

Keynote 2

Identification of skill needs in Nanotechnology (overview)

*based on the secondary analysis “Identification of
skill needs in the nanotechnology sector”*

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Germany



Content:

1. Research objectives

2. Methodological approach

3. Results

3.1 Nanotechnology sectors

3.2 International trends and developments

3.3 Skill needs

4. Proposed ways to implement innovative measures of qualification and training in Europe

4.1 Way A modular educational system

4.2 Way B qualification profiles

1. Research objectives

- *Determination of the nature of nanotechnology, fields and sectors of its application and its implementation, particularly in Europe.*
- *Review of estimates and forecasts of significance and scientific-technological developments of nanotechnology in various fields.*
- *Future demand on the specific nanotechnology labour market.*
- *Identification of major sources and institutions involved in identification of future skill needs for the nanotechnology sector*
- *Overview on research results on specific and general/basic skills and particularly innovative skills required and new occupations emerging in the context of nanotechnology.*
- *Proposed ways of implementation and verifying Europe-wide innovative qualification and training measures in the nanotechnology sector.*

2. Methodological approach

Investigating of various information about Nanotechnology

Secondary analyses

Systematization matrix

**Research of scientific,
technological and qualification
developments**

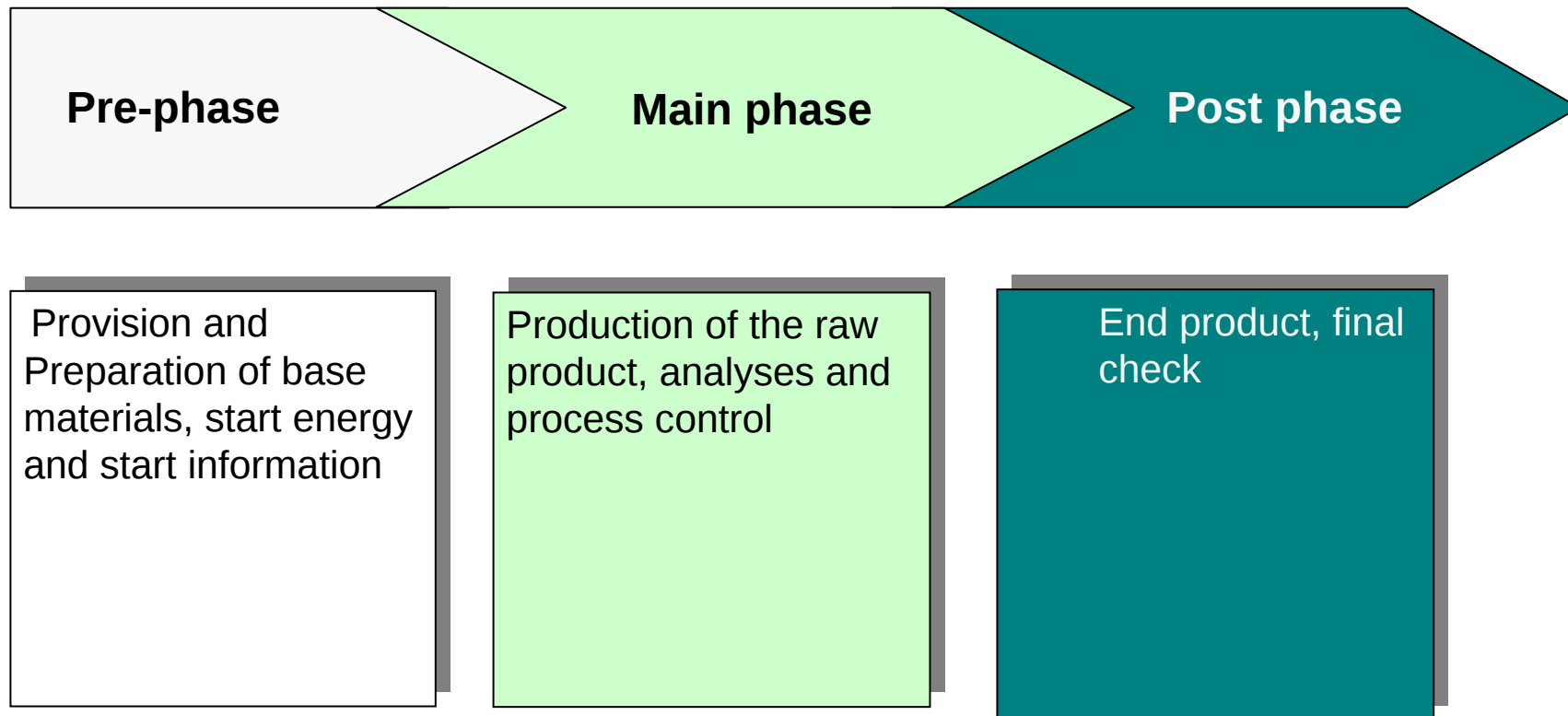
**Focus on technological
processes**

Identification of skill needs

Propose ways of implementation innovative qualifications

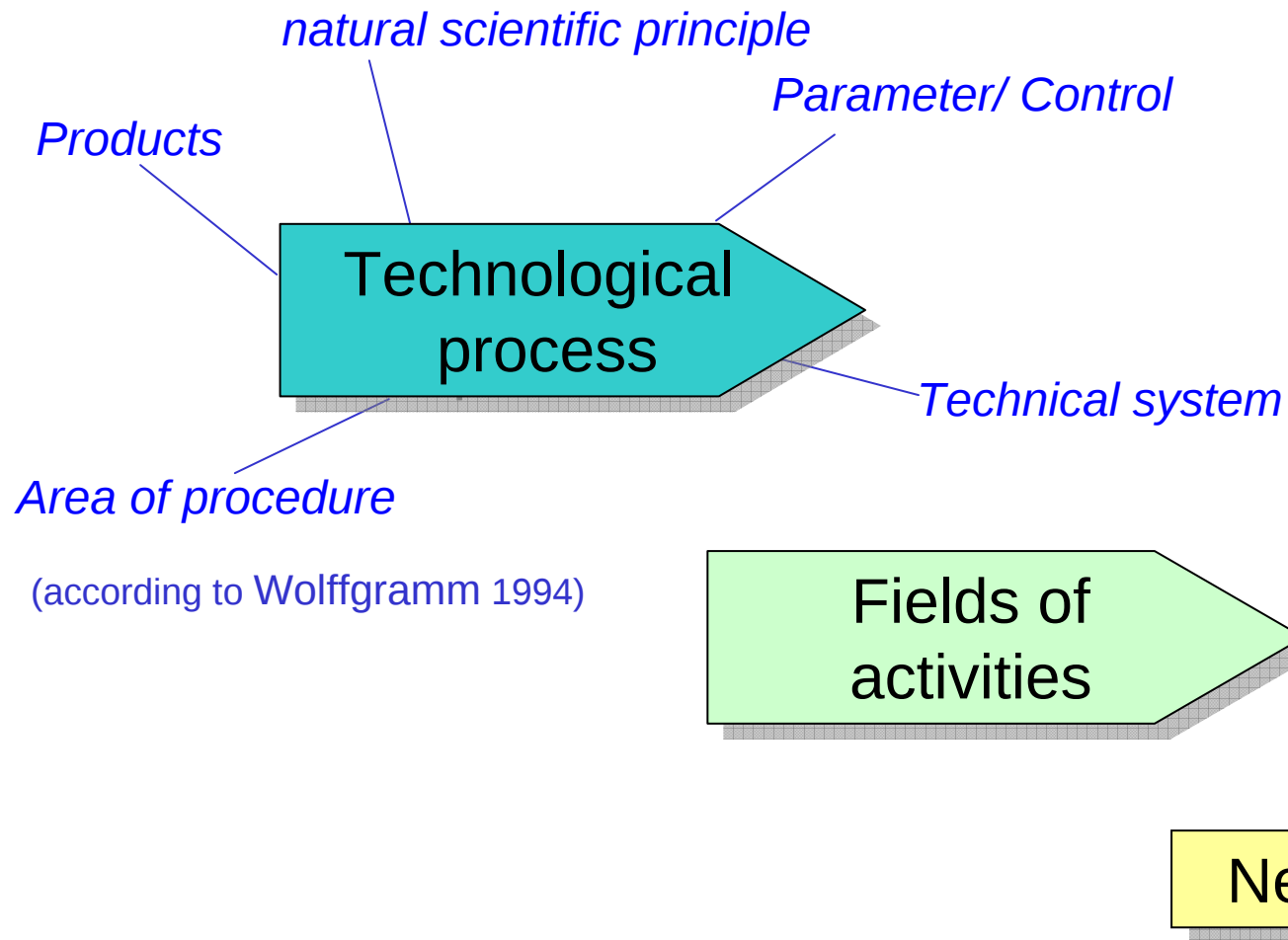
2. Methodological approach

Phase structure of technological processes



(according to Wolffgramm 1994)

2. Methodological approach



2. Methodological approach

Head of the Systematization matrix

Process of change (technology)	Strategy	Area of procedure	Nanobranches						Centre of competence						Job system							
	Top-Down▼/ Bottom-Up▲																					
		Producing	Processing	Apply	Measure/Control	Nanoelectronics	NanoOptics	Nanochemistry	Nanobiotech.	Nanoanalysis	Nano-materials	Nanoclub Lateral	NanOp	Ultra-thin funct. Coat	NanoChem	Ultra-precise Surf	Nano-Analysis	Nanomaterial	Nano.bionet	not available	available	observable

System of qualification			Product		System of change (technical means)	Parameter/ Control	Natural scientific principle	Description	Source
not available	available	observable	Initial condition	Final condition					

2. Methodological approach

The systematization matrix “complex application systems” (presented in excerpts)

Process of change (technology)	Strategy	Area of procedure	Nanobranches								Centre of competence				Job system			Sytem of qualification			Product		System of change (technical means)	Parameter/ Control	Natural scientific principle	Description																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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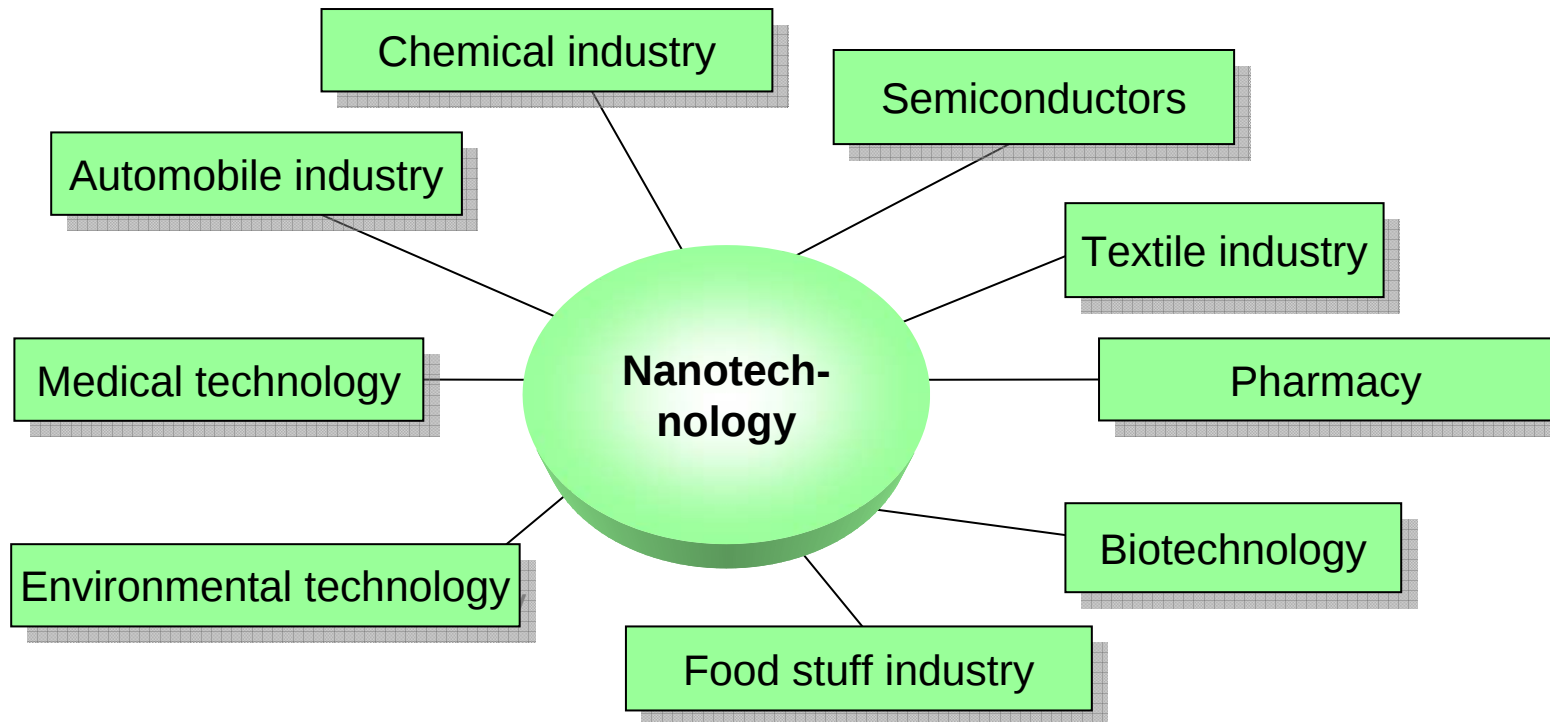
4. Proposed ways to the implementation of innovative qualifications in Europe

4.1 Way A modular education system

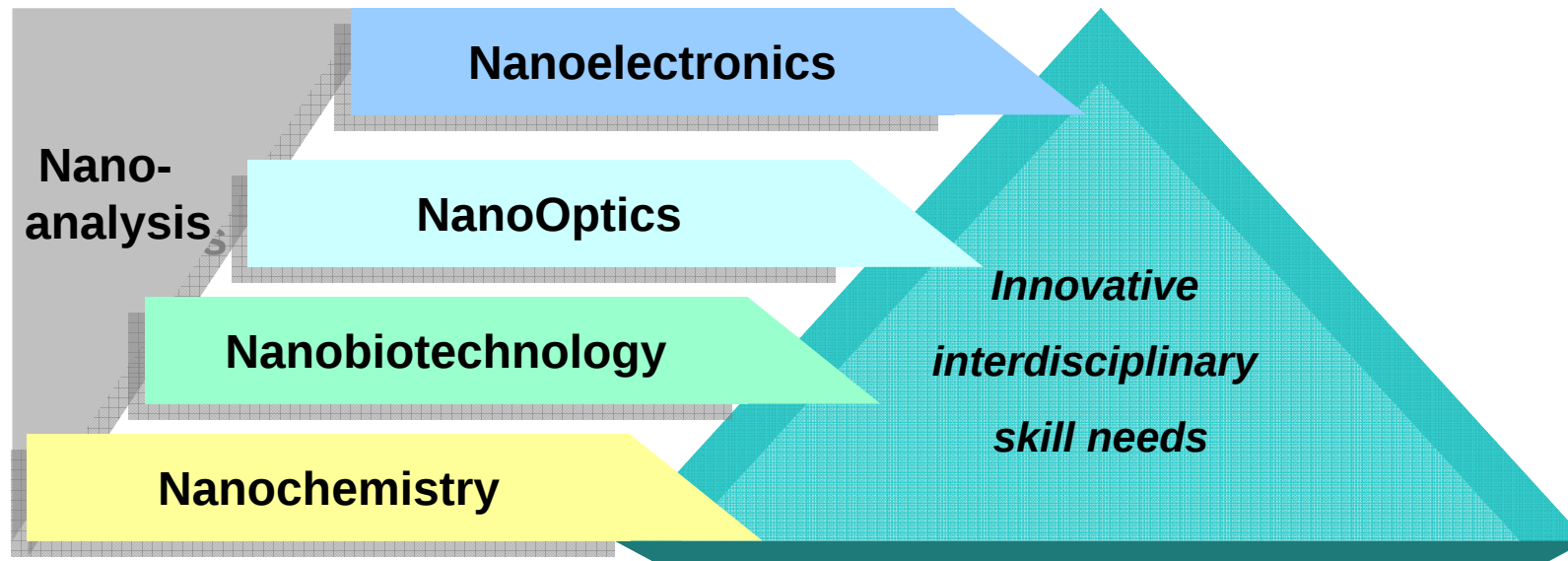
4.2 Way B qualification profiles

3. Results

The cross sectional quality of nanotechnology



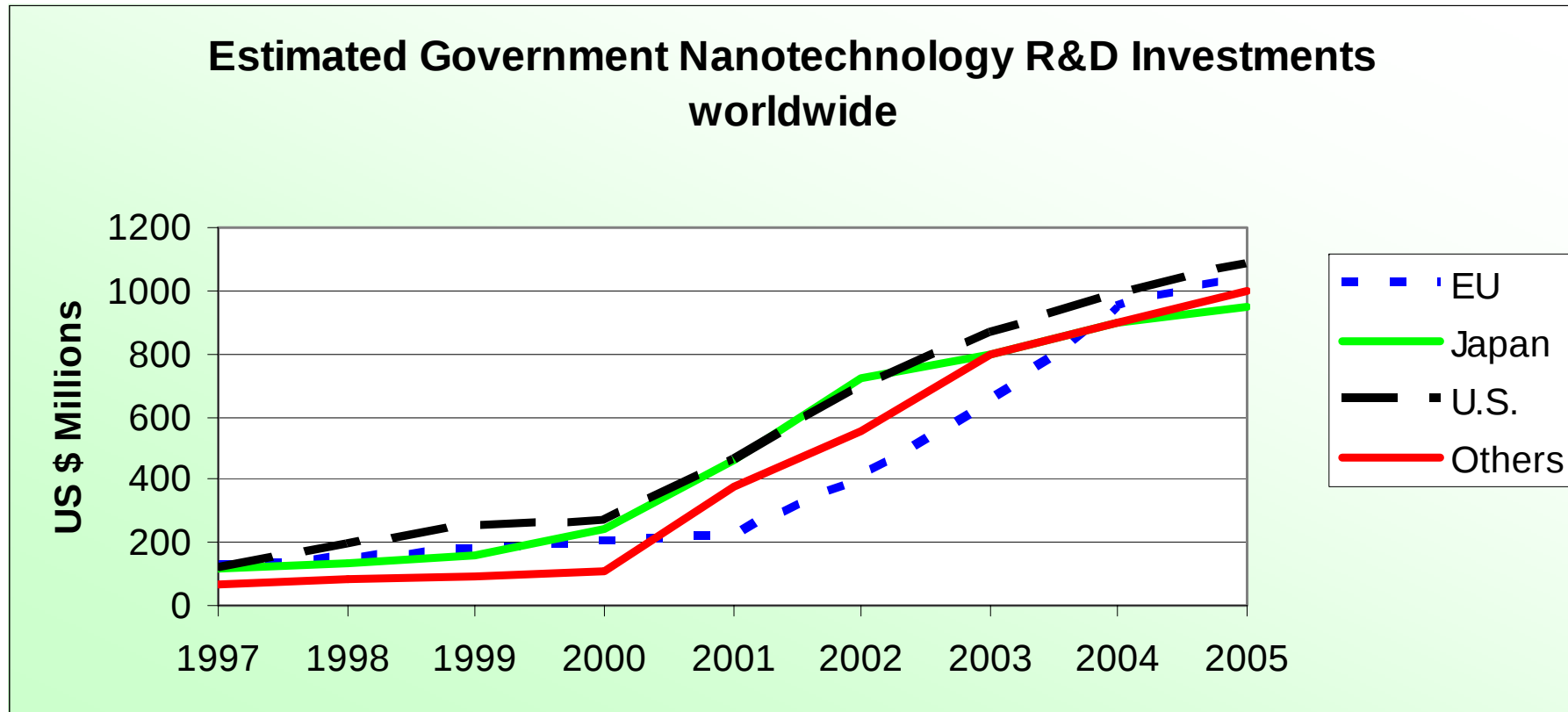
3.1. Nanotechnology sectors



3.1. Nanotechnology sectors

	Nanoanalyses	Nanobiotechnology/ Nanomedicine	Nanomaterials/ Nanotechnology	NanoOptics/ Nanoelectronic
Energy- and Environmental technology, technology of measurement	 			
Life Sciences, Medical Technology, Pharmaceutics, Cosmetic procedures		  		
Chemical industry, Textile industry, food stuff industry			  	  
Information- and Communications technologies			 	 
Automobile industry			 	
Household goods and sports equipments				

3.2. International trends and developments



(Presidents Council of Advisors on science and technology 2005)

3.2. International trends and developments

Special Fields of nanotechnology that are promoted by governments (Meridian Institute 2004)

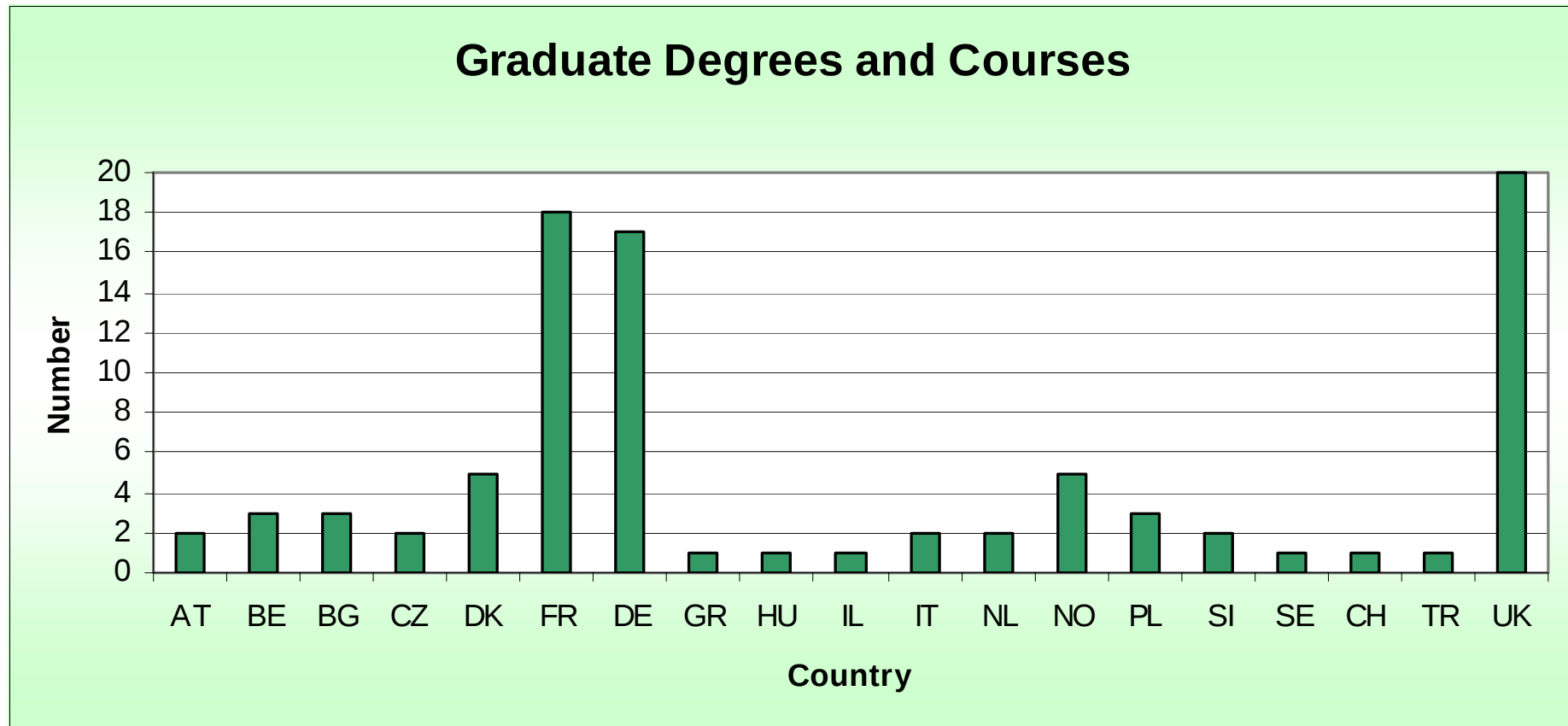
Country	Materials/ Manufact.	Devices Electronics (incl. & Optics)	Energy & Environme nt	Biotech / Medical	Instrument Developme nt	Education
Argentina	✓					
Australia	✓	✓	✓	✓		
Belgium	✓	✓		✓		
Brazil	✓	✓		✓		
Taiwan	✓	✓		✓		
Czech Republic	✓	✓		✓		
EU	✓	✓	✓	✓	✓	✓
France	✓			✓		
Germany	✓	✓		✓	✓	
India	✓	✓		✓	✓	✓
Ireland	✓	✓	✓	✓		

3.2. International trends and developments

Special Fields of nanotechnology that are promoted by governments (Meridian Institute 2004)

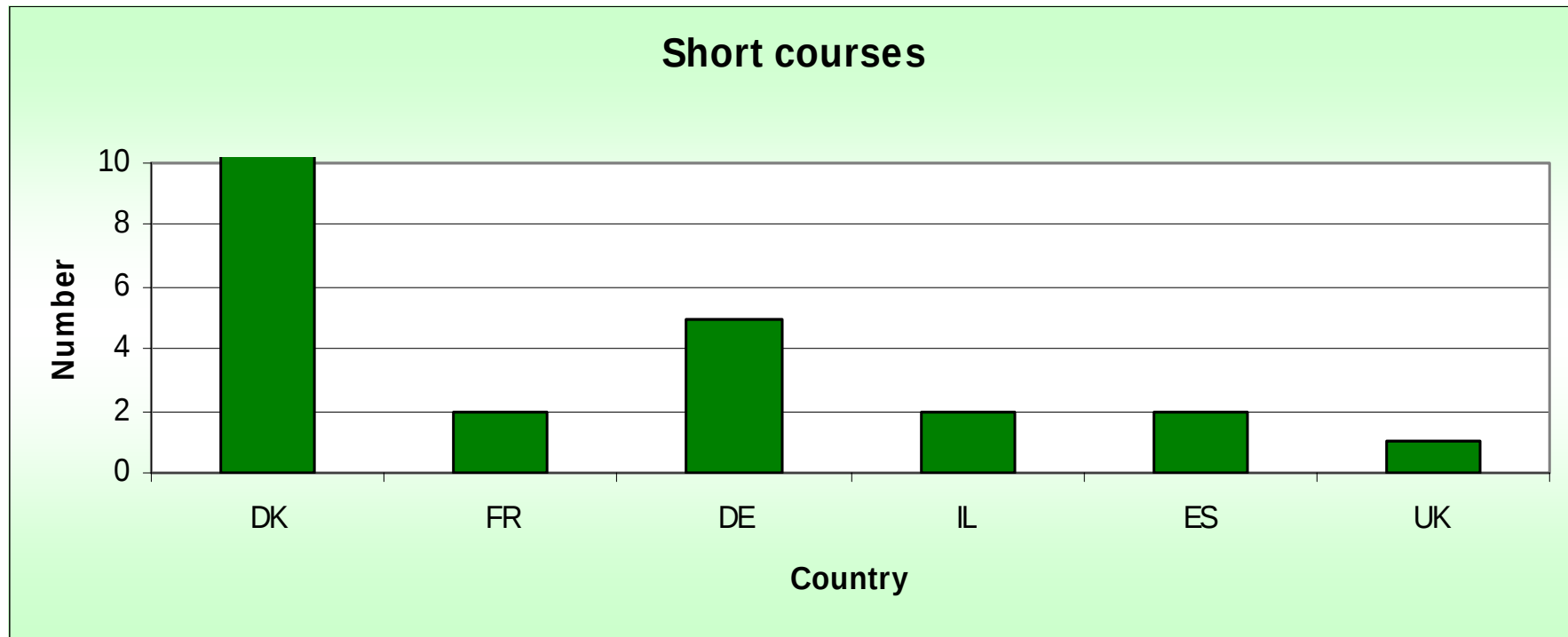
Country	Materials/ Manufact.	Devices (incl. Electronics & Optics)	Energy & Environm ent	Biotech/ Medical	Instrument Developm ent	Education
Israel	✓			✓		
Italy	✓	✓		✓	✓	
Japan	✓	✓	✓	✓	✓	
Korea	✓	✓				
Mexico	✓					
Netherlands	✓	✓		✓	✓	
New Zealand	✓					
Romania	✓			✓		
South Africa	✓		✓	✓		
Switzerland	✓	✓		✓	✓	
United Kingdom	✓	✓		✓		
United States	✓	✓	✓	✓	✓	✓

3.2. International trends and developments



(Nanoforum 2005)

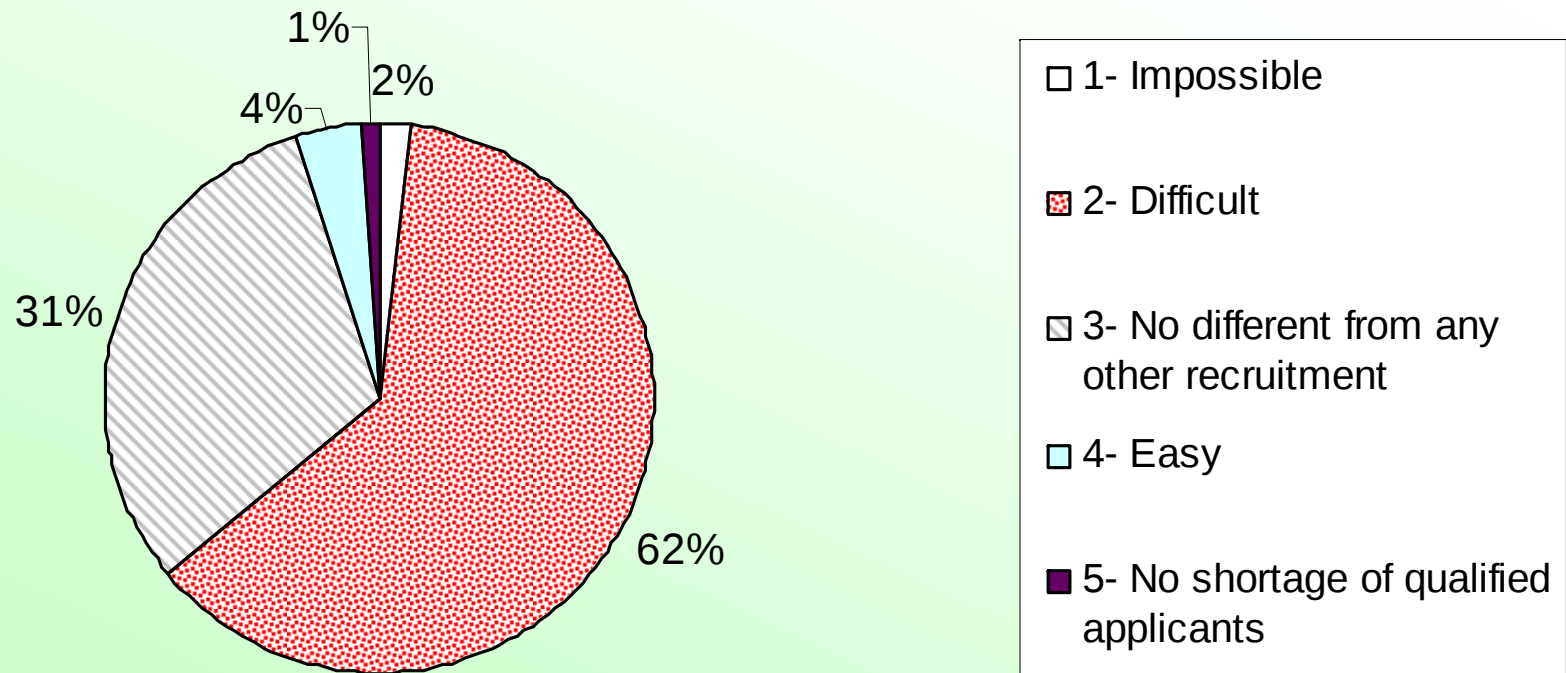
3.2. International trends and developments



(Nanoforum 2005)

3.3. Skill needs

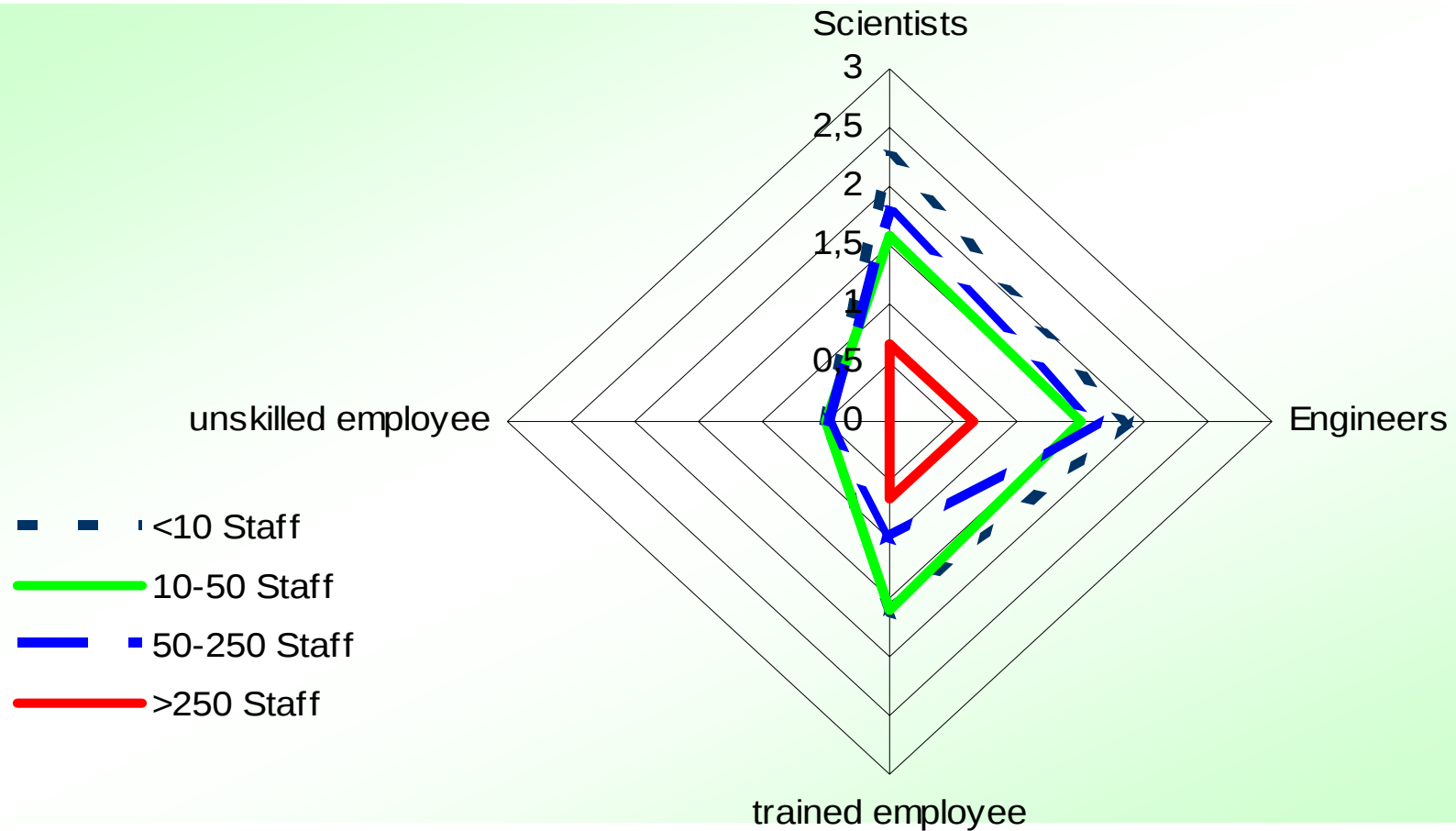
How easy is it on a scale of 1 to 5 to find personnel with the right skills?



(ENA 2005)

3.3. Skill needs

Manpower Requirements by nanotechnological companies after qualification and size of company within 2007 (n = 42)



(Henn 2004)

3.3. Skill needs

Five fields of activity in nanotechnology

1. Research & development

- Currently, R&D is the most important field of work in nanotechnology and Nanoscale Science respectively.
- In general, that is why it is a relatively new field of research.
- It is also because, new nanoanalytical methods such as AFM or STM (scanning tunnelling microscope) are available only just for a short time.

2. Production/ Process

- Nanotechnological intermediate products, products and final products are already produced in several branches, such as e.g. nanoparticles or nano-surface coatings
- further products are expected with up-and-coming tendency.
- increasing automation and process control becoming more meaningful.

3.3. Skill needs

Example procedures and products of nanobiotechnology

Groups of procedure	Products / Applications
Bioproduction/ Fermentation (often in micro-organisms)	Producing complex organic substances, proteins, enzymes, therapeutically proteins also of synthetic compounds genetic programming and protein design
Biomimetical procedures	Synthetic imitation of biological compounds, e.g. for bone or teeth material in prosthetics
Synthesis of nanoparticles	Natural or semi-natural nanoparticles (micella, liposome) as active substances
Tissue Engineering	On molecular level programmed culture of cells to restore tissues or to regenerate whole organs
Genetic Therapy	Repair of genetic defects on subcellular level by creeping in of healthy genotype by vectors such as nanoparticles or virus
Cancer therapy by nanobiotechnology	e.g. magnetic liquid hyperthermia, here iron-nanoparticles are creeped into cancer cells, to heat and destroy them by a magnetic field

3.3. Skill needs

Five fields of activity in nanotechnology

3. Quality assurance

- nanotechnology is a new field, so only little quality standards do exist so far.
- working with nanoscale objects requires special working conditions, so e.g. clean rooms, that demand high quality standards.
- this includes dealing with special protective clothing, materials and substances.

4. Documentation

- dealing with special nanotechnological data partly demands for specific corresponding data processing, e.g. information management systems in laboratory or the use of data bank with nanotechnological parameters
- literature and online research into different nanotechnological aspects

5. Marketing/Distribution

- Nanotechnological products and services need intensive explanations.
- there is a growing demand of nanotechnological, customer-related knowledge and commercial competences as a combination

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 - 3.3 Skill needs
4. **Proposed ways to implement innovative measures of qualification and training in Europe**
 - 4.1 **Way A modular educational system**
 - 4.2 **Way B qualification profiles**

4. Proposed ways to implement and verify innovative measures of qualification and training across Europe

Level I

***Analysis of nanotechnology and its institutions in Europe and
worldwide***

Level II

Survey of scientific-technological development

Level III

Recognition of innovative demands for qualification (competences)

Level IV

Development of Qualification Profiles

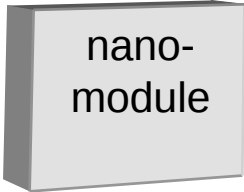
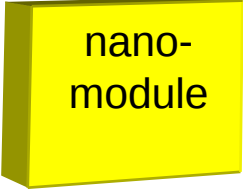
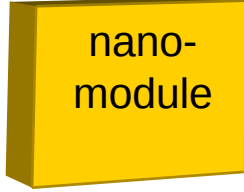
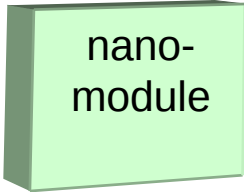
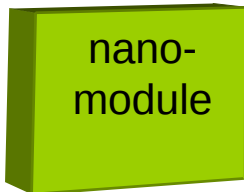
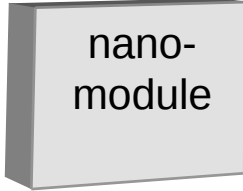
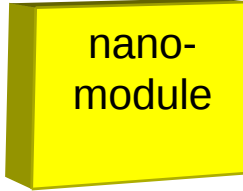
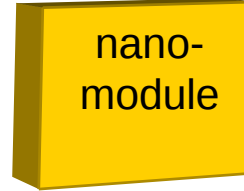
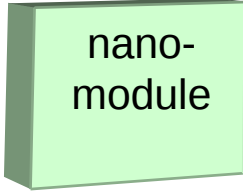
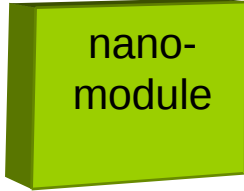
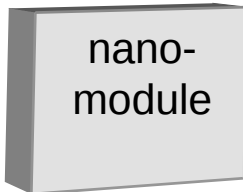
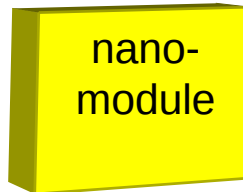
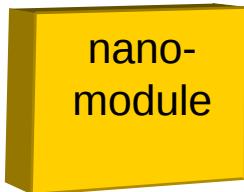
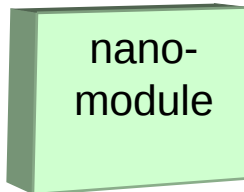
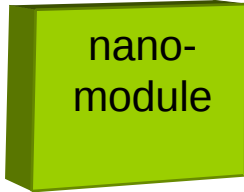
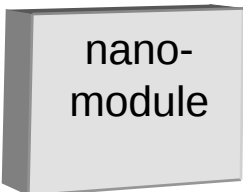
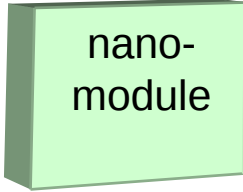
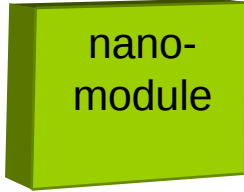
Level V

***Development and testing of new measures of qualification and training
across Europe***

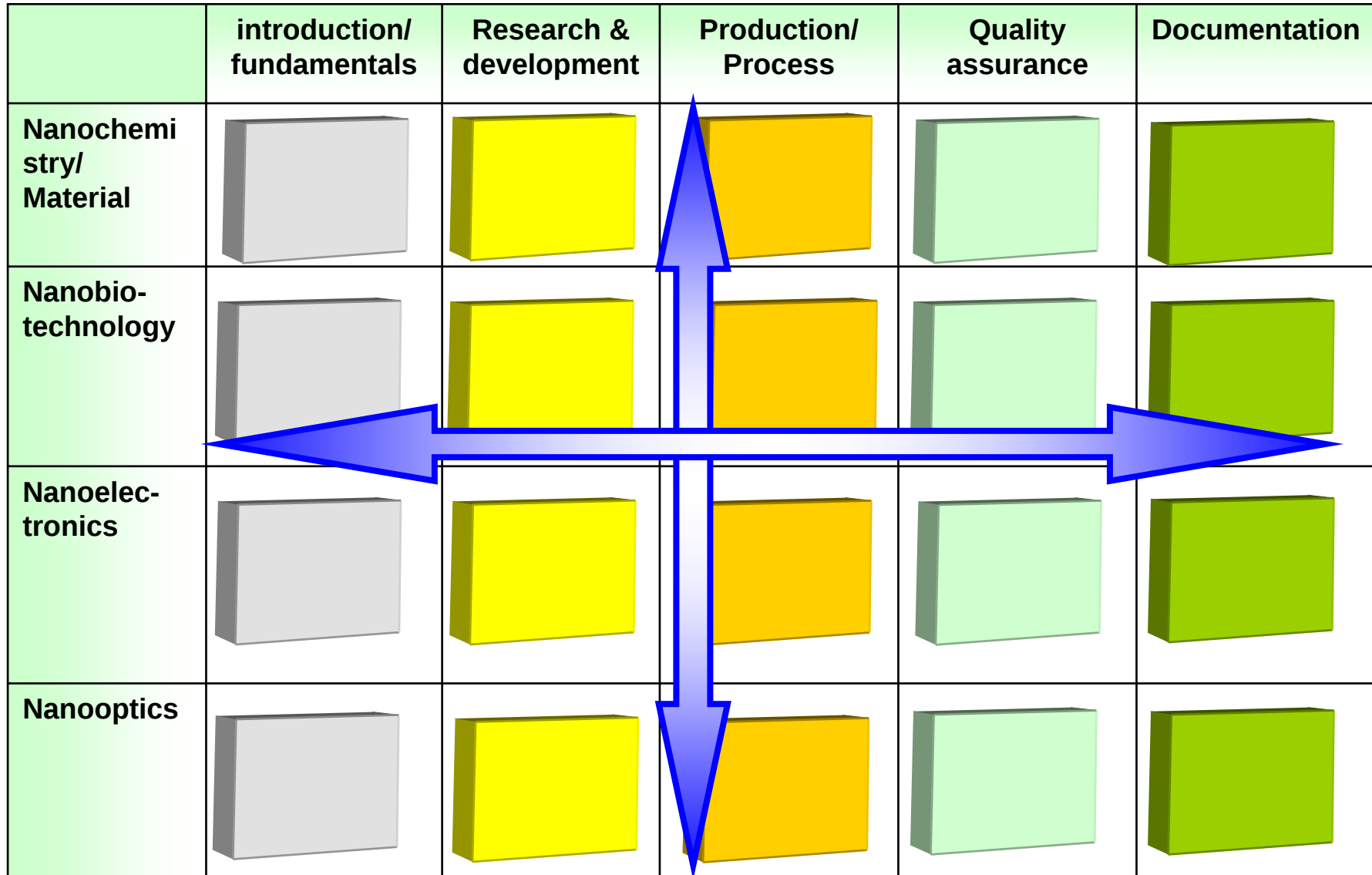
4.1 Way A of a modular educational system

- a convertible possibility without delay would be the development of modular courses of further education on different nanobranches
- taking into account of all relevant fields of work from R&D up to quality assurance
- these modules could be offered to the several branches
Nanochemistry/Materials, Nanobiotechnology, Nanoelectronics or NanoOptics
- beyond this the modules of further education could and should be combined or be based on each other.

4.1. Way A modular educational system

	introduction/ fundamentals	Research & development	Production/ Process	Quality assurance	Documentation
Nanochemis- try/ Material					
Nanobio- technology					
Nanoelec- tronics					
Nanooptics					

4.1. Way A modular educational system



Way B Qualification Profiles

- in Germany the isw investigated new demands for jobs and qualification on intermediate level in the project “*Identification of trend-setting skills in the nanotechnology sector*”
- as a result 18 so-called qualification profiles were developed
- Qualification profiles contain stated view on knowledge, skills and facilities, which are a prerequisite for certain jobs in the nanotechnology sector
- they cover offers for further education, the development of intermediate qualification and possibly also academic degrees.
- the qualification profiles shall be framed modular.
- corresponding acknowledgement of degrees even on international level can be guaranteed by the use of recognized score system, analogous to the ECTS system for higher education.

4.2. Way B qualification profiles

	Cluster-specific Qualification Profiles	Cluster-embracing Qualification Profiles
Nanochemistry/ Materials/ Nanoanalysis	(1) Nanochemical laboratory assistant (2) Nanoassistent (3) Materials scientific-laboratory assistant	(15) Nanoanalyst
Nanobiotech- nology/ Nanoanalysis	(4) Specialist in nanobiotech. Research (5) Specialist for biohybrid Technologies (6) Specialist for Quality assurance (7) Specialist for Documentations on Nanobiotechnology (8) Product adviser for nanobiotech. Applications	(16) Specialist for Nanosurface treatment (17) Specialist for Documentations on Nanotechnology
NanoOptics/ Nanoanalysis	(9) Specialist for Ultra-fine Optics (10) Sp. for Photonics/ Laser technology (11) Product adviser for nanooptical Applications	(18) Product adviser for nanotechnological Applications
Nanoelectro- nics/ Nanoanalysis	(12) Sp. for Nanoelectronics (13) Sp. for mask manufacture (14) Optoelectronics engineer	

4.2. Way B qualification profiles

Interdisciplinary qualification profile (16): **Specialist for Nanosurface treatment**

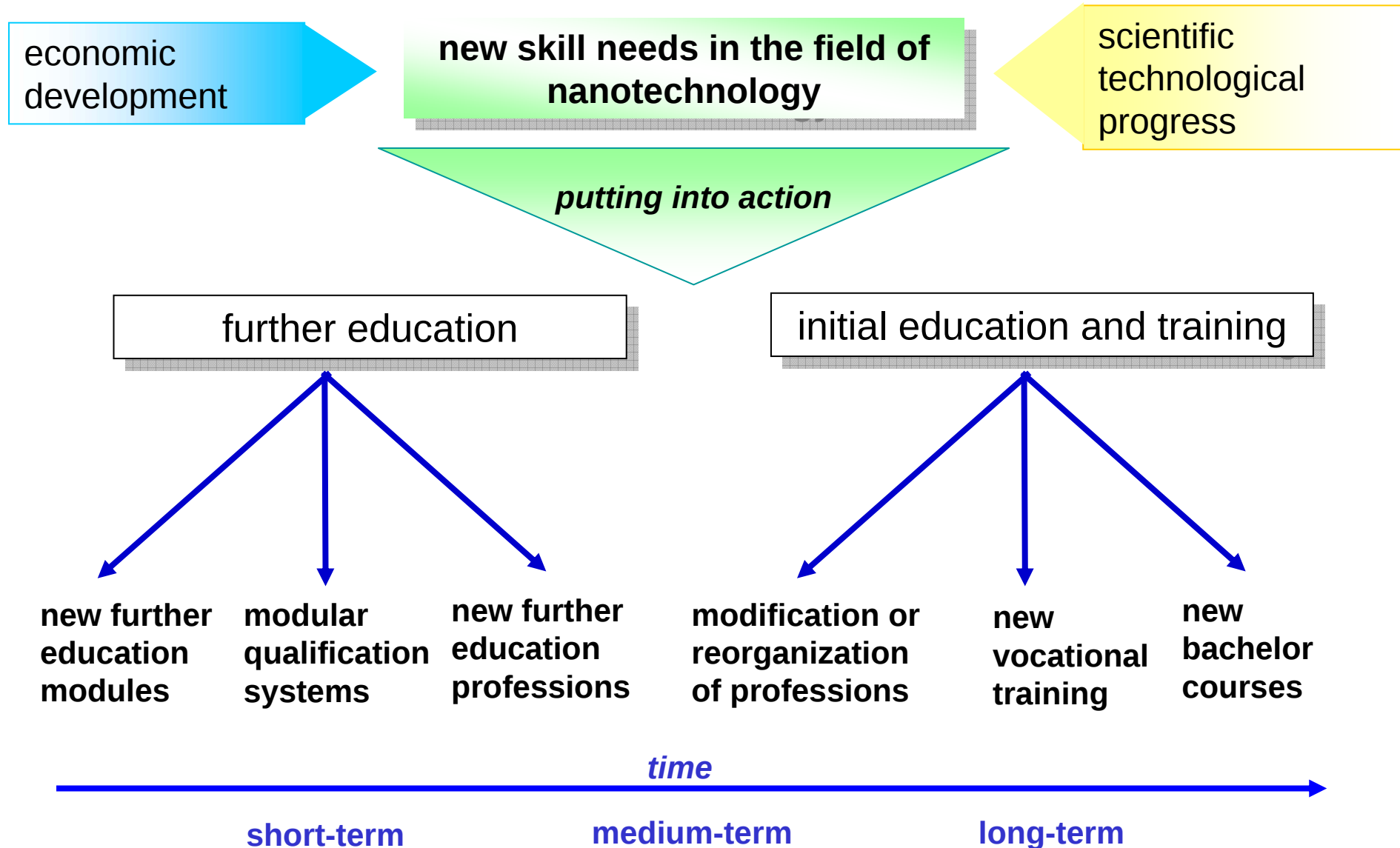
a) field of work and operation	- Specialists for Nanosurface treatment work in companies and in the field of R&D in scientific institutions with the focus on Nanocoating - this varied work centres on producing and treating of ultra-thin surfaces in a wide range of application - they are involved during the whole coatings process beginning with the preparation of surfaces and raw materials over carrying out the coatings to the follow-up treatment and quality assurance - Besides working in series production they also produce individual items
b) Knowledge and knowings – technical skills	- Thorough knowledge in the field of surface physics and surface techniques as well as surface analyses (e.g. Microscopy, Spectroscopy) - Basis of maths, chemistry and physics with deep knowings in the field of nano-dimensional surfaces and technology of thin coatings - thorough application-related knowledge and knowings in the field of coating and coating procedures - extensive knowledge of materials and their characteristics especially of glass, metals, polymers and ceramics - knowings of classification and quality standards e.g. ISO - standard as well as instructions, security data sheets, industrial safety and environmental protection - good knowledge of English, technical English

4.2. Way B qualification profiles

Interdisciplinary qualification profile (16): **Specialist for Nanosurface treatment**

c) skills and faculties – Methodological Competence	- carrying out surface coatings with modern machines and industrial plants - Specialists for nanosurface treatment master different chemical and physical procedures for coating ultra-thin surfaces, especially in the field of chemical vapour deposition (CVD), PECVD, MOCVD and physical vapour deposition (PVD), sputtering, arc deposition -Moreover procedures such as epitaxy techniques, vacuum coatings, thin film technology, sol-gel-procedure, galvanic separations, Coatings und chemical diving procedure are used -Coatings on metals and metal compounds, polymers, glass and ceramics are done -They use the industrial systems, instruments and machines for coating (e.g. caster, plasma or Sputtering systems) and do control the procedure process with the help of process technology -Quality assurance of semi-products and final products by analytical methods of ultra-thin coatings and nanosurfaces
d) Personality characteristics – Social Competence	- Flexibility - Discipline - Checking for technical faults - Sense of responsibility

Ways to implement innovative measures of qualification and training





Institute of structural policies
and economic development
gGmbH

International Workshop „Emerging Technologies new skill needs in the field of nanotechnology “

Thank you very much for your attention!

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