8 Skills and Innovation

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The rate, extent and success of innovation in organisations (and in society at large) is linked intimately with the presence and availability of trained and skilled workers. Such individuals generate and apply knowledge, intelligence, techniques and ideas in the creation of novel products and development of new processes, and in so doing, contribute crucially to the efficiency and competitive advantage of the organisations, sectors and regions in which they work. Not surprisingly, a long-term push towards enhancement of the stock of innovation-related skills can be seen across all developed economies, with enhanced linkages between the education and training sector and employer organisations a key priority in the policy environment. In addition, the importance of certain forms of skills—especially problem-solving, technical and collaborative working skills—is acknowledged across the spectrum of industrial and public agencies, and organisations across all sectors have demonstrated an eagerness to build the specialist capabilities that are expected to sustain and grow their operations. Thus, it can be suggested with some confidence that the centrality of a skilled workforce to innovative and competitive enterprise has never been more clear. This assertion is certainly accepted in the policy community, where urgent calls for a swelling of the human capital and skills pools have resonated increasingly loudly in unfolding political discourse.

Despite the current focus on skills and innovation capacity, our current understanding of the relationship between the two remains heavily constrained: differing and broad definitions of the concepts, inadequate attention to the linkages between training systems and the dynamics of the skills base, and difficulties in measuring human capital and innovation outcomes have all implied the persistence (and perhaps expansion) of knowledge gaps. It can be argued strongly that such ignorance cannot be permitted to continue: a lack of understanding implies potentially damaging consequences for managers and policy-makers, and for regional and national economies. Without more adequate and accurate understanding and intelligence, opportunities may be lost, competitive ground ceded, and future planning severely hampered. Where skills are a key determinant of innovation capacity, and such capacity correlates with competitive
advantage, sophisticated cognition of the articulation between capabilities and successful innovation becomes an urgent requirement.

It is now recognised universally that human capital and physical capital are the twin and fundamental ingredients in R&D and new product development. Thus, in addition to ensuring the availability of requisite physical resources, attracting and training skilled people is critical to the stimulation of innovation and to the acceleration of productivity growth. The competitiveness of firms, nations and trading blocs is clearly linked to their innovation performance, and to the skills and competences of their workers and citizens. Indeed, the presence of strong innovation-facilitating skills is the factor that confers competitive advantage on specific companies and locations, and where innovation leadership is evident, so too sophisticated education, skills and training regimes are invariably in place. It is clear, however, that some—even developed—regions lag behind others in terms of innovation (for example, Europe lags behind the US and Japan, despite concerted efforts to reverse the situation), and this raises the important question of just what skills and competences are implicated in successful and sustainable innovation. It also raises the question of just what forms of education and training systems are best suited to growing and supporting an innovation culture, and to the diffusion of progressive innovation practices. We may also wish to consider what needs to be done by those firms and regions that aspire to parity with current innovation leaders. Moving yet further to a more granular examination, we can also ask ‘what skills are needed to deliver success with respect to different forms of innovation’, ‘what are the skills that are found in the more innovative companies and regions’, and ‘how can innovation skills be measured’? It is questions of this nature that this chapter sets out to address.

The first section of the chapter deals with some general themes relating to (a) definitions and forms of skills and innovation, and (b) the role of skills in firm-level, regional and national innovation performance. Section two examines the types of skills that are required for different types of innovation processes, and for innovation in different types of organisations. We conclude with a short discussion of the status of existing knowledge with respect to the skills-innovation dynamic, and with a review of current directions (and remaining gaps) in the research and policy agenda.

CONCEPTUALIZING AND DEFINING ‘SKILLS FOR INNOVATION’

Human capital (or skills) accumulation and innovation have been described as the ‘twin engines of growth’ (Lloyd-Ellis and Roberts, 2002). It is argued that these engines act together and combine with other factors1 to accelerate economic development and growth at firm, regional and national level. In so doing, they both shape the ways in which we nurture and deploy
capabilities that are conducive to innovation, and create demand for new forms and combinations of skills. If the articulation between skills and innovation then is increasingly clear, the mechanisms through which they interact remain somewhat opaque. While we will explore the evidence with respect to inter-linkages and combinatorial modes later, first we need to set out what we mean when we use the terms ‘skills’ and ‘innovation’.

Skills, in their most general sense, can be viewed as the abilities of individuals for which there is a demand within the formal economy. Such skills can include management and leadership abilities, technical, scientific and production abilities, and soft/interpersonal abilities. Individuals typically acquire skills that enable them to implement and use existing technologies and to fit in with current ways of doing things. However, they also acquire skills that assist them in developing novel products or in organizing work and production processes in new ways. Tether et al. (2005) define a ‘skill’ as ‘an ability or proficiency at a task that is normally acquired through education, training and/or experience’. These authors also indicate that the term ‘skill’ is sometimes used synonymously with related concepts of ‘competence’, ‘expertise’, ‘knowledge’ or ‘human capital’. They suggest that there are many forms of skills and that the term is used in a wide variety of contexts. Here (and at a most basic level) it is useful to distinguish between different levels and different types of skills. Discussion of level implies that we consider the aptitudes, experience, credentials or abilities that are required of individuals in the performance of a task or function. With respect to types of skill, here we are concerned with various classes such as engineering, technical, organizational, problem-solving, language, relationship-building and communication skills.

Innovation is a complex and contested term that can be used in a variety of contexts. The OECD’s Oslo Manual (1995) defines innovation as: ‘The implementation of a new or significantly improved (to the user) product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relation’. This definition captures both the meaning of innovation as a process (implementation) and as a new artifact or practice (product, process, method, etc.). However, a more elaborate definition can be found in The Oxford Handbook of Innovation (2004, p.4) where Fagerberg notes that:

An important distinction is normally made between invention and innovation. Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice. Sometimes, invention and innovation are closely linked, to the extent that it is hard to distinguish one from another . . . In many cases, however, there is a considerable time lag between the two . . . Such lags reflect the different requirements for working out ideas and implementing them. While inventions may be carried out anywhere, for example in universities, innovations occur mostly in firms, though they may also
occur in other types of organizations, such as public hospitals. To be
able to turn an invention into an innovation, a firm normally needs to
combine several different types of knowledge, capabilities, skills, and
resources. For instance, the firm may require production knowledge,
skills and facilities, market knowledge, a well functioning distribution
system, sufficient financial resources, and so on . . .

Definitions of innovation often stress ‘the successful exploitation of new
ideas’—this particular formulation is from the UK government’s Depart-
ment for Business Innovation and Skills (DBIS) but echoes the emphasis on
success often found in the management literature. The concept of ‘success’
is, however, somewhat ambiguous—a technical success may be a commer-
cial disaster!

THE ROLE OF SKILLS IN INNOVATION

The definitions sketched earlier, and the wider discussions in which they
are set, indicate that there are different types of innovation and innovation
processes, varying for instance in terms of the following:

- Types of idea and underpinning knowledge (e.g., technological ideas
  are emphasized to the exclusion of cultural or organizational ones) ⁴
- Ways of generating ideas (e.g., research and development are priori-
tized as compared to innovations developed in practice or on the job)
- Forms of success (e.g., economic return or social benefit and/or
  acclaim) and
- Levels of novelty—since some new ideas are groundbreaking while
  others are minor changes in established ways of doing things, there
  is a classic distinction between incremental and radical innovation.
  Many related concepts have been introduced such as ‘revolutionary’,
  ‘architectural’ and ‘configurational’ innovations. In addition, innova-
  tion studies may ask whether an innovation is ‘new to the firm, new
to the industry, or new to the world’. ⁵

Different forms of innovation can be introduced too. For example, the
European Commission’s Community Innovation Survey (CIS4) deploys
four widely used classes:

- Product innovation (usually technological)—This is where innovation
  involves the development of new goods, services, machinery, equip-
  ment, components, software (or novel assemblages of these).
- Process innovation—Here innovation focuses on development of new
  systems or routines of production, again with an emphasis on the
tools, equipment and software that are to be used in novel processes.
• **Organizational innovation**—Here innovation relates to changing management practices or workflow structures.

• **Marketing innovation**—Here innovation involves new ways of relating to customers and potential customers (including new ways of promoting products). This is closely related to the idea of delivery innovations, targeted at transforming the ways in which products or services reach their consumers.

Much discussion centers on research and development (R&D) as the way in which innovations are generated. In practice, however, innovations often come from work on the shop floor or front office, and R&D departments are, anyway, rare other than in high-tech manufacturing (and a few high-tech services) companies. Often, major innovations are organized through project development teams. In some firms and sectors the main influences on innovation are the introduction of new machinery and software from suppliers of such tools; in others, professional associations and industry associations provide an important source of knowledge; in yet more, the clients are a major stimulus for innovative ideas, and so on.

Further, we should note that the innovation process is itself something that changes over time. From the first development of an idea (invention), through its development into a new product or process, the rollout of the idea in the innovating organization (translation), and then the distribution and implementation of this by further users (diffusion), new ideas may be introduced at any stage. In addition, the design of the innovation may be adapted in the light of feedback as to user requirements, technical problems or competitor products.

Two important ideas here are the ‘product life cycle’ and the ‘industry life cycle’. Each refers to a stylized path of development. In the product life cycle the picture refers to the development of an innovation from being expensive and hard to use, to being cheap and available for low-skill users (and often mass markets). The focus of innovative effort evolves from one of getting the product to work and to be well adapted to users, to one of mass-producing it easily and cheaply. The industry life cycle points to the parallel phenomenon, wherein firms rise and decline and production may be moved from highly knowledge-intensive locations to ones characterized by cheap and less skilled labor. These ‘life cycles’ are useful frameworks for thinking about labor product and industrial change, but there are many cases where the patterns described earlier are not followed with any precision.

Given then that there are many forms of innovation that do not follow a defined set of stages, the relationship between innovation and skills is inevitably complicated. Skills involved in innovation will depend on the following:

(a) The nature of the innovation in question (incremental vs. radical; product, process or organizational)
(b) The nature and distribution of skills within and available to an organization
(c) The possibility of transforming and growing new skills within enterprises and the wider economy

It is possible for an individual enterprise to go through the whole process of innovation without changing its skills set (especially if the innovation is incremental, rather than radical). However, it is also likely that innovation may lead to, or require, a change (possibly of various different kinds) in the skills profile of the business. It is also clear that at both the level of the firm and across the economy the various stages of innovation in manufacturing and services will at some point impact on the demand for skills and new skill composition, including that relating to management and leadership, technical and scientific work, and soft/interpersonal activities.

Following from the foregoing, it could be expected that different ‘types’ or classes of innovation will require different types of skills (i.e., skills differing in both form and level). These skills are needed to support development and diffusion. The configuration in Figure 8.1 is not intended to be comprehensive (as there are of course many generic skills involved in innovation of all forms). Rather, it is indicative, offering an overview of the types of core skills frequently associated with different classes of innovation. Data in Figure 8.1 draws upon work by Tether et al. (2005), Tidd et al. (2001) and Utterback (1996).

We can now look in more detail at classes of innovation and the forms of skills that are generally required to ensure their realization (Tether et al., 2005).

Product and technological innovation is commonly understood to concern the development of new goods, equipment and services that generate demand for scientific, technological, design and engineering skills (especially

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<tr>
<th>Class of Innovation</th>
<th>Skills</th>
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<tr>
<td>Product and Technological</td>
<td>Scientific and Technological; Engineering Design; Packaging Design; Market and User Research</td>
</tr>
<tr>
<td>Process</td>
<td>Technical; Project Management; Organizational and Workflow Design; Interaction and Relationship Management</td>
</tr>
<tr>
<td>Organizational</td>
<td>Opportunity Recognition; Systems Design; Leadership; Communication</td>
</tr>
<tr>
<td>Marketing, Delivery and Interface</td>
<td>ICT &amp; Systems Development; Web Design and Content Development; Data Analysis; Language and Communication</td>
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*Figure 8.1 Classes of innovation and associated core skills.*
in the case of innovation associated with development of tangible goods). Technological innovation in developed economies has been described as skill-biased, insofar as it is perceived to increase demand for higher-level skills and reduce demand for lower-level skills. Market research skills are also necessary for the collection of data relating to the orientations and preferences of potential consumers, as are client interfacing (and communication) skills in the case of new service development and delivery. Given the ‘distributed’ nature of much contemporary innovation, skills for the management and coordination of team-based working are perceived to be an increasingly necessary ingredient in innovation.

Process innovation involves the development and commercial exploitation of a new way of producing an organization’s product(s). Much discussion in the economics of innovation literature focuses on the ‘job reducing’ character of process innovation: this is because much of this innovation is of the kind where capital—in the form of new machinery or equipment—replaces labor (particularly where such labor is unskilled). However, process innovation can involve the use of more labor relative to capital, or the offsetting of job losses by the creation of jobs elsewhere in a company or the economy (for example, in the upstream production of new machinery). Process innovation itself is complex (and evident in many forms), and usually requires some technical and project management skills to ensure successful specification and implementation (especially where new deployment of technologies is implied). Organizational and management skills will usually be required in order to ensure successful redesign of workflow processes. Interaction and relationship management skills are also frequently necessary where introduction of a new process implies disruption to existing work routines.

Organizational innovation implies change in management practices and organizational structures and can have a variety of effects on the demand for skills. While it is closely related to process innovation (as the latter frequently requires some level of organizational change), at a basic level, the term implies the introduction of new management practices and/or the redesign and reorganization of work practices and routines (i.e., new ways of ‘getting the job done’, or the introduction of new jobs and methods of working). Skills for the initiation of organizational innovation include an ability to recognize opportunities for (and value to be derived from) the introduction of new systems. They also include an ability to conceive of and design appropriate new systems. The management of organizational innovation frequently involves leadership and communications skills, and an ability to convey a (positive) vision of change to secure the buy-in of workers affected by change.

Marketing, delivery and interface is concerned with the development of new ways of getting products and information to clients and service users. The extraordinary growth in the number and sophistication of commercial and public agency websites over the past decade is clear evidence of the
efforts of contemporary organizations to create novel ways of interfacing with their users, partners and customers. Importantly, this growth also highlights the central role of ICTs in the development and realization of interface innovations. New technologies, including mobile telephony and web infrastructure, have made it possible for firms and agencies to evolve novel business models (e.g., around e-business and remote transactions), and to use data captured via interactions with their customers in their innovation activity. Skills involved in the development of delivery and interface innovations are wide-ranging but there is a clear focus on high-level technology skills, such as those associated with systems development and integration, and cyber security. Web design, data analysis, and creative and content development skills are also important, as are language and communication skills where delivery innovations involve the establishment of remote customer service facilities. Enhancing services—or indeed providing these through alternative delivery channels such as by phone or Internet—often requires soft skills including oral communication, customer handling, local problem solving and teamwork. These skills applied through 'emotional labor' are increasingly important for businesses seeking to compete on the basis of enhanced quality of service, rather than price (Becker, 2001; Frenkel et al., 1999).

The classes of innovation sketched earlier are liable to vary across the product/industry life cycle, and stages in these life cycles are liable to affect both demand for and supply of various types of skills. Stages of the life cycle and associated skills are presented in Figure 8.2.

With respect to product innovation, Tether et al. (2005) report that businesses can be expected to transit through three stages, each differing in their demand for skills. During an early, ‘fluid stage’, the product is ill-defined, and the key skills needed are those of entrepreneurism (often combined with scientific or technical specialisms, and skills in marketing). Production skills at this stage tend to be general and adaptable, rather than specific and rigid. At this stage, production workers have to adapt to rapidly changing

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<th>Innovation</th>
<th>Fluid Phase</th>
<th>Transitional Phase</th>
<th>Specific Phase</th>
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<tr>
<td>Radically new products</td>
<td>Focus on process to achieve production scale efficiencies</td>
<td>Gradual cumulative improvements in productivity &amp; quality</td>
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**Key Skills**

- Entrepreneurial skills, coupled with high-level specialism in technology and/or marketing; also, an adaptive workforce, which develops more specific skills over time
- Organized, functional 'scientific management', plus development of specialist workforce skills associated with mechanization of production
- Small "elite" with managerial command & control skills, seeking to maintain control over a workforce with low or non-specific skills

*Figure 8.2* Characteristics of innovation and skills over the product/industry life cycle. Source: Tether et al. (2005).
technologies and demands. Subsequently the product tends to become more defined and standardized, and a ‘dominant design’ emerges. This is a ‘transitional stage’, in which there is a shift from product to process innovation. The emergence of a clearly defined product denotes entry into a ‘specific stage’ where firms increasingly compete on costs and price, rather than on product quality and features. During this phase, management skills become more functional and ‘scientific’, while workforce skills become more specific, and the division of labor more precise.

There is often a tension between how finely honed workers’ skills are to a task and their ability to learn and adapt. The introduction of specialist equipment may at first augment the skills of skilled workers. However, in the long run, capital (i.e., machinery, equipment) tends to replace skilled labor. During the mature phase of the industry the remaining labor force becomes increasingly low-skilled. Technologically-based product and process innovations, then, can have different effects on the demand for skills. Process innovation is generally assumed to be of the kind where capital replaces labor, particularly unskilled labor. However, innovation could increase demand for the firm’s products, stimulating employment, or jobs can be created elsewhere in the economy (for example, where firms supply capital equipment). Product innovation is broadly expected to generate employment, because it can increase demand for a firm’s products.

As we shall discuss later, innovation processes are also increasingly distributed or ‘open’, requiring clusters of firms and other stakeholders to work together rather than ‘going it alone’. These distributed processes require managerial skills in forming and sustaining collaborative arrangements for innovation.

Overall, it is difficult to disentangle the skills that drive innovation from those that are demanded as a result of change brought about by innovation. The skills of the workforce and management will help determine the innovation that takes place within a firm. This will then help determine the changed demand for skills in the firm, and this in turn will influence the innovation that takes place and so on. Understanding the relationships requires modeling that is currently not yet widespread.

Nevertheless, there is enough analysis and evidence available to be able to draw many conclusions about the nature of skills for innovation and their implications for developed economies. Ahead we will see how far these enable us to address the series of issues that have been posed.

SKILLS, INNOVATION AND PERFORMANCE

We can now turn to how needs for skills and innovation vary across different types of organizations, and the ways in which skills for innovation impact on their performance. Many companies—especially SMEs—are not able to put much effort into thinking about innovation, and so do not have
articulated views about their skill needs for innovation. We might conclude
that they have a need for management skills associated with maintaining
awareness of the challenges and opportunities with which innovation con-
fronts them! More generally, many firms will have difficulty in identifying
the broader management and workforce skills required for effective inno-
vation in their sectors and markets, and management capabilities for such
strategic skills analysis are extremely important. We should also note that
there is some evidence that innovative SMEs, at least, seem to see the main
issue as one of developing skills in their existing workforce, rather than
accessing them from external sources.

There is evidence for both national and regional economies that higher
skill levels tend to be associated with higher levels of economic performance
(e.g., productivity increases and/or ratings on competitiveness indices). One
regional analysis concerns the UK; Boddy et al. (2005) conclude that the
relative performance of different UK regions has much to do with differ-
ences in capital investment and in skill levels. At a cross-national level, the
2002 European Competitiveness Report reviewed studies demonstrating
the positive impact of human capital formation on national economic per-
formance. Skill shortages in the EU were seen to be related to the under-
performance of most EU economies when compared to the US (especially
in terms of productivity growth). The study puts emphasis on the need
to match skills with capital investment. Indeed, the literature here typi-
cally suggests that human capital cannot be considered in isolation; it is
the combination of skills with management, capital investment, and other
factors—for example, transport and communications infrastructure—that
is necessary for really effective performance.

Shortages of higher-level skills have been reported to have a negative
impact on performance insofar as they introduce delays into the innova-
tion process (Mason, 1999; 2000). The UK Technical Graduates Employ-
ers Survey in 1998 (reported in Forth and Mason, 2004) in the UK found
that two-thirds of employers that had experienced difficulties in recruiting
high-level skilled personnel reported the incidence of commercial problems
as a result. The most commonly mentioned problem was delays in prod-
uct development and process improvement projects, impacts that may have
no immediate effect on performance but may contribute to weaker perfor-
ance in the longer term. The link may not be a mechanical one—groups
of skilled workers may dig in their heels to protect their jobs, working con-
ditions and status, and resist the introduction of specific innovations. How-
ever, there is a wide consensus that innovation is in general more prevalent
where there are higher levels of workforce skills. Most of the evidence con-
cerns skills in general, rather than 'skills for innovation' specifically. A line
of useful evidence comes from innovation surveys that question firms with
respect to their innovative activities and other factors that relate to innova-
tion, including employment of graduates and expenditure on innovation-
related training.
An analysis of UK data from the fourth EC Community Innovation Survey (CIS4), conducted in 2005, points to there being a strong link between skills and innovation. This survey asked managers in firms with more than ten employees a series of questions about innovation-related issues. We analyzed data at firm and at sector level, with similar broad results. There was a positive relationship between the proportion of workers with higher education qualifications at firm or sector level, and the likelihood of firms engaging in product, process or organizational innovation in the previous three years. There was a weaker relationship between innovation propensity and the average amount of expenditure on innovation-associated training per employee—suggesting that greater training expenditure does not automatically result in more innovative ideas being put into practice. We would expect that the cost of training staff to use new technologies may vary considerably across sectors and types of innovations. We also note a positive relation between propensity to innovate and the prevalence of reports where a ‘lack of qualified personnel’ is a barrier to innovation. The more innovative firms experience this problem most, which suggests that skill shortages are more often a barrier to further innovation and commercialization, than they are something that prevents innovation initiatives altogether.

**MEASURING SKILLS FOR INNOVATION**

The need to develop improved measures for skills for innovation is a problematic but important area for the development of policy (Hanel, 2008; Toner, 2011). It is also an important issue for those sectors and firms that wish to benchmark their innovation capacity as a component in strategic and competitive positioning. One major obstacle resides in the fact that the definition of skills is not uniform across (or within) Europe, the US and Asia: in addition, qualifications are usually adopted as a proxy and these too are not uniform across countries. As a result we find that different methodological approaches are used. Taking the European case as an example, the most common definition for skills employs both occupational skills and educational attainment components (Ireland, France, the Netherlands, Poland, Finland and Romania). In addition to this common definition, the UK uses the term ‘qualifications’, as well as attempting to build on the generic skills concept (by including social and personal skills) to expand the definition. Greece also applies diverse skill concepts covering generic, technical and personal skills. In Estonia, Italy and Cyprus, skills are defined mainly in terms of occupations. In the Czech Republic and Germany more emphasis is placed on educational attainment and qualifications. Whatever approaches are apparent, there is little evidence that any European country measures skills for innovation specifically and explicitly. Indeed, in view of the foregoing it would be surprising if there was a consensus on what these might be.
The ideas sketched in Lorenz and Valeyre (2006) go some way towards identifying a set of indicators for skills and innovation. The approach is premised on evidence that suggests that firms that combine science-based learning and skills development with experience-based learning tend to be more innovative than those that are biased towards only one of the forms. However, it is important to recognize that national systems differ in terms of how learning is organized in both of these dimensions. The current confusion calls for a broad definition of skills for innovation, and some progress has been achieved in this regard. Lorenz proposed an STI-mode and DUI-mode characterization of skills development. The STI (science, technology and innovation) mode is characterized by a formal science approach and includes engineering training and skills. The DUI (learning by doing, using and interacting) mode refers to experience-based learning and skills that are tacit, embedded in routines and embodied in people. A Composite Skills for Innovation Index is thus proposed comprising four STI-mode indicators and four DUI-mode indicators, along with a set of skills maintenance, and foundation skills indicators. While this configuration has been helpful in aiding thinking about determining indicators for skills and innovation, there is clearly much space and need for further work to establish a holistic and internationally applicable framework for the measurement of skills for innovation.

CONTEXT-DEPENDENT SKILLS FOR INNOVATION

As outlined earlier, it is clear that different stages of the innovation process will require the application of specific types and combinations of skills. Attempts to ‘unpack’ and describe innovation activity are many and varied but most identify four or five broad stages in the process (see Zaltman, Duncan and Holbek, 1973; Rogers, 1983; Tidd, Bessant and Pavitt, 2001; Boden and Miles, 2000; Christensen and Raynor, 2003). Though differences in emphasis and delineation exist between commentators and theorists, stages of the innovation process are frequently cast in the following terms:

1. Sourcing and selection of ideas.
2. Development of ideas and experimentation with alternative configurations, assemblages and processes.
3. Testing, stabilization and commercialization.
4. Implementation and/or diffusion.

While this four-stage characterization probably captures the main steps in the innovation process for a majority of firms, it is important to recognize that different organizations and sectors (manufacturing, private services and public services) are likely to demonstrate sometimes sharply differing approaches to the organization and operationalization of innovation. Such
differences (or ‘specificities’) remain a subject of research and debate (Rubalcaba, 2006; INSEE, ZENTRUM, IFS, 2005), but relate closely to the constraints, operating and market conditions, assumptions and routines that are found across different firms and sectors. Differences will clearly impact perceived and actual skills needed for innovation, as will the classes of innovation activities (i.e., product, process, organizational or delivery-oriented) that are pursued within individual firms and organizations.

It is clear that some generic skills are central to the management of innovation throughout and across the various steps of the process sketched earlier. An ability to coordinate activities, select appropriate (and appropriately skilled) individuals, assemble teams, motivate and inspire, resolve problems and disputes, generate a creative (and protected) environment, communicate up and down the supply/value chain, and provide focus and leadership are just some of the skills that are required of managers and innovation leaders in contemporary organizations (Klein and Sorra, 1996; Deschamps, 2005). Beyond these, management of the innovation process requires the confidence to take ‘Go’ or ‘Kill’ decisions with respect to projects, or to identify and pursue more viable alternatives (Danneels and Kleinschmidt, 2001), and an ability to manage and maintain the complex of intra- and inter-organizational relationships that frequently characterize both large and more modest innovation projects (Hagel and Singer, 1999).

‘Stage-specific’ innovation skills are clearly more difficult to identify and delineate than generic skills, and they are to some extent conditioned by sector and ‘class’ of innovation, as noted earlier. Some recent work has started to grapple with the issue of stage-specific skills (Tether et al., 2005) and we now see the emergence of ideas relating to the competencies and capabilities that are required to drive innovation through the various steps of the emergence of a new product or process. These include sourcing and selection of ideas, where skills requirements are connected centrally with the identification, collection and filtering of ideas for innovation (Sundbo, 1997). Innovation managers—and employees—will ideally have an awareness of existing sources for innovation both within and outside their organizations, and an ability to ‘scan the horizon’ for (and develop relationships that will lead to) new sources of ideas and stimuli for innovation. An ability to interpret data (from market, consumer and competitor research) and to evaluate the viability of innovation ideas is also crucial. Knowledge of and an ability to apply relevant IP protection mechanisms constitute a further important skill. Once an innovation idea is selected for possible progression to the development stage, skills in arguing for its viability and potential value—often in the face of strong competition from competing projects—become paramount.

The development of ideas for innovation frequently requires skills connected with the assemblage of development teams, allocation and management of budgets and resources, generation of appropriate spaces and conditions for experimentation, sourcing and specifying complementary inputs, and
establishment of networks and partnerships. In contemporary environments, the latter factor can be critical: given the distributed and networked nature of much innovation, skills associated with the orchestration of a disparate range of actors and inputs can be central to success. Further, where innovation is focused on the development of new artifacts or technologies, the sourcing of technical and design skills is likely to be a central concern.

In the testing, stabilization and commercialization stage, evaluation of risks and benefits of continued experimentation is an important skill. Cost-effective innovation requires an ability to recognize the optimal point at which to call a halt to prototyping and the comparison of competing alternatives. It also requires a good knowledge of the preferences and requirements of the intended user or consumer base, and an understanding of the ways in (and extent to) which an innovative product or process will meet anticipated needs. An understanding of the ability of potential users to derive benefits from an innovation (i.e., their ‘absorptive capacity’) is also necessary. Stabilization and commercialization of a novel product require that an innovating company has the skills in place to ensure reproducibility of an artifact or service at an acceptable price (technical, engineering, design and marketing skills are often to the fore here). Commercialization also requires that attention is afforded to ‘capturing value’ from an innovation—here, skills associated with managing risk and designing appropriate marketing and rollout strategies are highlighted.

The marketization, implementation and diffusion stage is frequently understood to be connected intimately with project management and technology transfer skills. Beyond these, skills in managing and coordinating value and supply-chain relationships, and in evaluating innovation practice and performance are crucial. Reflexivity too is becoming an increasingly important component of innovation practice as firms recognize that collection and evaluation of data (i.e., knowledge management and intelligence generation) can result in the development of improved innovation processes and practices. In a similar vein, skills associated with the evaluation of alliance and partnership working modes can be highly valuable. Given the network-based nature of much innovation activity, companies need to nurture ‘valued’ partners, and build intelligence with respect to the factors that result in successful co-innovation activities.

REFLEXIVITY IN THE INNOVATION-SKILLS RELATIONSHIP

Another useful way of thinking about skills for innovation at different stages of the innovation process—and in associated value chains—derives from the study of ‘product life cycles’. Introducing the notion of circularity, Tether et al. (2005) argue that it is problematic to distinguish between the skills that facilitate and support innovation within an organization and
those that are required because of changes brought about by innovation. The authors suggest that the management and workforce skills that are present within an organization will have a major influence on the nature and style of its innovation. The process of ‘doing innovation’ in the firm will trigger changes in skills demands, and the emergent skills profile of the organization will in turn shape the direction and form of subsequent generations of innovation activity. Tether et al. (2005) link this idea to the notion of product life cycle and indicate that the latter can provide clues with respect to the ways in which innovation involves shifts in demand for skills throughout the development stages of a new product.8 Employing a three-phase model, Tether argues that in the first phase, ‘conception’, where product attributes and characteristics are still weakly defined, key skills requirements revolve around entrepreneurism, scientific and technical expertise and market research and development. In the second phase, ‘transition’, where the shape of a standard or ‘dominant product design’ has emerged, the skills focus tends to shift from product to process innovation: here, more operational, functional and scientific management skills (and sometimes, specialist workforce skills) are emphasized as firms gear up for production and distribution. In the third phase, ‘stabilization and incremental development’—where attention is directed towards reduction of production costs—managerial ‘command and control skills’ tend to be highlighted alongside relatively low-level and often non-specific workforce skills. Beyond this, however, where firms target product development—or strive to respond to low-cost competition via iterative improvement, movement into markets for higher-quality goods, or product differentiation—technical, design, branding and marketing skills are likely to take on increasing importance.

CLASSES, FORMS AND LOCATIONS OF INNOVATION—IMPLICATIONS FOR SKILLS

It is clear that innovation (a) has many forms, (b) takes place in widely differing sectors and locations, and (c) can be initiated and undertaken by actors across a broad range of roles and functions. This raises important questions about the skills that are necessary with respect to different types of innovation and the skills that are required in different industrial settings. In Figures 8.3, 8.4 and 8.5 we set out three broad innovation dichotomies9 and contrast the skills that might be required in radical versus incremental innovation environments, technological versus organizational processes, and manufacturing versus services settings. Of course, we cannot hope to provide comprehensive coverage of all the different classes of innovation and their associated skills needs; however, the figures present an outline map of the skills most commonly associated with core and specific classes of innovation activity.
<table>
<thead>
<tr>
<th>Innovation Type</th>
<th>Features</th>
<th>Associated Skills</th>
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<tbody>
<tr>
<td>Radical</td>
<td>Radical innovation, sometimes also described as ‘breakthrough’, ‘revolutionary’ or ‘disruptive’ innovation, is normally associated with major scientific and technological developments that result in highly significant and far-reaching changes across industries, markets and consumption behaviors (Harvard Business School, 2000). Radical innovations are perceived to bring about dramatic shifts, often ushering in whole new classes of products, new methods of production and even new industries or industrial sectors. Radical innovations can be many years in gestation and frequently result from a scientific or technological discovery or breakthrough (for example, steam power, isolation of DNA and development of computers). Radical innovations are relatively sporadic and rare – sometimes the result of long-term effort in R&amp;D and university labs – and often require much complementary effort and innovation before marketable products emerge.</td>
<td>Very high-level science and technology skills (computing, medicine, biology, physics). Synthesizing skills (bringing together ideas and knowledge from disparate disciplines and domains). Knowledge translation and transfer skills. Lobbying and negotiation skills (especially where long-term development funding and social acceptance are required, and licensing agreements are in play). Opportunity recognition skills. Market development skills. Coordination skills (especially where the realization of an innovation or class of innovations requires much distributed and complementary effort).</td>
</tr>
<tr>
<td>Incremental</td>
<td>Incremental innovation is much more common than its radical counterpart and involves the inception of relatively minor improvements or enhancements to goods, processes and services that are (usually) already in existence in one form or another. Such innovations are often managed and effectuated by actors who work on an ongoing basis with existing technologies, equipment, methods or processes (von Hippel, 2005). In essence, incremental innovation involves taking steps forward along a recognized technology or organizational trajectory, and such innovation is not likely to result in major changes to business operations, product ranges or markets. Although incremental innovations are targeted at relatively minor upgrading of organizational routines or product characteristics and functionalities, such innovations often require the input of science and technology specialists and are frequently developed within R&amp;D</td>
<td>Science and technology skills. Engineering skills. Design skills. Process management and technical skills. Coordination skills. Market research and analysis skills (and competitor analysis skills). Business and product positioning skills. Strategic analysis skills. ICT skills (especially in the case of services where the producer-consumer relationship is electronically mediated).</td>
</tr>
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</table>

Figure 8.3 Radical versus incremental innovation.
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<tr>
<th>Innovation Type</th>
<th>Features</th>
<th>Associated Skills</th>
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<tr>
<td>Technological</td>
<td>Technological innovation – As noted earlier, technological innovation is generally understood to concern the development of new equipment, goods and software. OECD’s Oslo Manual (2005, p. 31) describes technological product and process (TPP) innovations as those that ‘comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organizational, financial and commercial activities.’</td>
<td>Science and technology skills. Software development skills. Systems development and integration skills (especially in the domain of technological process development). Engineering and ergonomy design skills. Negotiation, coordination and communication skills (especially where licensing, royalties and distribution agreements, production partnerships and outsourcing, and organization of complementary inputs are concerned). Value-chain organization skills. Professional skills (for example, accounting and finance, marketing, sales, IP protection and legal skills).</td>
</tr>
<tr>
<td>Organizational</td>
<td>Organizational innovation involves the creation of transformation of commercial/business and public sector agency structures, models, routines and practices. Such innovation can embrace business model and marketing innovation and frequently involves the implementation of new production and interfacing processes. Organizational innovation often accompanies business repositioning and strategy development and, in the public sector in particular, has been triggered by government modernization and public service renewal agendas. Organizational innovation is commonly targeted at securing increased efficiency and effectiveness and has been implicated in the major off-shoring and outsourcing programs that have been witnessed in the past decade. While it can be conceived and managed internally, it is not uncommon for major organizational innovation to be designed and implemented by external agencies.</td>
<td>Strategy development and business modeling skills. Procurement and negotiation skills (especially where innovation involves the contracting of external consultants). Communication skills (especially where innovation implies major changes to work practices and impacts on employees). Workflow and job design skills. Professional skills (especially human resources). ICT and systems design skills (where reorganization is reliant on ICTs or involves relocation or off-shoring of work).</td>
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Figure 8.4  Technological versus organizational innovation.
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<tr>
<th>Innovation Type</th>
<th>Features</th>
<th>Associated Skills</th>
</tr>
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| Manufacturing   | **Innovation in the manufacturing sector** concerns the development or improvement of tangible products. Much manufacturing innovation is incremental by nature, involving (a) the gradual replacement of products or product lines, or (b) the introduction of new or enhanced functionalities to existing products and equipment. Though manufacturing innovation goes beyond mere re-styling, design and engineering have an important role. Much manufacturing innovation is triggered by competition; this is especially true in relation to established technologies or goods where attention has been directed increasingly over time towards the reduction of production costs. Iterative product development can assist manufacturers in their efforts to compete with low cost commodity producers and stay ahead of the pack (where this is feasible and desirable). | • Engineering and design skills  
• Science and technology skills  
• Market and competitor research skills (and data analysis skills)  
• Customer interfacing skills  
• Process organisation and management skills  
• Business development and positioning skills |
| Service         | **Service innovation** refers to the creation, marketisation and diffusion of service products (for example, insurance policies or health information programmes). Whilst service innovations are often perceived to be less dependent on scientific and technological knowledge than manufacturing/goods innovations, many are heavily reliant on developments in ICTs (connected as they are with information processing, communication and interaction). However, a key resource for innovation in services is close contact with customers and many service innovators are eager to exploit the detailed data that they derive from on-going interactions with clients, partners and service users. The organisation of innovation in the services sectors rarely resembles that in manufacturing where formalised processes for sourcing and development of new products is common. Service | • Client interfacing and communication skills  
• ICT skills (especially systems design and integration)  
• Data management and analysis skills  
• Market research and analysis skills  
• Team assembly, co-ordination and management skills  
• Ideas harvesting skills (gathering ideas for innovation from service workers, partners and service users)  
• Procurement and coordination skills (especially where service development involves partnership projects, complementary innovation and |

1 Miles (2004)  
2 For example, major food retailers are able to collect detailed transaction data and deploy this in customer profiling activities. Similarly, health service providers are able to collect data on patients and service costs and deploy this in the development of health promotion campaigns.

Figure 8.5  Manufacturing versus Services innovation.
The comparisons shown highlight some useful distinctions between classes of innovations in different sectors and point to the different types and levels of skills that are required in pursuit of innovation. However, it is also important to acknowledge the overlaps that exist across classes. This is particularly true in the case of manufacturing and service sector innovation. Beyond the bundling of services and artifacts in combined packages, it is notable that many manufacturing organizations are home to a range of service functions and service workers (designers, market researchers, sales staff). Thus manufacturers can be important producers of service innovation (so too, they are likely to be important loci of organizational and process innovations).

CONCLUSIONS

As inventions and innovations accumulate and are built upon each other, so the portfolio of knowledge that is required to master the creation of new products and processes grows. The scope of knowledge that is needed to bring a new idea to fruition may be much wider than previously understood, and the forms of knowledge that may be called upon to support the development of each innovation may be different in many respects. So, the range of skills required to facilitate innovation expands rapidly, and the complexity of linkages between actors with specific competencies is intensified. In addition, the increasingly networked nature of innovation calls for the acquisition of new capabilities, as orchestration and management of disparate groups of (sometimes geographically distributed) co-innovators become a common requirement. Given this growing complexity in innovation networks and activities, and the intensified focus on innovation as a driver of competitiveness, the future—at policy, sector and firm levels—is likely to see ever greater attention afforded to efforts to nurture human capital and build skills for innovation. As we have seen, however, current understanding of the articulation between innovation performance and skills remains somewhat fragile, and vigorous efforts are required if we are to be able to map connections, and work towards (internationally) standardized definitions and measures for innovation skills.

As we suggested in the introduction, this chapter set out to address a number of questions with respect to skills for innovation and, on the basis of existing evidence and theory, has provided a provisional answer to some. Importantly, we see the emergence of a better understanding of the types of skills that are needed to enable (a) different forms of innovation, and (b) innovation at different stages of the product development life cycle. So too, we have hinted at the factors and characteristics that can support improved innovation performance at sector and firm level. We have also noted the problems that confront efforts to develop appropriate metrics for skills for innovation, though it is clear that adequate remedies are not yet within our grasp. With respect to the improvement of regional competitiveness...
via human capital development, again, we have flagged the key issues without providing comprehensive recommendations (though policymakers in Europe may wish to cast an inquisitive eye both east and west). Indeed, there remains much to be done at policy and research level if we are to both understand the linkages between skills and innovation more comprehensively, and devise supports for the accelerated acquisition or development of innovation capabilities. Perhaps beyond policy too, there is an urgent need to stimulate increased attention and action. At firm and sector level, while it might be difficult to disentangle the skills that drive innovation from those demanded as a result of innovation, greater effort to map and nurture skills (and to plot future skills needs) is likely to pay significant dividends.

NOTES

1. Other factors include the impacts of international trade, labor market institutions (including the minimum wage and trade unions), the domestic competitive environment, education and training and their institutional structures, public expenditure and public policy more generally.

2. While this short passage cannot hope to review the different perspectives that have been brought to bear on the notion of innovation, it is important to recognize the complex, nuanced and contested nature of the concept.


4. Though ‘invention’ is more commonly applied to technologies than to organizational or artistic ideas.

5. Note that Fagerberg’s ‘first occurrence’ does not necessarily mean the ‘first occurrence’ anywhere at any time of the innovation. Indeed, often the first example of an innovation does not achieve wide uptake. The diffusion process involves many users effecting their first use of the innovation.

6. The rise of the ‘call center’ phenomenon is another example of the ways in which organizations are using technologies to enhance and streamline the delivery of public and private services. It is worth noting here too that ICTs have provided organizations with an opportunity to outsource or offshore many services, and to exploit the skills of workers in remote locations.

7. We should note here that Product Life Cycle theory derives principally from the study of manufacturing innovation and is normally applied at industry rather than firm level. See Cawson et al. (1995).

8. In essence, Tether recommends that we consider the ways in which skills for successful innovation change over the product life cycle.

9. Binary distinctions appear frequently in the innovation literature. These constitute a useful heuristic but frequently conceal the significant overlaps that exist between classes.

BIBLIOGRAPHY


