to the organization (including the role and the set of obtained competencies, abilities, performances, etc.) the business process optimization component (through the business process optimization methodology) is able to suggest a set of improvements to be applied to the business process at several levels.

The modification suggested by the methodology tries to exploit at the maximum level possible (applying defined optimization techniques) the knowledge, skill and competencies spread inside the enterprise. If applied in practice by the organization's management, they result in an improved business process model that can be re-used by the business process optimization component as a basis to suggest more improvements (so closing the business improvement loop). In other words, the assessment of actual business operations affects how business processes are carried out, and these could be used as inputs for the re-design of business processes. These include customer-oriented redesign and also redesign to improve the efficiency of internal processes.

Figure 6 The business improvement loop



On the other hand, updated business process models impact on the learning loop (especially on the group learning planning methodology), affecting the learning goals to be assigned at individual and group levels. Moreover, workers are constantly involved in learning activities through the learning loop. This results in a continuous updating of worker models (reflecting competences improvement) that impacts again on business optimization algorithms.

The features proposed here are also innovative with respect to research projects on the theme. PROLIX also aims to provide competence-oriented process decision support through simulation to give a quantitative feedback for business processes by providing a competency oriented process simulator. EMBLEMA goes further, not only providing simulation facilities to monitor and predict knowledge progression paths basing on historical data, learning goals, plans and performed activities at each level, but also defining optimization algorithms that are able to directly suggest process improvements that should be made to optimize organization performances based on knowledge.

As further innovative feature, a stochastic approach is adopted to model business processes in order to take into account the inherent stochastic nature of business processes in general and of learning processes in particular as well as the extremely dynamic nature of the environment where they are applied (organizations and enterprises). The work around this topic applies Markov decision processes (Puterman, 1994; Doshi *et al.*, 2004) to model and compose process workflows. The resulting workflows admit non-deterministic behaviors and are able to adapt to a changing environment.

Conclusions and future work

This paper has presented EMBLEMA, a concept and an initiative of the University of Salerno in cooperation with the Centre of Research in Pure and Applied Mathematics, an innovative solution for technology enhanced learning that integrates knowledge and human resources management features, tailored for organizations and based on a synergistic use of modern knowledge models, methodologies and technologies covering different steps of the knowledge lifecycle.

Rather than focusing on every single component, the purpose of this paper was to give the overall picture, since EMBLEMA is a work in progress and its components are in various stages of definition. A preliminary knowledge, competency and skill model is defined as well as a worker model based on it. Their connections with the underlying knowledge and the learner models are also clear. Preliminary knowledge sharing and elicitation methodologies and the related software components are under development.

The improvements proposed by EMBLEMA are relevant with respect to the state of the art and respond to a real need felt by enterprises at the international level. EMBLEMA, by closing at the same time not only the training loop but also the knowledge and the business improvement loops, goes further any other commercial solution and research project on the theme. By considering the impact of learning on every enterprise process, it also ensures a deeper integration of learning in business and a higher synergy with the whole enterprise ecosystem.

References

ADL Technical Team (2006), *Sharable Content Object Reference Model (SCORM) 2004 3rd Edition Documentation Suite*, Advanced Distributed Learning, Alexandria, VA, available at: www.adlnet.gov

Aviation Industry CBT Committee (1998), ''Web-based computer-managed instruction in AICC: guidelines and recommendations'', Aviation Industry CBT Committee, available at: www.aicc.org

Balabanovic, M. and Shoham, Y. (1997), ''Combining content-based and collaborative recommendation'', *Communications of the ACM*, Vol. 40 No. 3, pp. 66-72.

Capuano, N., Gaeta, M. and Micarelli, A. (2003a), ''IWT: Una Piattaforma Innovativa per la Didattica Intelligente su Web'', *AI*IA Notizie*, Year XVI, No. 1, pp. 57-61.

Capuano, N., Gaeta, M., Micarelli, A. and Sangineto, E. (2003b), ''An intelligent web tutoring system for learning personalisation and semantic web compatibility'', *Proceedings of the 11th International Conference on Powerful ICT Tools for Teaching and Learning (PEG 2003), St Petersburg*.

Capuano, N., Gaeta, M., Micarelli, A. and Sangineto, E. (2004), ''Diogene: a semantic web-based automatic brokering system'', *AIS SIGSEMIS Bulletin*, Vol. 1 No. 3, pp. 65-7.

Capuano, N., Gaeta, M., Miranda, S. and Pappacena, L. (2005), ''A system for adaptive platform-independent mobile learning'', in Attewell, J. and Savill-Smith, C. (Eds), *Mobile Learning Anytime Everywhere*, Learning and Skills Development Agency, London, pp. 53-6.

Capuano, N., De Santo, M., Marsella, M., Molinara, M. and Salerno, S. (2001), ''Personalised intelligent training on the web: a multi agent approach'', in Chin, W., Patricelli, F. and Milutinovic, V. (Eds), *Electronic Business and Education: Recent Advances in Internet Infrastructures*, Kluwer Academic, Dordrecht, pp. 125-46.

Davenport, T. (2005), ''An interview with Tom Davenport: the only way we can make our field more useful is to start doing and rewarding work that can be read and applied by businesspeople'', *AIS SIGSEMIS Bulletin*, Vol. 2 No. 2, pp. 5-9.

Doshi, P., Goodwin, R. and Akkiraju, R. (2004), ''Dynamic workflow composition using Markov decision processes'', *Proceedings of the IEEE International Conference on Web Services (ICWS'04), San Diego, CA, June 6-9*, pp. 576-82.

European Commission (2005), ''IST – Information Society Technologies – A thematic priority for research and development under the specific programme 'Integrating and strengthening the European research area' in the Community Sixth Framework Programme'', European Commision, available at: www.cordis.lu/ist

European Commission (2007), ''ICT – Information and Communication Technologies – A theme for research and Development under the specific programme 'Cooperation' implementing the Seventh Framework Programme (2007-2013) of the European Community for Research, Technological Development and Demonstration Activities – Work Programme 2007'', European Commission, available at: www.cordis.europa.eu/fp7

Felder, R.M. (1988), ''Learning and teaching styles'', *Engineering Education in Engineering Education*, Vol. 78 No. 7, pp. 674-81.

Gaeta, A., Gaeta, M., Orciuoli, F. and Ritrovato, P. (n.d.), ''A grid based software architecture for delivery of adaptive and personalised learning experiences'', *ACM Personal and Ubiquitous Computing*, forthcoming.

IBM, BEA Systems, Microsoft, SAP AG and Siebel Systems (2002), ''Business Process Execution Language for Web Services version 1.1'', available at: www-128.ibm.com/developerworks/library/specification/ws-bpel

IEEE Learning Technology Standard Committee (2002), ''IEEE Standard for Learning Object Metadata'', des. num. 1484.12.1-2002, available at:www. ieeeltsc.org

IMS Global Learning Consortium, Inc. (2002), ''IMS Reusable Definition of Competency or Educational Objective Information Model v.1.0'', IMS Global Learning Consortium, Inc., available at: www.imsglobal.org/competencies

IMS Global Learning Consortium, Inc. (2003), ''IMS Learning Design Best Practice and Implementation Guide – version 1.0'', IMS Global Learning Consortium, Inc., available at: www.imsglobal.org/learningdesign

Kolb, D.A. and Fry, R. (1975), ''Toward an applied theory of experiential learning'', in Cooper, C. (Ed.), *Theories of Group Process*, Wiley, London.

Lindstaedt, S. and Zimmermann, V. (2006), ''Managing knowledge for the new economy'', IST Results, available at: www.istresults.cordis.lu

Naeve, A., Yli-Luoma, P., Kravcik, M., Lytras, M., Simon, B., Lindegren, M., Nilsson, M., Palmér, M. and Korfiatis, N. (2005), ''A conceptual modeling approach to studying the learning process – with a special focus on knowledge creation'', technical report, Prolearn EU/FP6 Network of Excellence.

Nonaka, I. (1994), ''A dynamic theory of organisational knowledge creation'', *Organisation Science*, Vol. 5 No. 1, pp. 14-37.

Ponte, J. (2000) in Croft, W.B. (Ed.), *Advances in Information Retrieval*, Kluwer Academic, Dordrecht, pp. 73-96.

Puterman, M.L. (1994), *Markov Decision Processes: Discrete Stochastic Dynamic Programming*, Wiley Series in Probability and Mathematical Statistics, Wiley Interscience, Malden, MA.

Qin, J. and Hernandez, N. (2004), ''Ontological representation of learning objects: building interoperable vocabulary and structures'', *Proceedings of WWW2004*, ACM Press, New York, NY, pp. 348-9.

Trondsen, E. (2004), ''Learning in context of business processes and workflows'', SRI Consulting Business Intelligence (SRIC-BI) report, available at: www.sric-bi.com/lod

W3C (2004), ''OWL Web Ontology Language Overview'', W3C Recommendation, available at: www.w3.org/2004/OWL

Wentling, T.L. (1992), *Planning for Effective Training: A Guide to Curriculum Development*, FAO, Rome.

About the authors

Nicola Capuano is Research Assistant at the Department of Information Engineering and Applied Mathematics of the University of Salerno. His main research interest is artificial intelligence and, among its applications, intelligent tutoring systems and knowledge representation. He collaborates as Project Manager with the Research Centre in Pure and Applied Mathematics (CRMPA) of Salerno and with the Research Centre on Software Technology of the University of Sannio (Benevento) and as Research & Development Consultant with MoMA Software and Research s.r.l. Nicola Capuano is the corresponding author and can be contacted at: capuano@crmpa.unisa.it

Matteo Gaeta was awarded a degree in Information Sciences at the University of Salerno in 1998. At present he is Associate Professor of Systems of Information Processing within the DIIMA at the Faculty of Engineering of the University of Salerno. He is Member of the Working Group of MIUR acting as Experts for the Evaluation and Control of Projects under Article 14, and Coordinator of the Assessment Panel of Projects Submitted to the Strategic Programme No. 10. He is Project Supervisor and Coordinator of numerous R&D and technology transfer projects at the CRMPA. His scientific research activity is focused on various fields including systems, platforms software, distributed architecture and computing grids; artificial intelligence and learning methodologies and technologies; and artificial vision and image analysis.

Pierluigi Ritrovato obtained a BS degree in Computer Science at the University of Salerno in 1992. At present he is Assistant Professor in Engineering & Computer Science at University of Salerno and responsible for international research cooperation and technology innovations for the CRMPA. In the last five years, he has been focusing his scientific research on distributed learning management systems and grid technologies. He is the Chair of the Service Orchestration, SLA Usage and Workflow – Technical Group for the EU Software Services and Infrastructure Unit. He is also editor of the book *Towards the Learning Grid: Advances in Human Learning Services*.

Saverio Salerno obtained a degree *cum laude* in Mathematics in 1974 at the Scuola Normale Superiore di Pisa, also achieving the ''Diploma di Normalista'' and gaining a specialization grant. He has been full Professor of Mathematical Analysis since 1987 and of Simulation and Operations Research since 2001 at the Faculty of Engineering of the University of Salerno. He has held several prestigious institutional positions at both national and international levels, including coordinator of the Commission on ICT at the Ministry of Education, University and Research (MUR) and member of the Italian Delegation for the IST Programme of the Fifth Framework Programme of the European Commission. He was the Founder and, until October 2002, Director of the Research Consortium CRMPA, and is Chief Scientist at present. His main research interests include mathematical modeling, simulation and optimization of complex systems to distributed service-oriented software architecture and technology-enhanced learning. He is been author of more than 80 scientific publications including journal papers and several books.

To purchase reprints of this article please e-mail: reprints@emeraldinsight.com
Or visit our web site for further details: www.emeraldinsight.com/reprints