DOCUMENT RESUME

ED 470 174 IR 021 616

AUTHOR Sheu, Feng-Ru

TITLE Activity Theory Framework and Cognitive Perspectives in Designing Technology-Based Support Systems.

PUB DATE 2001-11-00

NOTE 8p.; In: Annual Proceedings of Selected Research and Development [and] Practice Papers Presented at the National Convention of the Association for Educational Communications and Technology (24th, Atlanta, GA, November 8-12, 2001). Volumes 1-2; see IR 021 504.

PUB TYPE Reports - Evaluative (142) -- Speeches/Meeting Papers (150)

EDRS PRICE EDRS Price MF01/PC01 Plus Postage.

DESCRIPTORS Cognitive Psychology; *Computer System Design; Educational Research; *Instructional Design; Learning Activities; Learning Theories; Social Psychology

IDENTIFIERS *Activity Theory; *Performance Support Systems

ABSTRACT

With the increased demand and interest in electronic performance support systems (EPSS), particularly for supporting knowledge-based problems solving expertise in the information age (Gustafson, 2000; Dickelman, 2000; Kasvi & Vartiainen, 2000), instructional designers are facing a new challenge designing a system that could deliver (or transfer) expertise in a particular knowledge domain to learners/users. This paper conceptually elaborates the traditional concept of expert performance by Glaser et. al, and discusses a series of attributes for supporting or nurturing an environment for expertise. An overview of EPSS is given, then two areas of studies related to (advanced) EPSS design are given. One is expertise from cognitive psychology; the other is activity theory proposed by socio-culture psychology. Then, an alternative point of view from a standpoint of activity theory (social constructive theory) is taken to see how one (an instructional designer) might support an expertise in the areas of designing technology-based performance support systems. (Contains 67 references.) (Author/AEF)

Activity theory framework and cognitive perspectives in designing technology-based support systems

Feng-Ru Sheu
Indiana University

Abstract

The paper conceptually elaborates the traditional concept of expert performance by Glaser et. al, and discusses a series of attributes for supporting or nurturing an environment for expertise. Then an alternative point of view from a standpoint of activity theory (social constructive theory) will be taken to see how one (instructional designer) might support an expertise in the areas of designing technology-based performance support systems.

Introduction

With the increased demand and interest in electronic performance support systems (EPSS), particularly for supporting knowledge-based problem solving expertise in the information age (Gustafson, 2000; Dickelman, 2000; Kasvi & Vartiainen, 2000), instructional designers are facing a new challenge designing a system that could deliver (or transfer) needed knowledge (expertise in a particular knowledge domain) to learners/users, because we do not really know what it is that learners need to learn to become effective problems solvers within the context that learning (or performance require) occurs (Backler, 1988). The questions include "What skilled/experienced problem solvers (or expert performer) go about solving a problem (a task)?" and "What kinds of knowledge they make use of when doing so?" In short, we do not really know what expertise is required for individual learners to perform particular tasks within certain conditions, and if we do not know this then how do we design an effective system to delivery them.

However, an alternate view of cognition has been developing over the past three decades or so: expertise researches from cognition psychology. Other researches that influence instructional design are so called: situated cognition, distributed cognition, activity theory, and other dimensions relating to social-cultural perspectives have been brought into attention by socio-culture psychology. Fundamentally, these notions stress the individual minds (expertise and mental model), the environment (or authentic contexts), and the tight interrelations among them (Hung, Koh, & Chua, 2000). In this paper, the author will focus on activity theory only.

Instructional designers are designing instructional environments both to understand the improvement of performance and to further define theories applicable to the design of conditions for learning. Therefore, the objective for the EPSS designer is for more people (novices and intermediate learners) to attain competence at higher levels (expert) than ever before. Given the notion that different performance may require different support, the EPSS designer needs to understand what knowledge expertise is required, how expertise (knowledge; skills) was acquired, for different individuals and in what conditions. To reach their goal, EPSS designers began to accommodate changes in theory and practice and did so in a way that added value to the discipline. Two disciplines that increasingly influenced instructional design are researches on expertise from cognitive psychology and activity theory from socio-culture psychology.

In this paper on the literature, the author will first give an overview of EPSS then review two areas of studies related to (advanced) EPSS design. One is expertise from cognitive psychology; the other is activity theory proposed by socio-culture psychology.

What is EPSS and why should instructional designers be interested in it?

What is an Electronic Performance Support System (EPSS)? "EPSS" is still a relatively new term in the field of corporate training and instructional design, having been first introduced by Gery in 1989. An EPSS refers to any electronic integrated system or infrastructure that can provide access to information and tools to enable individuals to achieve a high level of performance in a short amount of time and with a minimum of support from other people. According to *EPSS InfoSite*, an EPSS can also be described as any computer software program or component that improves worker performance by

1. reducing the complexity or number of steps required to perform a task,
2. providing the performance information an employee needs to perform a task, or
3. providing a decision support system that enables a worker to identify the action that is appropriate for a particular set of conditions.

Currently, corporations are benefiting from the implementation and usage of integrated electronic systems (Raybould, 1995; Kasvi, 2000; Gustafson, 2000). For example, a large corporation may combine its many electronic tools (such as databases, word processing, e-mail, and calendars) into an EPSS to facilitate ease of access and usage. By using an EPSS, information or tools are more easily accessible, thus increasing the workers' efficiency (Gery, 1991; Kavat, 1997; Raybould, 1990).

When the workplace becomes increasingly complex, quick, and accurate the speed and accuracy of information processing becomes a competitive necessity, especially in the technology-rich-rapidly changing information age. In the information age, even experts may have to struggle to maintain their level of performance (Winslow and Bramer, 1994). With advances in technology, it becomes possible to provide a variety of new forms of support to aid worker performance, promote workers' satisfaction (confidence), shorten the process of transforming a novice into an expert, and potentially reducing the amount of training they require.

The definition of EPSS varies. Among other terms used are: performance support, online performance support, performance support tool, performance support engineering, performance centered design, and Embedded Support (Gustafson, 2000). The definition of EPSS here tends to be broad and encompassing. Thus, it includes everything from the simple database that provides information to workers (for example item price and customer information) to EPSSs for the complex tasks that involve complex cognitive skills (such as air traffic control systems based on expert systems and artificial intelligence).

The elements and characters of what an EPSS constitutes also vary. Gery (1991) included four elements: an information base, advisor, tutorials, and tools to assist the user. In the past decades, EPSS design has matured; it is not limited to Gery's four elements. "Information bases may include multiple knowledge sources; advising may take on features of expert systems or artificial intelligence; tutorials may be extensive and contain contextual multimedia instruction; and the tools have become more sophisticated (Gustafson, 2000; p. 37)."

However, as an instructional designer, we have every reason to believe these trends will continue, the demand of creating/developing EPSSs will grow, and the design of EPSS will not become less complex and less challenging as the rate of change keeps accelerating.

What are these studies on expertise about and why should instructional designers be interested in the theory of expertise?

"It is likely true that all humans have some form of mental model or conceptualization of the operation and function of any piece of technical equipment (Johnson, 1988)." Whether accurate or not, understanding how humans learn and process knowledge (expertise) helps instructional designers in developing effective learning/support systems. As mentioned before, EPSS designers are interested in knowing what expertise is required for individual learners to perform particular tasks within what conditions and then how do we delivery them as instructional designers. In the past few decades, cognitive psychology has been studying and developing this.

Chase and Simon (1973) and deGroot (1965) were among the first to explore the development of expertise in master chess players and they proposed an information-processing perspective (theory) as the analogy of the human processor. Since then, a great deal of research has been carried out in the area of expertise in problem-solving areas, such as chess, bridge (Charness, 1979), physics (Chi, Feltovich, & Glaser, 1981), mathematics (Schoenfield and Herrmann, 1982), and medical diagnosis (Patel & Groen, 1986). More recently, research has expanded to the instructional design field (Rowland, 1992; Perez & Emery, 1995; Perez, Johnson, & Emery, 1995; Le Maistre, 1998; Julian, Larsen, & Kinzie, 1999), the sport domain, and parallels between sport and the more traditional cognitive tasks have been evidenced. However, with the studies to date, emphasis is the relationship between expertise and human competence in general. What we learn about expert performance and its acquisition is applicable to understanding and improving competence in the skills and knowledge learned in school and in the workplace.

1. Expert behaviors are different in terms of cognition structure (mental model). Experts have organized their knowledge into complex structures that link the abstract conceptualizations of the domain with the surface features of the system (Chi, Glaser, & Rees, 1982; Chi, Feltovich, & Glaser, 1981). The development of knowledge/expertise is acquired in such a way that it is highly connected and articulated, so that inference and reasoning are enabled, as is access to procedural

actions. In short, those organizations of knowledge provide a schema for thinking and cognitive activity.

2. The structures of knowledge expertise/skills are developed. The work of Laufer & Glick (1996) proved that the four major interactive skill components that expert performers coordinate when troubleshooting: system, procedural, strategic knowledge (macro-level cognitive skills architecture) and strategic decision factors (inform the decision-making process of strategic knowledge).
3. Learning/expertise is a continuum. The progression can be described in terms of three interactive phases: (a) external support; (b) transition (c) self-regulation (Glaser, 1996). At each different phase, the use of external support with the performer calling on competitors, performance situations, and the advice of coaches as particularly needed is very selective. In this regard, we should design improved and supportive environments for different kinds of learning (performance) (accordingly)

Putting it all together, we believe (a) cognitive performance models believed to be detailed enough to provide the criterion performance for an instructional system; (b) a developmental trajectory depicting the skill acquisition path from novice to expert; and (c) individual learning and performance differences that result in impasses or barriers along the skill acquisition trajectory (Gott & Lesgold, 2000) are important in learning/performance. Therefore, EPSS designers will be able to identify critical learning and support elements during the design process.

EPSS designers are interested in understanding how an integrated, un-simplified form of real-world competence evolves over time as well as in searching for detailed cognitive performance models that could drive effective instruction and then integrate them into learning systems (for effective learning), because real-world learning and problems are unpredictable, dynamic and complex.

Knowledge gained fromthese studies contributes to the design of optimal instructional processes for acquiring expertise, or at least facilitating its development. Most of the research cited above, however, is quite basic and was not guided by a desire to improve the process of designing EPSSs. What we would like to do here is describe an additional approach, *Activity Theory*, that has been emphasized in several recent research studies (Laufer & Glick, 1996; Jonassen & Rohrer-Murphy, 1999; Hung, 1999; Hung, Koh, & Chua, 2000; Hung & Wong, 2000)

Activity Theory

According to Hung & Chen (2000) the basic structure of an activity consists of the (a) intended object to be achieved by (b) subjects involved within the context of (c) a community where work is mediated by (d) tools, (e) rules of the practice, and (f) division of labor (Cole & Engestrom, 1991; Jonassen & Rohrer-Murphy, 1999; Kuutti, 1996). Thus Activity cannot be understood or analyzed outside the context in which it occurs.

Activity theory originated within the cultural-historical school of Soviet Psychology and classical German philosophy (Wertsch, 1981; Hung, 1999; Jonassen & Rohrer-Murphy, 1999; Hung & Wang, 2000). Following that, it was subsequently followed up by current researchers in Social-Cultural Psychology, such as situated cognition, distributed cognition, activity theory, and other dimensions relating to social-cultural perspectives (Hung, Koh, and Chua, 2000). The fundamental notion is that there are close interrelations between the individual mind with others and the environment or authentic context(s). As an EPSS designer, we need to be more concerned with the context in which learning and performance occurs, as well as the design process itself.

Knowledge is socially constructed based on the processes of internationality, history, culture, and tool mediation. The production of any activity involves individuals, the object of the activity, the tools that are used in the activity, and the actions and operations that affect an outcome (Nardi, 1996; Hung, 1999). Rather than focusing on knowledge states and representations, the work of Laufer & Glick (1996) focuses on the activities in which people are engaged, the nature of their tools, the social relationships, the contextual factors, and the goals and outcomes of activity. As a result, "learning occurs only in the context of meaningful activity, it is important to analyze the activity and the contexts as part of instructional design process (Jonassen & Rohrer-Murphy, 1999)."

Implementations To EPSS Design

Instructional designers should focus not only on the products or outcomes of learning but also on the historical and genetic processes that lead to the resultant phenomena. Hung, Koh, & Chua (2000) concluded two fundamental reasons for this.

1. Culture, though man-made, both forms and makes possible the workings of the human mind; thus, learning and thinking are always situated in cultural settings and always depended upon the utilization of cultural resources.
2. Because human action and learning are primarily socio-culturally situated, even when the individual sits in solitude and contemplates something, he or she is socio-culturally situated by virtue of the mediational means he/she employs

In addition, jobs are placing greater cognitive demands on workers. In job environments such as aviation, operating rooms, and command and control centers, especially where time-constrained decisions are critical to overall performance, there is a growing demand for cognitive analysis to support the design of job aids and training systems. Within these operational environments, cognitive analysis is evolving from research and development projects to applied cognitive analyses integrated with traditional instructional design processes (Redding & Seamster, 1994). Activity approach has been proposed in Laufer & Glicks' study (1996) for investigating an everyday work task by novices and experts.

Activity is not merely external behavior; rather, it is inextricably linked with consciousness. It is the key to understanding the relationship between consciousness and the objective world. Hence, conscious learning emerges from activity or performance, not a precursor of it. For this reason, activity theory has been introduced and used in the field of human-computer interaction (Bodker, 1991), constructivist learning environments (Jonassen & Rohrer-Murphy, 1999) and instructional design (Wilson, 1999) in order to provide a clear operational framework for designing complex learning/support systems.

These studies all emphasize the need to consider the larger context. They place an emphasis on social interaction within an activity context and the processes of internalization that take place through interaction and mediation. In this regard, EPSS designers need to understand the performer culture (organization culture) and work environment (learning context) to at least some extent in order to negotiate the needs (based on the situations) and design effective products (Wilson, 1999; Jonassen & Rohrer-Murphy, 1999; Hara & Schwen, 1999; and Hung, 1999)

The main contribution of this activity framework is that it proposes a different perspective for analyzing (examining of) work practices, as performed by people within natural settings. The framework is most useful in both ill-defined and well-defined task areas where routing and non-normal tasks have been specified through a task analysis or the ISD process. Recognizing the wide range of cognitive analysis methods, this framework (approach), in addition to the methods in ISD process, allows for studying different forms of human practices, factoring in the processes of context as developmental process, both at the individual and social levels at the same time (Kuutti, 1996; Hung & Wong, 2000).

Activity theory's approach to instructional design is clearly based on distinctly different epistemic and pedagogical assumptions than classical approaches to instructional design. According to Jonassen & Rohrer-Murphy (1999), activity provides an alternative perspective to the mentalistic and idealist views of human knowledge that claim that learning must precede activity. Activity theory posits that conscious learning emerges from activity (performance), not as a precursor to it. So activity theory provides us with an alternative way of viewing human thinking and activity. Activity theory is also a powerful socio-cultural and socio-historical lens through which we can analyze most forms of human activity.

In short, activity theory provides an alternative framework for designing effective systems by understanding the expertise of particular task/knowledge/performance, expert [as well as novice] behaviors (mental model, goals, rules, intention, motivation, social interaction), and learning context (culture, tools, objects, environments).

Conclusion

It is exciting that the development of technology provides many opportunities to enhance performance (and learning) that will involve EPSSs and other forms of environmental modification. In addition to employing classic instructional design methods, EPSS designers are aware of alternative approaches for designing and developing good instructional systems, such as rapid prototyping methodology (Jones & Richey, 2000) and concurrent engineering (Gustafson, 2000). At another level, the design of these modalities will also require alternative (or mixed/combination) approaches (such as activity approach) to understand change from a socio-culture perspective of focus from performance outcome to performance activity and the relationship of learning with their environment where learning and activities take places.

We need to design more effective EPSSs as the demand increases. It is important to know the difference between experts and novices because we can know how knowledge is transferred and how novices become experts as well as how instructional designers can support these people effectively based on the notion that different performance requires different support. However, to reach this goal, particular attention should be given to the question of how we design the environment (support system) of people and things about them, and use the situations they encounter to improve their performance. It would also be informative for EPSS designers to understand the properties of different disciplines and different situations of performance that are more or less amenable to designing conditions for improvement, and that require various kinds of participatory experiences and assisting devices for supporting performance in the course of acquiring competence.

Equipped with all the understanding and knowledge described above of how technical expertise appears to grow in the wild, the initial state of the learner and an explication of the process of learning (i.e., the transition from initial state to a desired state in an instructional setting), learners' individual differences, and the assumption of learning mechanisms (internalization, assimilation, and restructuring; Gott & Lesgold, 2000), we are ready to turn our attention to designing an instructional environment that could effectively reproduce such expert-like performance, but through systematic learning events, accelerating the lengthy process that occurred naturally (Gott & Lesgold, 2000).

With these theories, techniques and knowledge that make the knowledge structures and cognitive performance of competence explicit, knowable, and learnable, we believe a properly designed instructional environment could shorten the skill acquisition process, resulting in accelerated skill development for a group of novice learners.

Reference

Aster, D. J., & Clark, R. E. (1985). Instructional software for users who differ in prior knowledge. Performance & Instruction Journal, 24(5), 13-15.

Backler, M. (1988). Modeling expertise for instruction: An example from the auditing profession. Ph.D. thesis, Indiana University.

Bodker, S. (1991). Activity theory as a challenge to systems design. In H. E. Nissen, H. K. Klein, & R. Hirschheim (Eds.), Information systems research: Contemporary approaches and emerging traditions. Amsterdam: Elsevier.

Bredo, E. (1994). Reconstructing educational psychology: Situated cognition and Deweyan pragmatism. Educational Psychologist, 29(1), 23-35.

Brown, C., Hedberg, J., & Harper, B. (1994). Metacognition as a basis for learning support software. Performance Improvement Quarterly, 7(2), 3-26.

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-42.

Charness, N. (1979). Components of skill in bridge. Canadian Journal of Psychology, 33, 1-16.

Chase, W. G., & Simon, H. A. (1973). Perception in chess. Cognitive Psychology, 4, 55-81.

Chi, M., Feltovich, P., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. Cognitive Science, 5, 121-152.

Chi, M., Glaser, R., & Rees, E. (1982). Expertise in problem solving. In R. Sternberg (Ed.), Advances in the Psychology of Human Intelligence. Hillsdale, NJ: Erlbaum.

Cole, M., & Engestrom, Y. (1991). A cultural-historical approach to distributed cognition. In G. Salomon (Ed.), Distributed cognitions: Psychological and educational considerations. Cambridge, UK: Cambridge University Press.

DeGroot, A. D. (1965). Thought and choice in chess. The Hague: Moulton.

Dickelman, G. (2000). Performance support in internet time: The state of the practice. Performance Improvement Quarterly, 39(6), 7-17.

Dunn, T. G., & Taylor, C. A. (1989). Hierarchical structures in expert performance. Educational Technology Research & Development, 38(2), 5-18.

Ericsson, K., & Charness, N. (1994). Expert performance: Its structure and acquisition. American Psychologist, 49(8), 725-747.

Feltovich, P., Ford, K., & Hoffman, R. (1997). Expertise in context: Human and machine. Menlo Park, CA: AAAI Press.

Gardner, H. (1995). Why would anyone become an expert? American Psychologist, 50(9), 802-803.

Gery, G. (1991). Electronic performance support systems. Boston, MA: Weingarten Publishers.

Glaser, R. (1990). The reemergence of learning theory within instructional research. American Psychologist, 45(1), 29-39.

Glaser, R. (1991). The maturing of the relationship between the science of learning and cognition and educational practice. Learning & Instruction, 1(2), 129-144

Glaser, R. (1996). Changing the agency for learning: Acquiring expert performance. In K. A. Ericsson (Ed.), The road to excellence: The acquisition of expert performance in the arts and sciences, sports, and games. Mahwah, NJ: Lawrence Erlbaum Associates.

Gobet, F. (1998). Expert memory: A comparison of four theories. Cognition, 66(2), 115-152.

Gott, S. P., & Lesgold, A. M. (2000). Competence in the workplace: How cognitive performance models and situated instruction can accelerate skill acquisition. In R. Glaser (Ed.), Advances in instructional psychology: Educational design and cognitive science. Mahwah, NJ: Lawrence Erlbaum Associates.

Gustafson, K. (2000). Designing technology-based performance support. Educational Technology, 40(1), 38-44.

Hara, N., & Schwen, T. (1999). An instructional development model for Global organizations: The GoaL model. Performance Improvement Quarterly, 12(4), 99-116.

Hung, D. (1999). Activity, apprenticeship, and epistemological appropriation: Implications from the writings of Michael Polanyi. Educational Psychologist, 34(4), 193-205.

Hung, D., & Chen, D-T. (2000). Appropriating and negotiating knowledge: Technologies for a community of learners. Educational Technology, 40(3), 29-32.

Hung, D., Koh, T., & Chua, C. (2000). Social-cultural perspectives of R & D in educational technology. Educational Technology, 40(4), 29-32.

Hung, D., & Wong, A. (2000). Activity theory as a framework for project work in learning environments. Educational Technology, 40(2), 33-37.

Jeffries, R., Turner, A. A., Polson, P. G., & Atwood, M. E. (1981). The processes involved in designing software. In J. R. Anderson (Ed.), Cognitive skills and their acquisition. Hillsdale, NJ: Erlbaum.

Jones, T. S. & Richey, R. C. (2000). Rapid prototyping methodology in action: A developmental study. Educational Technology Research & Development, 48(2), 63-79.

Johnson, S. D. (1988). Cognitive analysis of expert and novice troubleshooting performance. Performance Improvement Quarterly, 1(3), 38-54.

Jonassen, D., & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. Educational Technology Research & Development, 47(1), 61-79.

Julian, M. F., Larsen, V. A., & Kinzie, M. B. (1999). Compelling case experiences: Challenges for emerging instructional designers. Proceedings of selected research and development papers presented at the 21st National Convention of the Association for Educational Communication and Technology, 7-28.

Kaplan, C. A., & Simon, H. A. (1990). In search of insight. Cognitive Psychology, 22(3), 374-419.

Kasvi, J., & Vartiainen, M. (2000). Performance support on the shop floor. Performance Improvement Quarterly, 39(6), 40-46.

Kasvi, J., Vartiainen, M., Pulkkis, A., & Nieminen, M. (2000). The role of information support systems in the joint optimization of work systems. Human Factors and Ergonomics in Manufacturing, 10(2), 193-221.

Kuutti, K. (1996). Activity theory as a potential framework for human-computer interaction research. In B. A. Nardi (Ed.), Context and consciousness: Activity theory and human-computer interaction. Cambridge, MA: MIT Press.

Larkin, J., McDermott, J., Simon, D., & Simon, H. (1980). Models of competence in solving physics problems. Cognitive Science, 4, 317-345.

Laufer, E. A., & Glick, J. (1996). Expert and novice differences in cognition and activity: A practical work activity. In Y. Engestrom & D. Middleton (Eds.), Cognition and communication at work (pp. 177-198). New York: Cambridge University Press.

Le Maistre, C. (1998). What is an expert instructional designer? Evidence of expert performance during formative evaluation. Educational Technology Research & Development, 46(3), 21-36.

Leont'ev, A. N. (1978). Activity, consciousness, and personality. Englewood Cliffs, NJ: Prentice-Hall.

Lewis, C. (1981). Skill in algebra. In J. R. Anderson (Ed.), Cognitive skills and their acquisition. Hillsdale, NJ: Erlbaum.

Li, Z., O'Neil, H., Jr., & Baker, E. (1991). Developing a research reference interface for knowledge-based instructional design tools. Educational Technology, 31(8), 7-16.

McPherson, S. L. (2000). Expert-novice differences in planning strategies during collegiate singles tennis competition. Journal of Sport & Exercise Psychology, 22, 39-62.

Nardi, B. A. (1996). Studying context: A comparison of activity theory, situated action models, and distributed cognition. In B. A. Nardi (Ed.), Context and consciousness: Activity theory and human-computer interaction. New York: Wiley.

Patel, V. L., & Groen, G. J. (1986). Knowledge based solution strategies in medical reasoning. Cognitive Science, 10, 91-116.

Perez, R. S., & Emery, C. D. (1995). Designer thinking: How novices and experts think about instructional design. Performance Improvement Quarterly, 8(3), 80-95.

Perez, R. S., Johnson, J. F., & Emery, C. D. (1995). Instructional design expertise: A cognitive model of design. Instructional Science, 23, 321-349.

Randel, J. M., & Pugh, H. L. (1996). Differences in expert and novice situation awareness in naturalistic decision making. International Journal of Human-Computer Studies, 45, 579-597.

Raybould, B. (1990). Solving human performance problems with computers. Performance & Instruction, 29(10), 4-14.

Raybould, B. (1995). Performance support engineering: An emerging EPSS development methodology for enabling organizational learning. Performance Improvement Quarterly, 8(1), 7-22.

Richman, H. B., & Simon, H. A. (1989). Context effects in letter perception: Comparison of two theories. Psychological Review, 96(3), 417-432.

Rowland, G. (1992). What do instructional designers actually do? An initial investigation of expert practice. Performance Improvement Quarterly, 5(2), 65-86.

Schoenfield, A. H., & Herrmann, D. J. (1982). Problem perception and knowledge structure in expert and novice mathematical problem solvers. Journal of Experimental Psychology: Learning, Memory, and Cognition, 8, 484-494.

Scribner, S. (1990). Manufacturing resource planning. Paper presented at the Second International Congress on Activity Theory. Lahti.

Simon, H. A. (1981). Information-processing models of cognition. Journal of the American Society for Information Science, 32(5), 364-377.

Simon, H. A. (1993). Decision making: Rational, nonrational, and irrational. Educational Administration Quarterly, 29(3), 392-411.

Ste-Marie, D. M. (1999). Expert-novice differences in gymnastic judging: An information-processing perspective. Applied Cognitive Psychology, 13, 269-281.

Stepich, D. (1991). From novice to expert: implications for instructional design. Performance & Instruction, 30(6), 13-17.

Taylor, J. C. (1994). Novex analysis: A cognitive science approach to instructional design. Educational Technology, 34(5), 5-13.

Tennyson, R. D. (1992). An educational learning theory for instructional design. Educational Technology, 32(1), 36-41.

Wertsch, J. V. (Ed.) (1981). The concept of activity in Soviet psychology. White Plains, NY: M. Sharpe.

Wilson, B. G. (1999). Adoption of learning technologies: Toward new frameworks for understanding the link between design and use. Educational Technology, 39(1), 12-16.

Winslow, C., & Bramer, W. (1994). Future work: Putting knowledge to work in the knowledge economy. New York: Free Press.

Witt, C., & Wager, W. (1994). A comparison of instructional systems design and electronic performance support systems design. Educational Technology, 34(4), 20-24.

Yacci, M. (1999). The knowledge warehouse: Reusing knowledge components. Performance Improvement Quarterly, 12(3), 132-140.