Manufacturing skills & competencies for the Factories of the Future

Prof. George Chryssolouris
Definitions

“Skill” is the ability to apply knowledge and use the know-how for the completion of well-defined tasks. Generally speaking, it identifies that an individual is able to do something within a specific context.


“Competence” is the capacity to successfully (according to certain formal or informal criteria) handle certain situations or complete a job. This capacity may be defined in terms of cognitive factors (e.g. different types of knowledge), intellectual and perceptual motor skills (e.g. dexterity), affective factors (e.g. attitudes, values, motivation etc.), personality traits (e.g. self-confidence) and social skills (e.g. communicative and cooperative skills)

Definitions

Skills & competences in the Industrial Learning process

[Definition]

Human capital & GDP

Impact of years of education on GDP growth

[Stefan Bergheim, 2005, Human capital is the key to growth - Success stories and policies for 2020, Global growth centres, Current Issues, Deutsche Bank Research]
Skills for Growth

Drivers of economic growth

[Department for Business, Innovation and Skills (BIS), 2010, Supporting analysis for “Skills for Growth: The national skills strategy”, BIS Economics Paper No.4]
Skills & industrial competitiveness

Skills & industrial competitiveness

Access to high-quality labor, including scientists and engineers, is the top ranked factor for manufacturing competitiveness

<table>
<thead>
<tr>
<th>Rank</th>
<th>Drivers</th>
<th>Driver Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Talent – driven innovation</td>
<td>9.22</td>
</tr>
<tr>
<td>2</td>
<td>Cost of labor and materials</td>
<td>7.67</td>
</tr>
<tr>
<td>3</td>
<td>Energy cost and policies</td>
<td>7.31</td>
</tr>
<tr>
<td>4</td>
<td>Economic, trade, financial and tax systems</td>
<td>7.26</td>
</tr>
<tr>
<td>5</td>
<td>Quality of physical infrastructure</td>
<td>7.15</td>
</tr>
<tr>
<td>6</td>
<td>Government investments in manufacturing &amp; innovation</td>
<td>6.62</td>
</tr>
<tr>
<td>7</td>
<td>Legal &amp; regulatory system</td>
<td>6.48</td>
</tr>
<tr>
<td>8</td>
<td>Supplier network</td>
<td>5.91</td>
</tr>
<tr>
<td>9</td>
<td>Local business dynamics</td>
<td>4.01</td>
</tr>
<tr>
<td>10</td>
<td>Quality and availability of health care</td>
<td>1.81</td>
</tr>
</tbody>
</table>

Skills & industrial competitiveness

Studies show significant positive effects of the share of high- and medium-skilled workers on productivity growth. These results suggest that a skilled labour force fosters productivity growth by increasing the capability of adopting, implementing or creating new technologies.

A higher share of high- and medium-skilled workers also spurs growth of exports.

[Michael Landesmann, Sebastian Leitner, Robert Stehrer and Terry Ward, Skills and Industrial Competitiveness, wiww Research Reports, No. 356, August 2009]
Skills & industrial competitiveness

- Similar analysis of EU KLEMS data between 1996 and 2005 suggests that 20% of the growth in UK productivity is attributable to labour composition.
- In the OECD economies, a one percent increase in the number of graduates is associated with a 1.1 percentage point rise in GDP growth rates.

[Michael Landesmann, Sebastian Leitner, Robert Stehrer and Terry Ward, Skills and Industrial Competitiveness, wiww Research Reports, No. 356, August 2009]
Skills & industrial competitiveness

Skills shortages are reported to have a negative effect on innovation performance.

The Scottish Employers Skill Survey, 2004 found that an inability to fill vacancies with adequately skilled workers caused delays in developing new products in 30% of firms and difficulties in introducing new working practices in 24% of firms.

Skilled labour in Europe

- In 2008, about a quarter of tertiary-education students at EU level chose science and engineering (S&E) as their main field of study, representing 7.3 % of the population aged 20–29 years.
- In 2009, the EU had 38.1 million of highly qualified knowledge workers by virtue of both education and occupation.
- In 2009, employment rates were generally significantly higher among HRST (Human Resources in Science & Technology) than among non-HRST.

[Science, technology and innovation in Europe, Eurostat Pocketbook, 2011]
Skilled labour in Europe

Development of the share of engineers in employment in Mechanical Engineering in Germany (1982-2010)

The share of engineers among staff in ME has more than doubled over the period 1982-2010, from 7% in 1982 to more than 16% in 2010, indicating that the skill level has increased considerably in the sector.

Source: VDMA 2010

[Ifo Institute, Cambridge Econometrics, Danish Technological Institute, 2012, Study on the Competitiveness of the EU Mechanical Engineering Industry, Final Report]
Skilled labour in Europe

Short term demand and supply in ME as perceived by associations

<table>
<thead>
<tr>
<th>Labour Sufficiency of supply</th>
<th>Sufficient</th>
<th>No need currently</th>
<th>Scarce</th>
<th>Bottleneck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine operators</td>
<td></td>
<td></td>
<td></td>
<td>1,2,6,7,8</td>
</tr>
<tr>
<td>Engineers</td>
<td>3,4</td>
<td></td>
<td>2,5,6</td>
<td>1,7</td>
</tr>
<tr>
<td>Researchers/scientists</td>
<td>4</td>
<td></td>
<td>3,6</td>
<td>7</td>
</tr>
<tr>
<td>Production control/planning</td>
<td>4</td>
<td>1,2</td>
<td>3,7</td>
<td>5</td>
</tr>
<tr>
<td>Other qualified blue collar</td>
<td>3,7</td>
<td></td>
<td>1,8</td>
<td></td>
</tr>
<tr>
<td>Management services, sales</td>
<td>1,2,3,6,7</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


[Ifø Institute, Cambridge Econometrics, Danish Technological Institute, 2012, Study on the Competitiveness of the EU Mechanical Engineering Industry, Final Report]
Skilled labour in Europe

Results of forecast studies show a considerable shift in labour demand towards skilled workers implying that future jobs will become more knowledge- and skills-intensive.

[CEDEFOP, 2010, Skills and Supply Demand in Europe, Medium-term forecast up to 2020]
Skilled labour in USA

- Jeffrey Immelt, CEO of GE and head of President Obama's Council on Jobs and Competitiveness has called for doubling manufacturing's % of US employment to 20%.

- There are though frequent reports of shortages of skilled manufacturing workers, even today when manufacturing capacity utilization is only 76%, up from 64% in June 2009, but still down from 79% in December 2007.

- The poor public image of manufacturing and manufacturing careers is considered to be the main reason for the shortage.

[Harry Moser, Revitalizing Manufacturing with Skilled Worker Training, Manufacturing Engineering, July 2011, pp. 116-118]
Skilled labour in USA

The poor image is due to a combination of factors:

- First, the largely outdated view of manufacturing as dirty, noisy, unsafe.
- Second, the belief that, for competent students, a university education offers higher income.
- Third, the belief that the US is a post-industrial economy whose future is in services, software, and innovation and that manufacturing will be off-shored to the LLCCs (Low Labor Cost Countries).
Skilled labour in China

- Bachelor graduates in engineering and technology in China rose from 150,000 in 1995 to nearly 600,000 in 2006. In engineering in the same period the number of masters increased eightfold.

- But the strong increase in education levels, especially in China, has not prevented increasing shortage and skill problems. Shortage of qualified staff is rated highest among 13 issues in top business concerns in China.

[SEOR, Technopolis, 2012, Assessment of impacts of NMP technologies and changing industrial patterns on skills and human resources - Final Report, prepared for ED DG RTD]
Skilled labour in China

- This is due to increased demand for higher level skills and quality problems.
- Industry considers the “big picture” mindset, leading innovation, communication skills, problem solving and interpersonal skills, working in teams and working across international borders and cultural differences being of major importance for Chinese engineers.
Skills for the Factories of the Future

How to identify necessary skills for the Factories of the Future?

- Needs related with skills shortage & gap (market pull)
- Needs related with sector strategic developments
- Needs related with R&D trends (technology push)

Supply / demand analysis studies
Foresight studies
S&T roadmaps
Skills for the Factories of the Future

An example of future skill profile

“Fitter” (Assembler)

The automation of long lines will lead to a decreasing demand for assemblers. Assembly work will continue to be relocated to low wage countries, and high volume productions will only take place at highly integrated plants with limited need for manual assembly. There will however still be a demand for fitters for production for the European markets. In addition, fitters will be needed in operations being prepared for outsourcing or relocation. In this case, the task of the fitter will be to develop, test and commission various production processes. These tasks will require both analytical skills and adaptability. In some cases, automation and technical solutions means that the customer can take care of final assembly. But relocation may also require that fitters accompany the equipment to the new location, with associated increased demands on language and communication skills.

Skills for the Factories of the Future

Technical skills

Skills on Processes

Skills on Equipment

Skills on Systems

Soft skills

Cultural & linguistic skills  Team working skills  Communication skills

Adaptability skills  Problem-solving skills  Decision-making skills

Planning and organisational skills …

A skills identification framework for the Factories of the Future
… A lot of the jobs that remain on the factory floor will require a high level of skill, says Mr Smith, Rolls-Royce’s manufacturing boss. “If manufacturing matters, then we need to make sure the necessary building blocks are there in the education system” …
Current status

Standard instructional methods

- **Presentations**
- **Discussions / Debates**
- **Tutorials**
- **Case studies**
- **Demonstrations**
- **Role plays**

**Computer-based training**

**e-learning**

**e-enhancement**

**Webinars**
Current status

Emerging ICT-based learning formats

- Technical training platforms
- Web-based interactive multi-media training methods
- Collaborative learning environments
- Serious games / game-based learning
- Virtual Reality environments
- Augmented Reality / contextual mobile learning
How to deliver skills – Teaching Factory

Teaching Factory” as a 2-ways “learning channel” communicating

... industrial practices to the classroom

... “new” knowledge to the factory
How to deliver skills – Teaching Factory

Teaching Factory

Manufacturing

Engineering Education

Practice theory

Observe problem solving techniques/methods

Product/Process

Student/Researcher

Come in touch with real problems/cases

Learn to work in teams

Core competence for Engineers → “Problem Solving” capacity
How to deliver skills – Teaching Factory

Factory Video Conference Equipment (H.323) Video

Internet TCP/IP H.264

Classroom Video Conference Equipment (H.323)

TCP/IP, live, on-demand streaming,

Engineers Trainers

CMS Web Server

Video, drawings, documents, forum discussions

Teaching material, chat …

TCP/IP, live, on-demand streaming,
The digitisation of manufacturing will make training easier. Companies cannot justify halting production equipment which may be running 24 hours a day so that trainees can play around with it. But computers can simulate production systems in a virtual environment, and products too …
How to deliver skills – an ICT Framework

ICT framework

build-up knowledge delivery tools

organize / classify knowledge

new knowledge

manufacturing research

industrial practice

diffuse knowledge

Laboratory for Manufacturing Systems & Automation (LMS)
Director: Prof. George Chryssolouris
Department of Mechanical Engineering & Aeronautics
University of Patras, GREECE
How to deliver them – ICT Framework

Web-based intelligent manufacturing data integration
- semantically enriched links to web sources
- ontologies for data fitting
- taxonomy algorithms for data analysis
- semantic-based knowledge search capabilities

Web-based educational / training toolbox for manufacturing
- digital libraries
- virtual machinery
- manufacturing games
- simulation engines
- production / logistics models

Web services for use of manufacturing knowledge
- access to knowledge
- on-line experimentation
- interactive training
- e-collaboration, e-team work

Digital libraries
Virtual machinery
Manufacturing games
Simulation engines
Production / logistics models
How to deliver them – ICT Framework

An indicative pilot instantiation of the ICT framework

- game-based web-enabled platform
- experiment with different scenarios
- realize consequences by utilizing embedded parametric simulation frameworks

Thank you for your attention!

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