BACHELOR OF APPLIED SCIENCE

Profile of a Competence-based Degree

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FOREWORD

The world keeps turning and just as well. But nowadays it is spinning so fast it seems to be racing away with us. We see this in the demands that national and international labour markets place on the graduates of our Universities of Applied Sciences. Requirements are stiff, especially in technical studies where knowledge has such a short shelf life. Demands, too, are high not only because of the high level of expertise expected of graduates, but also because of the universities' ambition to become innovative knowledge centres. High hopes lead to great expectations and Universities of Applied Sciences must live up to these expectations.

Here you have a profile of the competence-based degree, Bachelor of Applied Science. This brochure describes the level of expertise that Dutch Universities of Applied Sciences – in consultation with the relevant professional fields – expect of their graduates. The profile is based upon validated descriptions and includes illustrations of the various professional fields and occupations open to graduates. These case studies are a fantastic means of communicating with the labour market (what we train you for) as well as prospective students and their parents (this is what you can become and where you could be employed).

This is the latest in a series of four profiles of technology degrees offered by Dutch Universities of Applied Sciences. It follows the published profiles of the Bachelor's degrees in Information Technology, Engineering and the Built Environment. All four profiles are available on the website of the Netherlands Association of Universities of Applied Sciences (www.HBO-Raad.nl).

With this profile, the universities offering a Bachelor of Applied Science degree have, in my opinion, satisfactorily met their high hopes. It would be interesting to see if students and graduates think it meets their expectations.

Doekle Terpstra,
Chairman of the Netherlands Association of Universities
of Applied Sciences (de HBO-Raad).

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1

Introduction

1.1. BACKGROUND

In recent years, the Bologna Accord that established the common European Higher Education Area (1999) has led to radical changes in education. To facilitate internationally flexible learning paths and increase the employability of graduates in the global economy, the EU introduced a single system of academic titles in all member states. It adopted the Anglo-Saxon system of Bachelor's and Master's degrees in the Arts and Sciences (BA/BSc, MA/MSc)and introduced a European-wide accreditation system. In the European Credit Transfer System, one ECTS credit represents 28 hours of study by an individual student. In 2002, the Netherlands began introducing Bachelor's and Master's degrees in both tiers of higher education (vocational and academic). This change was the driving force behind the revision and simplification of the structure of existing technical studies. This was necessary because Dutch Universities of Applied Sciences used to award graduates 14 separate diplomas. The sector's advisory committees investigated how best to streamline the confusing old system and in 2003, following advice from the Working Group on the Development of Bachelor's Degree Studies, the Netherlands Association of Universities of Applied Sciences decided to merge their Bachelor's degree programmes in four domains: Bachelor of Engineering, Bachelor of the Built Environment, Bachelor of Information & Communication Technology and Bachelor of Applied Science.

Each domain comprises a cluster of studies containing related content and professional opportunities.

A set of competences for each domain has been formulated in order to increase its recognition factor. These are the common competences[1] or professional skills that every new professional graduate in every Bachelor's-awarding domain must attain. The competences for the domain of Applied Science were formulated on the basis of national professions and study profiles determined in 2003 and 2006 (see Chapter 7). When the new competence-based profiles were introduced, the previous profiles were discarded and the new descriptions were applied to each study. After validation by professionals in the field, these competence-based profiles were added to the information database run by the Netherlands Association of Universities of Applied Sciences.

1.2. COMPETENCES AND COMPETENCE-BASED EDUCATION

To improve the ties between the professional field and education, the Universities of Applied Sciences have opted for competence-based education. Its introduction has also motivated the writing of national study profiles in terms of competences. These have replaced the old concept of final attainment levels. In contrast to final attainment levels, which describe the knowledge and skills to be attained by a student upon graduation, a competence is defined as the ability to fulfil authentic tasks found in the professional field in an adequate process- and product-orientated manner. A competence encompasses the qualities that students should either possess or be able to apply, and that enables them to successfully complete a task in a particular professional field. Knowledge, skills and attitude are clustered in each competence.

[1] In industry, competences are usually understood to mean social or communication skills and are less frequently understood to include professional skills.

Figure 1 presents a scheme of the term competence. Several elements must be included in the definition of a competence:

- Central to the concept is the problem definition, the task or assignment in a specific context or environment;
- A result (technical content) should be attained;
- A combination of substantive knowledge and technical tools (resources), skills and attitude is needed to successfully complete the jobs and tasks.

The Bachelor of Applied Science includes the following eight competences: 'Research',' Experimentation', 'Development', 'Administration and Coordination', 'Consultancy and Trading', 'Instruction, Supervision, Teaching and Coaching', 'Governance and Management' and 'Self-Management'. Chapter 5 explains these competences in more detail.

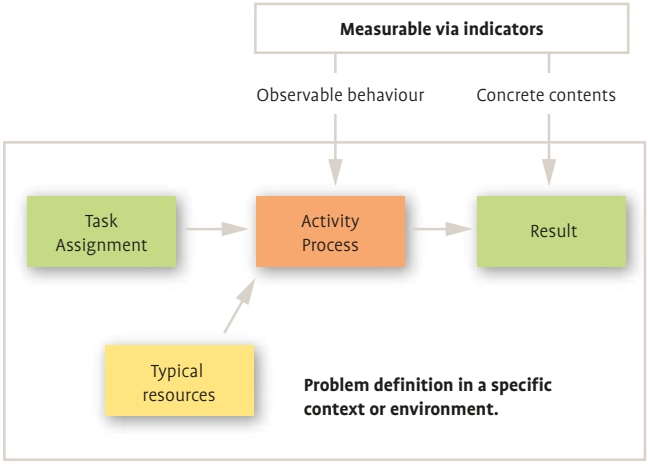


Figure 1: Schematic presentation of a competence.

Besides these work-related competences, a Bachelor's degree has two further sets of qualifying competences not especially related to one profession:

- Dublin descriptors (Appendix I): the internationally accepted level of attainment needed to qualify for a Bachelor's degree;
- University of Applied Sciences Core Qualifications (Appendix II): the Dutch, nationally accepted level of attainment required for a Bachelor's degree.

The Dublin descriptors and the core qualifications pertain to all studies awarding a Bachelor's degree and are included in the national study profiles that do not have to be listed separately (see Chapter 6).

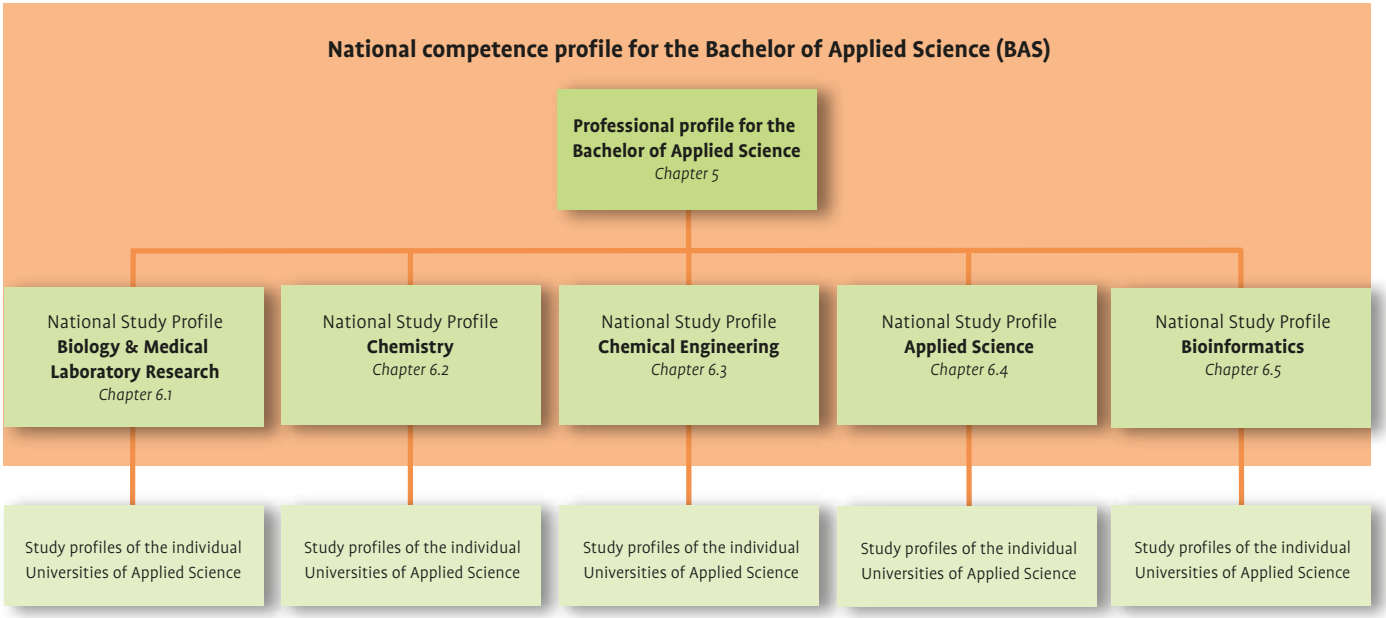
Through competence-based education, students acquire the knowledge, skills and attitudes necessary to pursue their future profession in an integrated way. Competence-based education primarily aims to establish a stronger connection between education and the professional field. It places the future profession centrally and emphasizes complex and authentic professional situations. Studies focus on current professional issues and are often organised in themes, in which various disciplines interact. Learning is then as authentic as possible: assignments are grounded in the professional field, on case studies or in internships.

This form of education necessitates close contact between the study and the professional field and that improves the relationship with the profession.

1.3. STUDIES IN THE DOMAIN OF APPLIED SCIENCES

Applied Science comprises the domain of research in the natural sciences and the application of the knowledge gained to practical issues and problems. In the current organisation of Dutch Univer-

Figure 2: Individual connections between the existing competence profiles.



sity of Applied Sciences education that is affiliated with the Central Register of Higher Education Programmes (CROHO), the core courses in the Bachelor's degree are Biology & Medical Laboratory Research, Chemistry, Chemical Engineering, Applied Sciences and Bioinformatics. In addition, several other study programmes may also award this degree, including Biotechnology, Forensic Research, Environmental Studies, Physical Engineering and Food Technology. Appendix III provides an overview of the study programmes and Universities of Applied Sciences in this domain.

Please note that individual Universities of Applied Sciences have the right to decide for themselves which degree they award. One university may offer another degree for the same study. This is true for Chemical Engineering and Physical Engineering: different universities award graduates of these studies either a Bachelor of Applied Science or a Bachelor of Engineering.

1.4. ORGANISATION OF TEXT

The purpose of this brochure is:

- to give a clear description of the Applied Science domain;
- to sketch the career opportunities available within the domain;
- to describe the competences required by various professions in the domain;
- to define a coherent and useful set of competences as the base for various study programmes.

This document does not claim to give a comprehensive picture of all the career opportunities available to the holder of a Bachelor of Applied Science degree. The competences in the national study profiles serve as a point of departure from which individual study programmes may formulate their own profiles. The national profiles enable individual institutes to determine their priorities and to meet their own regional needs. Figure 2 shows the interrelation between the various competence profiles. This scheme applies to all studies (see section 1.3) that award the Bachelor of Applied Science degree. The new set of competences for the Applied Science domain has been limited as far as possible without impeding the chances of developing broadly interpreted undergraduate programmes in Applied Science.

The brochure is organised as follows: Chapter 2 defines the terminology. Chapters 3 and 4 describe the content of the Applied Sciences domain and explain the professional field open to the holder of a Bachelor's degree in the Applied Sciences. Chapter 5 names the domain competences and describes the competence indicators. Chapter 6 presents the national study profiles. Initially, these profiles are for Biology & Medical Laboratory Research, Chemistry, Chemical Engineering, Applied Science and Bioinformatics. A future edition of this brochure will include the profiles of the remaining studies that grant a Bachelor of Applied Science degree (see Appendix III).

2

Definitions

The **professional image** covers the collection of possible professions, jobs or tasks and related competences for a Bachelor of Applied Science.

The **professional domain** is the context of the professional field, characterised by one word (or a short combination of words).

B&M stands for Biology & Medical Laboratory Research.

A **competence** is a cluster of knowledge, skills and attitudes that

- is necessary to carry out a particular job/task in a particular context;
- can be measured and tested against accepted norms;
- can be improved by training and development.

The **context** is the applied or natural scientific environment in which companies and laboratories operate.

The **CROHO** (Central Register of Studies in Higher Education) registers all the studies funded by the Dutch Ministry of Education, Culture and Science.

CE stands for Chemical Engineering.

A **job or task** is a collection of activities carried out by one or more persons employed in a particular context in order to contribute towards the production of a product or service whereby particular competences are used.

A **competence indicator** clarifies the measurement of a competence: a student shows that he has gained mastery in a competence by his behaviour.

A **qualification** is evidence of achievement (e.g. a Bachelor's degree in Applied Science) awarded when a person has attained the required level of competence at a particular moment. A **qualifier** is a competence in which a person must demonstrate mastery in order to be awarded a university degree.

The **professional field** is a collection of all the professional occupations in which the Bachelor of Applied Sciences graduate is likely to find employment.

3

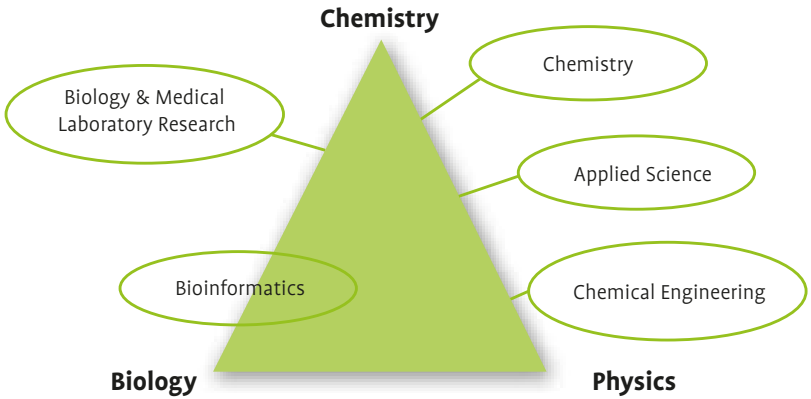
The Domain of Applied Science

The classic sciences form the basis of both natural and applied scientific research as well as the core of the Applied Science domain.

Studies leading to the degree of Bachelor of Applied Science include concepts from at least three of the classic sciences, namely chemistry, biology and physics. These can be viewed as forming a triangle with one field at each of the three angles. As most of the studies dealt with here include aspects of other areas of science, some may fall outside the classic chemistry-biology-physics triangle. For example, biology and information science both play a role in Bioinformatics. Studies that fall completely outside the classic triangle are excluded from the domain of Applied Science.

Figure 3 shows how Biology & Medical Laboratory Research, Chemistry, Chemical Technology, Applied Science and Bioinformatics fit into the classic chemistry-biology-physics triangle.

Figure 3: Studies in the domain of Applied Science included in the classic sciences triangle.



4

Professional Image of a Bachelor of Applied Science

4.1. GENERAL INTRODUCTION

The majority of people with a Bachelor's degree in Applied Science hold positions in laboratories and companies in a whole range of sectors. Their duties involve problem-solving, individually and in teams, or finding solutions through experimental research in the fields of physical sciences. Here we find advanced, often automated apparatus, as well as information technology becoming increasingly important.

Characteristic of Bachelor of Applied Science graduates is their analytical, abstract level of research and service-orientated approach. Central to this approach are not only the 'what' and the 'how' but also the 'why'. Graduates concentrate on gaining insights in order to contribute to solving problems and answering questions in the hard sciences. They function autonomously, often in a multidisciplinary context, and are aware of the risks to mankind, nature and the environment as well as the ethical implications of research. They follow the regulations applicable to the task and search for sustainable solutions.

Graduates work within proscribed guidelines and keep up with relevant legislation. Implementing the qualitative norms of their workplace and functioning efficiently by these norms are fixed elements of their work.

Whether in a research laboratory or in process-technology industry, holders of a Bachelor's degree in Applied Science are fully capable of focussing on a domain, such as a specialisation, fundamental or applied scientific research or developmental work for laboratory or process technology. Within a few years of commencing their career, they often move on to senior positions such as project leader or departmental head, and to roles such as quality controller or equipment controller, instructor or supervisor or information technology specialist. The Bachelor of Applied Science often works in big concerns under academic supervision, while in a small or medium-sized company they will carry the final academic responsibility themselves. Alternatively, graduates may take on a service-oriented role in education, such as lecturer or supervisor, or a commercial position in industry. The Bachelor's degree is a good stepping stone for further education, such as a Master's degree in medical biology, biomedical sciences, medicine, chemistry or chemical engineering.

The laboratories and companies employing Applied Science graduates are found in diverse sectors. Please note that this overview of (Dutch) multinational companies makes no claim to be fully representative.

Industry:

- Chemical and pharmaceutical industry (DSM, GEP, Shell, AKZO-NOBEL);
- Diagnostics companies (Philips);
- Biotechnology companies (Pharming, Crucell, Keygene);
- Food industry (Numico, Unilever, Nutreco);
- Consultancies in quality control and hygiene (Oxoid, Abbott);
- Toxicology companies (NOTOX);
- Process technology and/or product and materials technology (Philips).

NGOs, Universities and Research Institutes:

- RIVM, TNO, the Netherlands Food and Consumer Product Safety Authority, Alterra, ATO-DLO;
- Universities;
- Academic Hospitals.

Service Laboratories:

- Environmental laboratories;
- Laboratories for quality control and production in the organic, biochemical and analytical field.

Health Care and the Environment:

- Academic medical centres (research) and regional hospitals;
- Blood banks;
- Regional Health Care Laboratories;
- GP Laboratories;
- Food and Consumer Safety Authorities;
- Health Services;
- Institutes for Ecological, Toxicological and Environmental Research.

4.2. PROFESSIONAL DOMAINS

Holders of a Bachelor of Applied Sciences degree work in diverse subjects in an extensive field. Occupations vary, although common factors are the hard sciences and the basic tools of engineering. Other common factors are graduates' ability to complete tasks independently, innovatively, with enterprise, a sense of responsibility and orientation to results.

The nature of the occupations and the particular emphasis of the work done by the Applied Sciences graduate lead us to distinguish the following professional domains:

1. Research and Development;
2. Commerce and Service Industries;
3. Applications and Production;
4. Medical Laboratory Diagnostics;
5. Engineering and Manufacturing.

1. RESEARCH AND DEVELOPMENT

In the domain of Research and Development, the Bachelor of Applied Science is involved in the development of new or improved products, materials, methods and processes. To this end, the various disciplines of the natural sciences are integrated and directed towards various applications including scientific research, medical diagnostics, the pharmaceutical, chemical, food and fermentation industries, environmental and sustainability problems, biotechnology and more. As a researcher, the Applied Sciences graduate is able to conduct research in any of these applications.

Both government and industrial research laboratories are generally well equipped. Supervising academics are in charge of the research or determine the direction of the development and are responsible for the theoretical components of the task. The Applied Science graduates are responsible for carrying out the research. They develop the design, conduct and interpret practical experiments, (or supervise the process), make use of modern information and communication resources (such as internet, bioinformatics applications and IT applications), draw conclusions and make recommendations. In small and medium-sized companies, there is usually a less fundamental and more applied approach to professional tasks. Research direction, organisation and coordination are then considered the tasks of the Bachelor of Applied Science graduate.

2. COMMERCE AND SERVICE INDUSTRIES

In commerce, holders of the Bachelor of Applied Science degree are primarily employed as product specialists. Potential jobs include selling domain-specific products, systems, services and equipment. Graduates may also be involved in marketing. In the role of consultant, they may contribute towards solving more or less acute problems or may instruct and supervise new users and clients. They consult with clients and users, clarify problems, search for causes and potential solutions and advise the client. In all these cases, professional activities are related to the principles and systems viewed from the biological, medical, chemical or technological perspective.

Graduates may become a deputy or head of a department or service, or even start their own business. In service industries they could become a hygienist, for instance, or be involved in knowledge transfer

as an internship supervisor in the various levels of higher education, in a laboratory or the like. Other possible roles in institutes or companies could be in quality control or management, security (working in biological security or as a health and safety coordinator), the environment (environment consultant), hygiene (hygienist) or forensic research.

3. APPLICATIONS AND PRODUCTION

In this professional domain, Applied Science graduates are often employed in environmental laboratories or laboratories involved in quality control and production in the organic, biochemical and analytical fields. Here they principally conduct complex experiments that appeal to all of their practical and analytical skills. In synthesis laboratories, where safety is imperative, the emphasis is placed upon the graduate's knowledge and insight. Extensive variation in the types of experiments calls for a graduate to be capable of broad deployment and have a strong ability to apply their knowledge of technology, equipment, automation, quality control, health and safety issues and environmental control. Where possible, they seek sustainable solutions. The nature of the work requires good communication skills and a strong sense of responsibility. The holder of a Bachelor's degree in Applied Science must be a team player as well as reliable, critical and efficient, even when working under pressure or where deadlines are crucial.

4. MEDICAL LABORATORY DIAGNOSTICS

Diagnostic laboratories in the health care sector conduct research on human and sometimes animal tissue. These laboratories are involved in clinical chemistry, medical microbiology, cytohistopathology, haematology, immunology, endocrinology and clinical genetic research. Here graduate contribute towards finding answers to clinical questions by applying analytical methods from the natural sciences in the diagnosis, treatment and prevention of disease. They work in the total process of sample preparation from the moment the sample is taken to the reporting stage and the final archiving of data. In this job it is important for graduates to develop their knowledge and understanding so that, when involved in the interpretation of the research, they can establish relationships between the medical problem and the research results. The specific nature of working with patient samples plays a key role here.

The wide variation in analyses, ranging from manual to fully robotic or automated analyses, requires graduates to be broadly deployable and well capable of using equipment in the application of technologies, automation and quality control. The nature of the work requires good communication skills, a strong sense of responsibility and a supportive attitude. Another important aspect of the profession is being a team player. The graduate should also be capable of functioning in a reliable, efficient and critical manner, even when working under pressure or when deadlines are crucial.

In laboratory work, career moves involve personal development in specialised or managerial positions. The professional possibilities are countless.

5. ENGINEERING AND MANUFACTURING

In this domain, graduates are involved in or are primarily responsible for the management and control of production process, either entirely or in part. Working in teams, they develop or adapt new processes or improve existing processes, products or materials. They consult with operators, (senior) management or external parties, take decisions on process changes or prepare for these decisions to be taken, and report on the normal and abnormal progress of a process and its outcomes. Graduates apply their knowledge of chemical conversion processes and physical separation techniques to ensure an optimal price-quality ratio within socially acceptable risk margins.

This professional domain distinguishes two distinct points of emphasis, namely bio-process technology and products or materials technology. Bio-process technology usually involves large-scale processing plants which produce intangible gases and other products such as liquids, powders and/or granules. Products or materials technology often involves smaller production units which manufacture other tangible products such as plating, yarns, wire and foams.

5

Professional Profile

5.1. COMPETENCE PROFILE FOR APPLIED SCIENCE

This chapter defines and explains the competences in the domain of Applied Science. In addition to possessing professional skills, the novice professional must demonstrate mastery in two further sets of major qualifiers in order to be awarded a Bachelor's degree:

- the Dublin descriptors (Appendix I);
- the Generic University of Applied Sciences Core Qualifications (Appendix II).

Appendix I describes the internationally accepted level required for a Bachelor's degree while Appendix II describes the Dutch national degree requirements. One of the stipulations set by the Dutch government for awarding a Bachelor's degree is that the level of higher education must be in line with both international and national accepted levels.
The study profiles derived from the professional profiles and presented in Chapter 6 include the Dublin descriptors and the generic core qualifications. If students meet the demands of the course profile, by implication they will satisfy the internationally and nationally accepted levels for a University of Applied Sciences Bachelor's degree. The generic core qualifications are implicitly incorporated in the competences set for the domain of Applied Science.

The profile of the domain of Applied Science contains 8 competences:
1. Research
2. Experimentation
3. Development
4. Administration | Coordination
5. Consultancy | Trading
6. Instruction | Supervision | Teaching | Coaching
7. Governance | Management
8. Self-Management

These competences are defined in the sections below in terms of quantifiable indicators, which have been further refined on the basis of the level of work conducted by a practicing professional with some five years of experience. This is called level IV. As it is not reasonable for recent graduates to achieve level IV straight after finishing their Bachelor's degree, there are three lower levels as well, namely levels I, II and III. See Table I for an explanation of these levels. The formulation of these lower levels has made it possible to assess students' progress towards attaining their degree during the course of the curriculum. Using these level classifications also makes it possible to place particular emphasis on certain aspects of a competence in a study profile. For example, a strong research-oriented study may opt to train its Bachelor's degree students up to Level III in 'Research' and 'Experimentation'.

Table 1: Definitions of competence levels.

Level	
I	Show effective behaviour if the setting allows. **Keywords:** implementation, commissioned by
II	Show effective behaviour based on your own initiative. **Keywords:** solving, analysing
III	Strengthen effective behaviour in others in the immediate environment, mainly by example. **Keywords:** integration, development, transfer of knowledge and skills
IV	Inspire effective behaviour in others in the organisation and thereby raise the competence level within the organisation. **Keywords:** generate knowledge

5.2. DEFINITIONS OF COMPETENCES AND INDICATORS

This section defines each competence and its associated indicators required for the type of work the holder of a Bachelor of Applied Science will be qualified to undertake. The indicators are described at level IV, that is, according to five years of working experience. Please note, therefore, that this is not the same level as the Bachelor's degree.

1. RESEARCH

The Bachelor of Applied Science can conduct research that is either problem-solving or will lead to a greater understanding of a topic in their working environment.

The candidate demonstrates mastery of this competence by:

a. showing sufficient expertise and initiative to reveal and analyse problems in the field of hard science;
b. defining the research objectives from the perspective of the problem under investigation;

c. selecting and obtaining independent (scientific) literature in order to deepen understanding of the problem whilst correctly assessing the reliability of the information found in the literature;
d. preparing a viable and sustainable working plan (including a budget) taking into account quality control, health and safety, environmental and ethical issues;
e. executing the working plan systematically, using relevant methods, techniques and equipment;
f. being capable of working cooperatively in a team and being result-oriented in a multidisciplinary context;
g. summarising, structuring and interpreting the results in terms of the research question;
h. reporting results in accordance with the norms of the profession;
i. making proposals for further research based on the results obtained.

2. EXPERIMENTATION

The Bachelor of Applied Science can conduct experiments in the domain of Applied Science so as to obtain reliable research results.

The candidate demonstrates mastery of this competence:
a. translating a research question into an adequate experimental design, including working protocols;
b. showing the knowledge, insight, creativity and skill necessary to conduct experiments in a safe, secure and critical manner using appropriate methods, techniques and equipment;
c. independently gaining in-depth knowledge of methodologies and backgrounds (including the potential and limitations of equipment);
d. adhering to working protocols closely and, if necessary, adjusting them to produce demonstrably reliable and reproducible results;
e. taking into account health and safety issues, environmental and hygiene considerations and conducting experiments as sustainably as possible;
f. applying (statistical) techniques in processing or validating results as well as in ensuring their quality;
g. reporting findings in accordance with professional standards;
h. making proposals for further experiments on the basis of current research findings;
i. using project planning to achieve the desired objectives quickly and efficiently.

3. DEVELOPMENT

The Bachelor of Applied Science can develop, improve or implement products, processes or methods based on existing knowledge in the domain of Applied Science.

The candidate demonstrates mastery of this competence by:
a. establishing the most appropriate parameters so that the production process, product or method can be influenced positively;
b. establishing the criteria which the product, process or method must satisfy;
c. selecting and applying appropriate physical, chemical and biological models from the physical sciences;
d. selecting the most suitable raw materials and both qualitative (which) and quantitative (volume, dimensions) unit operations;
e. responsibly upscaling/downscaling the production processes;
f. reporting findings in accordance with professional standards;
g. making proposals for further developmental research.

4. ADMINISTRATION | COORDINATION

The Bachelor of Applied Science can develop, implement and maintain a data management system, or components thereof, in the domain of Applied Science so that the system complies with relevant laws and regulations, quality standards and norms and values of the organisation.

The candidate demonstrates mastery of this competence by:
a. analysing any problems related to the development, implementation and maintenance of a data management system;
b. preparing, implementing and evaluating a plan of improvement aimed at solving the problem in a creative, structured and economically viable way;
c. taking into account the laws and regulations and (international) standards and values, particularly with regard to sustainability and reliability;
d. coordinating activities related to the development, implementation and maintenance of the data management system;
e. reporting and presenting information in accordance with professional standards;
f. keeping employees adequately informed about the content and application of the data management system and any changes which may take place.

5. CONSULTANCY | TRADING

The Bachelor of Applied Science can give well-motivated advice on the design, development or application of products, processes and methods and will establish profitable operations with goods or services in the domain of Applied Science.

The candidate demonstrates mastery of this competence by:

a. acting in service-oriented manner;
b. clarifying client enquiries;
c. designing and conducting (market) research;
d. formulating proposals or advice (wholly or in part);
e. translating the requirements and enquiries of the client into viable solutions or recommendations in consultation with researchers and developers;
f. maintaining appropriate relations with customers;
g. preparing a marketing plan (wholly or in part);
h. applying appropriate negotiation techniques during purchasing or sales.

6. INSTRUCTION | SUPERVISION | TEACHING | COACHING

The Bachelor of Applied Sciences can instruct and supervise employees and clients in learning new knowledge and skills in the domain of Applied Science.

The candidate demonstrates competence in this by:

a. independently providing theoretical instruction and demonstrations to introduce employees, pupils, students or trainees to practical experimentation, the use of equipment, materials, etc.;
b. supervising / coaching staff, pupils, students or trainees in the use of methods, equipment and research literature during practical assignments;
c. applying didactic skills in various educational settings;
d. coaching staff and teams in the development of expertise;
e. evaluating and assessing the results of training or further education.

7. GOVERNANCE | MANAGEMENT

The Bachelor of Applied Science can provide guidance and direction to organisational processes and the staff involved to achieve the goals of the organisational component or the project under his leadership.

The candidate demonstrates competence in this by:

a. having and conveying a vision with regard to the organisational unit;
b. working in accordance with the project plan;
c. coaching staff by inspiring, persuading and motivating, by showing respect, promoting cooperation and delegating tasks appropriately;
d. acting as an example to employees;
e. giving employees a sense of shared responsibility;
f. chairing progress meetings and work discussions;
g. communicating in a process- and task-oriented manner;
h. managing a project in terms of time, funding, quality, information and organisation.

8. SELF-MANAGEMENT

The Bachelor of Applied Science can motivate himself to improve how he works and grows to ensure that he stays abreast of new developments, including those related to ethical dilemmas and socially accepted norms and values.

The candidate demonstrates competence in this by:

a. independently determining and carrying out both his learning objectives and learning strategies and applying the results and obtained feedback to his learning objectives;
b. adapting quickly to changing work conditions;
c. weighing up and taking decisions on professional and ethical dilemmas while taking into account accepted norms and values;
d. giving and receiving feedback;
e. critically evaluating his own points of view and actions and taking responsibility for them.

6

Competences in National Study Profiles

The competences and corresponding indicators of the Bachelor of Applied Science have been further defined in national training study profiles for studies in Biology and Medical Laboratory Research, Chemistry, Chemical Engineering, Applied Science and Bioinformatics. Tables have been compiled for these profiles containing the required competences and qualification levels.
The tables show the **minimum** qualification levels applicable at graduation. Depending on the chosen learning route, it is possible for a student at level I or II to increase mastery of selected competences and advance by at least one level. Individual studies can also opt to train students to higher levels of competence. Students studying Biology and Medical Laboratory Research and Applied Science are required to advance one level in at least one competence during their study.

For the definition of the competences and associated indicators at level IV, please refer to section 5.2. Individual institutions are free to formulate their own indicators for levels I to III. Appendix IV presents an overview of the validated status of the study profiles. The Dublin descriptors and generic University of Applied Sciences qualifications have been linked to the national study profiles. The results can be found in the tables.

6.1 BIOLOGY & MEDICAL LABORATORY RESEARCH

Table 2 presents the national study profile for Biology and Medical Laboratory Research. This study has an additional condition: students must advance at least one level in one of the competences in this profile. The relevant competences are marked with an asterisk (*) in the table. Tables 3 and 4 show how the Dublin descriptors (see Appendix I) and the generic University of Applied Sciences core qualifications (see Appendix II) are coupled with the competences for Biology and Medical Laboratory Research.

These two examples give a clear view of the possible professional occupations open to a Bachelor of Applied Science after graduating from the study of Biology and Medical Laboratory Research.

Table 2: National study profile for B&M.

	Competence						
	1. Research	2. Experimentation	4. Coordination	5. Consultancy	6. Instruction	7. Governance	8. Self-Management
End-level of Education	**II***	**III**	**I***	**I***	**I***	**I***	**II**

*) least one of these competences should be advanced by one level

Table 3: Links between Dublin descriptors and B&M competences.

B&M competences	**Dublin-descriptors**				
	'Knowledge and understanding'	'Applying knowledge and understanding'	'Making judgements'	'Communication'	'Learning skills'
1. Research	■*	■	a,b,c,g,i	f,h,i	c
2. Experimentation	■	■	c,e,f,h	g,h	c
4. Coordination	■	a,b,d	b,c,e	e,f	
5. Consultancy	■			■	
6. Instruction	■			■	
7. Governance	■			■	
8. Self-Management	■	■	■		■

*) a ■ means that all the indicators of a particular competence contribute to the contents of the Dublin descriptor.

Table 4: Links between core qualifications and B&M competences.

	Core Qualifications	Competences
1	**Broad Professionalism:** it can be demonstrated that the student is equipped with current knowledge related to recent (scientific) knowledge, insights, concepts and research, and is briefed in the professional (international) developments in the professional field, in order to be qualified to: ■ independently perform the tasks of a starting professional; ■ function in a professional organisation; ■ further professionalise the professional practice	1,2,4,5,6,7,8 (*)
2	**Multidisciplinary Integration:** the integration of knowledge, insights, attitudes and skills (of various professional disciplines), from the perspective of professional practice.	1,2,4,5,6,7,8 (**)
3	**Scientific Applications:** the application of the available, relevant (scientific) insights, theories, concepts and research findings related to questions which the graduate will face in professional practice.	1,2
4	**Transfer and Broad Employability:** the application of knowledge, insights and skills in a wide range of professional settings.	1,2,4,5,6,7,8 (***)
5	**Creativity and Complexity:** questions from the professional field where the problem has yet to be clearly defined and where standard procedures cannot be applied.	1,2
6	**Problem-oriented Practice:** independently define and analyse complex problems in the professional field on the basis of relevant knowledge and (theoretical) insights, the development and application of meaningful (new) problem-solving strategies and assessment of their effectiveness.	1,2
7	**Methodical and Reflective Thinking and Action:** setting realistic goals, planning and carrying out of tasks and reflection upon professional practice on the basis of the collection and analysis of relevant information.	1,2,4
8	**Social-Communicative Competence:** communicate and cooperate with others in a multicultural, international and/or multidisciplinary environment and meet the occupational requirements of working in a professional organisation.	1,2,4,5,6,7,8
9	**Basic Qualification for Management Positions:** carrying out straightforward supervisory and management tasks.	7
10	**Sense of Social Responsibility:** development of understanding and involvement in ethical, normative and social issues consistent with the application of knowledge and (future) professional practice.	1,2,4

*) Students develop broad professional skills through this mixture of qualities and associated competences. The competences range over the entire domain of the profession, as is described in the study profiles. Once they have gained mastery in these competences, graduates can independently perform various tasks, solve a great variety of problems and fill diverse functions at the level of a beginner in the professional field.

**) An essential aspect is the integrated and multidisciplinary character of competences. It teaches students how to apply their knowledge, skills and attitudes in carrying out professional tasks and solving problems in practice. Students who complete the study have demonstrated their compentency.

***) The basis of all competences is knowledge, insight and skills. An increasingly stronger call is placed on these fundamentals as students progress through the study. Creating learning situations that reflect professional practice as closely as possible stimulates students to learn how to apply or put into practice what they have learnt. Enhancing the learning potential of students to develop themselves further in their chosen profession also receives considerable attention.

Name: Bart Steendam
Age: 25
Study: Biology & Medical Laboratory Research
Workplace: Biological Centre, Department of Microbial Physiology, University of Groningen

‘I’m getting paid for my hobby’

‘I actually wanted to become a vet and was qualified to get into the study because I had my propedeuse (1st year diploma). Unfortunately, there were so few places available that it was almost impossible to follow the study. But my first year’s course in laboratory research went so well, I decided to stay.’ Bart Steendam now works at the Department of Microbial Physiology at the University of Groningen and has no regrets about following this study. ‘The work I do here is actually my hobby. And I’m getting paid to do it!’

Bart also did his internship and graduation project in the department. ‘I really like the atmosphere here and the work connects well with my main subject, biotechnology.’ He works a lot with DNA – or molecular biology to be precise – and the widely used polymerase chain reaction (PCR) technique or by cutting and pasting (restrictions and ligatures). After graduating, Bart applied for jobs. He was offered a position at a University of Applied Sciences as a lab instructor but when the e-mail arrived from Microbial Physiology, saying that they were urgently looking for an analyst, the choice was easy.

Antibiotics

‘During my internship and graduate project I researched glycocyltransferases, enzymes that act as a catalyst forming sugars on the basis of the antibiotic vancomycin.’ Some enzymes are flexible and form various kinds of base sugars. This enables us to adapt the properties of the antibiotic. These adapted antibiotics can then be used against, for example, the MRSA bacteria. ‘Those MRSA bacteria are already becoming resistant to the original form of vancomycin. Its increasing resistance means we need to develop new antibiotics. We examined whether various types of vancomycin could be produced from different bases.’

The work in his current job is an extension of this research. Bart has his own project that investigates the antibiotic produced by the bacteria Streptomyces coelicor. ‘This produces quite a few antibiotics. We’re trying to see whether we can increase production or if we can create other antibiotics from it.’

Attention

The work fits well with his study. ‘It means a lot to work with PCR and DNA cloning. We did that incessantly at school. What was exceptional about school was that we had the same – rather expensive – equipment as we have here to work on quantitative polymerase chain reactions (QPCR)’. Although the fit is very good, Bart sees one disadvantage. ‘The study should have placed more emphasis on the relevance of English. It’s not taken seriously. Reading English is not a problem but many companies and institutes are internationally orientated. English is the lingua franca. Our spoken English is not really good enough.’

Bart also has some doubts about the use of competences in education. ‘The available knowledge must definitely not decrease. At the beginning, I thought I knew very little. The new system carries the risk that people will just coast through the study. I saw free-riders during my study but they really got into trouble by their fourth year’.

Clearly Bart has found his dream job. ‘It’s great here. Lots of young people, many nationalities and a great atmosphere. Industry may pay better but I’ll stay here for now’. And he adds with pride: ‘If everything goes to plan, next summer a paper will come out with my name on it’.

PROFILE | BART STEENDAM

Organisation: Bart works for the Biology Centre at the University of Groningen (RUG).

Specifics: Bart works for the department of Microbial Physiology and does research into the production of antibiotics by streptomyces coelicor.

Situation: The Biology Centre of the RUG is located in the village of Haren, close to Groningen. About five hundred people work there. Bart's department – Microbial Physiology – has about thirty employees, including four interns.

PROFILE | POSITION

Tasks and activities: Bart runs his own project within a research group conducting a study into the production of antibiotics by streptomyces coelicor. The group researches whether the production of antibiotics can be increased and whether the bacteria can produce other kinds of antibiotics.

Background: Bart originally wanted to go to vets' school after completing his first year in laboratory research. But he liked the study so much during that first year that he ended up graduating in biotechnology.

Roles: Bart is a member of the team that carries out research into the production of antibiotics by streptomyces coelicor. He does a lot of work with the PCR, and has to clone much DNA. There is a special machine he can use for the quantitative polymerases chain reaction (QPCR).

Perspective for growth: There aren't many perspectives for growth in academic education. The best option would be to study towards a PhD, but (as yet) Bart does not have any plans in that direction. A transition to business would be a possibility for the future, but Bart is also drawn towards teaching. He has already been offered a job as laboratory teacher at his former university.

PROFILE | COMPETENCES

Research: Bart has sufficient knowledge to identify and analyse problems during his research. He is more than able to recognise problems himself and if push comes to shove he can always fall back on his colleagues and boss. Independent literature research does not play a major role in his job, but is sometimes done. The usual environmental and health and safety rules for laboratories are strictly adhered to: no modified bacteria in the sink and phenol-chlorophorm – which is often used – into the right waste container. Data from graphs and tables is regularly reported.

Experiments: Bart's education has given him enough knowledge to tackle the research question. He can take on the problems single-handedly and has sufficient insight to know when it's time to consult his colleagues. He has no problems carrying out work regulations, and the same holds true for planning and reporting.

Management: The implementation and maintenance of the management system is mainly the task of the head of the department, as is suggesting follow-up experiments. Together with the team the head decides between possible steps. For this, Bart must regularly read articles (literature) and give a presentation to the team.

'Helping people without seeing them in person'

'I want to help people without necessarily meeting them in person. That's what drives me.' Kim van Brandenburg has found exactly the right place to achieve her ambition. She works at the Department of Medical Microbiology of a medium-sized hospital. 'We moved recently to two floors of a smaller hospital because the other hospital really needed more space .'

Name:	Kim van Brandenburg
Age:	23
Study:	Biology & Medical Laboratory Research
Study:	Medical Microbiology
Workplace:	Alysis Zorggroep, Rijnstate Hospital, Arnhem

At secondary school, Kim followed the study 'Nature and Health' as she'd already made her choice for a medical laboratory study.

The first year was hard. 'Lots of science and, in particular, chemistry experiments. Not what I was really looking for.' Choosing to do a medical study after her first year meant she no longer had to do these subjects. Eventually she chose to graduate in microbiology. Kim: 'A clinical study means more working with apparatus. You put

something in and then you wait. In microbiology, you have more reflection and work with your hands.'

Refresher

Kim's internship took place at Rijnstate Hospital in the department directly related to her study: medical microbiology. 'I shouldn't really say it, but I actually learned just as much there as I did at school. The first two weeks was all personal coaching, reading up, preparation, explanation.' More or less she toured through all the various departments: bacteriology, serology, and parasitology. Subsequently, she conducted her graduation project in the same hospital, in serology. 'I researched a new device examining ENAs, extractable nuclear antigens, and double-stranded DNA in blood samples.' Serology wasn't as much fun as microbiology. She'd learned a great deal in her internship but that did not mean that school disappointed Kim. 'Certainly not. I needed the study, it's the basis. But my internship was very clear, it was a useful refresher.'

Sexually Transmitted Diseases

Kim began her internship in February and began applying for jobs the following summer even though her graduation project had yet to begin. 'Fine, you can stay' was the response whereupon, exactly a year after she started her internship, she began her job in the medical microbiology department. Currently they are doing research on STDs,

PROFILE | KIM VAN BRANDENBURG

Organisation: Alysis Zorggroep, Rijnstate Ziekenhuis, Arnhem.

Specifics: Kim works for the department of Medical Microbiology of Ziekenhuis Velp, a few kilometres away from the Alysis main branch in Arnhem. The department of Medical Microbiology has about 35 analysts and around fifteen administrative employees.

Situation: Ziekenhuis Velp has fifty beds in day care and has excellent facilities for laboratory and function analysis. Velp lies next to Arnhem.

PROFILE | POSITION

Tasks and activities: For the department of Medical Microbiology Kim does research into STD's, sexually transmitted diseases, HIV-infections, hepatitis B and C, and infectious diseases.

Background: At secondary school, Kim chose the profile 'nature and health' because she already knew she was going to do medical laboratory studies. She decided to graduate in microbiology because it's a more hands-on study, as opposed to the clinical direction.

Roles: For the department of Medical Microbiology Kim does research into sexually transmitted diseases (STD's), with a focus on the molecular side of things. Urine samples or cotton swabs are tested – usually using the polymerases chain reaction (PCR) – for DNA of a sexually STD. Kim also does research into HIV, hepatitis B and C, and to a lesser degree into rheumatism and infectious diseases.

Perspective for growth: Within the hospital the perspective for growth is limited. Applications for postgraduate degrees may be honoured. For now, Kim will continue to work in health care, but she does not exclude a transfer to business in the far future.

PROFILE | COMPETENCES

Research: Even though considerable attention was given to knowledge acquisition during her study, Kim soon found that she needed to learn a lot more for her job, certainly with regard to analysing problems and proposing solutions. She does not have to do independent literature research for her work. Quality and environmental control are guaranteed through the hospital regulations. The same holds true for safety requirements (working with HIV, hepatitis, etc.): always wear gloves, disinfect everything, do not enter other rooms wearing laboratory clothing. All these requirements are strictly adhered to. Acting responsibly is a major factor, according to Kim: never rush anything, always work carefully. In the molecular department Kim works in a team of seven people, led by the so-called 'attention analyst', to whom team members can turn with questions.

Experiments: Her study and work experience have given Kim sufficient knowledge to tackle the research question. She has found that she needed to learn a lot of new things for work that weren't covered in her study. Procedures and regulations are mostly standard and further study isn't necessary. The analysts make their own reports, that are given a final check by the physician-microbiologist.

Management: The coordinating tasks lie with the department heads. The analysts make their own reports, checked by the physician-microbiologist. Presentations are only occasionally given, for special projects.

sexually transmitted diseases. Kim: 'But more from the molecular perspective. Working with urine samples or swabs – including PCR – we are seeing if we can find the DNA of a STD.' She is not afraid of infection. 'You know what you're doing here, so you're careful and take the necessary precautions. It's your responsibility.'

Integrated

Kim seems to know the ins and outs of the changes in professional education. 'I hear stories about competence-based education from a colleague who also teaches a laboratory course part-time. I'm quite aware of what is happening and think it's a good thing. You not only learn the technology but also its background. We learned the technical theory but could only put it into practice a half a year later. Now it's all far more integrated and you remember things better. You learn the how and the why at the same time.' According to Kim, she acquired many skills in her study, 'but more personal attention is always good.'

Kim's future is not quite settled yet. 'First I want to gain lots of experience in the molecular field as well. I have tenure so I can take my development slowly. I'm starting further training soon. I'll think some more about my future in a few years time.'

6.2 CHEMISTRY

Table 5 shows the national study profile for Chemistry. Tables 6 and 7 show how the Chemistry competences are coupled to the Dublin descriptors (see Appendix I) and the generic University of Applied Sciences core qualifications (see Appendix II). The two examples below give insight into the possible professions and jobs open to a Bachelor of Applied Science graduate after completing a study in Chemistry.

Table 5: National study profile for Chemistry.

	Competence						
	1. Research	2. Experimentation	4. Coordination	5. Consultancy	6. Instruction	7. Governance	8. Self-Management
End-level of Education	**III**	**III**	**I**	**I**	**I**	**I**	**II**

Table 6: Links between Dublin descriptors and competences for Chemistry.

Chemistry competences	**Dublin-descriptors**				
	'Knowledge and understanding'	'Applying knowledge and understanding'	'Making judgements'	'Communication'	'Learning skills'
1. Research	■ *	■	a,b,c,g,i	f,h,i	c
2. Experimentation	■	■	c,e,f,h	g,h	c
4. Coordination	■	a,b,d	b,c,e	e,f	
5. Consultancy	■			■	
6. Instruction	■			■	
7. Governance	■			■	
8. Self-Management	■	■	■		■

*) a ■ means that all the indicators of a particular competence contribute to the contents of the Dublin descriptor.

Table 7: Links between core qualifications and competences for Chemistry.

	Core Qualifications	Competences
1	**Broad Professionalism:** it can be demonstrated that the student is equipped with current knowledge related to recent (scientific) knowledge, insights, concepts and research, and is briefed in the professional (international) developments in the professional field, in order to be qualified to: ■ independently perform the tasks of a starting professional; ■ function in a professional organisation; ■ further professionalise the professional practice	1,2,4,5,6,7,8 (*)
2	**Multidisciplinary Integration:** the integration of knowledge, insights, attitudes and skills (of various professional disciplines), from the perspective of professional practice.	1,2,4,5,6,7,8 (**)
3	**Scientific Applications:** the application of the available, relevant (scientific) insights, theories, concepts and research findings related to questions which the graduate will face in professional practice.	1,2
4	**Transfer and Broad Employability:** the application of knowledge, insights and skills in a wide range of professional settings.	1,2,4,5,6,7,8 (***)
5	**Creativity and Complexity:** questions from the professional field where the problem has yet to be clearly defined and where standard procedures cannot be applied.	1,2
6	**Problem-oriented Practice:** independently define and analyse complex problems in the professional field on the basis of relevant knowledge and (theoretical) insights, the development and application of meaningful (new) problem-solving strategies and assessment of their effectiveness.	1,2
7	**Methodical and Reflective Thinking and Action:** setting realistic goals, planning and carrying out of tasks and reflection upon professional practice on the basis of the collection and analysis of relevant information.	1,2,4
8	**Social-Communicative Competence:** communicate and cooperate with others in a multicultural, international and/or multidisciplinary environment and meet the occupational requirements of working in a professional organisation.	1,2,4,5,6,7,8
9	**Basic Qualification for Management Positions:** carrying out straightforward supervisory and management tasks.	7
10	**Sense of Social Responsibility:** development of understanding and involvement in ethical, normative and social issues consistent with the application of knowledge and (future) professional practice.	1,2,4

*) Students develop broad professional skills through this mixture of qualities and associated competences. The competences range over the entire domain of the profession, as is described in the study profiles. Once they have gained mastery in these competences, graduates can independently perform various tasks, solve a great variety of problems and fill diverse functions at the level of a beginner in the professional field.

**) An essential aspect is the integrated and multidisciplinary character of competences. It teaches students how to apply their knowledge, skills and attitudes in carrying out professional tasks and solving problems in practice. Students who complete the study have demonstrated their compentency.

***) The basis of all competences is knowledge, insight and skills. An increasingly stronger call is placed on these fundamentals as students progress through the study. Creating learning situations that reflect professional practice as closely as possible stimulates students to learn how to apply or put into practice what they have learnt. Enhancing the learning potential of students to develop themselves further in their chosen profession also receives considerable attention.

Name: Bob Smeets
Age: 25
Study: Organic Chemistry
Workplace: SABIC Europe, Geleen

‘At last I can get out of the fume cupboard’

‘Chemistry has always interested me. I’ve always been good at it’. Bob Smeets from Limburg has a simple explanation for his educational choice after grammar school. ‘In the first year, I couldn’t decide between biology & medical laboratory research, or biochemistry or organic chemistry. In the end, I chose the last. I’d rather not do research. With organic chemistry it is clear what you do, while the field of biochemistry is just too small.’

Bob’s first internship was with the Limburg University Centre in Belgium, where he did analytical research on polymers. For his second internship, Bob went to SABIC Europe, a multinational company specialising in petrochemical products like plastics and cracking products, located on the immense Chemelot complex (formerly DSM) in South Limburg. The research work focused on the development and optimisation of catalyst systems for the production of polyethylene and polypropylene. Bob: ‘I did research on a metallocene catalyst system, actually more in the organic direction.’ He examined whether the synthesis of this catalyst could be done more cheaply. When that proved impossible, in his graduation project he concentrated on analysing the catalyst system itself.

Roots

Bob liked SABIC Europe so well that during his internship he asked his boss if he could apply for a job. Nothing happened for a while until his boss turned up at the lab one day and suggested that Bob should apply for a vacant position. Bob: ‘I had three job interviews and now I’ve been working here for a year and a half.’ His job is taking him further away from his organic roots. ‘I’m going more in the technology direction, moving more towards factory production. That means more time constraints and less freedom but, on the other hand, you get direct results more quickly.’

This move away from organic chemistry showed Bob how important it is to have a broad education. Competence-based education seems appropriate. ‘The school should offer broadly based education while in-depth specialisation should be taught on the job. I’ve noticed how important group work is, knowing where to find relevant knowledge and that develops your initiative. Basic knowledge is important, but it’s more important to reach a certain level of thinking and work. You have to learn to work in a multidisciplinary environment and that meant a combination of chemical engineering, polymer chemistry and materials science. Bob also thinks that developing entrepreneurship is important.

Moving on

According to Bob, SABIC Europe is a good employer. ‘It’s a nice company with lots of growth potential. I have good colleagues and inter-

PROFILE | BOB SMEETS

Organisation: SABIC is a multinational that is headquartered in Riyadh (Saudi-Arabia); it is one of the ten largest petrochemical concerns in the world and also the largest non-oil related company in the Middle East. Bob works for SABIC-Europe within the market segments PE, PP, PVC & Polyester, olefins and aromatics.

Specifics: The R&D departments where Bob works has about seventy employees. Within R&D there are three departments, known as 'competence centres': 'Chemistry and Catalysis' (fundamental research into catalyst systems, new production routes, improvement of existing catalyst systems, synthesis of new products for mechanical evaluation, etcetera), 'Material Development' (research into material properties of polymers) and 'Process technology' (research into improvements of plants, into implementation of new findings by other departments and setting up new plants and production processes).

Situation: SABIC is located on the Chemelot premises in Zuid-Limburg, an enormous site with access to all kinds of facilities. R&D shares a building with DSM. The SABIC-Europe headquarter is in Sittard, in a 'state of-the art' building with almost futuristic facilities.

PROFILE | POSITION

Tasks and activities: Bob works for the department 'Chemistry and Catalysis', in a team that is known as the PP-group. This team works on the development of new catalysts and at finding out what existing catalysts systems can do in the field of PP-catalyse. Bob controls two 'bench-scale' setups, small batch plants that produce PP and that are operated by 'technicians'. He writes test programs for these setups and he processes the data of the tests that have been carried out. He then communicates these data to the 'technicians'. He also scouts for useful new technologies and devises improvements of existing processes, as well as possible new technologies for SABIC. Keeping up with the literature is of paramount importance.

Background: Bob studied organic chemistry and has been working for SABIC for three years, including the time he worked there as an intern and during his graduation period.

Roles: Bob's PP-group is made up of four people: a project coordinator, an official who controls a mini-plant and a controller of the two 'bench-scale' reactors. The fourth member is the former controller of the mini-'plant'. He is currently training his successor and will then move on to a new position.

Perspective for growth: In view of the size of SABIC the possibilities are endless, especially since the company is much in favour of changing positions. Following courses and getting extra education are stimulated and facilitated, both financially and by allowing study days. Bob is currently the post hbo-education process technology.

PROFILE | COMPETENCES

Research: Bob's main task is carrying out research into new catalysts and improving existing ones. He writes test programs and processes data. He says he has sufficient knowledge to solve and analyse problems independently. Bob also does independent literature research and communicates and reports to his colleagues. He thinks it's a good thing his study was very broad, but also says that he's had to delve much more deeply since starting work. He does not see this as a problem, however, but more as a challenge.

Experiments: Bob has sufficient knowledge to tackle the research question. He is able to gain more in-depth knowledge and to carry out the appropriate working regulations. He writes programs for new tests and plans follow-up routes, in consultation with others. He says that more experienced colleagues are a great help to him in doing this.

Management: Bob works on improving existing catalysts and developing new ones. Implementation and maintenance of a management system is therefore indispensable. Bob formulates improvement plans and communicates with the technicians. He coordinates the necessary work, records and regularly reports his findings.

esting work. The conditions are good and they encourage training. Right now I'm taking a post-bachelor's course in process technology and that's right up my street. No way, I'm not going anywhere else right now.'

Bob is, however, moving on to a new job at SABIC Europe. 'As an organic chemist you usually start in the advanced catalysis group to get a feel for the job and to help with the choice of where to go to next.' Bob is going to a position focussed more on supervising operators in bench scale exhibits and in a mini plant. He will consult with colleagues from other disciplines in order to resolve current issues. This move is taking him even further away from organic chemistry.

'I'll be working less often in the fume cupboard, yes. But it does mean a new challenge for me.' His successor has already been trained.
By Bob.

Name: Liza Wassenaar
Age: 24
Study: Analytical chemistry
Workplace: OctoPlus, Leiden

'I always want to know more'

'After intermediate secondary education, I went to a secondary level laboratory school. I liked it but wanted to go further, to go deeper. Besides, I was a year younger than the average secondary school pupil.' For Liza Wassenaar, the natural choice went to a higher level of laboratory education. Now she is an analyst with the pharmaceutical company, OctoPlus. In her higher level study, she opted for analysis. 'Working with the equipment suited me just fine.'

Liza went for a fast-track foundation programme and the next three years just flew by. 'I really enjoyed the secondary level laboratory school mostly because I had good teachers who stimulated me to learn. If the teachers are good, the study is far more fun.' Liza also felt comfortable with the mostly analytical direction of the educational level.

Tests

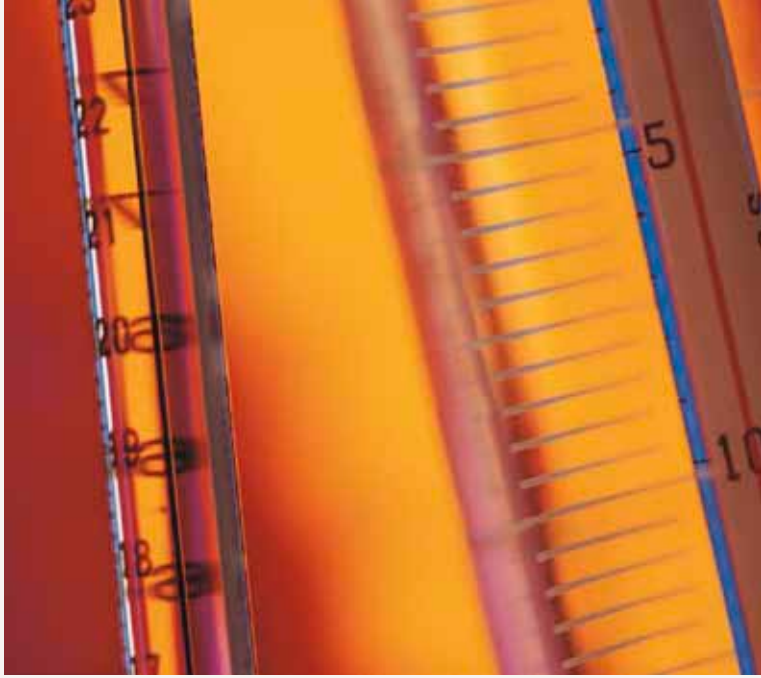
Liza went to TNO in Rijswijk for her internship, mainly out of intellectual curiosity. 'I consciously chose to do an internship in a different field, at the Department of Biochemistry, so that I could get more comprehensive experience of the profession.' She did lots of work on separating proteins by size on a gel with SDS-PAGE (polyacrylamide gel electrophoresis). But she still felt the pull of the analytical field and after graduation, she looked for a job on the internet and came across OctoPlus, a pharmaceutical company that develops drugs and conducts analysis and testing for both international clients and their own products. Liza: 'It seemed a nice company and the work appealed to me. I like it here fine.' OctoPlus employs about 150 people; the atmosphere is good and work varied. Liza is currently engaged most often in stability studies; testing changes over time in medication.

According to Liza, the work connects well with her studies. 'There are always particular skills I hadn't learned at school but I can always use the theory.' The equipment at school was outdated, but that's often the case. Schools don't have many funds. Fortunately I can put my HPLC experience to good use here.'

Difficult

Liza hasn't got a clear idea about the changes in higher vocational education. 'Is competence-based education better? That's a hard question. The practical aspects of a study remain important. When you start work, you notice just how important it is. But a theoretical background is also necessary.' She sees the advantages of skills development, but reckons the acquisition of knowledge should not suffer as a result. 'Basic knowledge is truly indispensable. Perhaps how I was taught at school is the best solution.'

[‘The practical aspects of a study remain important. When you start work, you notice just how important it is’]



Liza will stay at OctoPlus for the time being. ‘I always want to know more. I can satisfy my intellectual curiosity here.’ She can follow internal courses at this company and internal vacancies frequently arise so that she can develop even further. ‘But maybe at some point I’ll want something totally different.’

PROFILE | LIZA WASSENAAR

Organisation: Liza works for OctoPlus, a pharmaceutical company, founded in 1995 that focuses on products (drugs) with fewer side-effects and greater efficacy.

Specifics: OctoPlus has about one hundred and fifty employees. The company uses the quality control system GMP (Good Manufacturing Practices) that guarantees quality by not only analysing the contents of the drug but also by carrying out the production process in a carefully controlled way.

Situation: OctoPlus is housed in a modern building on the Zernikedreef 12 in Leiden. An extension to the existing building is currently being built.

PROFILE | POSITION

Tasks and activities: Liza is ‘technician’ for the department ‘QC analysis’. This department carries out analyses of pharmaceutical stabilisers. Frequently recurring analyses are HPSEC, RP-HPLC, Karl Fischer and SDS.

Background: In 1999 Liza started at the Secondary Laboratory School in Leiden, where she graduated in Analytical Chemistry. She then graduated in the same subject from the HLO (Higher Laboratory School), also in Leiden.

Roles: Liza works in a team of twelve people. Her responsibility is the correct execution of analyses and controlling the analyses that have been performed by her colleagues

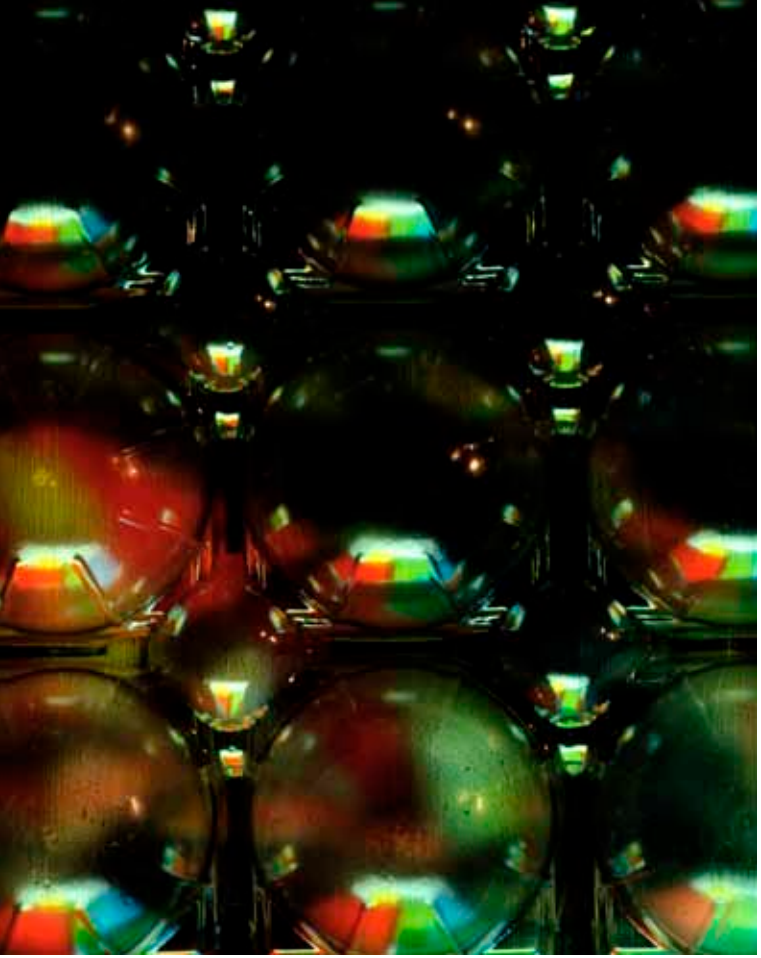
Perspective for growth: OctoPlus offers a broad spectrum of education possibilities, provided they fit in with the work. The Internet frequently lists vacancies to which employees can apply.

PROFILE | COMPETENCES

Research: Liza must (and can) occurring problems. She often does this after consulting her team colleagues. She does independent literature research and there are protocols in place to guarantee quality and environmental control and health and safety. Her position also requires her to regularly summarize and report results.

Experiments: Liza has sufficient knowledge to tackle the research question. She regularly needs to study analyses or research. OctoPlus applies GMP which means that working according to protocol is of great importance. Her position includes planning and reporting. Suggesting follow-up experiments is not very important to her position. She does make suggestions to the project leader, for instance, usually about solving ad hoc problems.

Management: Because OctoPlus works according to GMP, due consideration needs to be taken of the implementation of a management system, with its own conventions and values. Making reports and presentations are therefore regularly returning activities.



6.3 CHEMICAL ENGINEERING

Table 8 presents the national profile for the study of Chemical Engineering. The previous professional profile for Chemical Engineering (*Cluster Overleg Laboratorium en Procestechnologie* COLP 2003) mentions the competences 'Lifelong Learning' and 'Awareness of Social Responsibility'. The indicators of these competences are included in the new profile under the heading 'Self-Management. Tables 9 and 10 show how the Dublin descriptors (see Appendix I) and the generic University of Applied Sciences core qualifications (see Appendix II) are coupled with the competences for Chemical Engineering.

Table 8: National study profile for Chemical Engineering.

	Competence					
	1. Research	2. Experimentation	3. Development	4. Coordination	7. Governance	8. Self-Management
End-level of Education	**II**	**II**	**II**	**I**	**I**	**II**

Table 9: Links between Dublin descriptors and competences for Chemical Engineering.

Chemical Engineering competences	**Dublin descriptors**				
	'Knowledge and understanding'	'Applying knowledge and understanding'	'Making judgements'	'Communication'	'Learning skills'
1. Research	■ *	■	a,b,c,g,i	f,h,i	c
2. Experimentation	■	■	c,e,f,h	g,h	c
3. Development	■	■	b,c,d,e	f,g	c
4. Coordination	■	a,b,d	b,c,e	e,f	
7. Governance	■			■	
8. Self-Management	■	■	■		■

*) a ■ means that all the indicators of a particular competence contribute to the contents of the Dublin descriptor.

Table 10: Links between core qualifications and competences for Chemical Engineering.

	Core Qualifications	Competences
1	**Broad Professionalism:** it can be demonstrated that the student is equipped with current knowledge related to recent (scientific) knowledge, insights, concepts and research, and is briefed in the professional (international) developments in the professional field, in order to be qualified to: ■ independently perform the tasks of a starting professional; ■ function in a professional organisation; ■ further professionalise the professional practice	1,2,3,4,7,8 (*)
2	**Multidisciplinary Integration:** the integration of knowledge, insights, attitudes and skills (of various professional disciplines), from the perspective of professional practice.	1,2,3,4,7,8 (**)
3	**Scientific Applications:** the application of the available, relevant (scientific) insights, theories, concepts and research findings related to questions which the graduate will face in professional practice.	1,2,3
4	**Transfer and Broad Employability:** the application of knowledge, insights and skills in a wide range of professional settings.	1,2,3,4,7,8 (***)
5	**Creativity and Complexity:** questions from the professional field where the problem has yet to be clearly defined and where standard procedures cannot be applied.	1,2,3
6	**Problem-oriented Practice:** independently define and analyse complex problems in the professional field on the basis of relevant knowledge and (theoretical) insights, the development and application of meaningful (new) problem-solving strategies and assessment of their effectiveness.	1,2,3
7	**Methodical and Reflective Thinking and Action:** setting realistic goals, planning and carrying out of tasks and reflection upon professional practice on the basis of the collection and analysis of relevant information.	1,2,3,4
8	**Social-Communicative Competence:** communicate and cooperate with others in a multicultural, international and/or multidisciplinary environment and meet the occupational requirements of working in a professional organisation.	1,2,3,4,7,8
9	**Basic Qualification for Management Positions:** carrying out straightforward supervisory and management tasks.	7
10	**Sense of Social Responsibility:** development of understanding and involvement in ethical, normative and social issues consistent with the application of knowledge and (future) professional practice.	1,2,3,4

*) Students develop broad professional skills through this mixture of qualities and associated competences. The competences range over the entire domain of the profession, as is described in the study profiles. Once they have gained mastery in these competences, graduates can independently perform various tasks, solve a great variety of problems and fill diverse functions at the level of a beginner in the professional field.

**) An essential aspect is the integrated and multidisciplinary character of competences. It teaches students how to apply their knowledge, skills and attitudes in carrying out professional tasks and solving problems in practice. Students who complete the study have demonstrated their compentency.

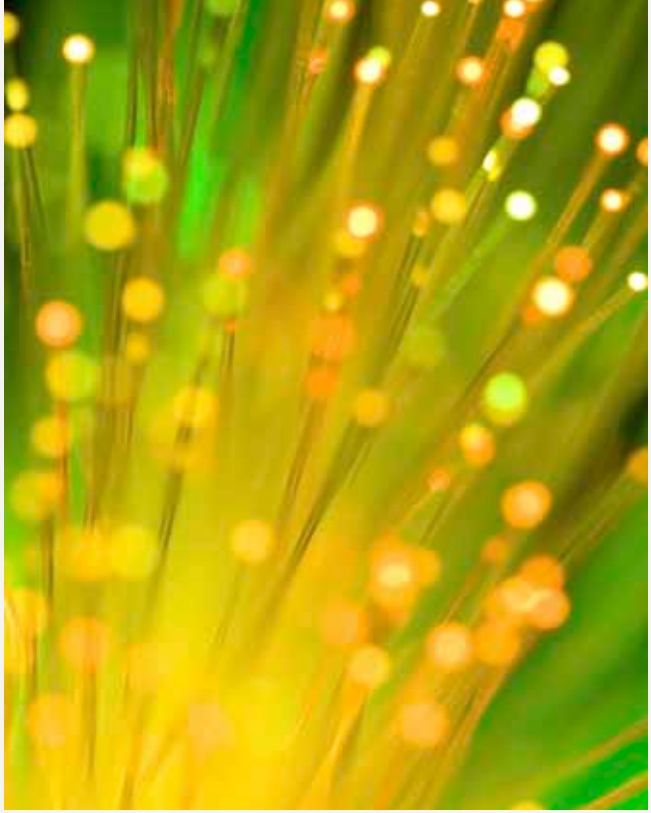
***) The basis of all competences is knowledge, insight and skills. An increasingly stronger call is placed on these fundamentals as students progress through the study. Creating learning situations that reflect professional practice as closely as possible stimulates students to learn how to apply or put into practice what they have learnt. Enhancing the learning potential of students to develop themselves further in their chosen profession also receives considerable attention.

Name: Arjen Barnhoorn
Age: 30
Study: Chemical Engineering
Workplace: DSM NeoResins+, Waalwijk

‘I’m in the right spot’

‘Sometimes it was hard, yes. You need lots of discipline. I saw many other students fall by the wayside.’ Arjen Barnhoorn followed a two-track path in his study of chemical engineering. On top of his day job, he went to school two half-days a week and had to do lots of autonomous studying. Arjen: ‘Meanwhile, I became a father twice over so my study took an extra year.’

Before studying chemical engineering, Arjen trained as a machine operator at Maritime college. ‘The training is similar to process engineering. We studied a number of subjects, except the nautical ones because we would not be going to sea. Continually developing yourself is very important to Arjen, so he decided to study chemical engineering. ‘I had a demanding management position with another company, but I traded the job in for one as a senior operator because the job fitted in well with my study.’ A classmate worked at DSM Neo-Resins+. After an open job application, Arjen was hired and went ‘from 100%



management to 100% carrying out the work. But I didn’t see it as a demotion. Shift work and two young children fitted well with my study plans.’

SAFETY

DSM NeoResins+ develops, manufactures and sells synthetic resins for the paint, printing ink and adhesive industries, which form the basis, the ‘intermediate product’, for final coatings. The resins of DSM NeoResins+ are used in paint (professional and do-it-yourself), parquet and furniture varnishes, concrete, metallic paints, plastic coatings, printing inks and packaging.

After seven months on the job, Arjen applied to be a team supervisor and was taken on. He now leads a team of 12 and is responsible for matters related to production and safety. Arjen: ‘I like working with people and I think the most important task of a team leader is to motivate people.’ He is also the ERL, Emergency Responsible Leader, in charge in case of emergencies.

‘Safety has the highest priority in the company. Almost every day we talk about safety, and risk inventory and evaluation are high on the agenda.’ Indeed, the whole culture of DSM NeoResins+ is focused on safety as the company wants to protect its employees, local residents and the direct environ-

ment. Attention is constantly paid to safe working practices for all. If incidents occur, they are immediately reported, investigated and corrected. This keeps everyone sharp and always learning. Results are measured continuously, so as to make improvements. People learn from and address each other on safety issues.

Never minded school

Arjen has upbeat stories to tell about his study. 'I never minded school. The course suited me. I really liked doing two subjects at a time and rounding them both off before going on to the next subject.' Practical exercises were harder, as they had to be done on the job. 'And so, on my own initiative. The company provided a supervisor and I had to hand in these exercises at school.' Before he started, Arjen asked himself whether an additional study was necessary. 'But now I'm glad I did.
The study fits in well with my work and I learned lots about developing and presenting projects.' Arjen is a strong advocate of competence-based learning. 'The old study was very broad, but you only used 5% of what you learned in the workplace. The knowledge was often too specific; the basics are sufficient, leaving more time for things like skills, teamwork and communication.'

Arjen has always aspired to a position in process technology and luckily his company offers countless opportunities for growth. 'I'm glad I work here. It is a viable company and all employees have opportunities to develop. I really am in the right spot.'

PROFILE | ARJEN BARNHOORN

Organisation: Arjen works for DSM Neoresins+, Waalwijk.

Specifics: DSM Neoresins+ produces semi manufactured products on the basis of synthetic resins, for instance for the paint industry and road construction. The company employs about seven hundred people; Arjen is team leader of a group of twelve employees.

Situation: DSM Neoresins+ is located on an industrial estate in Waalwijk. The company has branches in Singapore, Spain and the United States.

PROFILE | POSITION

Tasks and activities: Arjen is team leader of a group of twelve production employees. In addition, he is ERL, Emergency Responsible Leader, the person responsible during calamities.

Background: After training as a machine operator at Maritime College, Arjen studied the dual course Chemical Technology at higher education level.

Roles: Arjen is team leader of a group of twelve production employees. He is responsible for the production process as well as for safety. In addition, he is ERL, Emergency Responsible Leader: the person responsible during calamities.

Perspective for growth: DSM Neoresins+ stimulates its employees to grow within the company. The company creates conditions for study. It has seven hundred employees and a lot of staff turnover, which leads to great possibilities for promotion. Within a seven month period, Arjen went from operator to team leader. He sees plenty of opportunities for further development and has no plans to leave the company in the near future.

PROFILE | COMPETENCES

Research: According to Arjan, a manager must know what's happening on the work floor. Because of his previous training he has sufficient knowledge to analyse problems, especially through his broad secondary vocational training, where subjects such as electrical and mechanical engineering were taught. He regularly does independent literature research. The company uses many dangerous substances, which means high demands are placed on quality control, environmental control and safety. As team leader, Arjan has a great responsibility in these matters. Toolboxes about safety are an almost daily occurrence and risk inventories are high on the agenda. Teamwork is very important: Arjen is responsible for one of ten teams working in production. Planning (short and long term) is the responsibility of the department concerned and Arjan convenes a planning meeting every week.

Experiments: Through his previous training, Arjan has sufficient knowledge to tackle the research question. His broad training at Maritime College also proves useful, through subjects such as electrical and mechanical engineering.
In addition to the usual production reports, reports are mainly made of deviating matters, such as errors in the production process or of safety concerns. Presentations are seldom made because the team is close to the work floor.

Management: Arjen regularly submits improvement plans; many of these ideas come from the work floor. In such cases, an extensive report is made, with photographs and a modification proposal, to give the plan the greatest chance of success. He has also written an investment proposal. Because the company works with dangerous substances, Arjan has to deal with legislation, especially concerning surface water, the Chemical Decree or the Environment Act. He is responsible for everything relating to this legislation within his team and must for instance ensure that the emission levels are kept low. All protocols are checked on a weekly basis.

Table 11: National study profile for Applied Science.

	Competence								
	1. Research	22. Experimentation	3. Development	4. Coordination	5. Consultancy	6. Instruction	7. Governance	8. Self-Management	9. Sense of Social Responsibility
Qualification level	**III**	**II***	**I***	**I***	**I***	**I***	**I***	**III**	**II**

*) least one of these competences should be advanced by one level.

6.4 APPLIED SCIENCE

Table 11 presents the national profile for the study of Applied Science. This profile has the additional requirement that students must advance by one level in at least one competence, indicated by an asterisk (*). Tables 12 and 13 show how the Dublin descriptors (see Appendix I) and the generic University of Applied Sciences core qualifications (see Appendix II) are coupled with the study competences of Applied Sciences.

Table 12: Links between Dublin descriptors and competences for Applied Science.

Applied Science competences	**Dublin descriptors**				
	'Knowledge and understanding'	'Applying knowledge and understanding'	'Making judgements'	'Communication'	'Learning skills'
1. Research	■ *	■	a,b,c,i,j	c,h,k	d
2. Experimentation	■	■	c,f,g,i	h,i	d
3. Development	■	■	e		
4. Coordination	■	a,b,c,d	b,d,e	e,f	
5. Consultancy	■			■	
6. Instruction	■			■	
7. Governance	■			■	
8. Self-Management	■		■		■
9. Sense of Social Responsibility	■	■			

*) a ■ means that all the indicators of a particular competence contribute to the contents of the Dublin descriptor.

Table 13: Links between core qualifications and competences for Applied Science.

	Core Qualifications	Competences
1	**Broad Professionalism:** it can be demonstrated that the student is equipped with current knowledge related to recent (scientific) knowledge, insights, concepts and research, and is briefed in the professional (international) developments in the professional field, in order to be qualified to: ■ independently perform the tasks of a starting professional; ■ function in a professional organisation; ■ further professionalise the professional practice	1-9 (*)
2	**Multidisciplinary Integration:** the integration of knowledge, insights, attitudes and skills (of various professional disciplines), from the perspective of professional practice.	1-9 (**)
3	**Scientific Applications:** the application of the available, relevant (scientific) insights, theories, concepts and research findings related to questions which the graduate will face in professional practice.	1,(2),3
4	**Transfer and Broad Employability:** the application of knowledge, insights and skills in a wide range of professional settings.	1-9 (***)
5	**Creativity and Complexity:** questions from the professional field where the problem has yet to be clearly defined and where standard procedures cannot be applied.	1,2,3
6	**Problem-oriented Practice:** independently define and analyse complex problems in the professional field on the basis of relevant knowledge and (theoretical) insights, the development and application of meaningful (new) problem-solving strategies and assessment of their effectiveness.	1,2,3
7	**Methodical and Reflective Thinking and Action:** setting realistic goals, planning and carrying out of tasks and reflection upon professional practice on the basis of the collection and analysis of relevant information.	1,2,3,4
8	**Social-Communicative Competence:** communicate and cooperate with others in a multicultural, international and/or multidisciplinary environment and meet the occupational requirements of working in a professional organisation.	1,3,5,6,7
9	**Basic Qualification for Management Positions:** carrying out straightforward supervisory and management tasks.	7
10	**Sense of Social Responsibility:** development of understanding and involvement in ethical, normative and social issues consistent with the application of knowledge and (future) professional practice.	9

*) Students develop broad professional skills through this mixture of qualities and associated competences. The competences range over the entire domain of the profession, as is described in the study profiles. Once they have gained mastery in these competences, graduates can independently perform various tasks, solve a great variety of problems and fill diverse functions at the level of a beginner in the professional field.

**) An essential aspect is the integrated and multidisciplinary character of competences. It teaches students how to apply their knowledge, skills and attitudes in carrying out professional tasks and solving problems in practice. Students who complete the study have demonstrated their compentency.

***) The basis of all competences is knowledge, insight and skills. An increasingly stronger call is placed on these fundamentals as students progress through the study. Creating learning situations that reflect professional practice as closely as possible stimulates students to learn how to apply or put into practice what they have learnt. Enhancing the learning potential of students to develop themselves further in their chosen profession also receives considerable attention.

Name: Pieter Horstman
Age: 27
Study: Applied Science
Workplace: Philips Research, Eindhoven

‘You learn to plan well’

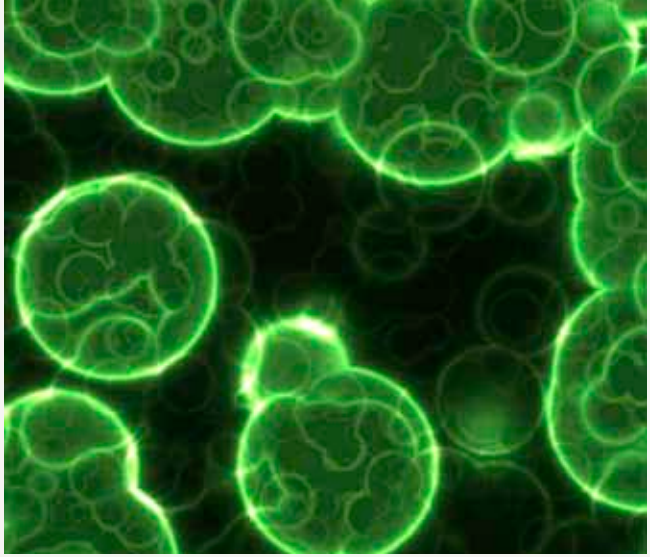
‘You can follow your own interests, organise your own time, you have a high degree of independence and learn to plan well.’ Pieter Horstman is clearly an advocate of the new learning methods. ‘I think it produces better laboratory staff. You learn things independently and, during the study, you practice many communicative skills. I have to admit that I was a little older than the other students. The system works much better when the student is motivated.’

After secondary school, Pieter followed tertiary level education at the ROC laboratory in Eindhoven where he studied microbiology. ‘I’ve actually been interested in biology since I was very young. At home, there were always copies of *Nature and Technology* lying around and I quickly became a big fan of [popular Dutch biologist and TV star] Midas Dekkers.’ Peter admits that at the time he never really liked school that much. After leaving the ROC, he thought he was done with studying and went to work in the virology laboratory of Intervet in Boxmeer. ‘I was mainly working on tissue culturing.’

Not Just a Moped

But after a year, Pieter started getting itchy feet. ‘My parents never promised me a moped if I didn’t smoke, but always said that they would pay for my studies. My mother reminded me of the agreement so I went to an open day for laboratory studies at a University of Applied Sciences.’ He quickly decided to continue studying at the Fontys University of Applied Sciences.

As with the ROC, where Peter had been allowed to start in the second year, at Fontys he could also skip a year. ‘I landed in a group who had already been following the new curriculum for while.’ Many classmates were moaning about the lack of clear instructions and had



problems with self-motivation and working independently. But Peter took to it like a duck to water. ‘I was a bit older and had already been working, so probably I understood better what was expected of me. I was just finishing off my education.’

Prize winner

Pieter’s previous education also meant he could skip one of the two internships. He preferred a research theme for his final internship and graduation project. ‘My dad works here on campus, so I went and asked him about it. “How do you feel about chemistry?” was almost the first thing he asked. I told him that as I’d been exempted from the first years of both of my studies, I was a bit rusty on chemistry but was prepared to brush up what I knew of it.’ Pieter was soon engaged in regenerative medicine dealing with a new technology used for cell therapy. He graduation project was a biological assessment of biomaterials used in regenerative medicine. He didn’t just graduate: his thesis won the annual Fontys Technology Award.

Contract

‘Once you have your degree, the first thing you want is a holiday. But I was offered a job straight away replacing a colleague on maternity leave. And could I start right away? So I had no holiday but, no regrets either.’ Meanwhile, Pieter has been given a year contract and works in a team of eight following two lines of research. He cannot reveal too much about what he is doing but can say he is doing basic research on bacteria and eukaryotic cells making much use of electronics from

– where else? – Philips. He develops new analytical methods in microbiology and selects and cultures various bacterial strains. In the field of biology, he isolates monocytes from blood, analyses chemotaxis and experiments with nanofluidic devices.

'The researchers in my team all have at least a Master's degree, but they definitely consider me an equal member of the team. I work independently and my contribution is well appreciated.' He does his own literature research, cultures bacteria, sets up his own tests and has full input during group meetings.

Pieter clearly enjoys his work and would like to stay in his current job. 'The atmosphere is very good and it is a very diverse and international team of chemists and physicists. We also meet as little as possible and that suits me fine. I would rather just get on with it.' Sounds like a dream job. 'Sure, I'm glad I studied Applied Sciences.'

['I've been interested in biology since I was very young. At home, there were always copies of *Nature and Technology* lying around']

PROFILE | PIETER HORSTMAN

Organisation: Pieter is laboratory technician with Philips Research in Eindhoven.

Specifics: The team of which Pieter is a member, is made up of eight researchers with an PhD and three people from higher vocational education. They perform fundamental research into new diagnostic technologies using bacteria and eukaryotes.

Situation: This Philips Research-department carries out its work in the High Tech 11 building of the extensive High Tech Campus on the outskirts of Eindhoven. A large number of the campus buildings were built recently and are pleasantly situated in green surroundings.

PROFILE | POSITION

Tasks and activities: Pieter is a laboratory technician with Philips Research, where fundamental research is being carried out into new diagnostic technologies using bacteria and eukaryotes. In addition to Pieter, the team consists of eight research employees and three people from higher vocational education.

Background: After finishing his secondary education, Pieter began secondary laboratory education (microbiology) at the ROC in Eindhoven in 2000. After graduation he worked a year for Intervet in Boxmeer and then studied Applied Science at higher vocational education level at the Fontys University in Eindhoven, where he graduated with an awarded thesis.

Roles: Pieter works in a team of eleven people. He is expected to support the research process through autonomous work.

Perspective for growth: Philips stimulates its employees to educate themselves and to apply for promotion. Pieter currently works on a one year contract and will certainly make use of the opportunities on offer.

PROFILE | COMPETENCES

Research: Pieter solves any problems himself because he possesses sufficient expertise and also shows lots of initiative. He can detect and analyse problems. He can assess the reliability of different sources of information through thorough literature study, especially of existing protocols. He cooperates intensively and result driven with the eight researchers in the team and his contribution is highly appreciated, partly because of his background in microbiology. There are regular meetings, during which he expected to summarize, interpret and present the results, and to use these as a basis for follow-up research.

Experiments: Pieter is expected to translate the research question independently into an experimental setup, such as the reaction of a certain antibiotic to bacteria. He uses the correct methods and techniques and has his own responsibility. For this, he has to read up on methods and equipment. Finally, Pieter has to report the results to the research group and has to make proposals for follow-up experiments.

Self-guidance: As Bachelor, Pieter is able to determine his own learning goals and strategies. He does this though literature research, internet and by asking colleagues. He is capable of making a well-founded assessment of ethical dilemmas, is able to give and receive feedback and has enough self-criticism to evaluate his own functioning and responsibility.

6.5 BIOINFORMATICS

Table 14 presents the national profile for the study of Bioinformatics. Tables 15 and 16 show how the Dublin descriptors (see Appendix I) and the generic University of Applied Sciences core qualifications (see Appendix II) are coupled with the study competences of Bioinformatics.

Tabel 14: National study profile for Bioinformatics.

	Competence						
	1. Research	2. Experimentation	4. Coordination	5. Consultancy	6. Instruction	7. Governance	8. Self-Management
End-level of Education	**III**	**III**	**II**	**I**	**I**	**I**	**II**

Tabel 15: Links between Dublin descriptors and competences for Bioinformatics.

Opleidingscompetenties	**Dublin-descriptoren**				
	'Knowledge and understanding'	'Applying knowledge and understanding'	'Making judgements'	'Communication'	'Learning skills'
1. Research	■*	■		f,h,i	c
2. Experimentation	■	■		g,h	c
4. Coordination	■	a,b,c,d	a,b,c	e,f	
5. Consultancy	■			■	
6. Instruction	■			■	
7. Governance	■			■	
8. Self-Management	■	■	■		■

*) a ■ means that all the indicators of a particular competence contribute to the contents of the Dublin descriptor.

Tabel 16: Links between core qualifications and competences for Bioinformatics.

	Core Qualifications	Competences
1	**Broad Professionalism:** it can be demonstrated that the student is equipped with current knowledge related to recent (scientific) knowledge, insights, concepts and research, and is briefed in the professional (international) developments in the professional field, in order to be qualified to: ■ independently perform the tasks of a starting professional; ■ function in a professional organisation; ■ further professionalise the professional practice	1,2,4,5,6,7,8 (*)
2	**Multidisciplinary Integration:** the integration of knowledge, insights, attitudes and skills (of various professional disciplines), from the perspective of professional practice.	1,2,4,5,6,7,8 (**)
3	**Scientific Applications:** the application of the available, relevant (scientific) insights, theories, concepts and research findings related to questions which the graduate will face in professional practice.	1,2
4	**Transfer and Broad Employability:** the application of knowledge, insights and skills in a wide range of professional settings.	1,2,4,5,6,7,8 (***)
5	**Creativity and Complexity:** questions from the professional field where the problem has yet to be clearly defined and where standard procedures cannot be applied.	1,2
6	**Problem-oriented Practice:** independently define and analyse complex problems in the professional field on the basis of relevant knowledge and (theoretical) insights, the development and application of meaningful (new) problem-solving strategies and assessment of their effectiveness.	1,2
7	**Methodical and Reflective Thinking and Action:** setting realistic goals, planning and carrying out of tasks and reflection upon professional practice on the basis of the collection and analysis of relevant information.	1,2,4
8	**Social-Communicative Competence:** communicate and cooperate with others in a multicultural, international and/or multidisciplinary environment and meet the occupational requirements of working in a professional organisation.	1,2,4,5,6,7,8
9	**Basic Qualification for Management Positions:** carrying out straightforward supervisory and management tasks.	7
10	**Sense of Social Responsibility:** development of understanding and involvement in ethical, normative and social issues consistent with the application of knowledge and (future) professional practice.	1,2

*) Students develop broad professional skills through this mixture of qualities and associated competences. The competences range over the entire domain of the profession, as is described in the study profiles. Once they have gained mastery in these competences, graduates can independently perform various tasks, solve a great variety of problems and fill diverse functions at the level of a beginner in the professional field.

**) An essential aspect is the integrated and multidisciplinary character of competences. It teaches students how to apply their knowledge, skills and attitudes in carrying out professional tasks and solving problems in practice. Students who complete the study have demonstrated their compentency.

***) The basis of all competences is knowledge, insight and skills. An increasingly stronger call is placed on these fundamentals as students progress through the study. Creating learning situations that reflect professional practice as closely as possible stimulates students to learn how to apply or put into practice what they have learnt. Enhancing the learning potential of students to develop themselves further in their chosen profession also receives considerable attention.

Name: Rudi van Bavel
Age: 28
Study: Bioinformatics
Workplace: Keygene, Wageningen

‘We were the pioneers’

Rudi van Bavel followed an unconventional path to landing his job in bioinformatics at Keygene in Wageningen. ‘I’d been out working for two years but had never seen the link between biology and information technology. But when the University of Groningen became the first to offer bioinformatics, I quit my job and went back to school. Turns out, it was an excellent choice.’

After his vocational training as an IT systems controller, Rudi went to work in a biotech company. There he encountered biology and was immediately intrigued. He became one of the first Dutch students of bioinformatics in a University of Applied Sciences. The study greatly impressed Rudi. ‘The programme was more or less fully developed and it was well organised. And because everything was so new, students were very involved in the study. I just had to brush up on my chemistry.’ In 2006, Rudi became one of the first bioinformatics graduates in the Netherlands.

Analysis

Rudi did his graduation project at the University Medical Centre in Groningen on research into lung cancer using micro-RNA. During this period, he went with the group of second-year students on an excursion to Keygene, a biotechnology company specialising in DNA marker technology and analysis. When Rudi heard that the company had vacancies in the bioinformatics department, he decided to apply. ‘My girlfriend wanted to move to this area, so the timing was just perfect.’ Working in the bioinformatics department, Rudi is the first person at Keygene with a degree in this field. The department employs 23 people out of a total of about 120 company employees. Keygene conducts several research projects simultaneously and Rudi’s department is involved in every one.

Rudi: ‘I’m involved in sequential analysis, for example, in a project that’s been running for a year. I’m helping to develop software for the apparatus that determines DNA sequencing purely from the output of the apparatus.’ He expects – in fact he is sure – that bioinformatics will become increasingly important. ‘New technologies will be developed and apparatus will become increasingly complex. More data will therefore need to be processed. The work is varied: analysis, programming and literature research. And it’s a nice company: many activities are organised for the personnel, in departments and for the whole company. For example, our annual bioinformatics barbecue.’

Competences

Rudi is well aware that much is changing in Universities of Applied Sciences. He has clear views on the introduction of competence-based education. ‘It’s a good thing that students can study more independently, but it should not become too vague. And a course that only teaches the facts is nothing, although a good basis is essential. All the necessary information is on tap but you need to know where to find it. Without having the basics, that would become a mess.’

He thinks there is a good connection between his training and his current job. ‘In most respects, the study prepares you well for the profession. In my case, perhaps the statistics could have been more applicable to biological issues. But the basics are there and from them you can specialise further on the job.’

Rudi thinks one more point is noteworthy for all studies. ‘As with many other internationally oriented companies, at Keygene we work with people from Israel, Brazil and France. The lingua franca is English and therefore it’s important that studies also concentrate upon developing our English language skills.’

PROFILE | RUDI VAN BAVEL

Organisation: Rudi works for Keygene, a biotechnical company in the field of molecular genetics, aimed at the development of innovative technologies and the application of these technologies in plant improvement.

Specifics: Keygene is a commercial company. The core business consists of contract research (project based), technology licences and product sales (for instance software). The projects are highly budget oriented (= hours) and are carried out simultaneously for one or more clients. Projects are led by one person from three units ('upstream research', 'applied research' and bioinformatics), but during execution intensive cooperation takes place with one (or several) employees of the other research departments. Keygene has an excellent IT-infrastructure with a high storage and processing capacity. In addition, Keygene has greenhouses and phytotrons to support the research.

Situation: Keygene is located in Wageningen. It is housed in a modern building that offers room for about one hundred and fifty employees. The company currently employs about one hundred and twenty people, divided over three research departments and one staff. Keygene has spacious and modern labs with a large diversity of modern equipment. Recently a new DNA-sequencer was acquired (Ilumina | Solexa) that can sequence 1 billion bases per run.

PROFILE | POSITION

Tasks and activities: Rudi's tasks as 'scientific software engineer' within Keygene are fairly diverse and he works on both large and medium-sized processes, as well as on smaller ones. In addition to many data-analyses he also writes a program for Sequence Analyse. This requires knowledge of programming, databases and biology. If necessary, he can also help with IT-matters that are related to the project he is then working on. In addition, he is a member of the editorial board of the Key Newsletter, the monthly internal newsletter.

Background: Rudi studied Bioinformatics at the Hanze University in Groningen. Before that, he trained as a system manager and worked in that capacity for a biotechnology company in Groningen.

Roles: Within the Bioinformatics team Rudi mainly works on making web-based tools for (internal) use. He occasionally helps out with more ICT-related jobs. To a lesser extent he is involved with the data analysis projects. His main work is for internal clients, 'applied- and upstream research'. He also meets once a month with the developers to discuss new technologies.

Perspective for growth: Keygene offers the opportunity to follow internal training courses. Amongst other things, Rudi did a course in 'data analysis pipeline' for the Solexa Sequencer in England. He then did a training for 'pipeline pilot'. This is a software package that can be used to automatically build biological pipelines. His position also offers opportunities for growth: he is currently only a 'junior'. He may indicate preferences and interests, and these will be taken into account for new projects.

PROFILE | COMPETENCES

Research: Although he is currently not directly involved with fundamental research | lead discovery, competences such as independent and problem-solving work are part of his job. If a project has certain demands, he must find solutions. Most of the problems he encounters are not purely biological, but more programming related or a combination of both. Problem solving and scientific thinking help him to arrive at a solution.

Experiments: Rudi is only to a lesser extent involved with experiments, but he must and can solve the problems he encounters independently. Planning is also part of his job, since the projects only have a limited budget. Making reports is also an obvious part of his position.

Management: As yet, Rudi has not have to deal with legislation. Coordinating is also not really a part of his job – this is mostly done by the project leaders. He has been asked to help with coordinating, and this went well. Together with the project coordinator, Rudi has developed a system for a central contact point for small research questions for the department of Bioinformatics. It is his task to manage this system and to redirect the various questions to the relevant person. Concluding a project often also means giving a presentation. This may be to the department, but also to the whole company during the two weekly meeting.

['Bioinformatics will become increasingly important. New techniques keep on coming, as well as more and more complex equipment. This means greater numbers of data need to be processed']

7

References

This document has been compiled from the following documents (Dutch only):

- Bachelor of Applied Science, beroepsbeeld en domeincompetenties, werkgroep Competent Applied Science (CompAS), concept 07, 24-05-2006.
- Beroepsprofielen van de laboratoriumopleidingen in een gemeenschappelijke competentiestructuur, werkgroep competent COLP, Cluster Overleg Laboratorium en Procestechnologie, 19-03-2003.
- Beroeps- en Opleidingsprofiel Applied Science, Fontys Hogeschool Toegepaste Natuurwetenschappen, Werkdocumentprojectgroep 'Ontwikkeling brede opleiding', 18-04-2006.

Further References

1. Report on: A Framework for Qualifications of the European Higher Education Area, Bologna, 2004. http://www.jointquality.nl/content/ierland/draft_report_qualification_framework_EHEA2.pdf
2. Hoger Onderwijs & Accreditatie: prikkelen presteren profileren, Commissie Accreditatie Hoger Onderwijs, J. Franssen 2001. (Dutch only)

Appendices

I. DUBLIN DESCRIPTORS

The Bologna Working Group on Qualifications Frameworks (2004) reported on the Dublin descriptors as follows. Qualifications that signify completion of the first cycle of higher education (Bachelor of Applied Science) are awarded to students who:

Knowledge and understanding

Have demonstrated knowledge and understanding in a field of study that builds upon their general secondary education, and is typically at a level that, whilst supported by advanced textbooks, includes some aspects that will be informed by knowledge of the forefront of their field of study.

Applying knowledge and understanding

Can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study.

Making judgements

Have the ability to gather and interpret relevant data (usually within their field of study) to inform judgements that include reflection on relevant social, scientific or ethical issues.

Communication

Can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.

Learning skills

Have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy.

II

II. GENERIC UNIVERSITY OF APPLIED SCIENCES CORE QUALIFICATIONS

The accreditation committee of the Netherlands Association of Universities of Applied Sciences (HBO-raad) stated in their report of September 2001 which core competences a graduate should possess.

	Core Qualifications
1	**Broad Professionalism:** it can be demonstrated that the student is equipped with current knowledge related to recent (scientific) knowledge, insights, concepts and research, and is briefed in the professional (international) developments in the professional field, in order to be qualified to: ■ independently perform the tasks of a starting professional; ■ function in a professional organisation; ■ further professionalise the professional practice.
2	**Multidisciplinary Integration:** the integration of knowledge, insights, attitudes and skills (of various professional disciplines), from the perspective of professional practice.
3	**Scientific Applications:** the application of the available, relevant (scientific) insights, theories, concepts and research findings related to questions which the graduate will face in professional practice.
4	**Transfer and Broad Employability:** the application of knowledge, insights and skills in a wide range of professional settings.
5	**Creativity and Complexity:** questions from the professional field where the problem has yet to be clearly defined and where standard procedures cannot be applied.
6	**Problem-oriented Practice:** independently define and analyse complex problems in the professional field on the basis of relevant knowledge and (theoretical) insights, the development and application of meaningful (new) problem-solving strategies and assessment of their effectiveness.
7	**Methodical and Reflective Thinking and Action:** setting realistic goals, planning and carrying out of tasks and reflection upon professional practice on the basis of the collection and analysis of relevant information.
8	**Social-Communicative Competence:** communicate and cooperate with others in a multicultural, international and/or multidisciplinary environment and meet the occupational requirements of working in a professional organisation.
9	**Basic Qualification for Management Positions:** carrying out straightforward supervisory and management tasks.
10	**Sense of Social Responsibility:** development of understanding and involvement in ethical, normative and social issues consistent with the application of knowledge and (future) professional practice.

III. OVERVIEW OF PARTICIPATING UNIVERSITIES OF APPLIED SCIENCES AND STUDIES IN THE DOMAIN APPLIED SCIENCE

This appendix gives an overview of the studies in Universities of Applied Sciences that participate in the domain of Applied Science. Specialisations that may be followed within various studies can be found on the domain website: www.appliedscience.nl.

University	Education Programme (CROHO)
Avans Hogeschool, University of Applied Sciences, Breda	Biology & Medical Laboratory Research
	Chemistry
	Chemical Engineering
	Environmental Science for Sustainable Energy and Technology (ESSET)
Fontys University of Applied Sciences, Eindhoven	Applied Science
	Physical Engineering
The Hague University of Applied Sciences, Den Haag	Chemical Engineering
Hanze University Groningen, University of Applied Sciences, Groningen	Bioinformatics
	Biological & Medical Laboratory Research
	Chemistry
	Chemical Engineering
INHOLLAND University of Applied Sciences, Amsterdam	Biology & Medical Laboratory Research
	Biotechnology
	Chemistry

University	Education Programme (CROHO)
Hogeschool Leiden, University of Applied Sciences, Leiden	Bioinformatics
	Biology & Medical Laboratory Research
	Chemistry
Rotterdam University; University of Applied Sciences, Rotterdam	Biology & Medical Laboratory Research
	Chemistry
	Chemical Engineering
	Health Technology
University of Applied Sciences Utrecht, Utrecht	Biology & Medical Laboratory Research
	Chemistry
	Chemical Engineering
University of Applied Sciences (HvA), Amsterdam	Forensic Research
HAN University of Applied Sciences Arnhem & Nijmegen, Nijmegen	Bioinformatics
	Biology & Medical Laboratory Research
	Chemistry

University	Education Programme (CROHO)
HZ University of Applied Sciences, Vlissingen	Chemistry
Zuyd University, Heerlen	Biology & Medical Laboratory Research
	Chemistry
	Chemical Engineering
NHL University of Applied Sciences | University of Applied Sciences Van Hall Larenstein, Leeuwarden	Biology & Medical Laboratory Research
	Biotechnology
	Chemistry
	Chemical Engineering
	Food Technology
Saxion University of Applied Sciences, Deventer	Biology & Medical Laboratory Research
	Chemistry
Saxion University of Applied Sciences, Enschede	Biology & Medical Laboratory Research
	Chemistry
Stenden University, Emmen	Biology & Medical Laboratory Research
	Chemistry

IV

IV. CONSULTATION WITH AND VALIDATION BY THE PROFESSIONAL FIELD

To ensure broad acceptance and support in the profession, representatives from companies, institutions, branch organisations and professional associations were consulted. Initially, the views of regional professional committees were drawn upon to compile a concept version of the competence-based profiles. Subsequently, this concept was the subject of intensive debate at professional conferences and between individual contacts on the national level. The document was revised according to the received feedback and then validated by a small but wide-ranging delegation of representatives.
Below is a brief description of the steps taken as well as an overview of the professional representatives involved. The study profile for Applied Science (Chapter 6.4) was validated separately. A list of validating organisations and institutions for Applied Science is also included.
During the entire consultation and validation process, regular discussions took place with representatives of the Confederation of Netherlands Industry and Employers (VNO-NCW) and the Royal Dutch Association of Medium and Small Companies (MKB) who advised on this process.

Conference of Professional Associations

The descriptions of competences for the Bachelor of Applied Science were presented on April 17, 2007 at the national conference of the Confederation of Netherlands Industry and Employers (VNO-NCW) in the Hague. All participants had previously been sent a draft copy in order to prepare for the conference.
The competence profiles were discussed in four conference workshops: Chemistry, Chemical engineering, Biology and Medical Laboratory Research: *Research and Development* and Biology and Medical Laboratory Research: *Medical Diagnostics*. These workshops compiled reports which recorded the observations and recommendations of the professional field. These reports and a revised version of the competence descriptions were then sent to all conference participants.
Representatives of the following companies and organisations were present at the conference:

- *Companies and Institutions*
  Alkmaar Medical Centre
  Community of Breda (Department of Environmental Management)
  DSM
  DOW Benelux
  Dutch Ministry of Transport, Public Works and Water Management (Department of Water Management)
  Haga Hospital
  Intertek Polychemlab
  Jeroen Bosch Hospital
  Laboratory for Infectious Diseases
  Netherlands Institute for Ecology
  Océ Nederland
  SGS
  Unilever
  University Hospital Maastricht
- *Professional Associations*
  The Royal Netherlands Chemical Society (KNCV)
  The Netherlands Association of Clinical Chemistry (NVKC)
  The Netherlands Association of Biomedical Laboratory Staff (NVML)
- *Branch Organisations*
  The Royal Metal Union
  The Royal Netherlands Association of Medium and Small Companies (MKB)
  The Confederation of Netherlands Industry and Employers (VNO-NCW)

Individual Consultants

Since not all representatives could be present on April 17, the document was also presented in contacts with a number of organisations. Representatives from Bioinformatics were consulted separately.
After the conference representatives of the following companies and organisations were contacted:

- *Companies and Institutions*
  Akzo Nobel
  Diaconesse Hospital Utrecht
  Shell Nederland
  St. Elisabeth Hospital
  University Medical Centre Groningen
  Wageningen University and Research Centre
  Wetsus Centre for Sustainable Water Technology
- *Professional Associations*
  The Netherlands Society for Medical Microbiology (NVMM)
  The Netherlands Society for Pathology (NVVP)
- *Branch Organisations*
  The Netherlands Chemical Industry Association (VNCI)

Written Validation

Feedback from the conference led to changes being made to the document. After the conference the revision including the changes stemming from the conference was sent to a small but wide-ranging delegation of representatives for written validation. Representatives of the following organisations validated the document in writing:

- *Companies and Institutions*
  DSM
  Intertek Polychemlab
  Medical Centre Alkmaar
  Océ Nederland
  OctoPlus
  Shell Nederland
  St. Elisabeth Hospital
  Unilever
  University Hospital Maastricht
  Wageningen University and Research Centre
  Wetsus Centre for Sustainable Water Technology
- *Professional Associations*
  The Netherlands Association of Biomedical Laboratory Staff (NVML)
  The Netherlands Association of Clinical Chemistry (NVKC)
  The Netherlands Association for Pathology (NVVP)
- *Branch Organisations*
  The Royal Metal Union
  The Netherlands Chemical Industry Association (VNCI)
  The Confederation of Netherlands Industry and Employers (VNO-NCW)

Consultation with the Profession and Validation Professional and Study Profile Applied Sciences

The Profession and Study profile of Applied Science (Chapter 6.4) was approved in a joint meeting of the Advisory Board and the Professional Field Committees of the Department of Applied Science at Fontys University. Given the broad professional field covered by the external members, approval was considered as validation. The Advisory Board and the Professional Field Committees was composed of representatives from the following companies and organisations:

Cyto-Barr
DOW Benelux
Intervet International
Océ Technologies
Open University of the Netherlands
Philips
Qiagen Operon
ROC-LMP Eindhoven
Syntens
Technical University Eindhoven
TNO
Vlisco
VU Medical Centre

Dynamic Document

Consultation and validation of the profession was not a solitary action: the competence-based profile descriptions were drawn up as a dynamic document. It will be regularly updated according to input from the profession through national professional field consultations and by regional professional field advisory committees of individual Universities of Applied Sciences. The first step to updating was set in motion by giving professional field representatives the opportunity to comment upon the document during a round of written validation.

Depending on the urgency of these comments, observations were either included immediately in the document or added in later rounds of revision. During the coming period, the document will be further complemented with study profiles and professional illustrations from additional studies represented by the Domain of Applied Science (DAS). These profiles will also be prepared and validated with the agreement of the professional field.