

Production of R&D-related skills by universities and PRIs

Universities and public research institutions (PRIs) are responsible for both the provision of skills and competencies for R&D-related tasks, and for the promotion of R&D-related skills in other individuals through education and training programmes. A wide set of competencies provided by universities and PRIs is important for improved innovation performance, such as skills directly related to research and development, as well as other soft skills that allow innovators to ensure that their research output reaches the market and meets the needs of consumers and wider social groups (e.g. business and entrepreneurial skills). Conditions ensuring the contribution of R&D-related skills and training to innovation performance include: stable university-industry links, the quality of education system, appropriate R&D infrastructure and university/PRI development strategies.

What is the production of R&D-related skills by universities and PRIs?

R&D-related skills provided by universities and PRIs are a critical component of the innovation system, allowing it to function properly and effectively through the support of interactive learning and competence-building mechanisms. Generally speaking, R&D-related skills present a set of competencies needed for the implementation of R&D-related tasks and are distributed among a wide group of actors, contributing to innovation processes during a specific time period or throughout extensive periods when strategic research and development are involved.

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Developing R&D-related skills is one of the main responsibilities of publicly funded R&D that plays a key role in innovation system development. In particular, proper education and training mechanisms needed for promoting R&D-related skills among stakeholders can make a significant contribution to resolving capability failures by fostering effective learning and competence-building.

As a rule, training happens at established education facilities such as schools, universities, academies, colleges and vocational education centers. However, there has been a recent trend to increase the number of distance learning courses and other less conventional ways of training through public lectures, S&T museums and entrepreneurship training courses. These new mechanisms don't provide the classical education required for more advanced scientific work and knowledge production; instead, they are usually quite applied, being focused on delivering practice-oriented training, and popularizing science and technology activity.

In general terms, the mechanisms for developing and promoting R&D-related skills imply a set of learning and skills-enhancing tools and programmes, both formal (established programmes, curricula) and more informal (improvised and impromptu lectures), lasting from one session to several years, and delivering a wide range of outputs that prepare participants to contribute effectively to innovation processes and related activities.

How does the production of R&D-related skills by universities and PRIs contribute to innovation performance?

It is now widely recognized that better skills have a direct positive effect on innovation performance. In this context, the role of education and training delivered by universities and other publicly funded research organizations is immense in preparing new generations of innovators and facilitating the successful transfer of innovation-related skills to commercial enterprises.

Universities are responsible for delivering a wide set of competencies, all of which are equally important for improved innovation performance. These include skills directly related to research and development (e.g. lab experience, experimentation practice, technical expertise, the ability to use established models and practices for problem solving, etc.), as well as other soft skills that allow

innovators to ensure that their research output reaches the market and meets the needs of consumers and wider social groups (e.g. communication, interpersonal, business and entrepreneurial skills, etc.).

This box (2011) provides a list of transferable innovation skills that are usually taught through the education process:

Skill category	Competencies
Interpersonal skills	<ul style="list-style-type: none"> Working with others/teamworking Mentoring and supervisory skills Negotiating skills Networking skills
Organizational skills	<ul style="list-style-type: none"> Project and time-management skills Career planning skills
Research competencies	<ul style="list-style-type: none"> Grant application writing skills Research management and leadership Knowledge of research methods and technologies beyond the doctoral project Research ethics and integrity
Cognitive abilities	<ul style="list-style-type: none"> Creativity and the ability for abstract thought Problem solving
Communication skills	<ul style="list-style-type: none"> Communication/presentation skills, both written and oral Communication/dialogue with non-technical audiences (public engagement) Teaching skills Use of science in policy-making
Enterprise skills	<ul style="list-style-type: none"> Entrepreneurship Innovation Commercialization, patenting and knowledge transfer

In the end, it is important to note that these skills may be transferred from universities to enterprises not only as a result of established education and training programmes but also in the course of collaborative activities and specific contractual relations, such as advice, consultancy and extension services. Generally speaking, any relation between universities and industry can be used in a practical way to transfer new skills and capabilities to the private sector.

Developing R&D-related skills: types of education and training programmes

- Primary and secondary school programmes usually last up to 14-15 years and deliver with simple lab equipment and improving their creativity, attention and concentration.
- High school provides more advanced knowledge and usually implies a certain amount of specialization in particular disciplines (e.g. science, arts, etc.), and may be considered as a first step towards building tangible innovation capabilities.
- Undergraduate degree programmes are usually established as Bachelor's programmes and provide students with a broad range of knowledge and skills, and may be considered as a first step towards building tangible innovation capabilities.

Different countries offer various forms of undergraduate degree programmes that may be delivered either at universities or at colleges (including community colleges, polytechnics and others). As a rule, undergraduate programmes prepare students for more practical jobs and only rarely allow them to go directly into PhD programmes without further training.

Some countries also have five-year degrees that are somewhere in between Bachelor's and Master's programmes. These usually graduate full-fledged experts in a particular field, ready to start specialist jobs and further develop their skills in the workplace.

Undergraduates are rarely directly involved in advanced innovation and R&D-related activities, although there have been several outstanding exceptions, such as Mark Zuckerberg, the founder of Facebook, and Bill Gates, the founder of Microsoft, both of whom never finished their undergraduate degrees.

- Master's degree programmes are higher-level tertiary education programmes that provide deeper and more specialized knowledge and skills. A master thesis may serve as a ground for further research or be applied in practice.
- PhD is the most advanced degree programme in most education systems. As a rule, PhD programmes involve full-time research work that can be published and/or applied directly in innovation activities.

Some countries also have a number of higher doctorate degrees, such as doctor of sciences (e.g. in Russia or Czech Republic) or doctor habilitatus (e.g. in Germany or Poland). These degrees are usually used to recognize great contributions from outstanding individuals to knowledge and scientific development but may still include a certain training component in order to meet established requirements (e.g. in Russia, a well-grounded and substantial dissertation must be defended in order to obtain a doctor of sciences title).

- Master's of Business Administration programmes are usually aimed at delivering applied knowledge and skills for innovation factors and management.
- Executive programmes have goals similar to MBA modules but are more concise and focused on providing innovative culture and improve the effectiveness of innovation systems.
- Public lectures and seminars may be organized at universities, colleges, SSF museums and other institutions to provide information on innovation systems and the latest research and findings. Engineers have an opportunity to present their work in a limited timeframe.
- SSF museums play a critical role in knowledge dissemination and legitimizing technologies and may also hold public exhibitions (e.g. nano-erfahrungen in Germany to popularize nanotechnology applications).
- Enterprise training usually takes place in the workplace and encourages staff members to improve skill sets related to particular tasks or more general applications.

Main actors

- Universities are the most widespread form of education establishments. They are critical for producing and transferring knowledge, and they are also responsible for training and educating future professionals. They sustain strong links with the government and other public organizations.
- Public research institutes are mostly responsible for providing required R&D-related skills to students and entrepreneurs, but this should hardly be considered their primary objective.

Conditions ensuring the contribution of R&D-related skills and training to innovation performance

- Stable university-industry links are the major requirement for ensuring the contribution of institutions so that they can contribute to innovation processes in the most productive manner.
- The quality of the education system is an important indicator and prerequisite for successful innovation. World University Ranking and Shanghai Ranking are among the most well-known ranking systems.
- Appropriate R&D infrastructure is imperative for effective learning and innovation. Good processes, appropriate infrastructure and good communication channels between scientists, engineers, industry and government.
- Transferable skills training should be seen as an essential part of university/PRIs development. OECD (2012) states that many countries have no strategy for promoting formal transferable skills training.

Measurement

The measurement of R&D related skills is a rather complicated task: skills are rarely codified and are often dependent on the features of individual researchers and innovators. Nevertheless, certain indicators are applied to evaluate the quality of training and effectiveness of education programmes.

The main methods of gathering such data include survey techniques and involve a wide range of experts who evaluate the contribution of university skills training programmes to innovation performance. For example, the World Economic Forum asks experts to assess the quality of education systems, while Times Higher Education collates a world university reputation ranking based on a number of indicators, including research outputs and alumni careers, which may indirectly show the effectiveness of skills transfer training in specific universities and schools.

Another proxy that may be used to study the level of skills transfer between universities/PRIs and industry is co-authorship (of publications) and co-inventorship (of patents) between academics and industrial researchers. These forms of collaboration often involve extensive discussions and interactive learning that not only transfer knowledge from one organization to another but also transfer skills required to achieve certain results or apply a particular technology.

What policies relate to the production of R&D-related skills by universities and PRIs

Policy rationales

The development of required R&D-related skills is a difficult task because it is hard to identify the need for skills and competencies from a long-term perspective. In other words, while it is possible to determine what particular skills are needed to solve a given problem in the short term, it is much harder to predict what skill sets may be required in 20-30 years. Therefore, policy rationales seeking to address this problem seem to be directly linked to capability failures that presume an ability to study the future through a number of strategic intelligence tools, such as foresight, technology roadmapping, scenario building and others.

From a market failure perspective, universities and PRIs can contribute to overcoming information asymmetries by transferring skills to firms, especially small- and medium-size enterprises, that may be struggling to fit into the market and compete successfully with more mature companies.

Training and education also create particular links between individual entrepreneurs, investors, scientists and policy makers through the growing network of alumni associations and personal contacts. These links permit to resolve network failures, as well as ensure sustainable knowledge and technology transfer from publicly funded research organizations to industrial enterprises.

Policy objectives

Policy objectives regarding the production of R&D-related skills by universities and PRIs include:

- improving the skill sets required for the resolution of immediate and strategic development objectives and national priorities
- increasing competitiveness of domestic firms
- integrating domestic universities and public research institutes into world science and technology
- promoting alumni associations, and other formal and informal links between universities and their former students (including through endowment arrangements)
- increasing absorptive capacity
- improving university-industry links to ensure the compliance of education and training programmes with market needs
- legitimizing particular sectors and popularizing scientific discoveries.

Policy instruments

Since R&D related skills are key capabilities and resources of innovation actors, basically all policy instruments relate to skills improvement in one way or another. As one example, direct financial allocations are productive ways to build new competencies in the economy, and promote innovation through the support of universities and public research institutes. These include research and development funding, education investments, and other budgetary allocations to science and education.

Policy instruments aimed at promoting general science-industry links, such as new communication platforms, tax incentives for research and development, benefits for establishing new departments and labs sponsored by private enterprises, also play an important role.

Better research career incentives and improved university research and training capabilities are required to promote innovation performance. For example, those countries that were largely following a model of separating teaching and research at universities and polytechnics in the past are now making every effort to bring research and training closer to each other, to ensure a better transfer of skills and improved preparation of university graduates for innovation activities.

OECD (2012) also mentioned the importance of regulatory frameworks that can serve as a general guidance for transferable skills training through university regulations or through wider education qualification frameworks (such as the forthcoming Norwegian National Qualifications Frameworks, which is based on the European Qualifications Framework). Awareness raising was recognized as a

crucial measure in improving transferable skills training and attracting additional attention to these activities.

Governments may promote industrial PhD schemes, which allow researchers to gain more workplace experience.

Other potential regulations and public interventions, such as accreditation and PhD quality control, may also be important in certain contexts to promote transferable skills training and where universities have basically failed to ensure sustained progress and improvement, although it is widely recognized that the institutional autonomy of publicly funded research organizations should be well protected and properly balanced with such measures.

Finally, an effective interplay between education, science and innovation policies is essential for the successful transfer of skills and innovation training.

References

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