Chapter 7. Competencies[1]

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The technical competence of a research organization is one of the major factors contributing to the quality and quantity of science it produces. In their paper on assessing the effectiveness of research organizations, Jordan et al. (1999) identify several organizational attributes that can be linked to the underlying concept of competence and that are essential to fostering excellence in research. These include the quality of colleagues and the knowledge base, facilities, equipment and support personnel, and the laboratory's core technical competencies and reputation. While it is almost a truism that good science requires good scientists, and that good scientists require good support, the simple existence of strong technical competencies is not in itself sufficient to ensure success in research and development activities. Ellis (1997:148-149), for example, finds only a weak relationship between ratings of technical competence and measures of research and development (R&D) productivity. Instead, the organizational literature suggests that the processes of selecting, organizing, and maintaining the technical and other competencies of the organization are of great strategic importance and filled with considerable complexity. In addition, it is clear that the manner in which competencies are managed is as important as the nature of the competencies themselves. A clear challenge for public science organizations is to develop the managerial leadership that can build the organizational competencies needed to balance knowledge generation and technology commercialization goals and maintain them within the increasingly competitive labor market. This review describes what is meant in the literature by competencies, outlines some of the challenges in selecting, organizing, and maintaining competencies, and proposes some implications of this literature and this area for publicly funded science.

What are Competencies?

The term *competencies* is used in various ways in the literature (McLagan 1997). A primary point of contrast is between individual competencies – those knowledges, skills, and abilities that individuals in the organization possess – and organizational competencies – those things that characterize collective action at the organizational level. In terms of individual competencies, the literature identifies a wide range of factors that are generally important for staff and management success in organizations (Parry 1998; McLagan 1997; Davis et al. 1996) and provides ample guidance for how to analyze specific jobs and positions to determine which knowledges, skills, and abilities are most relevant to a particular job, e.g. job-task analysis (Harvey 1991). However, determining which competencies have true strategic value to an organization requires a different perspective.

Figure 1 below illustrates the scope of the concept of competencies within the organizational literature (figure adapted from Green 1999: 23). Competencies refer to both organizational and individual characteristics. Individual characteristics include both the technical knowledge and skills and the performance skills and competencies of individual contributors. Although technical skills (discipline-based knowledge, research skills) are obviously important for scientific success,

[1] Related chapters include: Strategy; Knowledge Management; Organizational Culture; Innovation

the R&D literature increasingly stresses the importance of performance skills and competencies (communications skills, ability to work in teams) as factors in the productivity of R&D organizations, and, thus, desirable traits for workers in these organizations (Jonach and Sommerlatte 1999). Particularly in situations where cross-disciplinary work is essential for advancement of a research area, individuals with these types of skills, and organizations with the structures and processes that enable individuals to apply their skills effectively may make the difference between a program's success or failure. As research organizations are engaging more directly in the development and commercialization of intellectual property, additional and sometimes conflicting individual and organizational competencies are needed, adding further complexity to the identification and management of key organizational competencies.

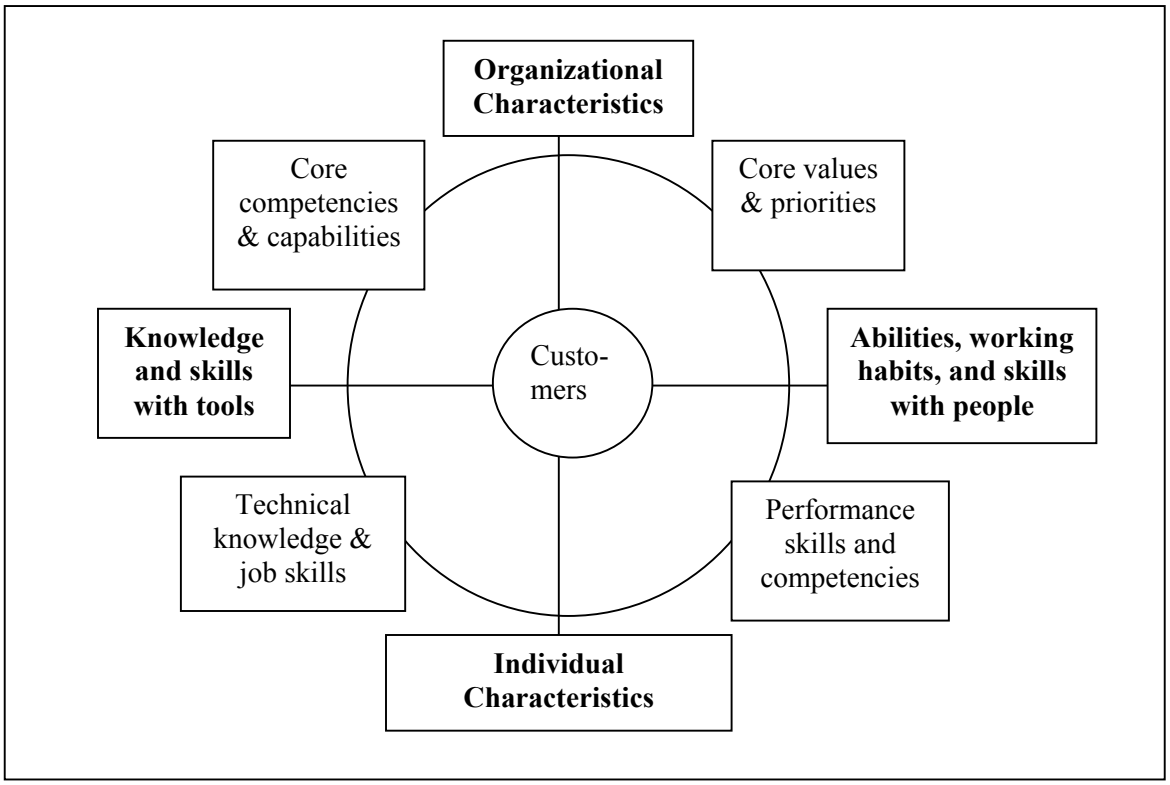

Figure 1. The Competency Scope (adapted from Green 1999:23)

Within the last ten years, the concept of core competencies has been added to the literature (Prahalad and Hamel 1990). Core (organizational) competencies refer to bundles of skills and technologies that enable an organization to provide a particular benefit to a customer and hence to compete more effectively. Organizations will have necessary competencies and differentiating competencies. Necessary competencies are all those that go into creating value, but differentiating competencies are those that give a particular organization or groups of organizations a competitive position (e.g., market share, scientific reputation). These differentiating competencies are what Itami (1987) refers to as the organization's competitive weapons, and what Stalk et al. (1992) and Lawler et al. (2001) consider to be the basis for competition in the future.

Hamel and Prahalad (1994a) then further argue that it is particularly important for an organization concerned about its future success to be preemptive in its development and alignment of

competencies in order to lead the way into new products and services. Thus, a strategy for future market competitiveness necessitates that the top managers of an organization concern themselves with the organization's core competencies and eschew a complete fit of strategy and resource alignment in the quest for current market success (Hamel and Prahalad 1994a; Collis and Montgomery 1998). The challenge is to select for strategic investment the set of the organization's capabilities that will most likely place it in the forefront of the delivery curve for yet-to-emerge research areas, products, or services. A strategic architecture must be developed that can provide a blueprint for building competencies for the future. For science- and technology-based organizations, part of this challenge is understanding the trends in technology and the science upon which it is based. As Figure 1 indicates, the organization's core competencies derive from a range of influences, including the market (customers), the bank of knowledge and skills available to the organization, and the core values and priorities of the organization.

Selecting Competencies

One of the lessons from the competitive environment, however, is that organizations cannot adequately support all competencies – either individual or organizational, technical or performance skills. Organizations must choose where they will emphasize investment and development. Indeed, choice of competencies is the essence of strategy, involving tradeoffs not only among particular competencies but also among such fundamental organizational strategies as stability versus change and commitment versus flexibility (Collis and Montgomery 1998). Organizations must also be alert to the emergence of new competencies among their competitors. Hamel (2000), for example, claims that technology-based organizations must develop an "innovation competency" if they are to survive in the new economy that has emerged in the late 1990s.

Certain types of competencies (e.g., project management) can be expected to be very important for all research organizations. However, other types of competencies (e.g., interdisciplinary research) may not be as important for some organizations as for others. One of the challenges in managing the research process is in understanding which technical and performance-related competencies are most crucial, and systematically recruiting for and developing them. For research organizations, core competencies are resident primarily in the research staff and may be defined as "…a group of skills, knowledge, cognitive strategy, meta-cognitions, beliefs, values and attitudes belonging to people that command the process of R&D" (Aquino Guimaraes et al. 2000:5).

For most R&D organizations, both current market demands and historical factors (previous market demand) shape perceptions about which of its many technical competencies qualify as core competencies. It can be very difficult for organizations to take an objective look at existing competencies and make the strategic decisions about where to invest for the near-term and long-term. A first clarifying step can be to conduct an audit of competencies against current or perceived future demand. For example Aquino Guimaraes et al. (2000) suggest the use of Delphi surveys of internal and external technical experts to help research organizations identify which technical areas are most central to success in particular markets or research areas. Klein et al. (1998) use statistical techniques to accomplish the same thing. Collis and Montgomery (1998) emphasize that effective analysis of core competencies requires disaggregation of organizational resources to a level that can reveal the competitive superiority that underlies their strategic value.

Because it typically takes years for an organization to develop a significant new technical competency, the organization's ability to accurately forecast emerging trends in science and technology is an important aspect of selecting and developing core competencies (Miller and Morris 1999:242). Jonash and Sommerlatte (1999) stress that organizations increasingly need sophisticated planning tools, such as technology scanning and forecasting, scenario analysis, and roadmapping, in order to establish an intelligent innovation strategy. Collis and Montgomery (1998:44), however, remind those struggling with the dilemmas created by the inevitable uncertainties associated with these forecasts that "[I]f all decisions were made with perfect information from the start, strategies would tend to converge and excess returns might not be possible….strategic uncertainty [plays a]…powerful role in creating strategic asymmetries and competitive advantage."

Organizing Competencies

The organization of technical competencies within organizations is a topic that received much early scholarly attention (Thompson 1967; Burns and Stalker 1961), although it has only recently re-emerged as a primary focus of investigation in the literature. Focusing primarily on manufacturing, earlier discussions identified how the demands of the production process (e.g., batch processing, assembly lines) essentially determined how competencies would be arranged organizationally.

Recently a revolution has occurred in the way that competencies are organized. Starting with the emergence of the Japanese production model, more and more organizations have moved in the direction of organizing by processes. Processes are those integrated sets of activities that produce usable products. The basic model behind such works as *Reengineering the Corporation* (Hammer and Champy 1993) and *The Great Transformation* (Martin 1995) is that by arranging competencies relative to processes, the organization can achieve greater efficiencies and better understand and meet external customer needs. Similarly, the management literature has also recently introduced the concept of team-based organizations in which permanent structures are rare and most work is organized around teams that are brought together for specific projects (Mohrman et al. 1995) – even for some aspects of research. The creation of interdisciplinary teams around customer-defined problems has led to faster and better development of new products (Matheson and Matheson 1998). In fact, the emergence of the knowledge-based economy calls for a new flexibility in the ways that diverse knowledges (competencies) and people from diverse organizational units can be brought together to produce intellectual capital for the organization (Stewart 1997). This requires leadership skills and, increasingly, the ability to build flexible, multi-disciplinary teams (Bennis and Biederman 1997).

However, in research organizations there is a potential paradox between the need to integrate various technical competencies into multidisciplinary teams, and the need to provide a critical mass of similarly trained and oriented technical staff to continue the process of developing a deeper and deeper understanding of the technical subject matter. Put another way, does organizing by processes, markets, or interdisciplinary teams make it more difficult to develop and maintain deep technical competence? There are several approaches to resolving this organizational paradox, including job rotation, creation of temporary interdisciplinary teams around projects, and the development of communities of practice to cross-cut whatever formal structure is implemented (Wenger and Snyder 2000; Miyazaki 1999). However, the management of this paradox is likely to be one of the greatest challenges in organizing and maintaining competencies within science-based organizations.

Maintaining Competencies

At the level of the individual worker, commitment to the organization – feeling that one is part of a bigger mission and that one's contribution is important – is a major factor in productivity and innovation. A significant factor in engendering the commitment of the staff to the organization and its products is visible and meaningful management commitment to the staff and to the competencies they represent. Two central aspects of maintaining the competencies that reside in an organization entail (1) the nurturing and development of the existing competencies that support the current mission and innovation for the future, and (2) the existence of an internal working environment that contributes to the staff's preference to work there rather than for some other company.

Competency Maintenance, Development, and Transition

Given the pace of change in knowledge and its applications, if the technical staff in knowledge-based organizations are to stay current, let alone move to the cutting edge, they must have opportunities for exposure to the state-of-the-art and access to information. As the need for intellectual capital increases, companies must find ways to ensure that their intellectual capital develops and grows (Ulrich 1998). The organization's performance management system, if appropriately designed, provides cues to individuals about which of their competencies are of most value to the organization (Ulrich and Lake 1990:Chapter 7) and thus warrant efforts for staying current. Particularly in knowledge-based organizations, effective incentives must also be provided to overcome professionals' reluctance to share information and help other members of the organization enhance their knowledge (Quinn et al. 1996:75). As markets move, the organization needs to be prepared to leverage its valuable human resources into areas where they can create value, or to transition them out of the organization – decisions that are at the heart of competency management.

Most managers have little difficulty saying that the people in the organization are their most important asset, but considerable difficulty demonstrating that this is true. Stewart (1997) points out that too many organizations think of staff in terms of what they cost rather than what their value is to the organization's output. Organizations that see their portfolios of technical competencies as central to their current and future success will want to engage actively in broadening, deepening, or reconfiguring these competency holdings. This is an investment, not a cost. Hamel and Prahalad (1994a) describe the need for a *strategic architecture* that provides a blueprint for building the competencies needed to dominate future markets. Stalk et al. (1992) point out that when an organization thinks in terms of portfolios of core competencies, it then has a basis for making decisions about where to invest in competency development at the individual level. In addition, by thinking about staff as central to the organization's core competencies, management is encouraged to think strategically about staff recruitment, retention, and professional development and to be alert to challenges posed by characteristics of their particular labor market. For example, anticipated shortages in particular disciplines or specialties, can lead organizations to develop individual coping strategies and/or to collaborate on policies that address the issues on a broader scale.

Retaining Staff and Sustaining Competencies

Whether or not significant investments have been made in staff development, continually having to replace individual staff members can be costly. This is especially true for those types of positions where it can take two or three years for a new professional or technical staff member to become well integrated into one of the organization's core competencies (Hamel and Prahalad 1994a). Employees interviewed as they are leaving a job tend to focus not on some lack in the financial and prestige elements of the work, but rather on the content of the job, e.g., "I wasn't able to use my skills as well as I should have been," "I was bored and needed more of a challenge," or "I wasn't doing what I really wanted to do" (Ulrich and Lake 1990:160). This indicates that management attention to the fit of individual competencies with the bundles of organizational competencies of the organization is critical to staff retention and motivation.

Secondly, large-scale staff reductions for financial rather than strategic reasons, or high levels of staff turnover due to dissatisfaction, can result in decrements to the organization's competency portfolio, which in turn can affect the organization's ability to compete with other organizations in the same industry (Hamel and Prahalad 1994a). When appropriately organized, each individual's personal knowledge is transformed into organizational knowledge valuable to his or her division, or to the company as a whole (Itami 1987; Nonaka 1991). In the realm of research and development, staff turnover can constitute major losses in the non-tangible but critical assets of knowledge, experience, and ideas. The potential consequences of sudden or creeping staff reduction to an organization's ability to remain competitive within an industry need to be considered in more than financial terms.

The design of organizational programs and processes can be a major factor in sustaining competencies. Ulrich and Lake (1990:Chapter 8) set forth the two management practices that they consider key to sustaining competencies – organization design and communication. *Organization design* includes the processes by which responsibility is allocated, roles are defined, control and accountability are established, and decision-making authority is delegated. *Communication* can be designed to ensure that each individual has a clear understanding of what should be done, as well as why the tasks identified are important. These conditions are important to the nurturing of commitment on the part of the staff, both to the organization, and to the alignment of their learning and producing with the organization's core competencies. In addition, the role of leadership in managing intellect in an organization is widely recognized. Quinn et al. (1996:73) liken effective intellect management to successful coaching, both relying heavily on the recruitment of talent and the ability to build an effective team. Organizational processes that support the emergence of vigorous self-organizing networks and communities of practice are increasingly recommended for knowledge-based organizations as a way to leverage knowledge and enhance individual expertise (Quinn et al. 1992; Liedtka et al. 1997).

The Application of Competencies to Public Science Management

Most of the literature focuses on the role of competencies in creating a competitive advantage for firms in the commercial sector. Relatively less is known about the way that competencies should be managed to help ensure success in the public science environment, and some care should be taken in applying this literature. Clearly, however, the creation, organization, and maintenance of core competencies is a critical issue for the public science community, which has responsibility for essential aspects of national security and public well-being. Stewardship for core national competencies in science and technology is called out as one of the primary functions and

responsibilities of public science organizations. The tension between collaborative development of national assets and core competencies and competition among organizations for opportunities, resources, and performance is longstanding, as is the debate about the appropriate degree and mode of competition among public science organizations and the appropriate metrics for measuring competence and competitive advantage in public science.

The drive for competitive advantage, and the uncertainties about which competencies will best create it, are seen as important drivers of innovation and diversification in the commercial sector. Public science organizations are increasingly drawn into this mode by their efforts to combine their core fundamental science, knowledge generating capabilities with capabilities that enable them to compete in the market-driven arena of intellectual property commercialization. How these dual objectives affect the selection/development and management of core competencies in these organizations is not clear, though all indications are that balancing these competing competencies is posing vexing challenges for managers and staff at all levels of public science organizations.

The literature on competencies is beginning to look at the planning and evaluation issues associated with a competency-based approach to organizational design and strategy development. Although rarely addressing science-based organizations directly, this literature provides a framework for examining some of the pressing issues facing manages of public science, for example:

- What is the appropriate planning and development horizon for competencies in the scientific environment? What tools and metrics are particularly relevant to this challenge?
- What is the right balance between organizing by competency and organizing by cross-disciplinary teams relative to the development of good science?
- What competencies are required for public science missions, and what competencies are required to maintain a national competency in science and technology?
- How can public science sponsors, and public science implementers, best preserve essential competencies for the long run, while responding to nearer term needs for more applied research and engineering?
- How can the sponsors of public science link the competencies of the various national laboratories and other research organizations to create additional critical mass, leverage experience, and benefit from synergies?
- What are the most appropriate selection criteria for research staff within the particular organizations of the public science establishment? What skills and characteristics are essential for success within these organizations, in addition to scientific knowledge and research skills?
- What are the threats to retaining the best competencies and what steps can be taken to meet these threats?
- When is it essential to develop and maintain a competency within a public agency's own laboratories, and when is that competency best acquired from outside the laboratories?
- What role should public science sponsoring organizations play in evaluating the ability of their laboratories' management to establish, align, and maintain technical competencies?

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