Technology for Performance-Based Lifelong Learning

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Abstract

Performance-based learning requires that a computer system have deep, exact knowledge of what a person is doing and what they already know about that task to determine what they should learn now. Lifelong learning requires that a computer system have broad, general knowledge over a number of years of what a person has learned to determine what they should learn now. Separately, these are each difficult goals to accomplish. However, both goals must be met to effectively provide a workforce that meets the evolving needs of industry and government for skilled workers. This paper describes a system that can meet both of these goals and support performance-based lifelong learning.

1. Background

Recent technology advancements in the areas of e-learning and knowledge management have set the stage for the fulfillment of the vision for lifelong learning put forth by Wayne Hodgins for the Commission on Technology and Adult Learning in February, 2000 [1]. According to Hodgins, a key aspect of this vision is performance-based learning. Performance-based learning is the result of a transition from "teaching by telling" to "learning by doing," assisted by technological and human coaches providing the low-level and high-level support. Furthermore, his key to the execution of performance-based learning is successful information management. Successful information management makes it possible "to deliver just the *right* information, in just the *right* amount, to just the *right* person in just the *right* context, at just the *right* time, and in a form that matches the way *that* person learns. When this happens, the recipient can act – immediately and effectively."

While the stage has been set for the fulfillment of a vision of performance-based lifelong learning, there are numerous social and technology obstacles that may yet stand in the way. These obstacles must first be understood and then proactive steps must be taken to overcome the obstacles or minimize their impact on attaining the vision.

2. Obstacles to Performance-Based Lifelong Learning

There are separate obstacles to implementing a system to support *performance-based learning* and implementing a system to support *lifelong learning*. However, there are even greater obstacles to implementing an integrated system to support *performance-based lifelong learning*:

- Performance-based learning requires that the system have *deep*, *exact* knowledge of what the person is doing and what they already know about that task to determine what they should learn now.
- Lifelong learning requires that the system have *broad, general* knowledge over a number of years of what the person has learned to determine what they should learn now.

Today, it is difficult to provide a system with deep, exact knowledge of what a person is doing and what they need to learn. Therefore, this capability is restricted to hand crafted systems in large organizations. Furthermore, this hand crafted system is limited in its access to broad, general knowledge about what the person has learned in the past because this knowledge is in databases that are not accessible to it.

The ultimate success of performance-based lifelong learning will be dependent on the sharing of knowledge and processes among the various organizations that make up the lifelong learning environment. Figure 1 describes some of these organizations along with the knowledge and the processes they must share:

- **Learner Profile:** A *learner profile* is needed that includes a description of the skills of an individual.
- **Competency Ontology:** Organizations must provide *competency ontologies* that describe the required competencies for specified job tasks and the relationships among these competencies.

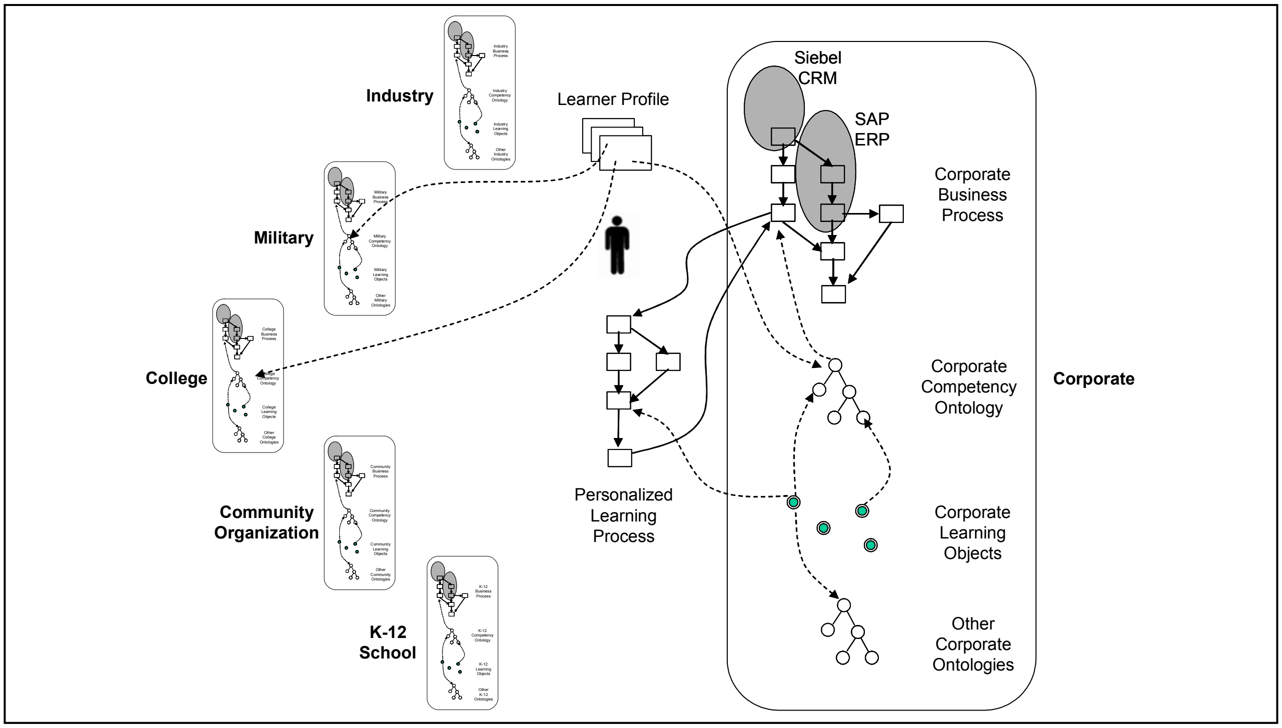

Figure 1: Sharing of Knowledge and Processes in a Lifelong Learning Environment

- **Other Ontologies:** Organizations must provide o*ther ontologies* that can be used to describe the products, customers, functional units, etc. of the organization.
- **Learning Objects:** Organizations must provide l*earning objects* that can be used to construct learning experiences.
- **Business Processes:** Organizations must provide representations of executable *business processes* that can be used to describe the context for personalized learning experiences.
- **Personalized Learning Processes:** *Personalized learning processes* will be automatically generated for an individual based on the task they are performing in a business process, the knowledge that they already have and any data on how they learn best.

For performance-based lifelong learning to be successful, Figure 1 illustrates that that the learner profile must be able to make reference to competency ontologies, learning objects and business processes in multiple organizations. This requires standards for representations of the various types of knowledge and standards for the protocol to access the various types of knowledge. Furthermore, it is likely that multiple organizations may create knowledge such as competency ontologies separately and mappings among the ontologies will be required.

But, technology advancements alone will not be sufficient to insure the success of performance-based lifelong learning. Much of the success will depend on a commitment by the various organizations in Figure 1 to share their knowledge. This commitment includes not only an organizational commitment to sharing system knowledge, but just as important, a commitment by individuals in the organizations to interact with individuals in other organizations.

The following section will list some potential technology issues related to overcoming the obstacles to performance-based lifelong learning.

3. Technologies for Performance-Based Lifelong Learning

3.1. Integration of E-Learning and Knowledge Management Technologies

E-Learning technology today is used primarily to handcraft training courses about carefully selected topics for delivery to people registered for those courses. On the other hand, knowledge management technology is used to rapidly capture, organize and deliver large amounts of corporate knowledge. These two technologies must be integrated in order to decrease the amount of time necessary to create learning experiences for large amounts of knowledge.

One way of understanding the impact of knowledge management on an organization is to look at the

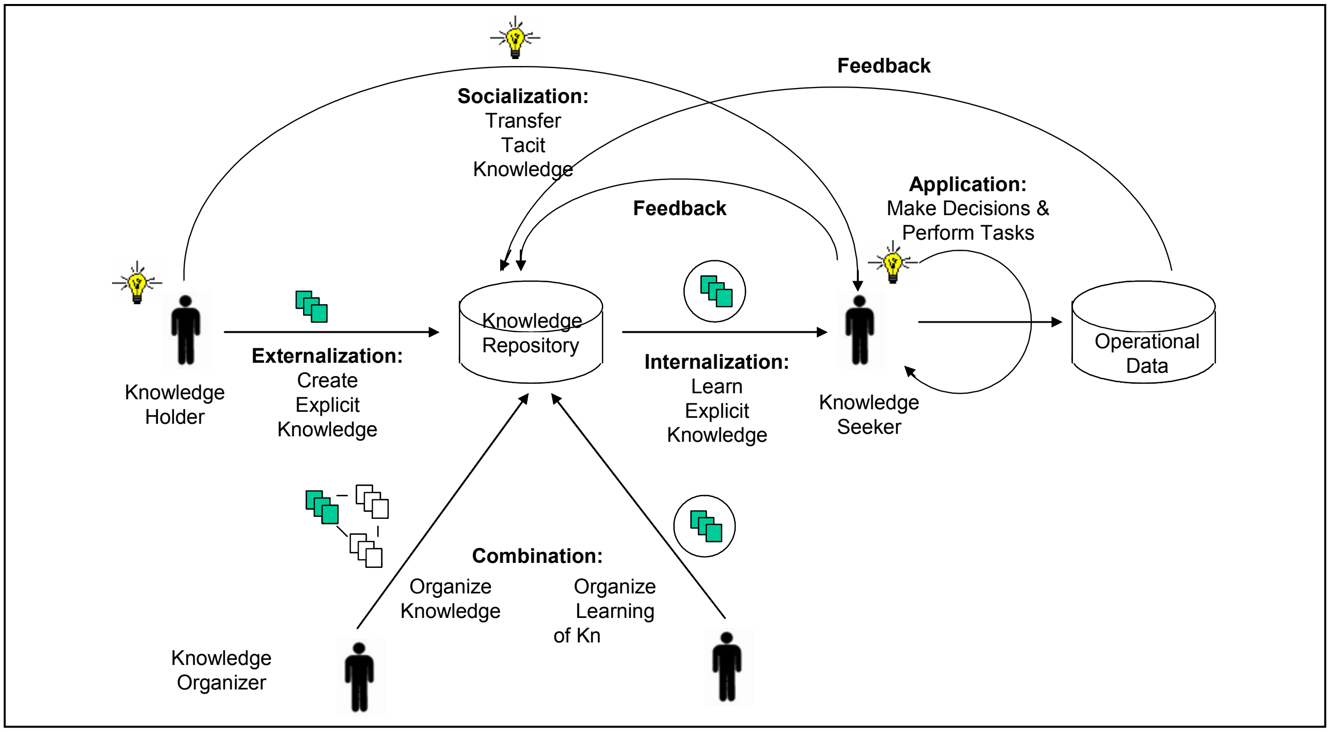

Figure 2: Knowledge Management with e-Learning Enhancements

knowledge management lifecycle and the flow of knowledge in the organization. Nonaka and Takenuchi [2] describe the relationship between tacit knowledge and explicit knowledge and have described four phases of knowledge conversion: Socialization, Externalization, Combination and Internalization. The goal of the implementation of knowledge management in an organization is to increase the amount of tacit knowledge that an individual has available to apply to solving business problems.

Figure 2 is a representation of the flow of knowledge described by Nonaka and Takenuchi with the addition of e-learning enhancements [3]. In Figure 2, a Knowledge Holder can either transfer tacit knowledge to a Knowledge Seeker through socialization or create explicit knowledge and store it in a knowledge repository. The Knowledge Organizer in Figure 2 is a person (or software program) who relates the created knowledge to other knowledge in the repository or further refines the created knowledge. The Instructional Designer is a person (or software program) who organizes the learning of the knowledge by adding pre-assessments, additional learning aids, post-assessments, etc. The Knowledge Seeker then learns the explicit knowledge through an online guided learning experience. The Knowledge Seeker then uses the knowledge gained through socialization or internalization to make decisions and perform tasks in the enterprise. The performance of the Knowledge Seeker on these decisions and tasks is measured and returned to the knowledge repository as feedback that can be used to help determine if the skills have been learned and to suggest additional e-Learning experiences perhaps to un-learn any old skills that interfere.

There has been some progress made in this integration of e-learning and knowledge management within a single corporation. However, broadening this progress to include the other organizations in Figure 1 will require sharing of *some* of the content of the *knowledge repository* and the *definition of tasks* of a corporation with other corporations in an industry and with other organizations related to that industry.

3.2. Creation and Sharing of Competency Ontologies

One the key components of the knowledge repository in Figure 2 that must be shared is the description of the competencies required for a given job task. This enables competency-based learning that uses required competencies to drive creation, organization and delivery of a learning experience. Figure 3 illustrates how a competency gap analysis and learning model selection are used to enable the creation of a personalized learning process [4].

Figure 3 illustrates the flow of activity to implement competency-based just-in-time learning services in an enterprise environment. At lower right is a representation

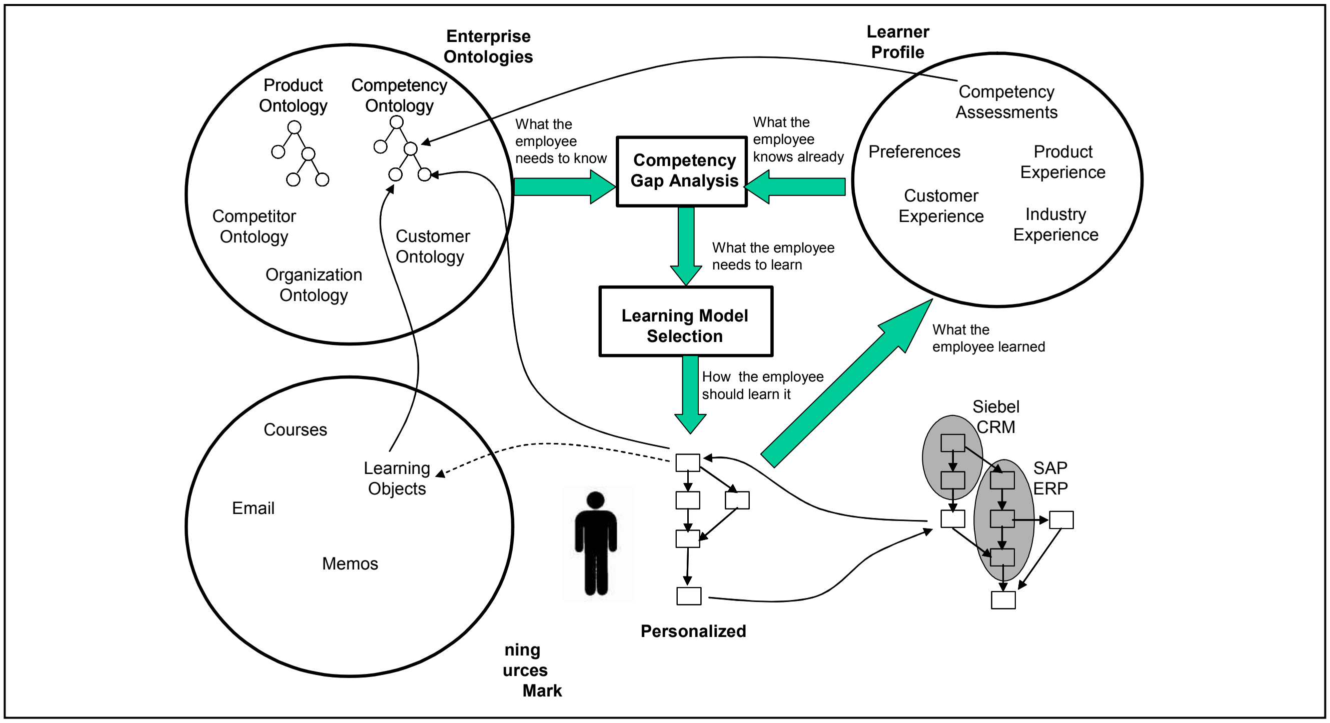

Figure 3: Competency-Based Learning

of a couple of the business processes of the enterprise. In the upper left are the ontologies that capture knowledge about the products, organizations, competitors, etc. of the enterprise. A competency ontology is included that captures the competencies that an employee must possess to participate in specific activities of the business processes. The lower left illustrates the learning resources such as learning objects, courses, email, etc. Each of these learning resources has been manually or automatically linked to various parts of one or more of the enterprise ontologies to enable people and software agents to more efficiently discover the correct learning resources. The upper right illustrates the learner profile for an employee that contains preferences, experiences and assessments of the employee's competencies. The box in the upper middle of the figure is a competency gap analysis that calculates what competencies the employee lacks to effectively carry out their job responsibilities. This calculation is based on what the employee needs to know and what they already know. Once the competency gap has been identified, a learning model is selected either manually or automatically. This establishes the most effective way for the employee to attain the competency and enables the system to create the personalized learning process at the lower middle of the figure. The personalized learning process may be created and stored for later use or it may be created as needed, thus enabling dynamic access to learning objects based on the most recent information about the learner and the environment. The results of the personalized learning process are then returned to the learner's profile.

There are some commercially available e-learning products that use competency hierarchies to capture the skills necessary for various job types. The competencies in these hierarchies are then mapped to courses that can improve an employee's competency in a certain area. This technique has been only moderately successful because of the lack of standard competency hierarchies. Furthermore, these existing competency representations do not capture the rich semantics that could be captured using an ontology representation [5]. A competency ontology can capture the relationships among various competencies and relationships with other ontologies, such as the product ontology for a corporation. A competency ontology will also allow reasoning about the competencies.

3.3. Web Services and Semantic Web Services

Each box in the business processes and the personalized learning processes in Figures 1 and 3 is an activity. These activities might be implemented as existing legacy applications or new applications on a variety of hardware and software systems. In the past, it would have been difficult to integrate applications executing on such heterogeneous systems. But the development of a set of technologies referred to as *web services* [6] has potentially simplified this integration.

However, present web services technologies have limited capability for representing semantic descriptions of available web services. The discovery of services is limited to using restricted searches of keywords associated with the service. This is insufficient for the discovery of learning objects and other learning services. The World Wide Web consortium and the Department of Defense have been funding an effort to develop specifications for a *semantic web* and *semantic web services* [7] [8], needed to integrate services inside of the corporation. This will be critical to integration of learning services across the organizations in Figure 1.

3.4. Integration of Business Processes and Personalized Learning Processes

A key requirement for the success of the systems in Figures 1, 2 and 3 is the ability to explicitly represent the processes in the corporation and other organizations. There must be a representation for the business processes so that competencies can be mapped to a specific activity in a business process. There must be a representation of personalized learning processes to enable integration of these learning processes with business processes. There have been various attempts to standardize the representation of business processes [9] [10]. There are now numerous efforts underway to standardize on a process representation for web services. At present, IBM and Microsoft have competing proposals for a process representation [11] [12]. There has also been an effort within the DARPA DAML program and the DARPA CoABS [13] program to standardize on a more semantically expressive representation of processes.

3.5. Deployment of Intelligent Software Agents

Intelligent software agents can be deployed in a system such as the one described in Figure 1, 2 and 3. In the past, there has been extensive research into the use of software agents for discovery of information [14], collaboration planning and automation of processes [15] and numerous other applications [16]. This research is now focusing on the use of software agents with web services [17]. Once the semantics of the services and processes in Figure 1, 2 and 3 have been adequately described, autonomous software agents can be much more effective. These agents can proactively search for learning objects both inside and outside of the enterprise that are needed to meet dynamically changing learning requirements. Furthermore, the role of simulations as a technique for training will be increased [18]. Developing a simulation of a business process using software agents will be simplified and the simulations can be integrated more directly with the business processes, especially if the teaching intentions inherent in learning objects can be modeled explicitly for use by agents [19].

4. Conclusions

Performance-based lifelong learning is critical to the goal of effectively providing a workforce that meets the evolving needs of industry and government for skilled workers. There are numerous obstacles to the implementation of performance-based lifelong learning but recent technology advancements have brought us one step closer. The final steps will require a coordinated effort among software vendors, industry organizations, educational institutions and standards organizations to evolve the technologies described in this paper.

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