Performance Improvement Quarterly, 18(2) pp. 37-55

Human Performance Technology and Knowledge Management: A Case Study

Anne P. Massey
Indiana University

Mitzi M. Montoya-Weiss
North Carolina State University

Tony M. O'Driscoll
IBM Almaden Services Research

ABSTRACT

As organizations respond to competitive environments and strive to enhance performance, knowledge management (KM) has increasingly become a strategic activity. A KM strategy entails consciously helping people share and put knowledge into action. A key challenge is how to develop and implement KM solutions that provide performance support to knowledge workers and seamlessly integrate KM into business processes. We propose that human performance technology (HPT) provides a systematic framework to help guide KM initiatives. Specifically, HPT provides a holistic view of a knowledge worker's performance environment by considering the complex interdependencies between the organizational context, business processes, and individual performers. Via a case study, we describe and illustrate how HPT guided one organization in its journey to identify the content and structure to best support performance and manage knowledge in a core business process. Based on the case study, we offer lessons for other firms on how HPT can be used to guide KM initiatives.

Global competitive environments and technological factors are driving organizations to examine how they can better leverage knowledge assets for value creation. The emerging field of knowledge management (KM) addresses the issues of creating, capturing, transferring, and applying knowledge-based assets (Alavi & Leidner, 2001; Burton & Schwen, 2003). Knowledge is defined as information that is relevant, actionable, and based at least partially on experience (Leonard & Sensiper, 1998). A KM strategy entails consciously helping people share and put knowledge into action by creating access, context, infrastructure, and simultaneously shortening learning cycles (Davenport & Prusak, 1998; Davenport, DeLong, & Beers, 1998; O'Dell & Grayson, 1998; Marshall & Rossett, 2000). A KM strategy takes place within a complex system of organizational structure and culture and can be enabled through information technology (IT). To achieve business results, a successful KM strategy identifies a firm's key leverage points that often reside in core business processes that may be reengineered to achieve dynamic improvements in performance by capitalizing on or expanding the organization's knowledge resources and capabilities (Hammer & Champy, 1983). Given that the business process is where work is accomplished, it is the fundamental link between organizational and individual performance. When individuals exploit knowledge in a business process, it is reflected in the quality of a valued outcome that benefits the organization.

In this paper, we propose that human performance technology (HPT) provides a framework to help guide KM initiatives. Specifically, a key challenge facing organizations is how to develop and implement systems or tools that provide performance support to knowledge workers and seamlessly integrate KM into business processes. If the intent of a KM system or tool is to enhance organizational performance, we need to understand the environment surrounding the underlying knowledge work (Ardichvili, Page, & Wentling, 2002). Generating performance improvements requires deep understanding of how work is organized, how human performers are managed, how knowledge is exploited, and how all of these factors relate to an organization's competitive strategy and culture (Rummler & Brache, 1992; Gilley, 2000). HPT provides a holistic view of a knowledge worker's performance environment by considering the complex interdependencies between the organizational context, business processes, and individual performers. By doing this, successful performance outputs can be described and the behaviors that will produce those outputs can be identified (Gordon, 1997). HPT offers a systematic way to analyze performance problems and their causes, and to develop and implement interventions to address problems and improve performance (Gery, 1997; Rosenberg, 1996; Cole, Fischer, & Saltzman, 1997).

In our case study, we describe a KM initiative undertaken by Nortel, a global telecommunications equipment manufacturer. Guided by HPT and principles of KM, Nortel reengineered the front-end of its new product development (NPD) process. NPD is knowledge-intensive work based on the individual and collective expertise of employees (Leonard & Sensiper, 1998). How well a company manages the NPD process is a critical determinant of how successfully organizational knowledge creation can be carried out (Nonaka & Takeuchi, 1995). Nortel implemented their newly designed front-end NPD process with a KM tool embodied in the form of an Electronic Performance Support System (EPSS). An EPSS is distinguished from other approaches (e.g., traditional systems development, expert systems development) by its attention to *enabling performance in the context of knowledge work*. That is, the EPSS and work tasks are integrated such that support is provided in the format that best matches the task facing a particular user (Karat, 1997; Brown, 1996; Moore & Orey, 2001).

In the following sections, we offer brief descriptions of HPT, the problem background and the context of Nortel's KM initiative. Then, we describe the results of HPT as applied at Nortel and the lessons learned from merging principles of performance support and KM.

Human Performance Technology

In Figure 1, we offer an HPT framework that can be used to facilitate understanding of the "performance system" surrounding organizational knowledge work (Stolovitch & Keeps, 1999; Rummler, 1999). Rummler and Brache's (1992) systems view of human performance suggests that knowledge workers operate within the context of this "performance system." Exploiting knowledge and improving performance will happen only if the whole system is understood and managed. Specifically, the framework allows for analysis of the system, a diagnosis of the changes required, and the design of suitable interventions needed to affect performance.

As illustrated in Figure1, the external environment presents organizations with opportunities, pressures, events, and resources. In response, the organization generates strategic goals and objectives and internal business process requirements (i.e., a

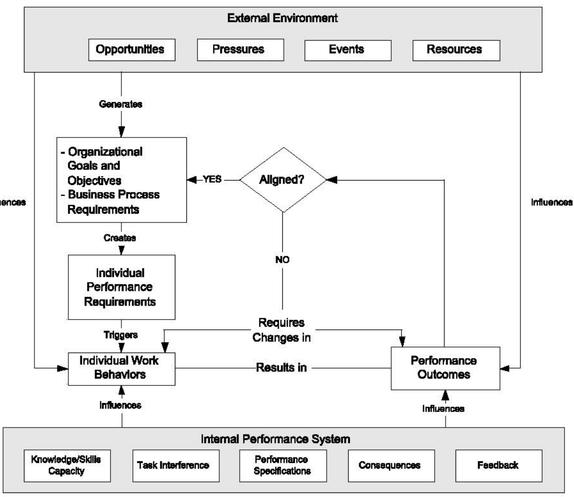

Figure 1. Human Performance Technology (adapted from Stolovitch & Keeps, 1999; Rummler & Brache, 1992)

set of actions that allow the organization to capitalize on opportunities and address external pressures). In turn, business processes create knowledge worker performance requirements. When defined, these requirements trigger work behaviors that result in performance outcomes. A knowledge worker's behaviors and performance are influenced by both the external environment and internal factors that influence a knowledge worker at the task/job level. Drawing from Rummler and Brache (1992), the internal performance system of knowledge workers at the task/job level influences both work behaviors and performance outcomes. Here, Rummler and Brache (1992) suggest that a knowledge worker's performance is not simply a function of knowledge, skills, or capacity. Rather, other factors, including the nature of the business process work tasks, performance specifications, consequences, and feedback influence performance. Ultimately, consistent performance is a function of all factors and the cause of poor performance is rarely solely attributable to a lack of individual knowledge, skills, or capacity.

Operationally, HPT involves three phases of analysis: performance analysis, cause analysis, and intervention analysis (Stolovitch & Keeps, 1999). Performance analysis examines the business process and knowledge worker requirements in light of organizational goals and objectives. Central to this phase is the comparison of desired performance to current performance, thus allowing for the identification of performance *gaps* in terms of their magnitude, value, and/or degree of urgency. Cause analysis identifies the specific factor(s) that contribute to a performance gap (Ramakrishna & Brightman, 1986). For example, the cause of an organizational performance gap may be business process level problems that, in turn, are caused by deficiencies in individual work behaviors. Finally, intervention analysis involves the selection, design, development, and implementation of interventions. Interventions are both responses to identified causes of performance problems as well as opportunities for improving performance (Rosenberg, 1995; Schaffer & Keller, 2003). Potential interventions include solutions that improve the development of individuals or teams (e.g., training), as well as solutions that center on managing and rewarding performance (e.g., incentive/reward systems). Other interventions include the redesign of business processes and tasks, as well as technology-based performance support applications and tools such as an EPSS (Rosenberg, 1995; Gery, 1997). Intervention selection should be done in light of appropriateness (internally and externally), economics, feasibility (given organizational constraints or barriers to implementation), and acceptability to the organization and knowledge workers (Stolovitch & Keeps, 1999).

As KM becomes a strategic activity in organizations, the most successful efforts will need to combine performance-centered analysis with the appropriate use of IT. KM systems and tools will be most effective when developed and implemented with a keen understanding of the performance system surrounding knowledge workers. In the following, we describe and reflect upon how HPT can inform KM initiatives.

Case Background and Context

The divestiture of AT&T in 1984 and the Telecommunications Reform Act (TRA) of 1996 spawned intense competition in the telecommunications industry. As a leading equipment manufacturer, Nortel's customers include long distance and local carriers, various large corporations, and numerous Internet Service Providers (ISPs). In light of the TRA and in order to respond to external market forces, new and innovative ideas were needed by Nortel to ensure that the company could distinguish itself from its competitors, win over new customers, and maintain the loyalty of existing ones. Continuous innovation through new product development (NPD) was deemed a mission critical business strategy.

Figure 2 shows a general stage-gate model of the NPD process. An NPD project is initiated when a concept is funded and moved forward into development. During development, there are various stages of activities simultaneously involving different functional areas in the organization. Typically, NPD is characterized by multiple review points (or decision gates) where projects are evaluated. At each review point, decisions are made to continue, kill, or recycle projects. As projects progress through development, resource commitments increase and decision criteria change.

In this case study, we focus on the front-end of Nortel's NPD process—concept development and selection activities. These activities are commonly referred to as the "fuzzy front-end" because they involve ill-defined processes and ad hoc decisions carried out by multiple and diverse performers (Cooper & Kleinschmidt, 1986). Despite the fact that these activities drive all subsequent decisions, research has shown that they are the least understood and most poorly managed activities in the entire innovation process (Cooper & Kleinschmidt, 1986; Khurana & Rosenthal, 1997). Concept development involves transforming a raw idea into a robust concept through careful definition of the underlying technologies, identification of expected customer benefits, and an assessment of the market opportunity. A product concept should be sufficiently developed so that decision-makers can sense whether the newly defined opportunity is worth committing

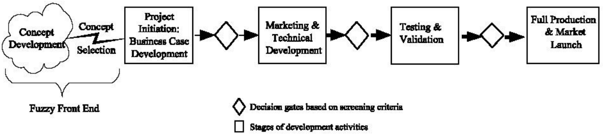

Figure 2. Generic Stage-Gate Model of the New Product Development Process.

resources for further exploration. Concept selection involves choosing which new product concepts will be funded and initiated as projects for development. Concept selection decisions dictate all further development activity downstream. However, past research indicates that many front-end concept selection decisions are made without the use of objective evaluation criteria (Cooper & Kleinschmidt, 1986). These decisions are often based on informal discussions with no checklists or criteria. Making such important decisions without any systematic or comparative analysis is not conducive to achieving competitive advantage through continuous innovation.

Applying the HPT Framework

Performance and Cause Analyses at Nortel

Two senior executives initiated a project to ensure that Nortel could continue to innovate and distinguish itself from competitors. Their immediate concern was that Nortel's products and services "war-chest" was empty and needed to be replenished immediately. With reference to the HPT framework in Figure 1, the overarching organizational performance objective was to increase the number and market acceptance rate of Nortel's new products. At the business process level, the NPD performance objective was to generate a continuous stream of innovative ideas.

A small task force consisting of representatives from engineering, business planning, and marketing was formed to address the sponsoring executives' perception that Nortel lacked innovative capability. The task force conducted secondary research into the NPD process (c.f., Crawford, 1994; Cooper, 1993, Cooper & Kleindschmidt, 1995). This steam of research suggested that while innovative ideas are typically plentiful in organizations, NPD front-end activities involving concept development and selection are often poorly managed. Given this, the task force conducted an informal email survey of three diverse employee segments (Sales and Support, Global Services Planning, and Marketing Development) to canvas for new ideas. Within three weeks, 112 new product and service ideas were received. The results of this effort seemed to support Crawford's (1994) assertion that the internal pool of new ideas from employees within most organizations was, in fact, large.

The task force also investigated the front-end of Nortel's existing NPD process to determine where its current idea sources originated. This research revealed that Nortel's existing NPD process was primarily customer-driven, largely reflecting requests for extensions in functionality to existing products and services. The task force concluded that the move toward increased competition and industry deregulation made the current NPD strategy of reacting to existing customers' requests for extensions (rather than proactively seeking and managing innovative opportunities) a very risky proposition.

Further assessment of Nortel's NPD process revealed a more troubling finding—there was no formal way in the existing process to capitalize on employee-generated ideas. That is, while the survey results suggested that employees had the skills, knowledge, and capacity to offer new and innovative product/service ideas, the organization did not provide a path or necessary support (e.g., data, resources, tools, processes or incentives) to leverage this innovative capability. The cause of the organizational performance problem (no new products or services) was attributed to the lack of a clearly defined front-end NPD process to identify, capture and evaluate employee-generated ideas.

Based on all this, the task force concluded that a lack of innovative capability at the individual knowledge worker/performer level within Nortel was not the underlying cause of the organizational performance problem. Rather, in a presentation to the executive sponsors, the task force argued that the cause of the problem was a business process obstacle (i.e., the front-end of the NPD process; see Figure 1). Furthermore, the lack of use of internal idea sources suggested that Nortel was not fully leveraging its own knowledge base. Based on the task force's presentation, the executive sponsors issued a new mandate to the task force: "…define and implement a consistent and structured approach for developing, screening, and cataloging product and service ideas such that the value of Nortel's intellectual capital can be realized."

> ***The task force concluded that a lack of innovative capability at the individual knowledge worker/performer level within Nortel was not the underlying cause of the organizational performance problem.***

An internal group was formed and charged with the task of addressing this strategic goal. The name given to this effort was "Project Galileo." This name was chosen because Nortel needed a mechanism (like Galileo's telescope) that would enable it to see the "stars" (i.e., high potential ideas) more clearly. The team was expanded and included representatives from information systems, psychology, human-factors, NPD, engineering, business planning, and marketing. Efforts began to create and implement a process that leveraged Nortel's knowledge base by cataloging innovative ideas, facilitating idea-to-concept development, and then enabling systematic screening for market viability. Guided by the systematic approach of HPT, formalizing the fuzzy front-end activities would simultaneously facilitate individual-level and business process-level performance, and ultimately support Nortel's strategic organizational objectives.

Intervention Analysis at Nortel

Intervention analysis represents the critical link between a performance problem and the solution. At Nortel, the performance and cause analyses focused on identifying where the most important performance gains could be realized in the front-end of the NPD process. The intervention analysis phase focused first on developing a conceptual model of a *process-based* *intervention* to address the fuzzy front-end problem. The conceptual model would describe the activities that should be completed in the front-end NPD process in a structure based on logical dependencies. However, as prescribed by the HPT framework, the conceptual model would be compared to the realities of the implementation environment such that the final intervention would be organizationally sustainable, systemically desirable, and culturally feasible. Thus, the intervention analysis phase focused on designing an appropriate *implementation technique* for the new front-end NPD process.

Intervention Design: Conceptual Process Model. The team conducted extensive external benchmarking to gain a better understanding of best-in-class front-end NPD processes. The team conducted case studies with companies renowned for their innovative capabilities (e.g., HP, Sun Microsystems, 3M), and reviewed academic and industry publications on NPD critical success factors (e.g., Brown & Eisenhardt, 1995; Cooper & Kleinshmidt, 1986, 1995; Griffin & Hauser, 1993, Montoya-Weiss & Calantone, 1994; Urlich & Eppinger, 1995). The team also contracted with outside consultants for objective evaluations. All of this research confirmed that Nortel, like many firms, had a generally unstructured and ad-hoc front-end NPD process.

The team set forth to map and formalize task logic (the sequences, relationships, and interrelationships) associated with the concept development and selection tasks in the front-end NPD process. They worked with an internal cross-functional NPD team of experts in order to surface and capture relevant knowledge. Interviews with the team members revealed that most initial ideas needed to be more fully developed into robust concepts through further marketing, business analysis, human factors, and technical analysis before a conclusive decision could be made. Working with the cross-functional NPD team of experts and drawing from their external research findings, the team developed detailed evaluation criteria for each of the four areas. Standardized criteria in these four areas would provide a consistent structure for the concept selection decision and also provide a framework for idea-to-concept development.

After several months of external and internal research, the team presented a conceptual process model to their corporate sponsors. Using their review of best practices, academic research, and internal knowledge elicitation, the team presented a four-phase front-end NPD process and a set of standard criteria. The Galileo process would comprise: (1) idea qualification, (2) concept development, (3) concept rating, and (4) concept assessment. The process was intended to support the performance of individual knowledge workers by providing standard, pre-defined sets of criteria and rating mechanisms.

The idea qualification phase provides a quick mechanism whereby many ideas can be narrowed to a few viable ones for concept development. This phase offers a set of questions used to pre-screen a new product or service idea at a very high level analysis of market and technological readiness. In the concept development and rating phases, each qualified idea is then developed into a robust concept and assessed in the four categories: (1) marketing, (2) business, (3) human factors, and (4) technical. Using external and internal knowledge resources, detailed requirements for each category were generated. These requirements facilitate the development of embryonic ideas into complete and robust concepts so decision-makers could subsequently evaluate the concepts. Developing concepts using standardized criteria and formats would allow concept evaluation by decision-makers to be more formal, consistent, and comprehensive. As a result, each product or service concept could be assessed and directly compared to any or all others that have been through the process.

Intervention Implementation: Constraints. The process implementation phase is often the point where the organization begins to resist the proposed change, particularly if the change threatens established norms and work practices within the organization (Tushman & O'Reilly, 1996; Sviokla, 1996; Schaffer & Keller, 2003; Smith, 2002). Upon review of the proposed Galileo process, the executive sponsors were very concerned that the first three phases were very labor-intensive. Maintaining multiple, full-time, cross-functional teams to conduct idea-to-concept development activities was neither cost effective nor organizationally feasible. Given the current market environment, the sponsors felt that it would be impossible to secure funding to staff these expert resources. Earlier performance and cause analyses had revealed that the existing customer-driven NPD process was already providing a demand for extension-type products that far outstripped the company's ability to supply them.

The team was faced with significant organizational constraints that would have to be explicitly considered or all their efforts could be derailed. The executive sponsors challenged the team to find an alternative means of implementation. An implementation solution had to be identified that best addressed performance goals and organizational constraints, with minimum organizational and human distress, and within time and budget. Given this, the team considered various implementation alternatives that would not compromise the conceptual design of the front-end process.

Intervention Implementation: Alternatives. A particular challenge facing the Galileo team was the fact that a diverse set of individuals (e.g., engineers, marketers, project managers, executives) have the knowledge and positions required to complete different aspects of the Galileo process (idea qualification, concept development, concept rating, and concept assessment). While concept assessment activities are the domain of decision-makers who have the authority to approve further development or funding, it was not a foregone conclusion whose domain the concept development activities should be. As noted earlier, the use of expert cross-functional teams to qualify and develop every submitted idea was deemed to be an exorbitantly costly alternative in terms of time commitment and opportunity cost of pulling individuals away from their jobs for pre-project analysis. Therefore, the team sought an implementation solution that would shift the burden of the first three phases of the Galileo process (i.e., idea qualification, concept development, and concept rating) to the original idea generator. The individual-level performance goal for idea generators would be to translate their embryonic ideas into robust concepts by conducting a thorough and disciplined analysis of marketing, business opportunity, human factors, and technical factors following a standard format. However, since idea generators (e.g., engineers) typically do not possess sufficient knowledge in all of four dimensions, the team considered three implementation alternatives:

1. Train all employees in the areas of marketing, technology, human factors, and business analysis so that they are able to qualify and develop their own idea.
2. Create a corporate directory of internal subject-matter-expert (SME) mentors in the area of marketing, technology, human-factors and business analysis and assign them (as needed) to each idea generator.
3. Capture the expertise of SME mentors and incorporate it into an electronic tool to guide and advise the idea generators.

Each alternative was evaluated according to its cost-effectiveness and feasibility given Nortel's organizational structure, resource availability, and culture. Training all of Nortel's employees in the four areas required by the Galileo process was clearly not cost effective or feasible. While assigning SMEs to idea generators seemed to be a good alternative, the reality was that these experts were already overextended. Furthermore, due to Nortel's functional organizational structure no one at the division level had the jurisdiction to mandate that corporate-wide internal experts assist idea generators.

Based on this analysis, alternatives that advocated the use of human expertise to implement the process were deemed too costly and difficult to implement effectively at Nortel. The team concluded that information technology (IT) could be leveraged to create an electronic version of a human SME and overcome the need to train or buy cross-functional expertise. An IT-based KM tool would enable the front-end NPD process to be structured, used, and managed in a consistent fashion across people and over time. IT offered additional benefits in that it could provide efficiencies in process oversight and administration as well as create electronic repositories of the intellectual property associated with idea generation. Yet, for a KM tool to be successful, the knowledge workers would have to employ it in an interactive and iterative manner while performing their work.

In order to develop a KM tool, the team explored Electronic Performance Support System (EPSS) technology. An EPSS integrates principles found in HPT, artificial intelligence, computer-based training, information systems, and performance-centered design. The attributes of EPSS technology made it an attractive paradigm for building a KM tool. An EPSS can be used to capture, store and distribute individual and corporate knowledge, enabling individuals to achieve desired levels of performance in the fastest possible time and with a minimum of support from others (Raybould, 1995; Brandenburg & Binder, 1999). The goal of an EPSS is to aid a knowledge worker's performance by providing access to integrated information, knowledge, learning experiences, advice and guidance at "the moment of need" (Gery, 1991). Idea generators and decision-makers would have immediate access to consistent expert advice, any time, any place, without the need for intermediaries. Thus, an EPSS-enabled front-end NPD process would facilitate knowledge access, generation, and ultimately decision-making. Importantly, an EPSS takes a *systemic* view of process tasks, the knowledge worker, and the workplace by recognizing that knowledge is inseparable from the human performers who develop and leverage it in the context of work. Knowledge flows from the processes that help generate and nurture it (Fahey & Prusak, 1998). Thus, the implementation goal was to provide, via one integrated system, performance support for the front-end NPD process to all relevant knowledge worker audiences.

> ***For Nortel, IT would be useful for managing the knowledge inherent in and generated from the front-end NPD activities.***

The team presented the EPSS implementation alternative to the executive sponsors. It was clear that using technology would address the human resource and organizational constraints identified earlier. For Nortel, IT would be useful for managing the knowledge inherent in and generated from the front-end NPD activities. Based on this, the executive sponsors provided additional funding and resource support to continue the project.

Creating Nortel's KM Tool: *Virtual Mentor*

Design Considerations

With the addition of system development experts to the team, efforts began to create Nortel's EPSS KM tool, called *Virtual Mentor*. The cross-functional team identified and followed several general system design requirements. Specifically, *Virtual Mentor* should: (1) facilitate and oversee the four phases for each knowledge worker as appropriate for each phase; (2) be intuitive and user friendly; (3) be flexible in use and allow for iterative, rather than forced sequential input by an idea generator; (4) provide a learning opportunity for all knowledge workers; (5) catalog the information associated with all ideas, thus providing a record of internal innovation activity; and, (6) minimize the administrative overhead.

In essence, *Virtual Mentor* would automate each stage of the Galileo front-end process, support the performance of those individuals working within the process, and manage Nortel's intellectual property. In addition to simultaneously supporting an idea generator and decision-maker, *Virtual Mentor* would support a process owner charged with tracking progress. In order to integrate varied performance requirements into a single, comprehensive tool, the team thoroughly analyzed the diverse, yet interdependent, needs of the three knowledge worker groups using Rummler and Brache's (1992) performance model, noted earlier in Figure 1. This model provided a useful mechanism for identifying and mapping the knowledge processes, outcomes, and drivers associated with each knowledge worker group as related to process activity, decisions, and information flows. By considering the complex interrelationship of knowledge worker, content and context, this approach facilitated the definition of the necessary "know-how" associated with the "know-what" of the front-end NPD process while acknowledging workplace realities (Ruggles, 1998). Importantly, the approach also guided the team as they explicitly considered motivational factors (i.e., feedback and consequences) that would ultimately influence each knowledge worker to accept the Galileo process and use *Virtual Mentor*.

The analysis revealed that each knowledge worker would require different kinds of performance support, and each would add or draw different content to/from the system. Since a fundamental intermediate purpose of KM is to build some degree of shared context among diverse knowledge workers participating in a process (Fahey & Prusak, 1998), *Virtual Mentor* was designed with this in mind. Interfaces were designed to provide various question-specific advice and resource pointers. In the following, we briefly describe Nortel's KM EPSS tool.

Virtual Mentor: Performance Support for Knowledge Workers

Virtual Mentor provides *knowledge-based support* to idea generators so they are not faced with ill-structured tasks attributable to knowledge inadequacies. This support is provided on-demand through context-specific advice for each question such that the assistance of a human SME is emulated. Similarly, *decision-based support* is provided to decision-makers enabling them to compare and contrast the various concepts' salient attributes as they relate to business needs and performance goals. Such support enables decision-makers to make informed funding decisions for new product/service concepts. Finally, *productivity-based support* is provided to process owners who are tasked with tracking the progress of both idea generators and decision-makers that interface with the system. *Virtual Mentor* provides this support via a customized interface to the system that automates many of the search and monitor tasks that would traditionally be carried out manually. In the following brief description of the electronic process, we focus on the idea generator and decision-maker roles.

Step 1: Idea Qualification. The purpose of this phase is to provide a quick, structured, and standardized mechanism whereby many ideas can be pre-screened at a high level (i.e., market readiness and technical feasibility) and narrowed to a few potential candidates for development. All submitted ideas are captured and managed in the Intellectual Property (IP) Catalog for potential future use. In this phase, an idea generator is presented with a list of ten screening questions. The idea generator is prompted to use secondary research (e.g., trend forecasts, Forrester Reports, etc.) to develop appropriate answers to open-ended questions and assign numerical ratings to their answers. Once the idea generator finishes, *Virtual Mentor* rates the idea using a scoring algorithm. If the idea passes, the idea generator may move onto Concept Development. If not, he/she is prompted to investigate specific questions that warrant further research.

Step 2: Concept Development. This phase assists idea generators in "growing" their embryonic ideas into robust concepts. By answering twelve templates of questions, ideas are developed in the relevant critical areas of marketing, technology, business analysis, and human factors. The questions were developed based on prominent NPD best practices research (e.g., Cooper, 1993; Crawford, 1994) and Nortel-specific NPD experience. While providing structure, the intent is not to restrict innovative creativity since people create knowledge in a largely self-generating process (Leonard & Sensiper, 1998). An important aspect of this phase is the consideration of potential customer uses and users. This ultimately facilitates the building of a shared context by providing decision-makers a way to understand what idea generators had in mind. The objective of concept development is not to simply collect information (which could be disjointed), but rather to imbue data and information with decision- and action-relevant meaning.

The objective of concept development is not to simply collect information... but rather to imbue data and information with decision- and action-relevant meaning.

Step 3: Concept Rating. The purpose of this phase is to provide a common framework within which all NPD concepts can be quantitatively rated. In this phase, the idea generator rates his/her concept using a standard set of questions related to the critical areas of marketing, technology, business analysis, and human factors. The idea generator provides a rating on a standard scale, a qualitative explanation of the rationale underlying the ratings, and a confidence level for each response. This phase is designed to continue the ongoing process of using, creating, and capturing knowledge relative to an evolving concept. Upon completion, the idea generator submits the concept to the Catalog for evaluation by a decision-maker.

Step 4: Concept Assessment. The purpose of this phase is to assist decision-makers in the evaluation process as they approve, reject, or recycle new product concepts for further development or funding. Importantly, *Virtual Mentor* translates the structure of the idea generators' inputs into the "local" language of the decision-maker (e.g., usage scenarios, SWOT analysis). *Virtual Mentor* also presents a multi-dimensional visual representation of each concept's quantitative ratings and provides access to all of the qualitative and quantitative reasoning provided by the idea generators. Since the first three phases were designed to generate and codify standard sets knowledge about new product concepts, *Virtual Mentor* supports higher order "Why/Why Not" decision-making that is more comparative in nature than the traditional "Go/No Go" type decisions that assess concepts independently of each other (Cooper, 1993). Importantly, the reasoning and knowledge employed by the decision-maker in the "Why/Why Not" decision is also captured. This provides a mechanism to give idea generators detailed feedback, necessary for learning and continuing incentive to participate. All of the knowledge associated with the idea generators' and decision-makers' work is cataloged by *Virtual Mentor*.

Validation and Implementation

A pilot test of Galileo and *Virtual Mentor* was conducted using the 112 ideas that had been generated earlier by employees from Sales and Support, Global Services Planning, and Marketing Development. The original idea generators used *Virtual Mentor* to work through Idea Qualification, yielding a list of 13 ideas that passed initial screening criteria and warranted further development. This subset of ideas was developed into robust concepts as the idea generators worked through Concept Development and Concept Rating. Following this, two executive-level decision makers completed Concept Assessment and selected seven robust product and service concepts for funding. These seven concepts were ultimately handed over to the appropriate internal groups for further development.

For the corporate sponsors, the pilot test provided a "proof-of-concept." The sponsors believed that the Galileo process and *Virtual Mentor* provided a means to exploit Nortel's knowledge assets and change the performance capability of front-end NPD process performers. The experiences of the employees involved in the pilot confirmed that *Virtual Mentor* supported the performance system within which they worked (Rummler & Brache, 1992). Idea generators and decision-makers indicated that *Virtual Mentor* provided the support and resources necessary to perform process tasks, made clear in a logical process flow what inputs were required, and clearly conveyed the desired process outputs of each. Additionally, idea generators found that the experience worthwhile as it provided a learning opportunity. Importantly, they had immediate access to the rationale for the "Why/Why not" decision associated with their concepts. The decision-makers indicated that using *Virtual Mentor* saved time and increased the certainty associated with selection decisions.

For the project team, the pilot test results laid to rest a major concern associated with many KM initiatives—is there incentive for knowledge workers to use the KM tool, and share their ideas and knowledge? Interviews with idea generators indicated that getting a product or service concept funded traditionally depended more on good presentation and sales skills than on the actual quality of the concept. *Virtual Mentor* provided a way to "level the playing field" by allowing good concepts, not good sales people, to rise to the top. According to the idea generators, *Virtual Mentor* was a thorough and rigorous process. Similarly, decision makers indicated that the increased certainty and comparative "Why/Why not" analyses would improve the decisions directly attributed and alleviate the professional risk associated with decision making by creating a historical record of the rationale used in selection decisions. The results of the pilot test confirmed that *Virtual Mentor* addressed the factors that Rummler and Brache (1992) identify as potential influences on work behaviors and performance.

Members of the project team conducted demonstrations and presented the results of the pilot study to divisional managers. Emphasis was placed on the alignment of the Galileo process and *Virtual Mentor* tool with organizational strategic goals. Using the pilot as evidence, the project team showed how Nortel's Galileo process and *Virtual Mentor* tool, with its strong linkages between context and content, would encourage innovation, knowledge sharing, and enhance decision making. Importantly, fewer resources would be required as divisions could avoid the time, effort, and funding necessary for cross-functional teams, who in the past were responsible for front-end analysis. And, executive decision makers would not be involved until the last phase of the process. Internal marketing efforts (demos, pilot study and analysis, corporate news) built demand for Galileo and *Virtual Mentor*. In concert with internal marketing efforts, a Web-based version of *Virtual Mentor* was installed on Nortel's intranet to facilitate wide access and use. Guided by principles of HPT and KM, the resulting solution enables the creation of a work environment necessary to achieve the performance requirement of generating a continuous stream of innovative ideas (see Massey, Montoya-Weiss, & O'Driscoll, 2002 for further details regarding the implementation and evolution of this project). Table 1 summarizes the core benefits realized by Nortel.

Discussion and Conclusion

As KM becomes a strategic activity in organizations, the most successful efforts will need to combine performance-centered analysis with

Table 1
Benefits of Galileo Process and EPSS

Leverage and growth of knowledge base	*Standardization of front-end NPD process*
• It captures, stores, and disseminates value-added, insight-laden knowledge.	• It facilitates consistent implementation across people and over time.
• It improves knowledge transfer across business, technology, marketing, and human factors areas.	• For idea generators, it "levels the playing field" and allows good concepts, not good sales people, to rise to the top.
• It leverages scarce organizational resources by electronically emulating cross-functional expertise.	• For decision-makers, it improves the quality and efficiency of concept selection.
• It reduces time wasted in finding data, information, or knowledge.	• For process owners, it improves the opportunity for process control and minimizes administrative overhead.

the appropriate use of IT. The objective of this paper was to illustrate how HPT can be used to successfully inform and guide KM initiatives. As summarized in Figure 3, Nortel successfully applied the HPT framework and EPSS paradigm to improve its innovation process, support the performance of those individuals working in the process, and capture the knowledge generated as a result. Specifically, by addressing "what to do," HPT facilitates the reengineering of knowledge-intensive business processes. By considering "how to do it," HPT informs the development and implementation of performance-centered KM solutions. Based on our experience in this case study, we offer lessons for other firms on how HPT can be used to guide for KM initiatives.

First, organizations should focus initial KM efforts on critical business issues that have high payoff and are aligned with organizational strategy. As prescribed by HPT, Nortel spent a substantial amount of time clearly defining the business issue and associated performance problems rather than worrying about semantic differences between data, information, and knowledge. With HPT's focus on performance outcomes, organizations can gain a deep understanding of how outcomes and activities at all levels (organization, process, and knowledge worker) inter-relate. In doing so, KM initiatives will be purposeful and systematic.

Second, knowledge should be treated as a process rather than as a product. Successful KM initiatives must recognize that knowledge is created, transformed, and transferred in an interconnected, complex system of functionally related components. With its system view, HPT facilitates the understanding that knowledge is meaningless when disconnected from the people and processes that generate and use it (Gilley, 2000). Since organizations are complex systems affecting the performance of knowledge

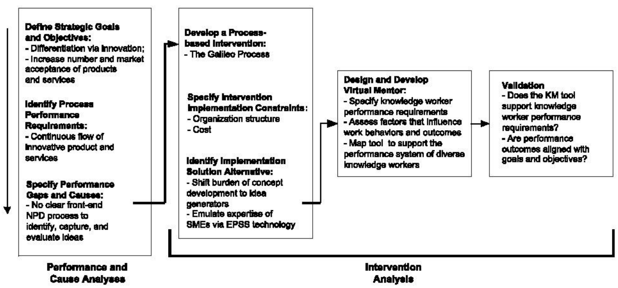

Figure 3. Operational Application of HPT.

workers, HPT guided KM initiatives require a collaborative effort involving all relevant stakeholders.

Third, much has been made of the need to assess the "know-what" associated with the "know-how" in KM initiatives. However, knowledge needs and gaps provide only part of the picture. Other factors affect the use and creation of knowledge by individuals. As illustrated in this case, issues related to process tasks, performance specifications, consequences, and feedback provide a deeper and broader view of the work and motivational environment in which performers create, share, and use knowledge. Rummler and Brache's (1992) human performance system model provides a useful approach to understanding, supporting, and integrating the "performance systems" of various stakeholders.

Fourth, while IT capabilities allow firms to access, embed, and transfer knowledge, the real challenge concerns the complex interplay between content, context, and the knowledge workers who pull the process pieces together. Technology in and of itself is not likely sufficient for effective KM. Rather, the key is to create links between technology and the performance system surrounding people. With a keen understanding of desired performance outcomes and the environment surrounding knowledge workers, organizations can then use technology in a systematic and systemic way to address performance problems. As the EPSS paradigm suggests, if technology supports a knowledge worker's performance system, then they are more likely to use it.

In conclusion, a KM strategy entails developing a portfolio of strategically focused initiatives required to achieve business results. HPT can inform KM initiatives by providing a systematic way to understand and bring about the changes necessary to enhance performance at all levels. We hope that the lessons derived from this case study will help guide other firms in their own endeavors.

References

Alavi, M., & Leidner, D. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Ardichvili, A., Page, V., & Wentling, T. (2002). Virtual knowledge sharing communities of practice at Caterpillar: Success factors and barriers. *Performance Improvement Quarterly, 15*(3), 94-113.

Brandenburg, D.C., & Binder, C.V. (1999). Emerging trends in human performance interventions. In H.D. Stolovitch & E.J. Keeps (Eds.), *Handbook of human performance technology: Improving individual and organizational performance worldwide* (pp. 843-866). San Francisco: Josey-Bass Pfeiffer.

Brown, L.A. (1996). *Designing and developing electronic performance support systems*. Boston: Digital Press.

Brown, S.L., & Eisenhardt, K.M. (1995). Product development: Past research, present findings, and future directions. *Academy of Management Review, 20*(2), 343-378.

Burton, C., & Schwen, T.M. (2003). Toward the validation of Ba. *Performance Improvement Quarterly, 16*(2), 41-67.

Cole, K., Fischer, O., & Saltzman, P. (1997). Just-in-time knowledge delivery. *Communications of the ACM, 40*(4), 54-59.

Cooper, R. (1993). *Winning at new products*. Reading, MA: Addison-Wesley.

Cooper, R., & Kleindschmidt, E. (1986). Benchmarking the firm's critical success factors in new product development. *Journal of Product Innovation Management, 3*(3), 71-85.

novation. *California Management Review, 40*(3), 112-132.

Cooper, R., & Kleindschmidt, E. (1995). An investigation into the new product development process: Steps, deficiencies, impact. *Journal of Product Innovation Management, 12*, 374-391.

Crawford, M. (1994). *New Products management*. Boston: Irwin.

Davenport, T.H., DeLong, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265-276.

Gery, G. (1991). *Electronic performance support systems: How and why to remake the workplace through the strategic application of technology*. Tolland, MA: Ziff Institute.

Gery, G. (1997). Granting three wishes through performance-centered design. *Communications of the ACM, 40*(7), 54-59.

Gilley, J.W. (2003). Performance management applied at the performer level. *Performance Improvement Quarterly, 13*(4), 87-105.

Gordon, J. (1996). Performance technology. In D. Zielinski (Ed.), *The effective performance consultant* (pp. 1-7). Minneapolis, MN: Lakewood Publications.

Griffin, A., & Hauser, J. (1993). The voice of the customer. *Marketing Science, 12*(1), 1-27.

Hammer, M., & Champy, J. (1983). *Reengineering the organization*. New York: Harper Business Books.

Karat, J. (1997). Evolving the scope of user-centered design. *Communications of the ACM, 40*(7), 33-38.

Khurana, A., & Rosenthal, S. (1997). Integrating the fuzzy front-end of new product development. *Sloan Management Review, 38*(2), 103-120.

Leonard, D., & Sensiper, S. (1998). The role of tacit knowledge in group in-

Marshall, J., & Rossett, A. (2000). An exploratory study of the relationship between knowledge management and performance professionals. *Performance Improvement Quarterly, 13*(3), 23-40.

Massey, A.P., Montoya-Weiss, M., & O'Driscoll, T. (2002). Knowledge management in pursuit of performance: Insights from Nortel Networks. *MIS Quarterly, 26*(3), 269-289.

Montoya-Weiss, M.M., & Calantone, R. (1994). Determinants of new product performance: A review and meta-analysis. *Journal of Product Innovation Management, 11*(5), 39-48.

Moore, J.L., & Orey, M.A. (2001). The implementation of an EPSS for teachers: An examination of usage, performance, and attitudes. *Performance Improvement Quarterly, 14*(1), 26-56.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company*. New York: Oxford University Press.

O'Dell, C., & Grayson, C.J. (1998). If only we knew what we know: Identification and transfer of internal best practices. *California Management Review, 40*(3), 154-174.

Ramakrishna, H., & Brightman, H. (1986). The fact-net model: A problem diagnosis procedure. *Interfaces, 16*, 86-94.

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

Rosenberg, M. (1995). Performance technology, performance support, and the future of training. *Performance Improvement Quarterly, 8*(1), 94-99.

Rosenberg, M. (1996). Human performance technology. In R. Craig (Ed.), *The ASTD training and development handbook* (pp. 370-393). New York: McGraw Hill.

Ruggles, R. (1998). The state of the notion: Knowledge management in practice. *California Management Review, 40*(3), 80-89.

Rummler, G., & Brache, A. (1992). Transforming organizations through human performance technology. In H.D. Stolovitch & E.J. Keeps (Eds.), *Handbook of human performance technology: A comprehensive guide for analyzing and solving performance problems in organizations* (pp. 32-49). San Francisco: Josey-Bass.

Rummler, G. (1999). Transforming organizations through human performance technology. In H.D. Stolovitch & E.J. Keeps (Eds.), *Handbook of human performance technology: Improving individual and organizational performance worldwide* (pp. 47-66). San Francisco: Josey-Bass Pfeiffer.

Schaffer, S., & Keller, J. (2003). Measuring the results of performance improvement interventions. *Performance Improvement Quarterly, 16*(1), 73-92.

Smith, M.E. (2002). Implementing organizational change: Correlates of success and failure. *Performance Improvement Quarterly, 15*(1), 67-83.

Stolovitch, H.D., & Keeps, E.J. (1999). What is human performance technology? In H.D. Stolovitch and E.J. Keeps (Eds.), *Handbook of human performance technology* (pp. 3-23). San Francisco: Jossey-Bass Pfeiffer.

Sviokla, J.J. (1996). Knowledge workers and radically new technology. *Sloan Management Review*, 25-40.

Tushman, M.L., & O'Reilly, C. III. (1996). Ambidextrous organizations: Managing evolutionary and revolutionary change. *California Management Review, 38*(4), 8-30.

Ulrich, K.T., & Eppinger, S.D. (1995). *Product design and development*. New York: McGraw Hill.

ANNE P. MASSEY is Lilly Faculty Fellow and Professor of Information Systems at Indiana University in Bloomington, Indiana. Her research interests include computer-mediated communication, technology adoption and implementation, knowledge management, and related topics. *Mailing address*: Indiana University, Kelley School of Business, Bloomington, IN 47405. *E-mail*: amassey@indiana.edu

MITZI M. MONTOYA-WEISS is Professor of Marketing and Innovation Management at North Carolina State University. Her research interests include new product development process management and the use of advanced information technologies in marketing and new product development. *Mailing address*: North Carolina State University, College of Management, Raleigh, NC 27695. *E-mail*: Mitzi_Montoya-Weiss@ncsu.edu

TONY O'DRISCOLL is a researcher at IBM's Almaden Services Research. His research interests include knowledge management, business process reengineering, human performance technology and design of electronic performance support systems. *E-mail*: odriscol@us.ibm.com