DEVELOP ADAPTIVE WORKPLACE E-LEARNING ENVIRONMENTS BY USING PERFORMANCE MEASUREMENT SYSTEMS

Weijia Ran and Minhong Wang

Division of Information & Technology Studies, Faculty of Education, The University of Hong Kong, Hong Kong

Keywords: Workplace Learning, Adaptive E-learning, Performance Measurement System.

Abstract: Workplace learning is an environmental contextual and dynamic procedure. Needs and desires in workplace learning arise from actions and practices in working environment; learning contents consist of explicit and tacit knowledge dynamically created and intertwined with working and practicing. The development of an effective workplace E-learning system is faced with several problems: 1) How to specify and update learning needs and desires in contextual and dynamic workplace settings? 2) How to activate and formalize knowledge sharing and contribution procedure for collecting knowledge emerged during practices in working communities? 3) How to organize and store knowledge pieces in a way that reflects workplace learning needs and supports adaptive learning content delivery? 4) How to incessantly update and adjust learning contents to keep up with the changing working context? In order to solve these problems, we propose an adaptive workplace learning model, in which the performance measurement result is used as an indication of working proficiency, a reflection of learning needs, and a sign of the level and quality of knowledge shared and contributed for achieving specific performance, with a view to organizing learning contents and effectively guiding learning and knowledge sharing process.

1 INTRODUCTION

Recently the focus of E-learning is shifting from implementation infrastructures and simply delivering learning materials (Shute and Towle, 2003) by incorporating theoretical aspects from domains such as education or cognitive science. The concept of adaptive E-learning environment is brought forward in this trend. The theory ground of adaptive E-learning is that learning effectiveness is influenced by differences among individuals. The true power of adaptive E-learning resides in its ability to provide instructional contents that adapt to learners' needs and desires (Shute and Towle, 2003).

Workplace learning is an environmental contextual and dynamic procedure. Needs and desires in workplace learning arise from actions, practices and activities in working environment and concern job requirements, working performances and proficiencies. A fundamental part of learning contents which can fulfil these needs and desires usually consists of explicit or tacit workplace knowledge dynamically created and intertwined with working and practicing. Many adaptive E-learning systems are designed in school settings where learning needs and contents are much different from those in workplace sceneries. To facilitate an adaptive E-learning environment in workplace E-learning by utilizing the typical adaptive E-learning mechanism is faced with several problems. Firstly, how to specify and update learning needs and desires in contextual and dynamic workplace settings? Second, how to activate and formalize the knowledge sharing and contribution procedure for collecting working knowledge emerged during practices in communities in workplace settings? Third, once workplace knowledge is collected, how to organize and store them to reflect workplace learning needs and desires and smooth the progress of adaptive learning content delivery? Fourth, how to incessantly update and adjust learning contents to keep up with the changing working context?

In order to solve these problems, we propose an adaptive workplace learning model using performance measurement systems to organize learning contents and effectively guide the knowledge sharing and adaptive learning content

delivery process. We hypothesis employees' performance measurement results are the indication of their working proficiencies, the reflection of their learning needs and desires, and the sign of the level and quality of knowledge shared and contributed by them.

In the following, we review the typical mechanism of adaptive E-learning system in the first section. The second and third sections examine problems encountered when using this mechanism under a workplace learning context and review relevant workplace learning theories, which lay the foundation for our solution to these problems. The fourth section presents our adaptive workplace E-learning system model, and the fifth section introduces the architecture design of this system. Finally, there is a conclusion of the current work and a brief introduction to the further work.

2 ADAPTIVE E-LEARNING MECHANISM

The primary goal of an adaptive E-learning system is to deliver the right content, to the right person, at the right time, in the most appropriate way (Shute and Towle, 2003). In other words, by referring to individuals' needs and desires, an adaptive E-learning system decides what should be delivered, when should be delivered and how should be delivered.

In order to achieve the adaptability, the first step in an adaptive E-learning system is to capture learners' needs and desires. A diversity of needs and desires are identified to be adapted, such as learners' learning goals, general abilities, and curriculum achievement levels, etc. (Mödritscher et al., 2004). There are typically two approaches to retrieve all these different needs and desires. Macro-adaptation approach retrieves needs and desires by using diagnostic assessments before learners start to learn certain learning contents. These needs and desires are called domain-dependent information, which shows learners' proficiencies in learning contents (Shute and Towle, 2003). Micro-adaptation approach retrieves needs and desires by conducting assessments of learners' on-task performance such as response errors, latencies etc. These needs and desires are called domain-independent information, which includes learners' cognitive abilities, preferences and so on (Shute and Towle, 2003). Conventional tests are usually used in the first approach, while in the second approach assessments embedded within interactive, problem-solving, or open-ended tasks may be used (Shute and Towle, 2003).

After learners' needs and desires are identified and retrieved, the next issue in adaptive E-learning concerns how to interpret these needs and desires to deduce what content should be delivered at what time and in what an approach. Course materials are decomposed into a set of Learning Objects (LOs) (Learning Technology Standards Committee of the IEEE, 2002) and stored in the content model. Information about dependency relations among LOs are identified and subsequently are used to decide upon adaptations (Brusilovsky, 2003). The learner model contains information that is collected from assessments and is used by system to decide what, how and when to deliver next (Shute and Towle, 2003). The instruction model defines adaptation rules to describe how adaptation should be performed (Paramythis and Loidl-Reisinger, 2004). At last, adaptive model presents adaptive learning contents depending on information retrieved from former models (Shute and Towle, 2003).

To summarize, an adaptive E-learning system delivers tailored learning contents at proper time in an appropriate way relying on learners' specific needs and desires. Learning contents are stored in the content model as LOs with a knowledge structure. Needs and desires are deduced from learners' assessment results and represented in learners' models related to LOs. The adaptive model picks up suitable LOs and presents to learners in a proper way by interpreting adaptation rules defined in instruction model.

3 PROBLEMS OF ADAPTIVE E-LEARNING MECHANISM IN WORKPLACE SETTINGS

Adaptive E-learning systems are usually designed and implemented in school settings. However, learning in workplace is much different from school learning in terms of the learner, learning content and learning context. In order to facilitate adaptive E-learning in workplace, we should tackle the following questions: 1) What are learners' needs and desires in a workplace context and how to capture them? Can we use the usual approach such as pre-task and on-task assessments to capture them? 2) What are learning contents in a workplace context and how to present and organize them? Are they common course materials and can be presented as a set of related LOs?

In workplace learning, learning needs and desires are more objective oriented and considerably inspired by learning environments. From the viewpoint of Malcom Knowles's adult learning study, adult learners are goal-oriented, relevancy-oriented and practical. Needs and desires of adult learning are distinct from college students learning in that in organizations. Employees learn in the aim of immediate application. Learners in school context may put more emphasis on understanding of theories and concepts and habitually aim at higher grades (Constantine, 2004). From the perspective of expectancy model in workplace learning transfer theory (DeSimone et al., 2002; Kontoghiorghes, 2002), employees are motivated to learn if they believe skills and knowledge learned can be utilized back to job and are linked to intrinsic and extrinsic rewards, and skills and knowledge learned can help to enhance individual and organizational performance. Other workplace learning theories include learning is driven by learners' needs of meaning making(Winch and Ingram, 2002) and social identity establishing (Brubaker and Cooper, 2000) in organizations.

To sum up, most significant learning needs and desires in workplace learning are neither domain-dependent (knowledge proficiencies of course content) nor domain-independent (personal traits such as cognitive abilities and preferences), rather, they are driven by job contents, working performances, achievements and recognitions in organizational settings. Therefore, it might be hard to deduce needs and desires in a workplace context using assessment approaches in typical adaptive E-learning systems.

In terms of learning contents, knowledge in workplace is environmental contextual and dynamic (Wang et al., 2005, 2006). Situated learning theory believes that knowledge is defined under a specific setting or context and facts are determined by cultural standards and social practices (Tyre and Hippel, 1997). (Lave and Wenger, 1991) have described workplace learning as a process of "changing participation in the culturally designed settings of everyday life" and indicated that knowing is created and intertwined with doing and knowledge emerges during practices in communities. Working knowledge is local and constantly created and recreated inside communities eventually (Fenwick, 2001). Explicit knowledge can be generalized, codified and formally transmitted within organizations (Brookfield, 1992; Megginson, 1996; Rigano and Edwards, 1998). In contrast, tacit knowledge embeds in actions and practices of specific social and cultural context in an organization and is hard to capture. Much research efforts have been put into how to convert tacit knowledge into explicit knowledge with the intention that to utilize tacit knowledge to benefit the organizations (Nonaka, 1994; Eraut, 2000).

In brief, rather than pre-defined and fixed course materials in conventional school instructions, workplace learning contents dynamically generate from working environments and are in explicit or tacit forms inhabiting in various carriers such as work documents, employees' experience, experts' advice etc. They are discrete and independent pieces of information loosely distributing in an organization. Although each piece of information can be treated as an LO, it is difficult and less meaningful to organize them within a knowledge structure defining interdependent relationships such as learning sequences or abstract levels.

4 ADAPTIVE WORKPLACE E-LEARNING MODEL

In light of all this background considerations, we propose an adaptive workplace E-learning model driven by the performance measurement system in organizations. The underlining hypothesis is that the performance measurement results are the indicator of employees' in time working proficiencies, learning needs and desires. Learning contents are contributed by employees, stored and organized in the system tagged with contributors' performance measurement results, and adaptively delivered to employees relying on their performance expectations.

Performance measurement is a crucial procedure for organization development and a main driver of employees' learning activities (Stephanie, 2005). (Slizyte and Bakanauskiene, 2007) have summarized it as a systematic procedure to improve performance by setting performance objectives, assessing performance, collecting and analyzing performance data, and utilizing performance results to drive performance development. There is a diversity of performance measurement systems, such as Key Performance Indicators (KPI), Balanced Scorecard (BSC), and Excellence Model (EFQM) etc. Different system emphasize on measurement of different aspects. For example, BSC assesses performance from perspectives such as financial, customers, processes, learning and growth; EFQM focuses on a range of elements such as people, leadership, products etc. KPI is a flexible performance measurement system which is used to assess almost

any perspective, whatever financial or non-financial, depending on individual organization's design. Plus, it is still in the dominant role although there are a growing number of organizations who have implemented BSC and EFQM (Robinson et al., 2005). Hence, KPI is selected as the performance measurement system in our model.

KPI show a clear picture for each individual in organization what is important and what they need to do (Slizyte and Bakanauskiene, 2007). In a KPI performance measurement system, organizational vision and mission are interpreted into clear defined department goals and objectives, which are then broke down into performance targets related to each job category reflecting specific organization strategies, official and technical requirements for individual employees. Thus, each job is assigned a specific KPI, which is a set of items measuring different performance perspectives. During a performance assessment process, an employee's actual working performance is compared with performance targets defined in his/her job KPI and each KPI item is marked with a score similar to the score in examinations. The set of score is called the employee's performance result or KPI Value. An organization conducts performance measurements with a certain frequency and an employee obtains a certain performance result in each performance measurement event.

Learning contents in our model come from working knowledge contributed by employees in the form of digital files. Each digital file is similar to an LO in a typical adaptive E-learning system, and is called a learning case in our model. Different learning cases may contain different materials. A case can be a piece of course material, a paragraph of programming code, a recommended booklist or an article about a project experience. We provide four groups (Study Plan, Course Material, Recommendation, and Experience) to categorize cases. Each case is stored in the system under a certain group, indexed with contributor's system ID and performance result obtained at the time of contribution.

Learning content storage or delivery is triggered when an employee inputs his/her current performance result and expected performance result into the system to retrieve a tailored learning solution. If the employee's performance result meets predefined criteria, we assume that there might be valuable working knowledge embedded in this employee and the system would ask the employee to contribute learning cases. Otherwise, the system would deliver a learning solution containing cases matching the employee's input according to predefined matching rules. Each learning solution belongs to an employee and has its own lifetime, which starts when it is delivered and ends when its owner closes it. Employees control learning pace by themselves and can evaluate and revise learning cases once they finish learning them. Learning cases with too much negative comments or too low access rate would be eliminated from the learning content base.

There are three major differences between a typical adaptive E-learning mechanism and our adaptive workplace E-learning model: 1) the former retrieves the learner's attributes relevant to learning contents through assessments within the system; the later deduces these information relying on performance measurements in realistic organizational settings; 2) the former has fixed learning contents within a course scope; the later bears a learning content base generated from workplace knowledge and dynamically contributed, adjusted and refined by learners and managers; 3) the former stores learning contents as interdependent LOs with distinct attributes; the later organizes learning contents as learning cases under the KPI system hierarchy and indexes them with contributor's KPI Value.

5 ARCHITECTURE DESIGN

Architecture of our adaptive workplace E-learning system is designed as a conventional three-layer structure (see Figure 1). Interface Layer is responsible for interaction with employee-learners. Application Layer contains four function modules. The Learning Solution Manager deals with basic events happened in a learning solution's lifetime and acts as a platform to use other modules when necessary. It updates a learning solution record when the learning solution starts or ends, uses the Learning Case Creation Manager to store learning cases when a learner has knowledge contribution, asks the Case Retrieval Manager to search learning cases when a learner requires a learning solution, and requests the Case Adjustment Manager to refine a learning case when a learner ends the learning case. The Repository Layer stores learning content as well as accessorial information supporting adaptive learning content delivery (such as data stored in the KPI System and the Employee). The Learning Case is the organizational learning content base, including all
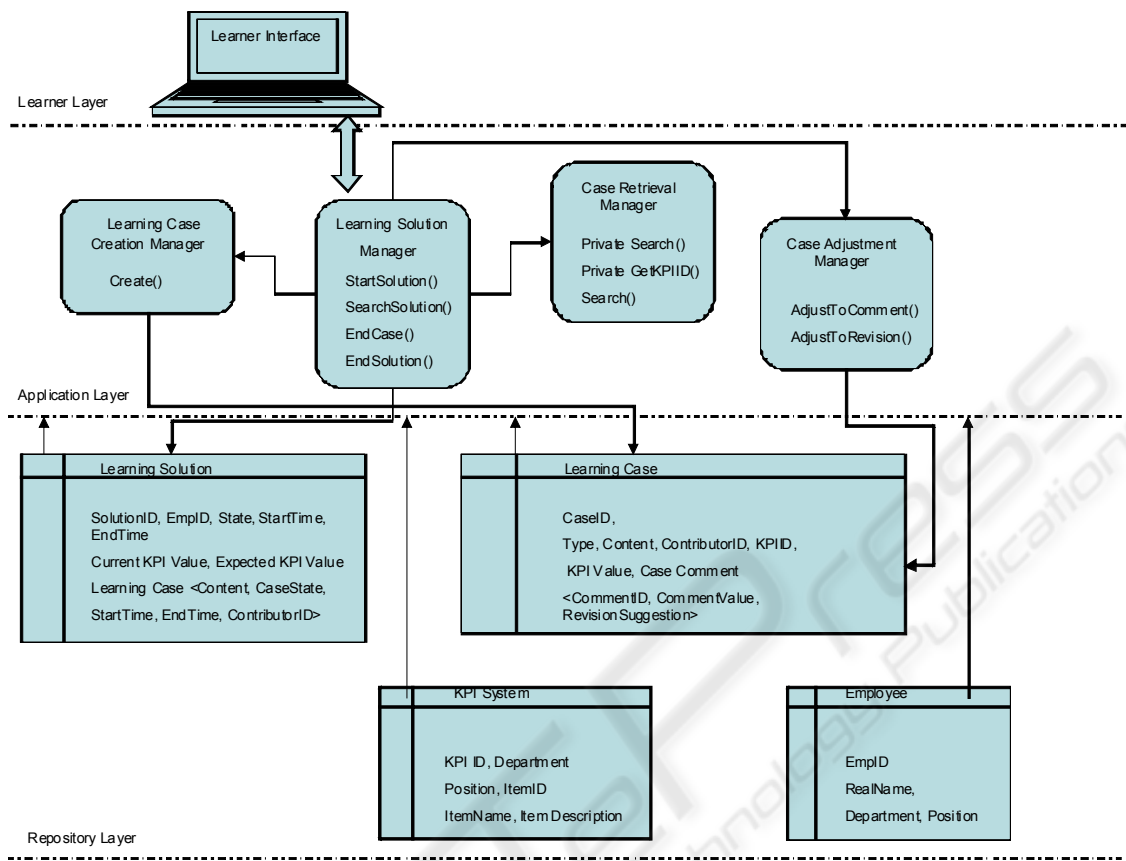
Figure 1: Adaptive Workplace E-learning System Architecture.

learning cases contributed by all learners; The Learning Solution is individual learning content base, including a set of personal adaptive learning cases.

6 CONCLUSIONS

In order to improve the effectiveness of workplace E-learning, we have proposed an adaptive workplace E-learning model based on adaptive E-learning mechanism and workplace learning theories. It aims to facilitate an adaptive workplace E-learning environment where 1) employees' workplace learning needs can be clearly specified and personally satisfied; 2) working knowledge in organizations can be well organized and dynamically refined. The objective is achieved by: 1) using employees' performance measurement results to define their learning needs and desires; 2) collecting working knowledge from employees, storing them as learning cases, and indexing them with contributors' performance measurement results;

3) adjusting and refining learning cases based on learners' feedback. Three-layer system architecture has been designed based on this model. The further study consists of a detailed system design, a prototype construction and the justification of the effectiveness of this system.

ACKNOWLEDGEMENTS

REFERENCES

Brookfield, S. 1992. Uncovering Assumptions: The Key to Reflective Practice. *Adult Learning*, 3(4):13-18.
Brubaker, R., Cooper, F. 2000. Beyond 'identity'. *Theory and Society*, 29:1-47.

Brusilovsky, P. 2003. Developing adaptive educational hypermedia systems: From design models to authoring tools. In Murray, T., Blessing, S., Ainsworth, S (eds.). *Authoring tools for advanced technology learning environment*. Dordrecht: Kluwer Academic Publishers.

Constantine, K. 2004. Reconceptualizing the learning transfer conceptual framework: empirical validation of a new systemic model. *International Journal of Training & Development,* 8(3).

Derouin, R. E., Fritzsche, B. A. & SALAS, E. 2005 E-Learning in Organizations. *Journal of Management,* 31:920.

Desimone, R. L., Werner, J. M. & Harris, D. M. 2002. *Human Resource Development.* 3rd ed. Orlando, FL: Harcourt, Inc.

Eraut, M. 2000. Non-formal Learning and Tacit Knowledge in Professional Work. *British Journal of Educational Psychology*, 70:113-136.

Fenwick, T. 2001 Tides of Change: New Themes and Questions in Workplace Learning. *New Directions for Adult and Continuing Education***,** 92:3-17, Win.

Kontoghiorghes, C. 2002. Predicting motivation to learn and motivation to transfer learning back to the job in a service organization: a new systemic model for training effectiveness. *Performance Improvement Quarterly*, 15:114-129.

Lave, J., & Wenger, E. 1991. *Situated Learning: Legitimate Peripheral Participation.* Cambridge: Cambridge University Press.

Learning Technology Standards Committee of the IEEE. 2002. Draft Standard for Learning Object Metadata. IEEE 1484.12.1-2002 ed. New York, Institute of Electrical and Electronics Engineers.

Megginson, D. 1996. Planned and Emergent Learning. *Management Learning*, 27(4):411-428.

Modritscher, F., Garc A-Barrios, V. M. & G Tl, C. 2004. The Past, the Present and the Future of adaptive E-Learning. *Proceedings of ICL*. Villach, Austria.

Nonaka, I. 1994. A Dynamic Theory of Knowledge Creation. *Organization Science*, 5(1):14-37. Pedler, M. (ed.). 1991. *Action Learning in Practice*. 2nd ed. Aldershot: Gower.

Paramythis, A. & Loidl-Reisinger, S. 2004. Adaptive Learning Environments and e-Learning Standards. *Electronic Journal on e-Learning,* 2(1):181-194.

Rigano, D. & Edwards, J. 1998. Incorporating Reflection into Work Practice. *Management Learning*, 29(4):431-446.

Robinson, H. S., Anumba, C. J., Carrillo, P. M. & Al-Ghassani, A. M. 2005. Business performance measurement practices in construction engineering organisations. *Measuring Business Excellence,* 9(1):13-22.

Shute, V. & Towle, B. 2003. Adaptive E-Learning. *Educational Psychologist,* 38(2)**:**105-114.

Slizyte, A. & Bakanauskiene, I. 2007. Designing performance measurement system in organization. *Organizacij Vadyba: Sisteminiai Tyrimai,* 43.

Stephanie, S. 2005. Signs of the times. *Training Magazine*.

Tyre, M. J. & Hippel, E. V. 1997. The Situated Nature of Adaptive Learning in Organizations. *Organization Science,* 8(1):71-82.

Wang, M., Wang, H. & Xu, D. 2005. The Design of Intelligent Workflow Monitoring with Agent Technology. *Knowledge-based Systems*, 18 (6): 257-266.

Wang, M. & Wang, H. 2006. From Process Logic to Business Logic -- A Cognitive Approach to Business Process Management. *Information & Management*, 43(2):179-193.

Winch, A. & Ingram, H. 2002. Re-defining the focus of workplace learning. *International Journal of Contemporary Hospitality Management,* 14:361-367.