DAS

BACHELOR OF SCIENCE
in the
APPLIED SCIENCE DOMAIN

A competence-oriented profile description

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The most up-to-date version of the BAS profile description can always be found on the Domein Applied Science website.
Whenever reference is made to ‘he’ or ‘his’ in this document, this should be read as he/she and his/her respectively.
N.B. The interviews in this document date from 2013; the work situation and views of the interviewees may have changed in the meantime.

Foreword

A smooth-running collaboration is usually a lasting collaboration as well. This seems obvious, but people often underestimate how vital good relationships are. In this new competence-oriented profile description for a Bachelor of Science in the applied sciences, the Applied Science Domain shows how higher professional education and the world of commerce and industry can and should collaborate.

Just as the previous versions, this profile description has been written in close cooperation with representatives of the professional field. The programme profiles have been discussed and adopted at regional level and the domain profile at national level. In this way, the universities and the professional field are jointly responsible for creating a common and recognisable foundation of knowledge and skills, armed with which graduates from this domain will enter the labour market. This collaboration also ensures that graduates possess the knowledge and skills that employers need. As employers' federations, we cannot stress strongly enough how important that is. This document is a shining example of how universities and employers can achieve this together.

Students in the Applied Science domain are now trained to become Bachelors of Science, instead of Bachelors of Applied Science. Fortunately, this does not alter the way the students are taught. Higher professional education and university education are absolutely equivalent, but they are certainly not the same. And neither should they be. Higher professional education is of great value to the Dutch labour market. That's something you can be proud of!

Gertrud van Erp
Secretary for Education, Confederation of Netherlands Industry and Employers [*VNO-NCW*] and
The Royal Association MKB-Nederland [*MKB-Nederland*]

Welcome

Welcome to the third edition of the competence-oriented profile description of a Bachelor of Science in the Applied Science domain – a dynamic document providing details of education programmes and occupations within this domain. In this revised version you'll find updated descriptions of the Research and Experimentation competences. It also contains details of the newly added national training profile for the Forensic Science programme, and includes the changes previously published in an addendum, such as the updated Bodies of Knowledge & Skills for the Bio-Informatics and Chemical Engineering programmes. The addendum therefore no longer applies.

This document contains background information on competences and final qualifications, practical examples of professional fields and jobs as well as specific programme profiles with their Bodies of Knowledge and Skills. You can read what all this knowledge and these skills mean in practice in the interviews with young Bachelors who are already fully active in professional life. We hope that we have painted an informative picture of the present but also, more importantly, of a promising professional future.

Contents

Section 1

The Applied Science domain within higher professional education

The Applied Science domain includes the higher professional education (HBO) programmes that award a Bachelor of Science in the applied sciences. As of mid-2020 the domain consists of fifteen universities offering nine different programmes at which almost 13,000 students are attending a study programme and 40 research coordinators ('lectors') conducting applied research which relates to the programmes or interfaces with other disciplines. The national partnership Applied Science Domain Foundation (Stichting Domein Applied Science or DAS) is committed to providing a coherent range of high-quality education and research that is tailored to the needs of the professional field.

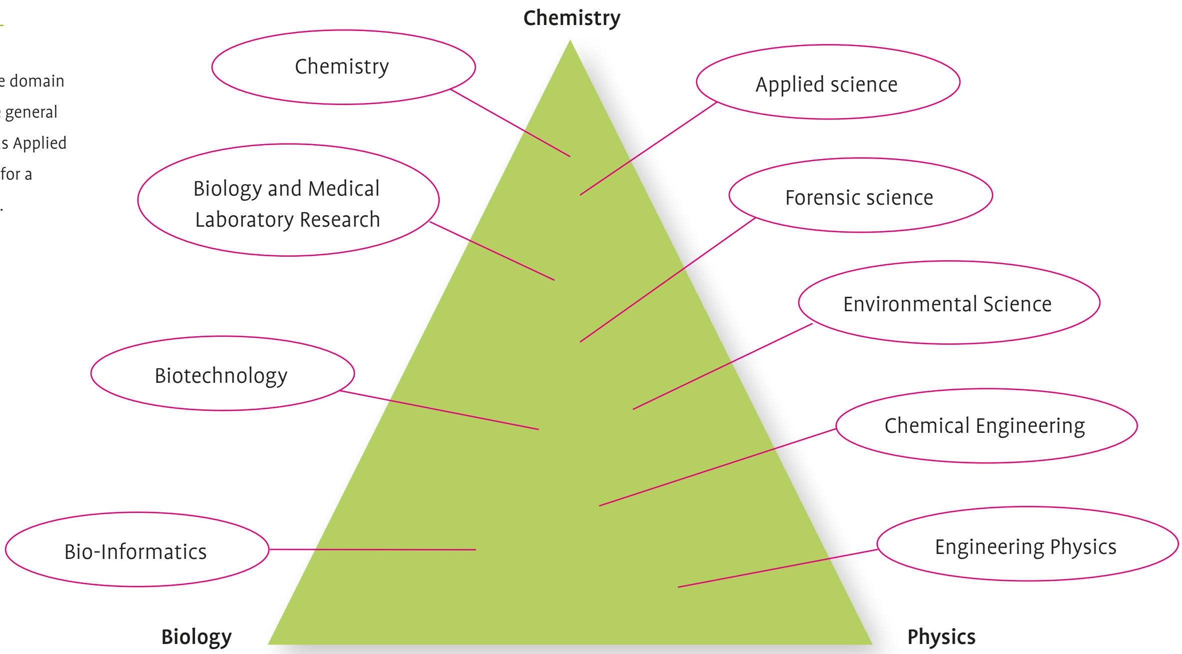
A **domain** is a group of study programmes related to each other in terms of content and career options. The professional context in the Applied Science domain is usually a laboratory, test or production environment or pilot plant.

The classic natural sciences are at the heart of the Applied Science domain. Programmes that award a Bachelor of Science degree in the domain therefore involve studies that cover at least the three classic natural sciences of chemistry, biology and physics:

- Applied Science*
- Bio-Informatics
- Biology and Medical Laboratory Research
- Biotechnology
- Chemistry
- Chemical Engineering
- Engineering Physics
- Environmental Science
- Forensic Science

The programmes can be viewed as fields forming a triangle. As most of the programmes in question also involve aspects of other areas of science, some of them fall outside the chemistry-biology-physics triangle in certain respects. This applies, for example, to Bio-Informatics which contains aspects of both biology and informatics. In the case of the programmes in the domain, at least half of the course content is inside the triangle. Programmes that fall completely outside the triangle are not considered part of the Applied Science Domain.

Figure 1: Programmes within the Applied Science Domain in the classic natural sciences triad biology, chemistry and physics.



* The Applied Science domain also contains a more general programme known as Applied Science; see page 22 for a detailed explanation.

Section 2

Professional field and occupations for Bachelors of Science

The professional field for graduate Bachelors of Science in the Applied Science domain is wide and varied. This is true both of the occupations that they hold and of the sectors in which they are employed. As a rule, they are engaged in solving problems on their own or in teams or answering questions relating to the natural sciences by means of mainly experimental or model-based research. This increasingly involves the use of advanced and often computerised equipment and information technology.

In a laboratory or process-technology company, a **Bachelor of Science (BSc) in the applied sciences** can specialise in a particular field. This could be a specialisation within the professional field, fundamental or applied scientific research or product or process development in a laboratory or process technology environment. Over time, he can progress to management positions such as project manager or head of department and to positions such as quality coordinator, instructor, safety officer, IT specialist, etc. In large companies, the BSc will often be under the ultimate management responsibility of an academic whereas in small and medium-size enterprises (SMEs) he will usually bear ultimate responsibility himself. In addition, he may find employment in service provision roles, e.g. as a school teacher or in commercial posts in industry. The higher professional education programme is also a good foundation for various academic master programmes in natural science subjects.

Below are some examples of companies and institutions within the professional field of the BSc:

Industry
- chemical and pharmaceutical industry (e.g. AkzoNobel, DSM, Dow, MSD, Shell);
- diagnostics companies (e.g. PathoFinder, Philips Healthcare, Roche);
- biotechnology companies (e.g. Crucell, Keygene, OctoPlus, Pharming, Janssen);
- food industry (e.g. Purac, Danone, Unilever, FrieslandCampina, Nutreco);
- quality control and hygiene consultancies (e.g. Eurotrol, BioLab);
- toxicology companies (e.g. WIL Research);
- high-tech companies (e.g. Océ, Sensata, Thales, Vredestein);
- process technology and/or product and material technology (Albemarle, Fluor, SABIC, Tata Steel, Teijin Aramid, Zeton).

Governmental and quasi-governmental bodies, universities and research institutes
- Energy research Centre of the Netherlands (ECN), National Aerospace Laboratory (NLR), Government Institute for Quality Control of Agricultural Products RIKILT, National Institute for Public Health and the Environment (RIVM), Institute of Industrial Technology (TNO), Netherlands Food and Consumer Product Safety Authority (NVWA);
- universities;
- teaching hospitals.

Contract laboratories
- environmental laboratories;
- quality control and production laboratories in the organic, biochemical and analytical fields (e.g. PROXY Laboratories, Eurofins).

Healthcare and environment
- teaching and peripheral hospitals;
- blood banks;
- regional public health laboratories;
- laboratories in medical practices;
- Netherlands Food and Consumer Product Safety Authority;
- health services;
- institutes for ecological, toxicological and environmental research, etc.

In view of the wide diversity in companies and sectors, this is obviously not an exhaustive list.

Diversity of careers
Bachelors of Science in the Applied Science domain work in a particularly wide professional field on

A professional field is a collection of all the occupations/jobs in whichgraduate Bachelors of Science in the Applied Science domain are employed.

A professional domain is a collection of similar occupations.

a very diverse range of subjects. The common starting point consists of the scientific approach to work and the use of technology as a tool. In addition, graduates share the ability to take on tasks in an independent, innovative, enterprising, result-oriented and responsible way.
Depending on the nature of the work and the main focus of the post held by the Bachelor of Science, we can list the following professional domains:

1. **Research and development**
2. **Commerce and customer service**
3. **Application and production in laboratories**
4. **Medical laboratory diagnostics**
5. **Engineering and manufacturing**

1. RESEARCH AND DEVELOPMENT

Working as a researcher in a **research and development** environment, the Bachelor of Science is involved in developing new products, materials, methods and processes or improving existing ones. To this end, the individual disciplines of the natural sciences are combined and focused on different applications, such as medical diagnostics, environmental and sustainability issues, biotechnology, etc.
In research laboratories of governmental bodies and large companies, it is usually academics (doctorate level) who direct research or development as part of a research team. The BSc operates individually within the team and is often responsible for a separate piece of research. He develops and builds an experimental test setup, conducts and interprets experiments – usually using the latest information and communication tools such as bio-informatics and specific ICT applications – draws conclusions and makes recommendations.
In smaller companies, the approach adopted is often less fundamental and more applied. In this case, the duties of the Bachelor of Science will also include organising, coordinating and directing the work.

2. COMMERCE AND CUSTOMER SERVICE

In the world of **commerce**, Bachelors of Science will mostly be employed as product specialists. For example, their job could be to sell products, systems, services and equipment. They could also be working in marketing. In their role as adviser, they will help to solve problems or instruct and supervise new users. They consult customers and users, identify problems, look for causes and solutions and give advice. In all these cases, the work relates to principles or systems from a biological, medical, chemical or technological perspective.
They could be the head or deputy head of a department or service but could of course also start their own business. In the service sector, the BSc could become a hygienist, for instance, or be involved in knowledge transfer, possibly as an internship supervisor in education or in a laboratory. Other possible roles in institutes or companies could be in quality control or management, health and safety (e.g. as an environmental care coordinator or a QHSE coordinator), the environment or forensic research.

3. APPLICATION AND PRODUCTION IN LABORATORIES

In this professional domain, Bachelors of Science are often employed in environmental laboratories, quality control laboratories and production laboratories in the organic, biochemical and analytical fields, or similar laboratories. This usually involves conducting **complex experiments** that challenge graduates' practical skills and analytical ability.
In synthesis laboratories, where the safety of the work is of paramount importance, great reliance is placed on the graduate's knowledge and understanding. The great diversity of experiments calls for the wide-ranging and effective application of technologies, equipment, automation, quality assurance and HSE issues.

4. MEDICAL (LABORATORY) DIAGNOSTICS

Diagnostics laboratories in the **health sector** conduct research into material of human (or sometimes animal) origin. In general, these laboratories work in the fields of clinical chemistry, medical microbiology, cytohistopathology, haematology, immunology, endocrinology or clinical genetic research. Working as researchers, graduates help to find answers to clinical questions by applying scientific methods of analysis in the diagnosis, treatment and prevention of disease. They are involved throughout the sampling process, from taking a sample of the material to reporting on the result and archiving data. It is important for graduates in this post to accumulate the knowledge and understanding required to include clinical data in the performance and (provisional) interpretation of the research and to make connections between medical issues and (provisional) research results. The great diversity of analyses, ranging from manual to fully automated and robotised analyses, requires the graduate to be versatile and deploy technologies, equipment, IT and quality assurance effectively. BSc graduates can also be employed in the development of new diagnostic or treatment techniques or equipment (based on physical, chemical or biological principles). In a laboratory setting, BSc graduates can progress to specialist and/or management roles.

5. ENGINEERING AND MANUFACTURING

In this domain, graduates are involved in or even primarily responsible for managing and controlling some or all of the **production process.** Working as part of a team, they develop or apply new processes or improve existing processes, products or materials. To this end, they consult both operators and senior management and external parties, take decisions on process changes or prepare for these decisions and report on the progress of the process and the result. In this case, graduates use their knowledge of flow, heat transfer, chemical conversion processes, physical separation techniques and materials to arrive at the optimum price-quality ratio within socially acceptable risks. All aspects of sustainability are always taken into account. This professional domain contains two priority areas, i.e. bio and other process technologies and product and material technology. Bio and other process technologies usually involve large-scale processing plants which produce unformed products such as gases, liquids, powders and/or granulates. Product and material technology often involves smaller production units which produce formed materials such as sheets, wires and foams.

Day-to-day practice

What does day-to-day practice in these different professional domains look like? On the pages that follow, young professionals talk about this; each of them is employed in a different domain.

Group interview*

Clearly defined domains

Because graduates from the study programmes in the Applied Science domain have received a broad education, a wide range of occupations and employers are open to them. Technical higher professional education graduates can be found working anywhere from universities, teaching hospitals and diagnostic laboratories to food multinationals, the petrochemical industry and manufactures of consumables. However, by no means all of them work in laboratories because the fact that the programmes contain a variety of competences means that advisory, commercial or management positions are also within reach. The five professional domains (see page 8-9) provide a good overview of this diversity. But what do these comprehensive domain descriptions mean in the real world? When is a particular competence important? Is there a particular type of person for a particulair domain? We simply asked the graduates themselves.

Does the domain description resonate with your job?

Brigith: 'Yes, it really does. I assess pathological biopsies, especially kidney biopsies. I take care of the entire sampling system, from receipt, fixation, draining, plastifying, sectioning, using an electron microscope and storing the samples for different tests and analyses. Eventually, I discuss my findings with the pathologist, who makes the final diagnosis. In addition to electron microscopy, I use some other specialist techniques for diagnostic analysis, including scanning electron microscopy and EDX (element analysis). I do actually recognise everything from the description.'
Henk: 'When I look at the Research and Development domain description, I recognise in particular the emphasis on innovation. As part of my PhD programme, I am trying to grow artificial organs by sowing stem cells in three-dimensional matrices of collagen and other proteins. In this way, I am attempting to replicate simple hollow organs such as a blood vessel, oesophagus or bladder. To achieve this, I have to be able to communicate with doctors and laboratory staff as well as with commercial companies that should eventually be manufacturing the product. Maybe the domain description is based a bit too much on the practice side, whereas I also take on a large chunk of theory. But I have actually progressed further than the average higher professional education graduate because I've also done another HBO-Master in Life Sciences.'
Marcel: 'A substantial part of my work consists of optimising and improving processes. As a process engineer, I manage all the technical changes in the synthetic resin manufacturing processes in our production plant. They could be major changes, such as setting up a new process or developing a new plant. But they could also be small things such as changing a setting in the software program that monitors the process. Anyone in the company can submit an idea for an improvement. We then set up a project group from several disciplines to consider whether the change has added value and is safe. Finally, I instruct the team members how to deal with the new things. And of course I am also responsible for writing the necessary reports. It's a great job!'

* This group interview dates from 2013. Some interviewees are now working elsewhere.

Engineering and manufacturing

Marcel de Kok, 35
Process engineer at Resinall Rütgers Resins BV

'One day I'm sitting round a table with officials from the regional government and the next day I'm helping the guys on the shift with a production problem. The variety is great.'

Commerce and customer service

Karlijn van Soest, 29
Account manager and sales representative at Life Technologies

'Within a week after my application, I was on a flight to Glasgow: "Show us what you can do." Working hard and seeing the result straight away in sales figures, that really appeals to me.'

Research and development

Henk Hoogenkamp, 25
PhD candidate in tissue engineering at Radboud University in Nijmegen

'I always have a lot of ideas and like to think outside the box. Research into artificial organs is still a bit like the Wild West, there is so much being discovered and yet to be discovered!'

Linda: 'I also really do recognise myself in the description. I work in a research lab which is contracted by customers to investigate how to produce and purify a sufficient quantity of protein or culture *C. elegans* worms for toxicological research. It is very practical and analytical work, which always involves teamwork because everyone has his own specialism and knowledge. We also have to meet strict deadlines, so it is very important to perform experiments, conduct research and do efficient work.'
Karlijn: 'I mainly recognise myself in the first part of the Commerce and Customer Service domain description. As a sales representative for Life Technologies laboratory supplies, it is my job to contact potential customers for products such as restriction enzymes or growth media and persuade them that we are the right people to supply their materials. I am indeed a specialist in this field and I help customers by giving advice on their research and the best products to use to conduct that research. But what the domain description says about safety and environmental coordination does not apply at all to my job. You have to be very precise and analytical for that and I am not.'

Could you and would you switch professional domains?

Henk: 'I'm also attracted to commerce but I really wouldn't want to do medical diagnostics. I would find that a bit boring.'
Brigith: 'I'm actually quite content for the time being. I'm not attracted to the other domains so much, maybe in future.'
Marcel: 'I'd also like to stick to my own domain.'
Karlijn: 'I think I could work in any domain but not in practical implementation in the lab. I see myself more as a coordinator or organiser, so the subject doesn't matter so much.'

What percentage of your time at work do you spend in the lab?

Brigith: 'A lot, at least 80% of each working day.'
Marcel: 'It's different for me. I once worked in an analytical lab where I performed techniques such as HPLC analyses but now I just interpret data that comes from the lab.'
Karlijn: 'Not at all! First, I found it difficult that my job was not so practical. But I don't operate on autopilot as Brigith obviously does. As soon as actions start to be repeated, I stop being observant and you really need that in a lab.
Brigith: 'Funny, I actually enjoy the regularity of my

Labaratory-scale application and production

Linda Peters, 26
Research analyst, HAN BioCentre

'For me, blindly following a protocol is not enough. We develop our own methods for answering customers' questions, which means that I'm doing something different every two weeks.'

Medical laboratory diagnostics

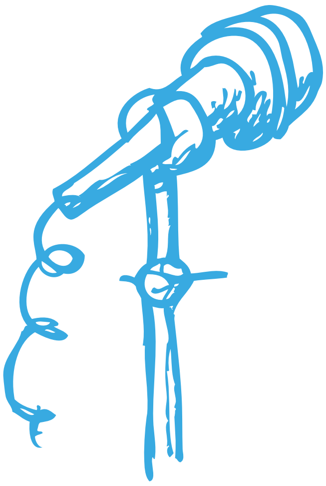
Brigith Willemsen, 24
Pathology analyst at Radboud Hospital, Nijmegen

'Because I work with material from patients, I am contributing to a successful diagnosis and therefore helping patients. The fact that my work can do something for other people is important to me.'

job. It allows me space in my head to work on new methods or research in smaller projects.'
Henk: 'I couldn't do that either, doing the same tests over and over again. I'm far too pig-headed to be able to follow instructions properly. But I can still be found in the lab on a regular basis if I'm developing a new idea or experiment or supervising a student. There are also months when I'm mostly engaged in writing or discussing follow-up steps with our industrial partners.'
Karlijn: 'I still visit customers' laboratories regularly because I'm selling the items that the researchers and analysts use there. And because I've also done it, working in a lab, I know what's important when it comes to using my products.'

Which competences are the most important in your job?

Henk: 'To me, research, experimenting and of course self-management are very important. Also, when doing your PhD, you have to have a bit of a nerve and not listen now and again. There are no well-trodden paths when it comes to research.'
Linda: 'In addition to what has already been said, management and coordination are very important in our company. Working on multiple projects with tight deadlines means having to plan your time very well. And an analytical mind, because you always have to be able to take a critical look at your own results.'
Brigith: 'For my job, you have to work in a structured way and focus on quality. This is required when conducting experiments.'
Marcel: 'Management and coordination are the top priority: I often have ten to twenty small projects running at the same time. But I also do a lot of coaching and providing information, and being the only process engineer in the plant, self-management is really a requirement.'



How did your study programme match your job, are you still lacking in any competences?

Linda: 'Not in terms of lab skills, but I would have liked to learn more about how to put things down properly on paper.'
Brigith: 'Oh, I think I picked that up reasonably well. What I needed was a bit more English because that's the language used in our research project meetings and I found it quite difficult at first. In other respects, it was a very good match, but then I also did an internship at my current workplace. I was able to work unsupervised after a week.'
Karlijn: 'In my case, the match was minimal. When I was a student, I didn't even know that a sales job was an option. We only had some idea of becoming a research or diagnostic analyst. But, apart from the fact that my study and job are about the same subject, I did not actually acquire any useful skills. You have to learn sales on the job, it's sink or swim.'

What are the career prospects like in your domain?

Marcel: 'Very good, actually. A lot of process engineers and similar will soon be retiring and the number of new recruits arriving is really too small. I don't have many worries about job security, either in the Netherlands or internationally.'
Linda: 'Really? Well, in that case, today's students should perhaps incline a little more in your direction. When I started out, the idea was still that if you were an analyst the jobs would be there for the picking, but this is the wrong time for that now.'
Brigith: 'I agree with Linda, and you also have people moving on from MLO level in the medical diagnostics sector.'
Henk: 'After most analyst jobs, you can progress as a methods specialist or the manager of a diagnostic lab. But if you want to be a manager in the world of research, you have to compete with university graduates. That was one of the reasons why I decided to continue my studies, which incidentally is going very well. And with a PhD on your CV you can progress much further in R&D, to professor or principal investigator.'
Marcel: 'Things are a bit better in my sector, I think. In engineering companies, a PhD from a university is not a requirement and you generally have excellent opportunities for continuing studies in your job.'
Karlijn: 'Things are still good for me. I get regular calls from head-hunters. What is also great about my sector is that your previous education definitely does not determine your career prospects. If you can show that you have it in you, you could even make it to CEO.'

Section 3

Knowledge and skills: final qualification Bachelor of Science in the applied sciences

A Bachelor of Science in the applied sciences is characterised by his analytical, abstracting, enquiring and service-oriented attitude. A BSc always asks himself 'why' as well as 'what' and 'how'. His attention is therefore focused on acquiring knowledge so as to be able to assist in solving problems or resolving problem statements in the field of applied science. He is capable of operating both independently and in a multidisciplinary setting and is conscious of the risks to people, animals and the environment and of the ethical implications of research. He is aware of the applicable statutory regulations and works within their limits, with the aim of producing the most sustainable solutions possible.

From student to BSc: competences and competence-oriented education

A competence is a combination of knowledge, skills and attitude which is required to perform a task or fulfil a position within a specific context. To put it another way, 'competent' means the ability to apply knowledge, skills and attitude in practice. Competences are always defined in such a way that they can be measured and tested, and improved by means of training and development.

The competences of a Bachelor of Science in the Applied Science domain are:

1. Research
2. Experimentation
3. Development
4. Management
5. Advice
6. Instruction | coaching
7. Leadership | managing people
8. Self-management

The first three competences are the most important elements of the Applied Sciences.

Competences and competence indicators

Details of the eight domain competences and the associated **indicators** for an experienced professional are provided on the pages that follow. Of course, a new graduate has not yet achieved that final level but will have reached a certain intermediate level for each competence. The competence 'research' is clearly visualised by means of an example in Figure 2 on page 14. Appendix III contains a description of the intermediate levels of all the competences which are achieved on the way to the level of an experienced professional. The level that a student has reached at the end of his studies will differ from programme to programme. The programme profile contains details of the *minimum* intermediate level required for each competence.

The competence indicators are not separate learning goals or final attainment targets: they are criteria for assessing whether the competence is being met. They have been formulated in such a way that they can visualise a growth process in a practical way and therefore lend themselves to giving students feedback when they carry out research or conduct an experiment. This enables them to work towards meeting the criteria in a targeted way.

To give an example: where a student is carrying out research and it appears that his way of collaborating is preventing him from achieving a good result, he can use the indicators to conduct a piece of follow-up research in a targeted way. A student can also focus additional attention on keeping a good lab journal, e.g. when conducting an experiment. The student will have to be able to demonstrate his competence(s) in a working environment relevant to Applied Science. A senior student could, for example, work on the competence 'instruction' by supervising first-year students in field tests.

Competence indicators: tools for making competences practicable; students show that they have a specific competence by acting in a specific way.

1. COMPETENCE: RESEARCH

Within the Applied Science domain, the Bachelor of Science conducts research that either contributes to solving a problem or developing a method, or leads to greater insight into a subject within his professional environment.

	Level I	Level II	Level III	Level IV
	The student *performs simple research in response to a problem statement and setup provided.* He demonstrates this by:	The student *makes a major contribution to a research strategy provided and conducts the research.* He demonstrates this by:	The student *translates a problem provided into a research strategy and conducts the research.* He demonstrates this by:	Experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* He demonstrates this by:
a. Setting an objective for the research assignment	Communicating with the client about the problem and the objective of the research.	Analysing a problem in consultation and in a coordinated way and translating it into the objectives of the research assignment.	Analysing, independently, a problem provided and translating it into the objective of the research assignment.	Analysing a problem independently and translating it into the objective of the research assignment.
b. Using literature or sources	Gaining an insight into the professional aspects of the research by studying the literature or sources provided.	Gaining an insight into the problem and the professional aspects of the research by studying the literature or sources the student has selected.	Selecting and obtaining, without assistance, scientific and other literature or sources in order to study the problem in greater depth, thereby validating the reliability of the different sources of information.	Selecting and obtaining, without assistance, scientific and other literature and/or sources in order to study the problem in full depth, thereby validating the reliability of the different sources of information.
c. Determining the research design	Explaining the relationship between the research question provided, sub-questions and research activities.	Formulating, under supervision, sub-questions and research activities regarding the research to be carried out.	Formulating, without assistance, sub-questions and research activities regarding the research to be carried out.	Formulating, without assistance, sub-questions and research activities regarding the research to be carried out.

Figure 2: Example of competence indicators; they have been designed to make a growth process visible in practice. Full details of all competences can be found in Appendix III.

THE EIGHT DOMAIN COMPETENCES WITH COMPETENCE INDICATORS

The indicators apply to an experienced professional in the Applied Science domain. The intermediate levels used by the programme have been derived directly from them. See also Appendix III.

1. RESEARCH

Within the Applied Science domain, the Bachelor of Science conducts research that either contributes to solving a problem or developing a method, or leads to greater insight into a subject within his professional environment.

This is demonstrated by:

a. analysing a problem independently and translating it into the objective of the research assignment;
b. selecting and obtaining, without assistance, scientific and other literature and/or sources in order to study the problem in full depth, thereby validating the reliability of the different sources of information;
c. formulating, without assistance, sub-questions and research activities regarding the research to be carried out;
d. methodically drawing up a work plan, allowing time for evaluation and adjustment and taking account of preconditions and uncertainties;
e. implementing a complex work plan effectively and efficiently and working with dynamic scheduling as necessary. Acquiring relevant knowledge and putting it into practice;
f. summarising, structuring and interpreting the results in relation to the research question. Ensuring that the results are reliable;
g. making proposals for follow-up research based on the conclusions and other insights;
h. reporting on the results of the research in accordance with the standard applicable/valid in the professional field;
i. collaborating in a result-oriented way in a multidisciplinary setting. Communicating and reporting effectively on progress and coordination.

2. EXPERIMENTATION

The Bachelor of Science conducts experiments within the Applied Science domain in order to obtain demonstrably reliable results.

This is demonstrated by:

a. translating a research question into objectives by means of a suitable experimental design;

b. demonstrating such knowledge, insight and skill as makes it possible to carry out the work in a responsible, safe and critical way using the correct methods, techniques and equipment;
c. being capable of learning about the possibilities and limitations of the equipment in order to be able to deal with experimental problems;
d. drawing up and implementing work instructions so that demonstrably reliable and reproducible results can be obtained and maintaining accurate and clear documentation;
e. designing an approach in accordance with HSE, ethical and sustainability standards, assuming responsibility for the local environment;
f. using (statistical) techniques to process/validate the results and ensure their quality;
g. taking a decision on the follow-up, based on the results.

3. DEVELOPMENT

The Bachelor of Science develops or improves a process, instrument, product or material or scales a process up or down in the Applied Science domain.

He demonstrates this by:
a. setting the criteria with which the product, process, instrument or material must comply in a complex situation, based on the clients requirements or whishes (specification of requirements);
b. identifying without assistance, in a complex situation, discipline-specific concepts in the specification of requirements;
c. selecting, in a complex situation, the most suitable discipline-specific design parameters that can affect the process, product, instrument or material;
d. selecting, in a complex situation, the most suitable discipline-specific models, verifying them or applying and validating them in accordance with the specification of requirements.
e. investigating, in a complex situation, the discipline-specific and economic feasibility and sustainability of the result;
f. selecting, in a complex situation, the most suitable feedstocks and unit operations in both qualitative (which) and quantitative (quantity, dimensions) terms;
g. preparing the documentation for the development and the result in accordance with the standard applicable in the professional field for a complex situation.

4. MANAGEMENT

The Bachelor of Science develops, implements and maintains a data management system or parts thereof in accordance with legislation, quality standards and the organisation's norms and values.

He demonstrates this by:
a. analysing any problems relating to the development, implementation and maintenance of a data management system;
b. preparing, implementing and evaluating an improvement plan that will solve the problems in a creative, structured and economically viable way;
c. taking account of legislation and national and international standards and values, particularly in the area of sustainability and reliability;
d. coordinating activities relating to the development, implementation and maintenance of the data management system (or parts thereof).
f. reporting and presenting information in accordance with the standard applicable in the field concerned;
f. keeping employees fully informed of the contents and use of the data management system and any changes.

5. ADVICE

The Bachelor of Science provides properly substantiated advice on the design, improvement or use of products, processes and methods and effects profitable transactions involving products or services.

He demonstrates this by:
a. adopting a service-oriented attitude;
b. clarifying the issue raised by the client;
c. setting up and implementing market and other research;
d. preparing advice (or parts thereof);
e. translating customer's wishes and questions into feasible solutions or recommendations in consultation with researchers and developers;
f. maintaining relationships with customers in an appropriate manner;
g. using negotiation techniques when buying and selling.

6. INSTRUCTION | SUPERVISION | TEACHING | COACHING

The Bachelor of Science instructs and supervises employees and customers while teaching new knowledge and skills.

He demonstrates this by:
a. independently providing employees, trainees, students or course participants with theoretical introductions, instructions and demonstrations with regard to practical experiments, the use of equipment, materials, etc.;
b. supervising employees, trainees, students or course participants in the use of methods and equipment as well as in conducting desk research for practical assignments;
c. applying teaching skills in different educational settings;
d. coaching employees and teams on the development of expertise;
e. evaluating and assessing the results of the instruction, training or courses.

A competence is a combination of knowledge, skills and attitude which is required to perform a specific professional task within a specific context. Competences can be measured and assessed, and improved by training and development.

7. LEADERSHIP | MANAGING PEOPLE

The Bachelor of Science provides direction and guidance for organisational processes and the employees involved in them in order to achieve the goals of the division/department or the project which he is managing.

He demonstrates this by:
a. having a vision for the division/department and sharing it;
b. working on the basis of a project and according to a plan;
c. coaching employees by inspiring, persuading and motivating them, showing them respect, encouraging collaboration and delegating;
d. acting as a role model for employees;
e. giving employees a feeling of shared responsibility;
f. chairing meetings, including progress meetings;
g. communicating in a task- and process-oriented way;
h. managing a project in terms of time, money, quality, information and organisation.

8. SELF-MANAGEMENT

The Bachelor of Science manages himself in performing his duties and in his development and ensures that he is up to date with the latest developments in terms of knowledge and skills and in terms of ethical dilemmas and socially accepted norms and values.

He demonstrates this by:
a. setting and implementing a learning objective and a learning strategy without assistance and feeding the result back into the learning objective;
b. quickly adapting to changing working environments;
c. weighing up professional and ethical dilemmas and taking a decision in accordance with accepted norms and values;
d. giving and receiving feedback;
e. critically evaluating his own actions and thinking, and accepting responsibility for them and taking this on board.

The practical aspects of competence-based learning

Competence-based learning focuses on a final competence level: students must be capable of using the knowledge and skills that they have acquired in a specific professional setting. A programme of study can use different teaching formats to work on competences or a particular aspect of a competence. Whether it is an innovative teaching format or a traditional one, the contents are always dictated by the professional situation. One way of working on competences is to link an assignment (e.g. conducting an experiment) to a competence. Students are deliberately instructed to take account of the indicators established for the competence concerned (e.g. 'make sure to draw up a work plan, search the literature, explain the principle of the technique', etc.). The Level 1 assignments will be formulated at the beginning of the programme; the assessment will be carried out on the basis of the competence indicators that belong to that level.
An assignment is also an ideal way of working with students on their attitude to work: on what level is a particular attitude required? For example, consider the difference between an experiment in which someone merely follows a work plan and writes a report and a situation with someone who also understands what the different steps mean, works safely and can draw conclusions from the result. Day-to-day professional practice usually requires several competences. This kind of professional situation can be replicated in class, e.g. in the form of a group project. A work placement is another excellent way of training and evaluating competences.

Section 4

Justification for the final qualification Bachelor of Science

In order to create international learning pathways, the Bachelor/Master (BA/MA) structure used in the English-speaking world was introduced into continental Europe in 1999, providing a clear nomenclature for all the member states and a single European academic credit system. The aim was to improve the chances of graduates finding employment in a globalising economy.

The *international* level with which each graduate has had to comply since then has been set out in the Dublin descriptors (see Appendix IV). The *national* level of a bachelor graduate is described in the higher professional education (HBO) standard for 2011. This states that a Dutch HBO/Bachelor programme must ensure that students are given a sound theoretical foundation, that they acquire research capabilities to enable them to contribute to the development of the profession, that they have sufficient professional expertise and that they develop the professional ethics and social orientation fitting for a responsible professional.

A **competence profile** has been created for each of the various technical HBO domains in order to make the Bachelor degrees recognisable within a single domain. These competences were formulated in the Applied Science Domain in 2007 on the basis of national professional and programme profiles dating from 2003 and 2006. After validation by the professional field, this competence-based profile description was included in the database of the Netherlands Association of Universities of Applied Sciences [*Vereniging Hogescholen, formerly HBO Raad*]. The profiles for each programme have been aligned with the professional field and with the Dublin descriptors of the Bachelor level. This means that a student who matches the programme profile also conforms to both the nationally and the internationally accepted HBO/Bachelor level.

On validation of the profile in 2008, the professional field requested the inclusion of a description of the knowledge and basic skills that each student must have, irrespective of the university he attended or his eventual specialisation, the next time the document was updated. Since 2010, work has been done in the domain on this common national description, referred to as the *Body of Knowledge and Skills* (BoKS). After validation by the professional field during the period 2012-2013 (see Appendix V), these descriptions were included in the updated version of the profile description for the individual programme profiles in Section 5.
In order to carry out a complete update of the document, the descriptions of the competence levels were once again submitted to the professional field in 2012, who concluded that they were still suitable for the Bachelor of Science in the Applied Science domain. The three core competences of the domain were revised in 2016 (Development) and 2019 (Research and Experimentation). The national professional field has given a favourable assessment of the revised competence descriptions.

Domain profile
In the current structure of the HBO, the core of the Applied Science Bachelor programmes comprises the **CROHO**-registered programmes for Biology and Medical Laboratory Research, Chemistry, Chemical Engineering, Applied Science, Bio-Informatics and Applied Physics. In addition, there is a variety of different additional programmes that award this Bachelor degree, i.e. Biotechnology, Forensic Research and Environmental Science. Appendix VI lists the fifteen universities and programmes in the Applied Science Domain.
All technical HBO Bachelor programmes have been awarding the Bachelor of Science degree since 1 September 2015. The difference in types of degree between the various domains has therefore disappeared. However, each domain retains its own competence profile and the related programme profiles.

National programme profile
A national programme profile specifies the *minimum final level* of a Bachelor of Science in terms of domain competences, the competence profile and the **Body of Knowledge & Skills (BoKS)**. It is an im-

CROHO is the Central Register of Higher Education Study Programmes of the Dutch Ministry of Education, Culture and Science.

Competence profile: the common competences that every new professional graduate in every bachelor-awarding domain must attain.

BoKS is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO programmes in consultation with the professional field.

portant means of improving quality, which is used throughout the HBO; see Appendix II for details. The individual programmes in the Applied Science domain have a consultation structure in which they coordinate their activities and implementation among themselves; the national programme profiles of a large number of programmes is laid down at these consultations.
The Applied Science domain contains nine programmes, each of which is offered at one or more locations by a total of fifteen different institutions. Students follow part of their study course with students from other Applied Science programmes. At the time of graduation, we see how students who have followed the same programme can still differ considerably in terms of their specialisation or profile.
The challenge for programmes is to provide students with this flexibility while at the same time responding to the needs of the professional field and its call for recognisable programmes. Such flexible learning pathways are possible because the *same* competences always form the starting point for competence development within the domain. Each institution then formulates – on the basis of the national programme profile – the specific final level, the specialisations and the profile of the student. Because of this, the level is guaranteed, the programme remains recognisable and it is possible to respond to needs in the professional field.
The competence profile of a programme is drawn up on the basis of the eight shared Applied Science **domain competences**. A national programme profile determines for each of these eight domain competences the minimum final level that each graduate must attain. Details of this are set out in Section 5 for each programme.
The substantive context of a programme is determined by the Body of Knowledge & Skills. Moreover, each graduate acquires further knowledge that is relevant, for example, to his chosen specialisation. An institution can also decide to accentuate aspects that specifically focus on the professional field at regional regional level. As far as knowledge and skills are concerned, there is not therefore a national *final* level but there is a national *basic* level.
Programmes themselves specify the professional domains that they will be focusing on. In this way, the professional field knows the specific jobs that the student has been trained for.

Domain competences: all of the competences that a professional graduate must have at his disposal in order to be able to perform his profession/job properly. Programmes must develop these competences in students to the level of a new professional graduate.

ECTS: the unit used to express the workload of a programme or part thereof. ECTS stands for *European Credit Transfer System* and is used by all the countries within the European Higher Education Area. One ECTS is equal to 28 hours of study.

Education at institutional level

The final qualifications aimed for are made specific at institutional level. The programmes put their educational programme and final qualifications on view and design tests on the basis of this in terms of learning goals and final competences. As stated above, the programme contains the option of profiling on the basis of final qualification and providing multiple profiles for each programme. This increasing specification from domain profile to programme profile to institutional profile is shown in Figure 3. The description focuses both on potential occupations and on competences and substantive context.

The profiling can be expressed in different ways:

- based on form, e.g.:
  - part-time
  - full-time

- based on content, e.g.:
  - wide knowledge of analytical chemistry
  - wide knowledge of microbiology

- based on potential career, e.g.:
  - research analyst
  - process engineer

- based on level, e.g.:
  - a higher final competence level than the national minimum
  - an additional competence
  - excellence or honours programmes

This profiling enables institutions to stand out for potential students and respond specifically to the needs of the professional field at regional level. The final qualification must in all cases comply with the national programme profile. The knowledge, skills and competences linked to each graduate profile must be described accurately and clearly.

Graduation tracks

In 2015, joint arrangements were made to offer graduation tracks for a number of programmes. A unique name has been agreed for each graduation track with similar content. These graduation tracks describe the professional expertise of graduates and must consist of 30 **ECTS** for graduation and 30 ECTS for supplementary tuition. To supplement the name of the graduation track, a university can specify a social theme or context, which is short and to the point. In this way, the institution can give the graduation track a regional flavour. Names for graduation tracks have been agreed for the programmes referred to in Figure 4 on page 19.

Domain profile	National programme profile for each DAS programme	Programme profile for each university institution
Professional domains ■ Research and development ■ Commerce and customer service ■ Application and production ■ Medical laboratory diagnostics ■ Engineering and manufacturing **Professional competences** ■ Research ■ Development ■ Experimentation ■ Management ■ Advice ■ Instruction | coaching ■ Managing people ■ Self-management **Focus on substance** Applied sciences	**Potential career** Extent to which the programme specifically trains a student for a specific professional domain **Competence Profile** Minimum final level of each competence in the domain profile **Body of Knowledge and Skills** Knowledge base and basic skills that must form the foundations of the subject covered in the programme	**Graduation tracks or specialisations** The specific orientation towards the professional domains or professional situation **Competence Profile** ■ The specific attainment target of the domain competences ■ Any additional other competences that the institution applies **Substantive attainment target** The attainment target for knowledge and skills

Figure 3: The relation between domain, programme and institutional profile shows an increasing specification of orientation, level and content.

The most up-to-date summary of graduation tracks offered by the universities can be found in the map under the heading 'Applied Science op de kaart' on the DAS website: www.appliedscience.nl.

Body of Knowledge and Skills
We have already referred to the Body of Knowledge and Skills (BoKS) above. The BoKS allows the professional field to gain insight into a graduate's knowledge and skills. The BoKS is not defined by final attainment targets but by subjects. A list of characteristic textbooks gives an impression of a graduate's knowledge and skill level. The objective of the BoKS may also be to determine, in the dialogue between an institution and the representatives of the professional field, the extent to which the subjects are offered in the programme. This obviates the problem that it is not possible to refer to a general national final level because of the different graduation tracks. In practice, the BoKS will always be the starting point when a programme is evaluating the offering, the extent and depth of the knowledge and skill components of its curriculum.

Programme CROHO	Graduation tracks
Biology and medical laboratory research	■ Biological data science ■ Diagnostics ■ Laboratory animal science (to obtain Article 6 declaration)* ■ Microbiology ■ Molecular biology ■ Nanotechnology ■ Research
Chemistry	■ Analytical chemistry ■ Biochemistry ■ Physical chemistry ■ Organic chemistry
Chemical engineering	■ Materials science ■ Process technology
Engineering Physics	■ Applied Physics ■ Enabling Physics

Figure 4: Unique name for the graduation tracks per programme.

* The programmes that offer Laboratory animal science as a graduation track or minor apply the programme requirements for the Biotechnician programme as specified in Article 6, section 1b, of the 2014 Dutch Animal Testing Regulations [Dierproevenregeling]. See reference 3, page 75.

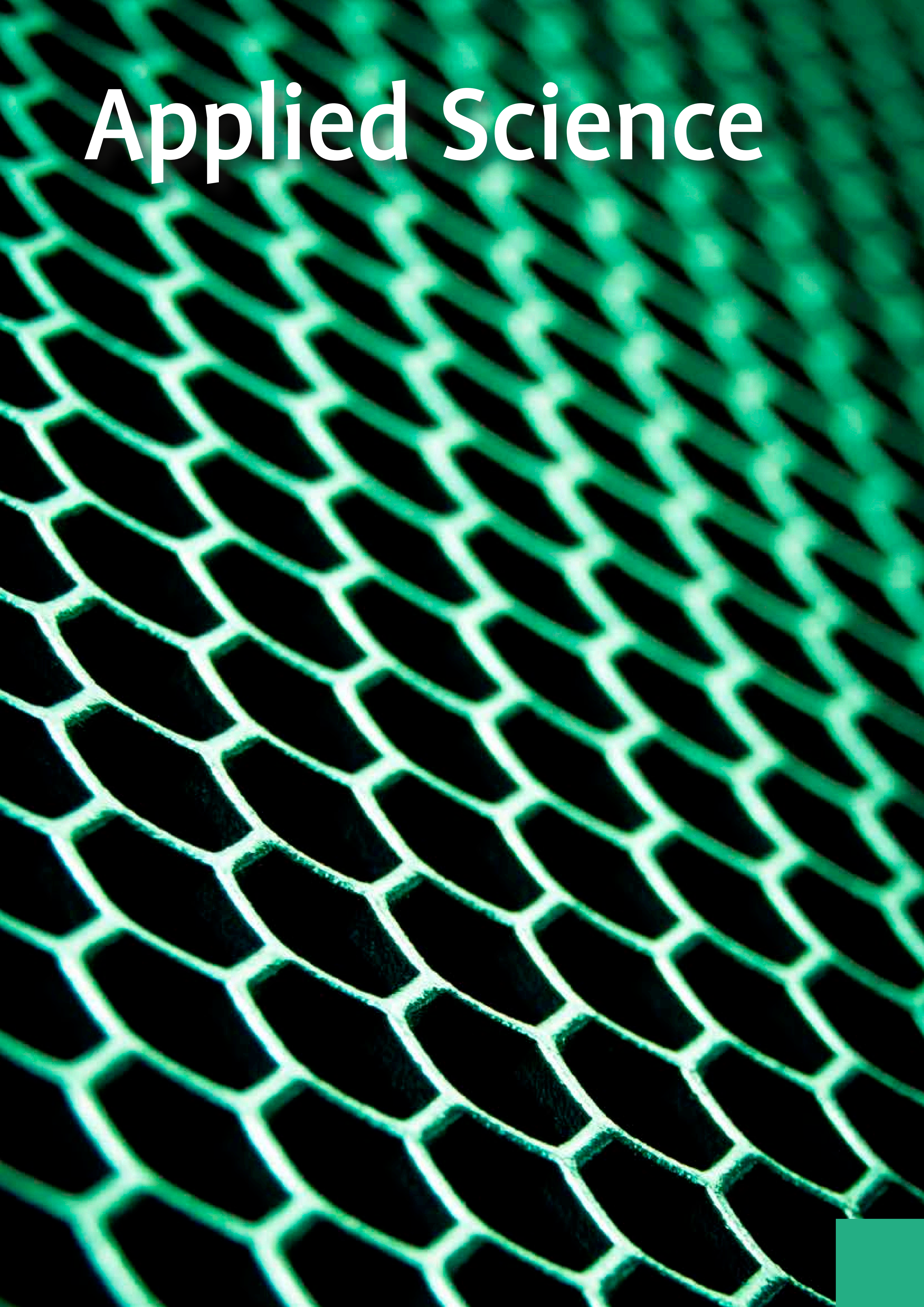
Section 5

Programme profiles

The Applied Science Domain contains nine programmes of which eight programme profiles have been established nationally through cooperation between domains. This section presents the national programme profiles for:

One programme in the Applied Science Domain is only being offered at one university within the domain. This means that there is not a programme profile which has been agreed nationally in terms of DAS. This document therefore outlines the situation at the individual university. The institutional profile for this programme is consistent with the domain profile of the Bachelor of Science in the Applied Science domain. The programme involved is:

Applied Science



APPLIED SCIENCE trains students for a range of jobs, from the microbiology to the chemistry and technology fields, from researcher to analyst. Its main features are its broad orientation in the first year in the fields of biology, chemistry, materials science and technology and a wide range of graduate project places in commercial companies, the health sector, universities and research institutes.

After the first year, students choose a specialisation that best suits their interests and ambitions. These learning specialisations are variable, which means that there is also great flexibility in the professional domains in which the graduates will find employment. A lot of attention is focused on the competence of self-management during the programme because of the wide range of choices that it offers.

Institutions that offer the programme

- Fontys University of Applied Sciences, Eindhoven
- Zuyd University of Applied Sciences

National programme profile

	Competence							
	Research	Development	Experimentation	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	**III**	**–***	**II***	**I***	**I***	**I***	**I***	**III**

* at least one of these competences must be raised one level

ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Research and development
- Biological laboratory research worker
- Chemical laboratory research worker
- Vaccine development
- Materials research
- Food research

Application and production
- Analytical chemist for quality control of products

Medical laboratory diagnostics
- Analyst in hospital or diagnostic centre

Engineering and manufacturing
- Process engineer

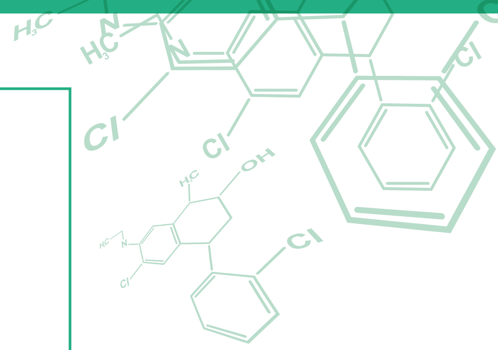
Commerce and customer service
- Patent law assistant

TYPICAL TEXTBOOKS

- *Chemistry*, J.E. McMurry. R.C. Fay e.a.
- *Organic Chemistry*, D. Klein
- *Principles of Instrumental Analysis*, D.A. Skoog, F.J. Holler e.a.
- *Campbell Biology*, L.A. Urry, M.L. Cain e.a.
- *Molecular Biology of the Cell*, B. Alberts, A. Johnson
- *Brock Biology of Microorganisms*, M.T. Madigan, K.S. Bender e.a.
- *Klinische Chemie en Hematologie voor Analisten*, E. ten Boekel, B.A. de Boer
- *Procestechnologie, delen 2, 3 en 4*, VAPRO
- *Kunststof- en Polymeerchemie*, R. van der Laan
- *Statistiek om mee te werken*, A. Buijs

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Applied Science



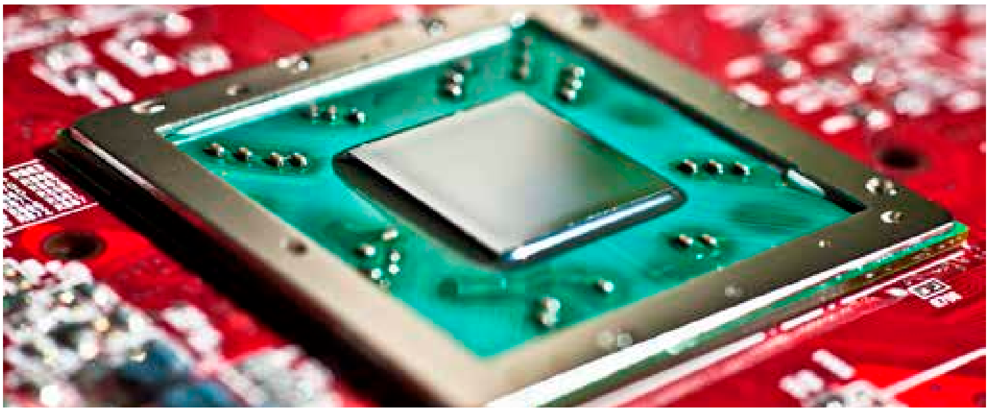
KNOWLEDGE

- **Basic chemistry:** atomic and molecular structure, hybridisation, molecular structures, molecular bonds and interactions, reaction equations, chemical balances, reaction kinetics, redox reactions, buffer solutions
- **Analytical chemistry:** spectroscopy, chromatography
- **Physical chemistry and physics:** electrochemistry, electronics, gas law, mass and energy balances
- **Organic chemistry:** synthesising functional groups, reaction mechanisms, substitution and elimination reactions, alkanes, alkenes, carboxylic acids, esters, aromatics, alcohols, ethers, alkyl halides, isomers, eniantomers, stereochemistry
- **Materials science:** monomers, polymers, biopolymers, radical polymerisation, thermal and mechanical properties
- **Statistics:** data processing, normal distribution, confidence intervals, testing
- **Mathematics:** chemical arithmetic, functions, differential calculus
- **Biochemistry:** biomolecules, DNA (structure, translation, transcription, replication), RNA, nucleic acids, proteins, cell membrane, heredity
- **Cell biology:** structure and function of eukaryotic and prokaryotic cells, cell division, metabolism, transport
- **Microbiology:** growth and classification of micro-organisms, pathogenetic mechanisms, infectious diseases
- **Health, safety and environment:** sustainability

SKILLS

- **General laboratory skills:** weighing, pipetting, making solutions (buffers), keeping a lab journal, chemical arithmetic, microscopy
- **Chemical analysis methods:** titrimetry, spectrometry (e.g. UV/VIS, IR, AAS, NMR), chromatography (e.g. GC, GC-MS, electrochemistry, enzyme analysis, bonding analysis)
- **Using standard laboratory equipment:** pH meter, spectrophotometer, centrifuge, power sources, microscope, fume cupboard
- **Laboratory techniques:** distillation, extraction, microbiological techniques
- **Safety at work:** in the laboratory and in the professional field
- **Computer skills:** word processing, spreadsheets, chemical drawing programs and presentations
- **Research skills:** problem analysis, research questions, desk research, research planning and implementation
- **Social and communication skills:** collaborating, meetings, reporting (lab journal, research report), oral presentation, project-based work, self-management

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.



R&D engineer Esther Roeven:

'I was given time to decide what direction to take'

Name: Esther Roeven
Age: 22
Course of study: Applied science
Place of employment: Surfix BV, Wageningen
Job: R&D engineer in surface chemistry

'When I started my course, I found it difficult to make a choice. I knew that I wanted to do a technical course but I had no specific preference for a particular subject. The first year of the applied science programme is very wide-ranging (both biology and chemistry/technology and food); as you progress through the course you can choose between four learning pathways. Because of this, I felt I had more time to make a decision about the direction I really wanted to take.

Nano

During the first year, I discovered that I liked chemistry a lot more than biology. After that first year, I chose my subjects and projects in that discipline. During my internship at TNO in the third year, I was involved in a nanotoxicology project and found out that I liked nanotechnology much more than "bulk" chemistry. The programme offers an internal "deepening minor" in which you can carry out six pieces of research into a number of subjects of your choice for six months. I used this minor to delve further into micro- and nanotechnology and then ended up in surface chemistry, which eventually also became my graduation project.

I now work at Surfix BV, a young company within Wageningen University. We develop chemical surface modifications in the form of nanocoatings for the micro-and nanotechnology markets, in particular microchips and biosensors.

I feel that study and practice fitted seamlessly together. There was already a lot of contact with the private sector during the programme. From the first year, every project was linked to a business, which quickly gives you an idea of how things are done in businesses. At the end of the day, I think that the competences you really use will very much depend on your job. I also supervise interns and graduating students, where I regularly use the competences of **instruction | supervision | teaching | coaching** and **leadership | managing people**. The competence of **management** also comes up almost every day because I work for a young company, which still requires a lot of organisation, and I think it's really great that I'm making a contribution. The competence of **advice** sometimes comes up when materials, systems or chemicals have to be sourced and ordered.

There are certainly opportunities for advancement in the company. At present, my ambition for advancement is therefore in this company but, in the long-term, it may be in another job. We are based in the organic chemistry department of Wageningen University so I can also take subjects and courses here. I'm happy to do so!'

QCT Lukas Balk: ‘There’s a reason why there are so many competences!’

‘On the prevocational course, my interest in applied science was aroused by an inspirational chemistry lecturer. Both of my parents work in education so teaching has always been in my blood. The plan was therefore to become a chemistry teacher but for that I needed at least a higher professional degree. When studying laboratory technology at senior secondary vocational level, I found that Applied science suited me; I obtained good results and it was decided that I could start the higher professional course. I wanted to gain some practical experience first and therefore decided not to start on the teacher training programme immediately but the more practice-oriented applied science programme. I wanted to study in depth what I already knew from my senior secondary specialisation (analytical chemistry) and expand my studies to include what I did not yet know (organic chemistry/process technology/material science). During my graduation project, I conducted fundamental research into the formation of nanocrystals with fluorescent properties (quantum dots) made of semiconductor materials.

As a Quality Control Technician FP, I am currently responsible for analysing pharmaceutical and nutritional finished products in the form of gel capsules (finished product: Banner Pharmacaps EU) mainly by means of HPLC and GC analysis.
I am also charged with planning and delegating in the distribution of analyses and in the near future I will be providing assistance in the establishment/acquisition of new analysis techniques. The widening of knowledge that I found in the higher professional course means that I contribute to and share ideas in many different subjects. However, I do think that the programme has a very strong emphasis on research and less, fro example, on working within strict guidelines (GMP, FDA, EP, USP, etc.). Yes, a lot of people opt for research but I myself think that graduates have greater opportunities for advancement within a quality control environment than in a research environment.

Self-management
The competence of **management** plays a great part in my job. Also, as a QC technician, I do have a lot to do with **experimentation**, a little with **research** and **development**, but mostly with **self-management**. Here, we work within very strict guidelines in which almost every operation is laid down. You aren’t allowed to deviate from them and that makes self-reliance and self-management essential. As an analyst/technician, you also have to **instruct** and **train** new colleagues. There is a reason why a Bachelor of Applied Science* has such a variety of competences!

Over the next few years, I would like to progress within the QC department to a job such as senior technician and would like to concentrate on introducing new methods. After that, I would like to progress to a management position in QC/R&D or perhaps use my qualities in another company. That’s all in the distant future, but a job such as QC or R&D manager also appeals to me. And teaching is always another option.’

Name: Lukas Balk
Age: 23
Course of study: Applied science
Place of employment: Banner Pharmacaps Europe, Tilburg
Job: Quality Control Technician Finished Products

* At the time of this interview, the title of Bachelor of Applied Science was used.

Bio-Informatics

BIO-INFORMATICS is the professional field in which computer and information technology is used to collect, store, share, analyse, interpret and disseminate data from biomedical and/or biological research.

The main subcategories of this specialisation are: genomics, transcriptomics, proteomics (including protein modelling, structures and functions), metabolomics and the integration of data from these areas. Bio-informaticians are employed to conduct biological and biomedical research in scientific institutions and in companies in the pharmaceutical, biotechnology, food and plant-breeding industries.

Institutions that offer the programme

- HAN University of Applied Sciences, Nijmegen
- Hanze University of Applied Sciences, Groningen
- University of Applied Sciences Leiden

National programme profile

	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	III	III	_**	II	I	I	I	II

** Students can choose to raise the level of these competences by making certain choices in their range of subjects, internship and graduation project during the last two years of their course.

ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Research and development
- Analysing large data sets from high-throughput laboratory research
- Scientific programmer

Application and production
- Managing gene and protein databases
- Analysing gene-sequencing data flow

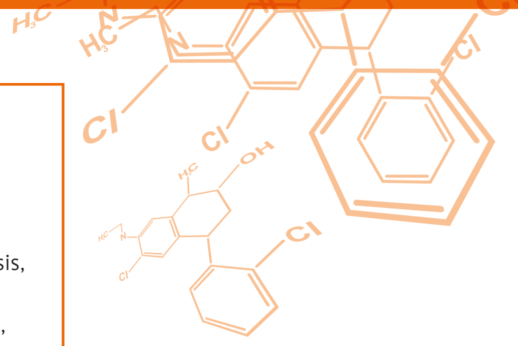
Commerce and customer service
- Biotechnology data consultant

TYPICAL TEXTBOOKS

- *Campbell Biology,* L.A. Urry, M.L. Cain e.a.
- *Essentials of Genetics / Concepts of Genetics,* W.S. Klug, M.R. Cummings e.a.
- *General, Organic and Biochemistry,* K. J. Denniston, J.J. Topping e.a.
- *Starting out with Python,* T. Gaddis
- *Data Structures and Algorithms using Python,* R.D. Necaise
- *Bioinformatics and Functional Genomics,* J. Pevsner
- *Using R for Introductory Statistics,* J. Verzani
- *Data Mining, I. Witten,* E. Frank e.a.
- *Statistics for the Life Sciences,* M. L. Samuels, J.A. Witmer e.a.

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Bio-Informatics



KNOWLEDGE

Biology

- **General Biology:** organisms, tissues, evolution
- **Cell biology:** cell structure, energy supply, transport, cell-cell communication, mitosis, meiosis, gene regulation, signal transduction routes, metabolic routes
- **Genetics:** DNA structure, replication, code, transcription, translation, epigenetics, mutations, SNPs, structural variations, inheritance, population genetics
- **Microbiology/virology:** construction, diversity, metabolic strategies, evolution

Chemistry

- **General chemistry:** atomic structure, periodic system, molecules, nomenclature, reactions, kinetics
- **Biochemistry:** building blocks, macromolecules, carbohydrates, lipids, proteins, enzymes, metabolism

SKILLS

Informatics

- **Programming in Python:** data structures, control structures, modular approach, GUIs, Biopython, python database approach, data types, object-oriented programming
- **Programming in Java:** object-oriented programming, application of algorithms, inheritance
- **Programming in R:** scripting, data analysis, statistics, data visualisation
- **Web technology:** HTML, CSS, web services
- **Databases:** relational design, implementation, querying and programmatic interaction (MySQL)
- **Workflow tools:** e.g. Galaxy, Snakemake
- **Linux:** bash scripting, Regex

Bio-informatics

Knowledge and analytical skills of at least the subjects listed below:

- **Sequencing technologies:** NGS technologies, assembly, mapping, NGS application areas (e.g. de-novo & re-sequencing) exome sequencing
- **Algorithmic aspects of sequences:** alignment, mapping, graphs, scoring matrices
- **Sequence annotation:** BLAST and related software
- **Gene expression analysis:** RNA-seq data, Bioconductor
- **Homology and phylogenics**
- **Practical use of bio-informatics tools:** e.g. BLAST, OMIM, Genome Browsers, Genbank, Uniprot, KEGG, MSA tools, topology prediction, PFAM, PROSITE, YASARA PDBe, Gene Expression Omnibus, FASTQ, mappers & aligners & assemblers

Statistics & data analysis

- **Sampling:** data types, population and sample, errors, bias, variation, (un)certainty
- **Descriptive statistics:** e.g. average, median, standard deviation, range, interquartile range
- **Visualization:** e.g. box-plot, histogram, scatterplots, Venn diagram, trees, heatmaps
- **(Hypothesis) tests:** e.g. t-test, ANOVA, chi-squared, Wilcoxon, non-parametric
- **Cluster analysis:** distance measurements, hierarchical clustering, k-means clustering
- **Regression:** linear, non-linear, multivariate, PCA
- **Dataming/machine learning:** e.g. Decision Trees, Naive Bayes, k-Nearest Neighbour, Neural Networks, SVM

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

Programmer Freerk van Dijk:

‘A lot of data requires a lot of computing power’

Name: Freerk van Dijk
Age: 25
Course of study: Bio-Informatics
Place of employment: Genomics Coordination Centre, Genetics Department, University Medical Centre Groningen
Job: Scientific programmer

‘I chose this programme because I was interested in biology. One of my hobbies is computers/gaming and I quickly made the link with this course of study. As I had a pre-university diploma, I was able to follow the fast-track bio-informatics programme. I more or less started in the second year and then had to take a number of subjects from the first year. I made up the lost ground in programming languages by putting in extra hours. A lot of attention was also focused on biology and laboratory work during the programme.

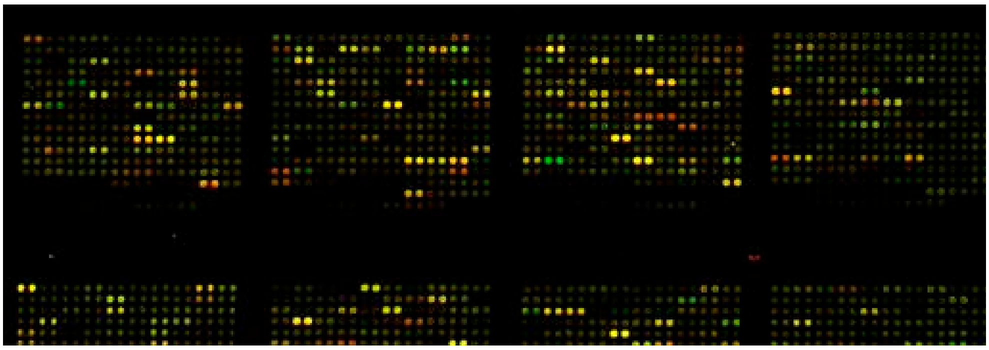
My work currently involves setting up pipelines/systems for analysing next-generation sequencing (NGS) data. This technology is used to replicate human DNA (mainly from the exons) and analyse it, which generates massive amounts of data. The analysis part requires a lot of computing power, which means that these analyses have to be performed on computing clusters. Consideration has to be given not only to the open source software required but also to ways of distributing these analyses in parallel. The ultimate goal is to detect variations in the genome and validate any causal variations in the laboratory. We are also responsible for supplying servers and storage capacity for software which the genetics department uses in different DNA analyses and assisting the researchers by providing scripts, software, etc.

Genome

I am currently working on the “Genome of the Netherlands” project, in which we have mapped out the complete genome of 250 father-mother-child trios. The aim is to provide a clear picture of all natural variation in the Dutch population. This data can be used to rule out frequently occurring variations in our population as being the cause of illness in sick people.

The programme fitted in really well with my job. Initially, I did notice that I had followed the fast-track programme: I was lacking a number of hours of programming experience, although you catch up in the course of your work. Lab technologies are also important because they are used to prepare samples for NGS. The analysis of NGS data was not included in the programme, because that technology was still new at the time.

Experimentation and research are the most important competences in my job. The professional field is still fairly new, which means that a lot of software and analyses have not been standardised. The result is that a lot of new software and analysis methods have to be designed and implemented. To me, UMC Groningen is a challenging environment where the focus is on research. This ensures that there is enough variety to keep the job interesting and there are all kinds of opportunities for advancement in the area of research.’



Bio-informatician Varshna Goelela:
'You always have to be eager to learn'

'I chose the bio-informatics programme because the combination of programming and biology appealed to me, partly on account of my previous ICT manager programme in senior secondary education (MBO). In addition, bio-informatics emerged from a course evaluation test as the best match for me. It was a fairly new course at the time – a lot of challenges and a lot of opportunities on the jobs market. And what I also regard as a major advantage: as a bio-informatician, you can progress in a very broad area or a very specialised area.

The programme was everything I expected it to be: a good combination of biology and programming. Now, during my day-to-day work, this combination seems to have been an ideal match. My choice of subject for my graduation project was mainly a practical and technical one. At the time, Next-Generation Sequencing was a relatively new technology that was making great advances and did not yet figure very much in the programme. I deliberately chose a graduate internship that did provide this opportunity and was able to learn how to analyse Next-Gen data. Looking back, this seems to have been a good choice as I am still making full use of the knowledge that I acquired at that time.

As a bio-informatician, I am responsible for carrying out data analysis and visualising various type of experimental data, such as transcriptomics, microbial data and metabolomics. I am also working on the development of bio-informatics pipelines and tools which are used both inside and outside our group. An example of this is a pipeline I have developed for automating quality control, preprocessing and normalisation of Illumina microarray data.

As far as I'm concerned, the programme fitted in really well with my job. During my studies, I also did various projects that provided me with the knowledge that I still use every day in my job. What the programme didn't cover so much was how important the design of a study is for data analysis. That's a pity, because the design of a study has a major impact on the performance of the analyses.

Communication

Research is an important part of a bio-informatician's job, so it's an essential competence for me. Sometimes, something will come your way that you have to learn about yourself, so I think you always have to be eager to learn. Good communication is another requirement. As a bio-informatician, you are surrounded by statisticians, scientists and ICT specialists, so it's useful to be able to communicate with each of them to streamline projects and analyses. **Self-management** is also important, for example, for enabling you to meet your deadlines.

I would still like to do a Masters degree in bio-informatics so that I can specialise further. In the professional field, I can see the way bio-informatics is playing an increasingly important part in science and advances in science ensure that tools are becoming increasingly efficient and analyses can be carried out faster and more accurately. I hope that I will be able to be part of these exciting advances in future.' ■

Naam: Varshna S. Goelela
Age: 26
Course of study: Bio-Informatics
Place of employment: TNO Zeist, Microbiology and Systems Biology department
Job: Bio-informatician

Biology and Medical Laboratory Research

BIOLOGY AND MEDICAL LABORATORY RESEARCH is a programme that trains students to work as research staff in a laboratory. The key element is biology as referred to by the term Life Sciences, a wide-ranging course in molecular biology focusing on research into bacteria, plants, animals and humans.

The course started out as two programmes and this division is still apparent in the main professional domains, with biological research and development on the one hand and medical laboratory diagnostics on the other.

As a researcher, the graduate is involved in developing new products, materials, methods and processes or improving existing ones, particularly in the pharmaceutical and food industries, academic research groups, research institutes and crop breeding and protection. Graduates participate unsupervised in research teams. They develop and build an experimental test setup, conduct and interpret experiments, draw conclusions and make recommendations. In smaller organisations, the approach is often more hands-on, with the graduate also being responsible for organising, coordinating and directing the work.

Institutions that offer the programme

- Avans University of Applied Sciences, Breda
- HAN University of Applied Sciences, Nijmegen
- Hanze University of Applied Sciences, Groningen
- HU University of Applied Sciences, Utrecht
- Inholland University of Applied Sciences, Amsterdam
- NHL Stenden University of Applied Sciences, Emmen
- NHL Stenden University of Applied Sciences | VHL University of Applied Sciences, Leeuwarden
- Rotterdam University of Applied Sciences
- Saxion University of Applied Sciences, Deventer
- Saxion University of Applied Sciences, Enschede
- University of Applied Sciences Leiden

Diagnostics laboratories in the health sector conduct research into material of human (or sometimes animal) origin. These are usually laboratories working in the fields of clinical chemistry, medical microbiology, cytohistopathology, haematology, immunology, endocrinology or clinical genetic research. Working as researchers, graduates help to find answers to clinical questions by applying scientific methods of analysis in the diagnosis, treatment and prevention of disease. They work throughout the sampling process and it is therefore important for those occupying this post to accumulate the knowledge and understanding required to include clinical data in the performance and interpretation of the research and to make connections between medical issues and (provisional) research results. The great diversity of analyses, ranging from manual to fully automated and robotised analyses, requires versatility and the effective deployment of technologies, equipment, IT and quality assurance. In a laboratory setting, graduates can progress to specialist and/or management roles.

National programme profile

	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	II*	III	_**	I*	I*	I*	I*	II

* At least one of these competences must be raised by one level.
** Students can choose to raise the level of these competences by making certain choices in their range of subjects, internship and graduation project during the last two years of their course.

ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Research and development
- Laboratory researcher
- Animal testing worker
- Vaccine development

Medical laboratory diagnostics
- Analyst in hospital or diagnostic centre
- Introducing new diagnostic tests
- Developing test methods

Application and production
- Quality assurance in food industry
- Small-scale production of drugs

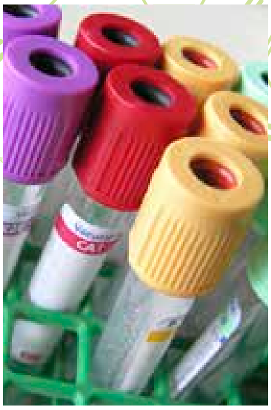
Biology and Medical Laboratory Research

KNOWLEDGE

- **Cell biology:** structure and function of eukaryotic and prokaryotic cells, metabolism, transport
- **Chemistry:** basic chemistry (atomic structure, reactions in water, kinetics), analytical chemistry (spectroscopy, chromatography), organic chemistry (functional groups)
- **Biochemistry:** biomolecules, protein and enzyme chemistry
- **Molecular biology:** DNA, heredity, molecular genetics, recombinant DNA, simple bio-informatics
- **Anatomy/physiology/pathology:** structure and function of organ systems, blood, endocrine system etc., for research and diagnostics (clinical chemistry, haematology)
- **Immunology:** innate and acquired immunity, molecular mechanisms, practical applications
- **Microbiology:** growth and classification of micro-organisms, pathogenetic mechanisms, infectious diseases, resistance
- **Mathematics:** chemical calculations, functions (differentiating, integrating)
- **Statistics:** data processing, normal distribution, confidence intervals, testing

SKILLS

- **General laboratory skills based on GLP rules:** weighing, pipetting, making solutions (buffers, culture media) and preparations, colourings, microscopy, lab journal, chemical calculations
- **Safe working in the laboratory, working in accordance with GMT rules (good microbiological techniques):** working in aseptic conditions, culturing micro-organisms and eukaryotic cells, working with special media, biological materials (tissues, cells, etc.) and biomolecules (proteins and/or antibodies, DNA)
- **Using standard laboratory equipment:** pH meter, spectrophotometer, centrifuge, power sources, electrophoretic equipment, fume cupboard, safety cabinet, microscope
- **Molecular-biology techniques:** DNA/RNA-isolation, digestion, ligation, transformation, PCR, gel electrophoresis
- **Chemical analysis methods:** spectrometry, chromatography, enzyme analysis, bonding analysis
- **(Bio)chemical procedures:** fractionation methods, SDS-PAGE, blotting, preparative chromatography
- **Computer skills:** spreadsheets, slide presentations, bio-informatics tools, simple imaging
- **Social and communication skills:** collaborating, meetings, reporting (lab journal, research report), presentation, project-based work, ethics
- **Research skills:** problem analysis, research questions, desk research, research planning and implementation



The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

TYPICAL TEXTBOOKS

- *Campbell Biology,* L.A. Urry, M.L. Cain e.a.
- *Medical Microbiology,* P.R. Murray, K.S. Rosenthal e.a.
- *Biochemistry,* J.M. Berg, J.L. Tymoczko e.a.
- *Chemistry,* J.E. McMurry. R.C. Fay e.a.
- *Molecular Cell Biology,* H. Lodish, A. Berk
- *Immunology,* D. Male, S. Peebles e.a.
- *Brock Biology of Microorganisms,* M.T. Madigan, K.S. Bender e.a.
- *Bacteriologie voor laboratorium en kliniek,* N.M. Knecht, J. Doornbos
- *iGenetics,* P.J. Russel
- *Toegepaste Wiskunde voor het hoger onderwijs,* J.H. Blankespoor

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Junior scientist Romy Waber:
'You acquire real expert knowledge while you work'

Name: Romy Waber
Age: 22
Course of study: Biology and Medical Laboratory Research
Place of employment: PathoFinder BV, Maastricht
Job: Junior scientist

'I was interested in biology from an early age and found DNA in particular extremely interesting. At the end of my senior secondary education, my subject cluster project was: CSI, what's true and what's not? At the time, we had the opportunity to do the practical work at Zuyd University of Applied Sciences, where I encountered pipettes, test tubes and of course DNA technologies for the first time. I thought this was so interesting and enjoyable that I decided to delve more deeply into biochemistry.

The programme met my expectations, although I thought the first year in my department was somewhat wide-ranging. I knew for sure that I wanted to go further in biochemistry and therefore found subjects like chemical engineering and process technology less interesting, although I did of course understand that a wide-ranging course can be very useful. I wanted to know more about DNA, RNA, PCR and real-time PCR but we only got the basics at university. I therefore went in search of an internship which offered a lot in terms of DNA and RNA technologies and ended up at PathoFinder: a young company which does a lot of research into the development of new molecular diagnostics. It's not only conventional methods that are used, new technologies are also designed and tested there.

As a junior scientist at PathoFinder, I am jointly responsible for developing a point-of-care instrument for diagnosing highly contagious respiratory pathogens, resistance patterns and biomarkers. We are also developing a new generation of molecular diagnostics focusing on the rapid detection and identification of human pathogens caused by an infection. PathoFinder uses multiparameter analysis technologies which are designed to perform analyses of highly complicated samples quickly and easily. As far as I am concerned, education and work fitted seamlessly together, especially as I had completed an internship at the company. You mostly learn general theory during the programme but I think you acquire real specialist knowledge while you work.

I do of course need the competences of **research** and **experimentation** a lot because I am employed in the Research and Development department. **Development** is another important competence. PathoFinder is an ISO 13485 certified company and **management** is therefore also a frequently used competence.

Further study
Over the next few years, I intend to study the various technologies in depth to give me a greater feel for the subject. I would also like to continue participating in international projects so that I can acquire knowledge of other companies and get to know more people in the world of molecular diagnostics. I would like to continue working at PathoFinder or its sister company PathoNostics so that my colleagues and I can put even better and even more products on the market.' ■

General analyst Joyce Scheerman:

'Theory provides a solid foundation'

'Chemistry and biology were my favourite subjects at secondary school. The school counsellor advised me to do a laboratory course. After attending an open day, that seemed to be a good idea. Fortunately, biology and medical laboratory research did indeed turn out to be a very enjoyable and interesting course. I decided to specialise in cyto-histopathology because I used to get good marks for that subject and the specialisation has a lot to do with the human body, which is what attracted me.

My current job involves processing tissues sent in by the hospital and external parties (general practitioners and clinics) so that the pathologists can examine them under the microscope. This means that the samples are assessed macroscopically in the cutting room to ascertain which areas are relevant for making a diagnosis. These areas are excised and processed in a machine to become a paraffin block. Very thin slices are cut from these blocks containing tissue and pasted on to a glass slide. The tissue is coloured (HE). It can then be examined by a pathologist. Further (additional) research can also be carried out on the paraffin block.

The theory part of my programme provided a solid foundation for the work I do now. On the other hand, the practical lessons were minimal in terms of histology and were actually somewhat outdated. During my internships I only used histology techniques for research purposes. Compared with a senior secondary vocational student, higher professional students know little about the practical side of diagnostics. When I came to work in the pathology department at VUmc, I had no idea of what went on in the cutting room.

Various competences

We follow Standard Operating Procedures (SOP) in our work. If we want to change procedures or if, for example, new colourings or pieces of equipment are being used, the competence of **experimentation** is of major importance. Coincidentally, the **development** competence is playing an important role at the moment. This is because we have been involved with **lean management** in the department for a little while. We also use this competence when new equipment is introduced. It is always validated in accordance with a protocol and if necessary a new protocol is written or existing protocols are amended.

We use a number of management systems (chemicals management, quality management, incidents), so I also need the competence of **management**. **Instruction** is also involved in terms of familiarising new staff and supervising interns. The competence of **self-management** also comes into play, as we all work independently and in a group.

In future, I hope to be able to work in a different unit (e.g. molecular biology) within the pathology department and combine this with histology. Maybe I will be able to follow an internal study programme. There are plenty of opportunities!' ■

Name: Joyce Scheerman
Age: 24
Course of study: Biology and Medical Laboratory Research
Place of employment: VUmc, pathology department, histology unit
Job: Histology general analyst

Lean management is a series of methods and techniques for reducing throughput times of processes and cutting costs without compromising on quality.

Biotechnology

The BIOTECHNOLOGY programme trains students for the role of analyst in a professional field which is strongly focused on product development. The emphasis is on the link between knowledge of living organisms and technical applications for making products that people can use.

Institutions that offer the programme

- Inholland University of Applied Sciences, Amsterdam
- NHL Stenden University of Applied Sciences | VHL University of Applied Sciences, Leeuwarden

The professional field for biotechnology analysts can be divided into green, red and white biotechnology. In all these areas, the emphasis is on the link between knowledge of living organisms and technical applications. In green biotechnology, this knowledge is applied to issues arising from agriculture and horticulture. Red biotechnology is concerned with medical issues and white biotechnology is concerned with applications for industrial or laboratory analysis. A biotechnology analyst will have shown a clear preference for one of these colours during his course of study.

In a research and development environment, the BSc is involved in developing new products, organisms (including micro-organisms and plants), materials, methods and processes or improving existing ones. The BSc operates individually within a research team and is often responsible for a separate piece of research. In research, production, quality control or diagnostics, the BSc conducts complex experiments that challenge his practical skills and analytical ability and helps to find the answers to diverse questions. This can happen in laboratories in various areas, ranging from the food industry to laboratories dealing with forensic and agricultural questions. The great diversity of analyses, ranging from manual to fully automated and robotised analyses, requires the effective deployment of technologies, equipment, IT and quality assurance. The BSc can also be involved in or primarily responsible for managing and controlling some or all of a research or production process. Working as part of a team, he develops or applies new technologies or processes or improves existing processes, organisms, products or materi-als. All aspects of sustainability are always taken into account.

National programme profile

	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	III	II	–**	I	I	I	I	III

** Students can choose to raise the level of these competences by making certain choices in their range of subjects, internship and graduation project during the last two years of their course.

ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Research and development
- Researcher
- Forensic laboratory worker
- Vaccine developer
- Plant breeder

Commerce and customer service
- Advisor with consultancy or research firm
- Advisor with safety or environmental consultancy

Application and production in laboratories
- Quality control in food industry or horticulture
- Production of medicines or ingredients

Engineering and manufacturing
- Bio-process engineer
- Production manager
- Reactor designer

Biotechnology

KNOWLEDGE

- **Cell biology:** structure and function of eukaryotic and prokaryotic cells, metabolism, transport
- **Chemistry:** basic chemistry (atomic structure, reactions in water, kinetics), analytical chemistry (spectroscopy, chromatography), organic chemistry and synthesis
- **Biochemistry:** biomolecules, protein and enzyme chemistry
- **Molecular biology:** DNA, heredity, molecular genetics, recombinant DNA techniques
- **Mathematics:** chemical arithmetic, functions (differentiating, integrating)
- **Genetics:** basic concepts and application (e.g. population genetics, QTL analysis)
- **Statistics**: data processing, normal distribution, confidence intervals, testing
- **Bioinformatics:** sequence analysis, annotation of genomes, transcriptome analysis, Bioinformatics Web Services (e.g. EBI, NCBI)
- **Botany:** basic knowledge (evolution, anatomy, photosynthesis, genetics); optional subjects: domestication, resistance, breeding (including at molecular level), hormones, components
- **Immunology:** innate and acquired immunity; optional subjects: autoimmune diseases, immunodeficiency diseases, immunology and cancer, immunology techniques
- **Pathology:** anatomy, physiology and pathology of organ systems
- **Microbiology:** taxonomy, determining and quantifying micro-organisms
- **Sustainability**

SKILLS

- **General laboratory skills based on GLP rules:** weighing, pipetting, making solutions (buffers, culture media) and preparations, colourings, microscopy, lab journal, reporting, chemical arithmetic
- **Safe working in the laboratory, working in accordance with GMT rules (good microbiological techniques):** working in aseptic and sterile conditions, culturing micro-organisms and eukaryotic cells, using special media, biological materials (tissues and cells from plants and animals, blood, urine, etc.) and biomolecules (proteins and/or antibodies, DNA); waste processing
- **Using standard laboratory equipment:** pH meter, spectrophotometer, centrifuge, power sources, electrophoretic equipment, fume cupboard, safety cabinet, microscope
- **Molecular biology techniques:** DNA/RNA isolation, digestion, ligation, transformation, PCR, qPCR, gel electrophoresis; column chromatography; flow cytometry; HPLC and FPLC
- **Chemical analysis methods:** spectrometry, chromatography, enzyme analysis, bonding analysis
- **(Bio)chemical procedures:** fractionation methods, SDS-PAGE, preparative chromatography, western blotting, ELISA, fluorescence microscopy, flow cytometry
- **Computer skills:** word processing, spreadsheets, slide presentations, bio-informatics tools, simple imaging
- **Social and communication skills:** collaborating, meetings, reporting (lab journal, research report), oral presentation, project-based work, ethics
- **Research skills:** problem analysis, research questions, desk research, research planning and implementation

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

TYPICAL TEXTBOOKS

- *Campbell Biology*, L.A. Urry, M.L. Cain e.a.
- *Biotechnologie for beginners*, R. Renneberg, V. Berkling e.a.
- *Plant Biology*, A.M. Smith, G. Coupland e.a.
- *Essential Cell Biology*, B. Alberts, K. Hopkin e.a.
- *Biochemistry*, J.M. Berg, J.L. Tymoczko e.a.
- *Bioprocess Engineering Principles*, P. M. Doran
- *Introduction to Genetic Analysis*, A. Griffiths e.a.
- *Molecular diagnostics: Fundamentals, Methods and Clinical Applications*, L. Buckingham
- *Practical Skills in Forensic Science*, A. Langford, J. Dean e.a.
- *Statistiek, validatie en meetonzekerheid voor het laboratorium*, J.W.A. Klaessens

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Research associate Jelte-Jan Reitsma:

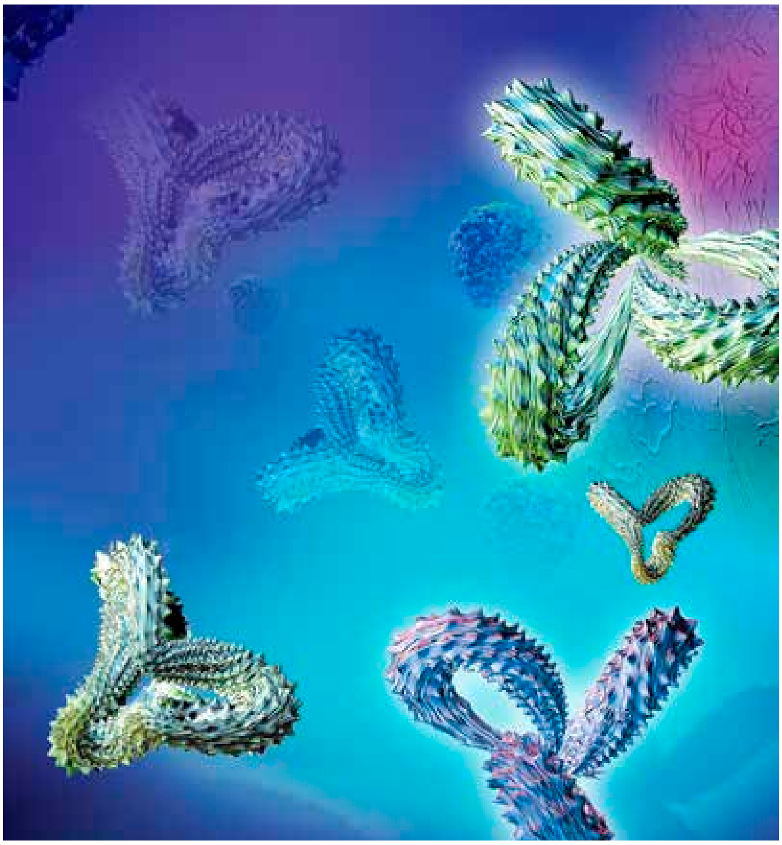
'Collaboration may be the most important competence'

Name: Jelte-Jan Reitsma
Age: 30
Courseof study: Biotechnology
Place of employment: Genmab B.V., Utrecht
Job: Research Associate Cell and Molecular Sciences

SOP: a written work instruction that lays down in detail how a specific action must be completed.

'I began my working life as a joiner. After about a year, I realised that I still wanted to study. I then sat an aptitude test and explored all the higher professional education programmes that aroused my interest. In the end I chose Biotechnology. It's a programme that enables you to do a lot of good things and as a biotechnologist you collaborate much of the time – something that I really enjoy. There are also research groups you can join all over the world.

The programme lived up to my expectations, although project-based working was in its infancy at the time. You certainly noticed that there were still a lot of obstacles to be overcome. As a group, you could split up and all solve small problems.

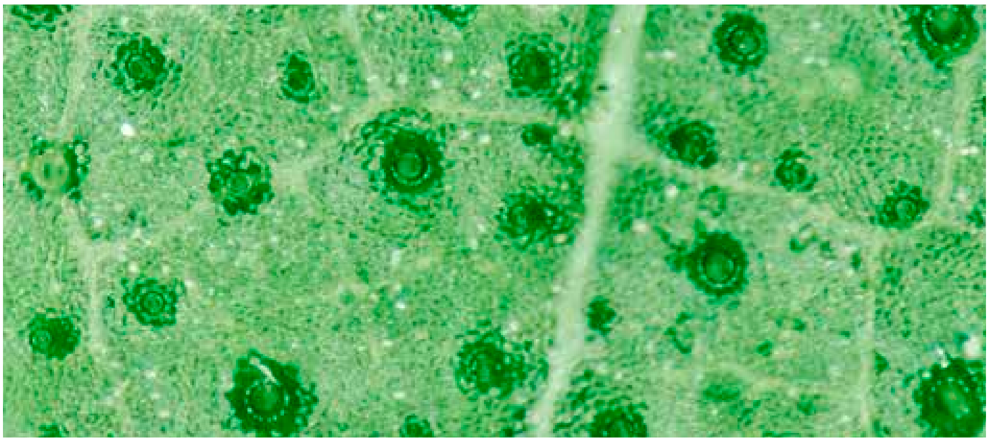


You then had to pull them all together as a coherent whole in the group. All that group work doesn't really teach you how to work on your own, but I think the essence was that you can do more together. My specialisation (process engineering) arose from my particular interest in bioreactors. I wanted to know more about the technology behind them.

I feel that the programme prepared me quite well for real life, although I did miss out on some theoretical background. But it is, of course, a wide-ranging course. My current job mainly involves me in protein production (by means of transient and stable transfections) in bioreactors and other culture bottles. As the laboratory manager, I am also responsible for scheduling cleaning work, placing orders, equipment management and innovations. I also try out new equipment, culture methods and media and specialise in planning and producing cell banks. I discuss deadlines and quantities with project managers. With my own group I discuss who is to perform particular tasks. I enjoy this planning process and would like to be in a management job in future.

Knowing what suits you

Research and experimentation are always important to innovative people. Yet many people have absolutely no interest in them. Their strength may lie, for example, in the perfect completion of work which has to be done in accordance with precise rules (SOPs). In our company, we also use competences. I believe it is highly advisable to first find out what kind of person you are and then consider which competences are in keeping with your personality. This is, of course, difficult, and it will take weeks or months to become clear to most people. Collaboration may be the most important competence. However well you solve problems or conduct experiments on an individual basis, you also have to be able to convey the results to colleagues so that they can also use them.' ■



Biotechnologist Pieter Nibbering:

'As a researcher, you never stop learning'

'After leaving secondary school, I opted for the Higher Laboratory Studies programme because I learned at an open day that the first year would be a mix of Chemistry and Life Sciences (Chemistry, Biochemistry and Medical Laboratory Research). I didn't yet know exactly what I wanted to do and this variety during the first year was an enormous help to me. At a certain point, I decided on Life Sciences and, finally, in the third year, I opted to specialise in Green Biotechnology because that was what suited me best. I am currently busily engaged with my graduation project.

The programme met my expectations, although, if I am honest, I had a completely different idea of laboratory research before I started. I now know that Life Sciences is a very wide concept and that you can find a job anywhere in the world after completing this programme.

For my graduation project, I am working at the Umeå Plant Science Center (UPSC) in Sweden. I am conducting research into the function of a certain protein in *Arabidopsis thaliana* (scientific model organism). I am using a variety of laboratory techniques. This is my second project and I did not have any problems in either project with relating my study course to the professional field. Almost all the techniques I have used had already been covered in the programme. I also believe that I will manage to find a job after this programme, but I would rather continue my studies. After completing this BSc course, I plan to follow the Master course in Plant Biotechnology in Wageningen. I expect that my BSc will stand me in good stead.

Keeping up

To me, the most important competences for a researcher are **research**, **experimentation**, **development** and **self-management**. As a researcher, you actually never stop learning. More new articles are being published each month and more new techniques and protocols are being devised all the time. As a researcher, you have to keep up with the latest trends and that's what makes these competences so important.
Other competences, such as **management** or **leadership | managing people** may become important in future, but that depends on career choices. As a BSc, you will not get a top job in a company, institution or university straight away, but that can change in the course of your career.

I would really like to do a PhD after my Master programme. I don't yet know what the subject will be, but I do know that I want to stay in plant biotechnology. I still have no idea what I will do after my PhD. Time will tell!' ■

Name: Pieter Nibbering
Age: 22 jaar
Course of study: Biotechnology
Graduating in: Green biotechnology

Chemistry

The higher professional course in CHEMISTRY leads to a job as experimental laboratory worker. The professional field of chemistry is the key element. It can be roughly divided into three major components: analytical chemistry, research into and synthesis of molecules and compounds and the development of products based on functional molecules or components.

Chemists working in research laboratories in government institutions and large companies are responsible for the practical implementation of a complete or partial research project. They develop and build experimental test setups, conduct and interpret experiments (or arrange for this to be done), draw conclusions and make recommendations. In research laboratories in the SME sector, the approach adopted is often less fundamental and more applied. In this case, the chemists tasks also include directing, organising and coordinating the work.

In other domains, including application or manufacture, the chemist is mainly employed as an experimental laboratory worker. This can be in environmental laboratories or quality control and production laboratories in the organic, biochemical and analytical fields or similar laboratories. This usually involves conducting complex and intricate experiments that challenge graduates' practical skills and analytical ability. In the manufacturing domain, chemists are involved in product development and introduction, particularly the aspects completed in the laboratory.

Institutions that offer the programme

- Avans University of Applied Sciences, Breda
- Avans University of Applied Sciences, Den Bosch
- HAN University of Applied Sciences, Nijmegen
- Hanze University of Applied Sciences, Groningen
- HU University of Applied Sciences Utrecht
- HZ University of Applied Sciences, Vlissingen
- Inholland University of Applied Sciences, Amsterdam
- NHL Stenden University of Applied Sciences, Emmen
- NHL Stenden University of Applied Sciences | VHL University of Applied Sciences, Leeuwarden
- Rotterdam University of Applied Sciences
- Saxion University of Applied Sciences, Deventer
- Saxion University of Applied Sciences, Enschede
- University of Applied Sciences Leiden
- Zuyd University of Applied Sciences, Heerlen

ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Research and development
- Chemical laboratory research worker
- Product development based on functional components
- Analytical chemist
- Research into new functional molecules or compounds

Application and production
- Analytical chemist in a quality control laboratory
- Laboratory-scale production of molecules or preparations for diagnostic tests or research purposes

Engineering and manufacturing
- Developing analyses for quality control
- Research into parameters of chemical reactions or processes for upscaling

Commerce and customer service
- Safety and environmental consultant
- Sales engineer

National programme profile

	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	III	III	_**	I	I	I	I	II

** Students can choose to raise the level of these competences by making certain choices in their range of subjects, internship and graduation project during the last two years of their course.

Chemistry

KNOWLEDGE

- **Analytical chemistry:** spectroscopy, chromatography
- **Basic chemistry:** atomic and molecular structure, reactions in water, chemical balance
- **Biochemistry:** biomolecules, protein and enzyme chemistry
- **Physical chemistry** (e.g. electrochemistry, phase theory, colloid chemistry)
- **Information technology** (e.g. chemometrics, experimental design, simulation and design programs)
- **Physical applications** (e.g. optics, electronics)
- **Organic chemistry:** synthesising functional groups, reaction mechanisms
- **Polymer chemistry and materials science**
- **Statistics:** data processing, normal distribution, confidence intervals, testing
- **Thermodynamics and kinetics**
- **Health, safety and environment**
- **Mathematics:** chemical calculations, functions, differential and integral calculus

SKILLS

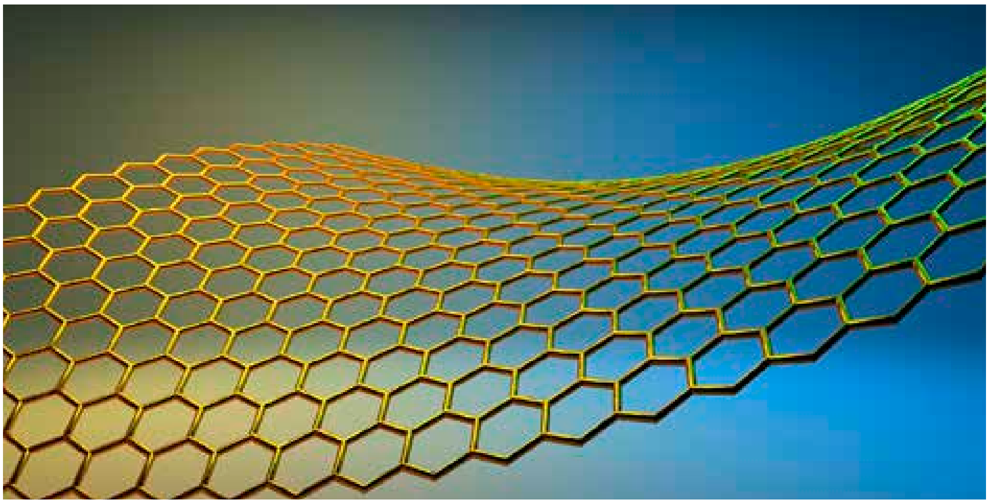
- **General laboratory skills:** weighing, pipetting, making solutions (buffers), keeping a lab journal, chemical calculations
- **Chemical analysis methods:** spectrometry (e.g. UV/VIS, IR, AAS, NMR, ICP), chromatography (e.g. GC, GC-MS, HPLC) and other methods such as titrimetry, electrochemistry, enzyme analysis, bonding analysis
- **Computer skills:** word processing, spreadsheets, chemical drawing programs, presentation techniques
- **Research skills and systematic approach to problems:** problem analysis, preparing research questions, desk research, research planning and implementation
- **Social and communication skills:** collaborating, meetings, written reporting (lab journal, research report), oral presentation, project-based work
- **Safe working in the laboratory in accordance with HSE rules**
- **Using standard laboratory equipment:** pH meter, spectrophotometer, centrifuge, power sources, electrophoretic equipment
- **Using setups for organic synthesis:** reflux, distillation, extraction, evaporators

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

TYPICAL TEXTBOOKS

- *Chemistry*, J.E. McMurry. R.C. Fay e.a.
- *Campbell Biology*, L.A. Urry, M.L. Cain e.a.
- Elements of Physical Chemistry, P. Atkins, J. de Paula
- *Organic Chemistry*, P.Y. Bruice
- *Quantitative Chemical Analysis*, D. C. Harris
- *From Polymers to Plastics*, A.K. van der Vegt
- *Principles of Instrumental Analysis*, D.A. Skoog, F.J. Holler e.a.
- *Statistics and Chemometrics for Analytical Chemistry*, J. Miller, J.C. Miller
- *Exact communiceren*, R. van der Laan
- *Wiskunde voor hoger onderwijs*, S. Kemme e.a.

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.



Support staff member Diane te Brake:

‘A lot of freedom requires self-management’

Name: Diane te Brake
Age: 21
Course of study: Chemistry
Place of employment: Wageningen University
Job: Support staff member in two Chair Groups

‘I chose this course because I had always been interested in natural sciences, especially chemistry. I also believed that chemistry was a course that devoted a lot of attention to research, with a good chance of a job at the end of it. Did the course ultimately meet my expectations? Yes and no. Attending Open Days and Orientation Days does give you a reasonable picture of what the programme involves in advance. But when I actually started on my chemistry programme, I had not been expecting it to contain so many different subjects within it. To that extent, it was a surprise. That’s the time when you really notice how much you still have to learn and how many directions you can go in. I eventually started specialising in nanotechnology because it was a challenging and relatively new subject involving a multidisciplinary approach. Then you’re no longer just a chemist – as a nanotechnologist, you also learn to communicate and cooperate with other disciplines and have to start working with biologists and physicists, for example. That’s why I also chose nanotechnology for my graduation project.

I now work at Wageningen University and have a support role in the two Chair Groups, Physical Chemistry and Colloid Science and Bio-device NanoTechnology. My work is extremely varied. The support I provide is mainly in the area of organic syntheses. Another important task for me is assisting in the first year practical education programme. Of course, I didn’t have much teaching experience in the beginning but I fortunately managed to pick it up quickly. I also feel that the programme and my job fit seamlessly together. Aspects such as setting up experiments and carrying out desk research frequently came up during the programme.

Growth

When I look back on the competences I learned from my programme, I can say that – because of the great diversity of my work – several competences are relevant to me. This applies in particular to the competences of **self-management** and **instruction**. Self-management because I have a lot of freedom in scheduling work and instruction because I use this competence to provide explanations to a group of students.
I see a lot of opportunities for growth in my current job. I can also take courses within the university, which organises a lot of lectures; I also find group discussions with debates very instructive.’

Chemical analyst Rudy van Eekelen:

'Real learning begins at work'

'At secondary school, I had most fun in chemistry. I didn't know exactly what I wanted to do, so I just chose my strongest subject. I did a higher professional course in chemistry which, in retrospect, was a good decision. Fortunately, I still had a number of demanding teachers on that course as I'm afraid that standards are slipping at secondary level and therefore also at higher professional level.
My choice of graduation project was mostly dictated by the fact that I wanted to learn something new and use technologies that I hadn't seen at school. At Philips I was given the opportunity to set up **liquid XRF** at the Materials & Analysis lab in Eindhoven.

I was taken on by Philips to carry out wet chemical analyses, especially titrimetric and ICP determinations. Because the workload was too low for me, I got myself transferred to another group in the department. I now do XRF, micro XRF and glass property determinations. I am responsible for and specialise in the micro XRF system that was purchased a year and a half ago.

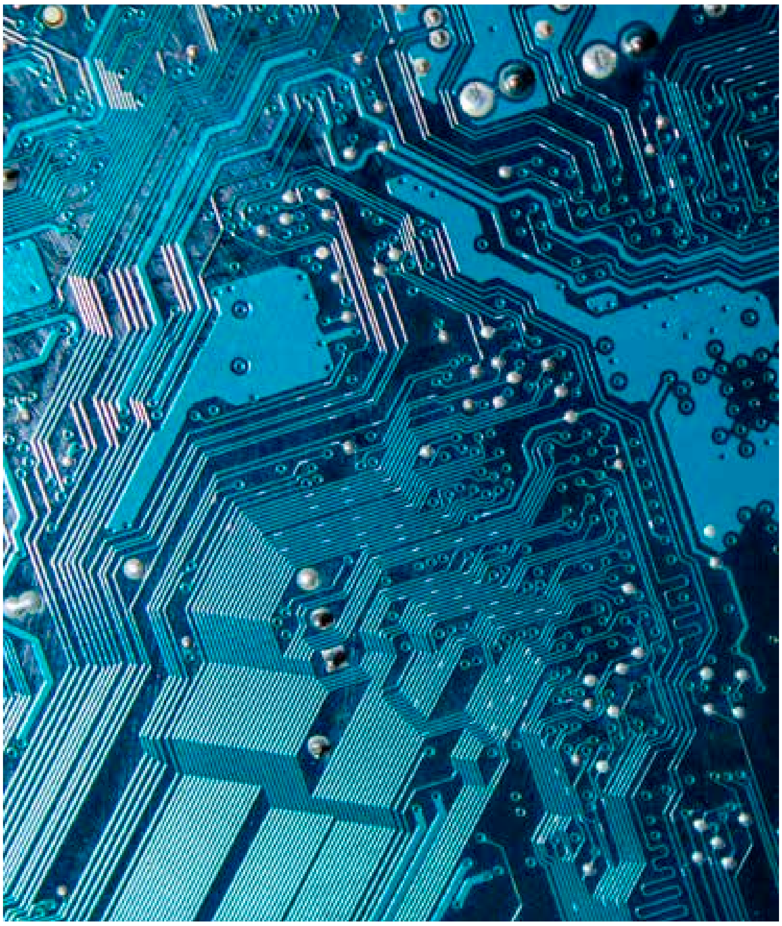
New technologies
I think a chemistry programme provides you with a relatively small foundation of knowledge. Because real learning only begins when you start work. In my case, the programme did not fit so well with the job that I eventually did, because most of the technologies I needed for my work did not feature in the programme. That's understandable, as it's just too expensive for a higher professional establishment to maintain technologies such as ICP (due to the high cost of argon consumption. However, learning how to write reports and network has actually been very useful in the professional field.

'Competences' are hardly ever used in my job. I do of course do a lot of **research** and **experimentation**, especially with establishing new measurement methodologies on the new micro XRF system. I am, to a great extent, allowed to decide for myself the working methods to use. I get help from colleagues who have a wealth of experience of the department's commonly used working methods.

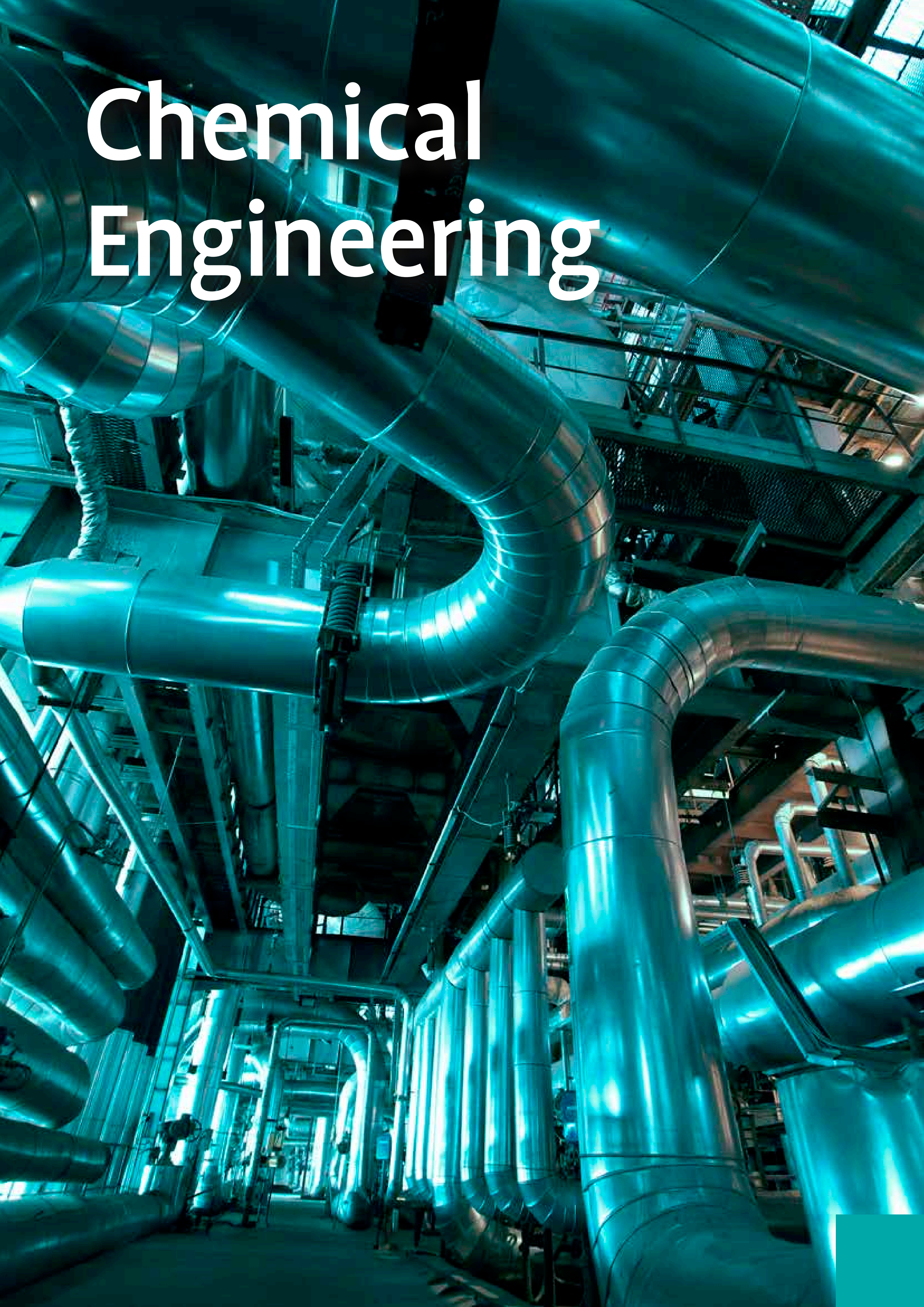
So long as I can continue to grow and learn, I am doing really well in my current job. I have agreed with my manager that the intention is for me to move on to a new and/or more senior job within six years. I've set my sights high!' ■

Name: Rudy van Eekelen
Age: 24
Course of study: Chemistry
Place of employment: Philips
Job: Chemical analyst

XRF is a non-destructive, rapid quantitative analysis method for all the elements in the periodic table, from boron to uranium.



Chemical Engineering



The CHEMICAL ENGINEERING programme trains professionals involved in the production process in the process industry, with the emphasis on the chemical industry. Graduates concentrate their efforts on designing, developing, upgrading, implementing and evaluating integrated systems of plant and equipment, energy, materials, feedstocks and processes in the process industry.

The chemical engineer's objectives are to optimise reliability, ensure safety and meet product specifications while eliminating wastage of materials, energy, time and other resources. The chemical engineer knows about physical and chemical processes, product characteristics and process steps and is able to place all of this within the context of more abstract theoretical models.
Graduates are involved in or even primarily responsible for managing and controlling some or all of the production process. Working as part of a team, they develop or apply new processes or improve existing processes, products or materials. To this end, they consult both operators and senior management and external parties, take decisions on process changes or prepare for these decisions and report on the normal or abnormal progress of the process, changed process conditions and the result.

Because of the powerful focus on the process industry, graduates can also be deployed more widely throughout the process industry, including the food or paper industry, waste processing, in water supply companies and in the bio-process industry.

ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Engineering and manufacturing
- Process engineer
- Project manager for upscaling
- Production process designer
- Production quality manager
- Production safety officer
- Process engineer and troubleshooter
- Production manager and plant manager
- Pilot plant manager
- Manager of a production line

Research and development
- Product developer for chemical products
- Product developer for production facilities such as reactors and separation technology

Commerce and customer service
- Safety and environmental consultant
- Fire officer

National programme profile

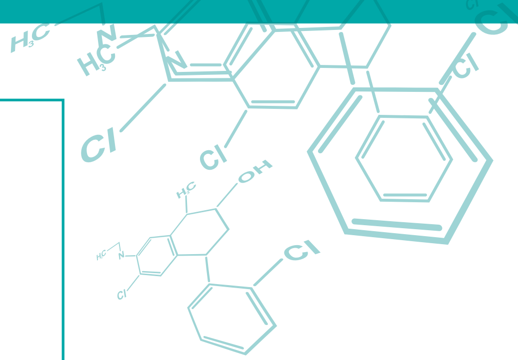
	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	II*	II	II*	I	I	_**	I	II

* At least one of these competences must be raised by one level.
** Students can choose to raise the level of these competences by making certain choices in their range of subjects, internship and graduation project during the last two years of their course.

Institutions that offer the programme

- Avans University of Applied Sciences, Breda
- The Hague University of Applied Sciences, The Hague
- Hanze University of Applied Sciences, Groningen
- HU University of Applied Sciences, Utrecht
- NHL Stenden University of Applied Sciences | VHL University of Applied Sciences, Leeuwarden
- Rotterdam University of Applied Sciences
- Saxion University of Applied Sciences, Enschede

Chemical Engineering



KNOWLEDGE

- **Safety*:** personal safety, process safety (e.g. HAZOP) and environmental aspects
- **Unit operations:** heat exchangers, separation techniques (e.g. distillation and membrane technology)
- **Thermodynamics**: 1st and 2nd main law, phasing, chemical thermodynamics
- **Statistics and mathematics:** chemical calculations, differentiation, integration, differential equations, reliability of measurements, data processing and data analysis (e.g. statistical tests, statistical software)
- **Chemical reaction engineering:** model reactors (batch, CSTR, PFR), kinetics (e.g. reaction mechanisms, catalysis, enzyme kinetics)
- **Process engineering:** process design (e.g. BFD, PFD, P&ID), measurement and control technology, process control
- **Process modelling:** simulation, modelling (e.g. stationary, non-stationary), experimental design, optimisation
- **Materials science:** material properties (e.g. metals, plastics) and applications for materials (e.g. processing techniques)
- **Physical transport phenomena:** fluid dynamics, mass and energy balances, stationary and non-stationary models
- **Chemistry:** *basic* (atomic and molecular construction, reactions in water, chemical equilibrium), *analytical* (such as spectroscopy, chromatography), *organic and polymer chemistry* (such as synthesis, functional groups, reaction mechanisms)
- **Economic aspects:** e.g. cost price calculations, operational and investment costs, feasibility studies

SKILLS

- **Research skills and systematic approach to problems:** problem analysis, preparing research questions, desk research, research planning and implementation
- **Design skills/upscaling:** translating lab-scale/pilot-scale experiments to production scale, setting up process models
- **ICT skills:** use and deployment of state-of-the-art digital tools/software (e.g. simulation, design, reporting and presentation software, data analysis and processing software)
- **Experimenting with pilot set-ups:** separation equipment (e.g. distillation, extraction, membranes), flow equipment (e.g. heat exchanger, pump) or reactors
- **Morally responsible actions:** making responsible choices based on safety, sustainability, technological and economic criteria
- **Safety at work in laboratory and industrial environment**
- **Social and communicative skills:** collaborating, issuing reports and giving presentations (internationally, at all events in English and locally e.g. in Dutch), project-based work
- **General laboratory skills and chemical analysis methods:** conducting experiments at laboratory scale, performing chemical analyses (e.g. titration, spectrometry, chromatography)

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

*The Chemical Engineering Safety Curriculum has been developed especially for the Chemical Engineering courses, in collaboration with the professional field. This is a comprehensive educational programme that is in line with the BoKS and that has been included in the curriculum by a number of programmes.

TYPICAL TEXTBOOKS

- *Chemistry*, J.E. McMurry. R.C. Fay e.a.
- *Shreve's Chemical Process Industries*, G.T. Austin
- *Elements of Physical Chemistry*, P. Atkins, J. de Paula
- *From Polymers to Plastics*, A.K. van der Vegt
- *Exact communiceren*, R. van der Laan
- *Wiskunde voor hoger onderwijs*, S. Kemme e.a.
- *Procestechnologie*, VAPRO
- *Chemical Engineering Volume 1: Fluid Flow, Heat Transfer and Mass Transfer*, J.R. Backhurst, J.H. Harker e.a.
- *Elements of reaction engineering*, H.S. Fogler
- *Statistiek om mee te werken*, A. Buijs
- *Chemical Engineering Safety Curriculum*, see https://appliedscience.nl/ veiligheidsonderwijs

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Chemical engineer Hanneke Bukkems:
'Social skills are very important'

Name: Hanneke Bukkems
Age: 28
Course of study: Chemical Engineering
Place of employment: Nyrstar Budel
Job: Chemical engineer

'In the first year of my studies, I opted for chemistry and subsequently, more specifically, for chemical engineering. That seemed to suit me best – abstract, a lot of working with figures, a man's world, good prospects. I discovered during my graduate internship that I had definitely made the right choice. I really wanted to do my graduate internship abroad and ended up at Nyrstar Hobart in Australia, where I was allowed to work on all kinds of assignments of my own. I got the ideas for them by talking to operators, heads of department, technicians, laboratory staff, etc. I also took a good look around me, for example at possible ways of improving the process and the business (can operations be simplified? Can test results be improved by using different analysis methods, etc?).

As a chemical engineer, I am responsible for one of Nyrstar Budel's four production departments. I look at ways of improving the current process, cutting costs, facilitating increased production, making the process more stable or, for example, extending the service life of materials. I also monitor the statutory environmental standards for emissions, waste, etc. and make adjustments where necessary. In addition, I am involved in maintenance when, for example, the catalyst in a reactor has to be inspected, replaced, etc. I then delve into the relevant history, contact contractors/experts, consider the pros and cons of the different suppliers, etc. And I have all kinds of routine duties. For example, I check a number of standard graphs (flows, pressures, temperatures, etc.) and test results every day, discuss them and, if necessary, adjust them. To do this, I work with a lot of people, including laboratory staff, mechanical engineers, technicians and operators.

Clear advice

The competences of **research**, **experimentation** and **development** are very relevant to my job; supervision, coaching, instruction and leadership | managing people less so. I have a very independent job that requires you to give properly substantiated, clear advice so that even a manager who is not familiar with the problem can understand you and take a well-considered decision. You also have to give instructions to or obtain information from operators, laboratory staff and external experts on a regular basis. Communication and social skills are therefore very important.

The theory you learn during the programme is very useful as a foundation and the practice gives you an idea of what the equipment does. The thing that was missing from the programme for me was: what happens if a graph does not follow the standard course or the analysis results are not within the specifications? What can be wrong and how can I solve the problem?

In future, I would like to work internationally, e.g. as an expert in shutdowns (overhauling production plants). Fortunately, I can continue to grow in my job with my current employer.' ■

R&D engineer Erik Heijkamp:

‘There are always processes that can be optimised’

‘I was looking for a course that featured physics and chemistry and offered good prospects of future employment. Working in projects with different companies really appealed to me and I thought it was an advantage that my programme was provided entirely in English as that is almost indispensable in this professional field. So I opted for chemical engineering. It turned out better than expected: I had fellow students from all over the world and got to know many different cultures. I did my graduation project at DSM Special Products, where I made a basic engineering design for an extraction/pertraction system. I ended up at DSM through a friend, eventually arriving here at Unilever via Dosign Engineering.

I specialise in testing detergents for the European market: setting up and running my own tests, performing analyses and reporting the results and possibly obtaining claim support from them. I also make sure that the equipment keeps working and is in good condition, and I am on the lookout for possibilities of optimising the work.
In addition, I am responsible for maintaining the water plant – a plant in which all types of water (every country in the world has a different type of water) at different levels of hardness are produced. This system consists of all kinds of pumps, tanks and chemicals and is used by different departments at Unilever. Added to this is troubleshooting: you’re expected to put down your work immediately when problems arise. Of course, prevention is better than cure but everything wears out eventually.
I feel that the programme and my job fitted seamlessly together. You do gain an insight into how certain processes work, which allows you to detect problems more quickly. You can also do calculations more quickly and predict reactions of certain liquids. The only thing is that I am doing less engineering now, which I do sometimes miss.

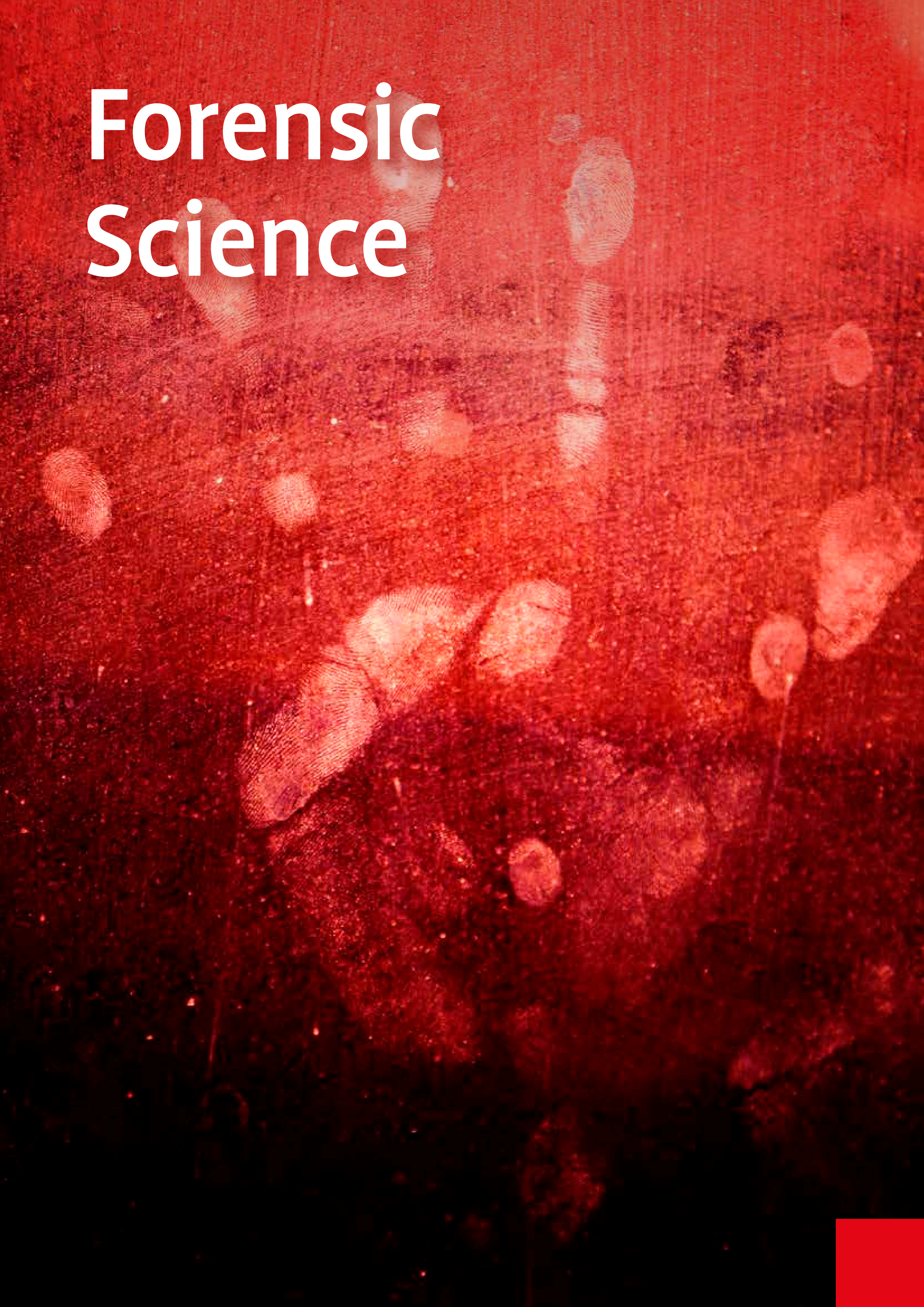
Own initiative

There are always processes or operations that can be optimised. This is done on the basis of **research** and **experimentation**. These two steps must be completed properly so that you can convince your boss of all the advantages and disadvantages. It is always appreciated when you develop certain ideas on your own initiative, **manage** them and make plans which will improve things in future.
I sometimes work on projects with a number of people and sometimes alone. It is important that you should be able to **manage** your work effectively and also give responsibility to other people. This will often require some coaching, but if you do it properly you will benefit from it more later and be able to achieve more.

I am very happy with my current job, where I still have many new things to learn and organise. Eventually, I would like to progress within Unilever. I would like to **train** and **advise** more people in my professional field, which I’m doing too little of at the moment.’ ■

Name: Erik Heijkamp
Age: 24
Course of study: Chemical Engineering
Place of employment: Unilever R&D
Job: R&D engineer laundry

Forensic Science



The FORENSIC SCIENCE programme trains professionals who investigate the facts of a crime or incident. They help to solve a crime or incident with the aid of scientific, digital, investigation and detection techniques.

Forensic analysts and investigators work in all kinds of professions where the question of cause or guilt must be established. This involves not only crimes, but also incidents such as fire, fraud, accidents, or damage caused by the failure of products, materials, constructions or human actions. A forensic investigator can therefore work at an 'incident scene' or 'crime scene', but also in analytical, medical or forensic laboratories. In the legal profession or insurance industry, a forensic investigator will often act as an advisor or policy officer. In addition, forensic investigators make an innovative contribution to the field by developing new methods and techniques and/or applying existing techniques in a different context (forensic engineering). In all cases, forensic investigators are able to use their knowledge of natural sciences, investigative techniques and technology to help establish the circumstances of a crime or incident and who is (or is not) responsible for it.

Occupations, positions and roles of the Bachelor can be found in the following professional domains (for a full description of the professional domains, see Chapter 2). The professional field can be defined in 'classic' FS professions, in which forensic investigation plays a key part. Growth in the field of forensic engineering is particularly rapid. Since a detailed definition of the posts in which forensic investigators work would lead to too narrow a definition of the developing professional field, we are not attempting to do so for the time being.

Institutions that offer the programme

- Amsterdam University of Applied Sciences
- Saxion University of Applied Sciences, Enschede

Research and development
- Forensic (digital) specialist, (research) analyst or digital investigator (with the National Police, ECFO, the NFI or, for example, the NVWA)

Application and production
- Forensic crime scene investigator (operational specialist) (with the National Police)

Medical laboratory diagnostics
- Research analyst (chemical or biological) in the lab (e.g. NFI or Sanguin)

Engineering and manufacturing
- Forensic engineer, fire investigator or failure analyst (at various engineering firms)

Commercial and services sector
- Private investigator, commercial advisor or investigator (with insurance companies, in the legal profession or for one of the Dutch security regions)

KENMERKENDE STUDIEBOEKEN

- *An Introduction to Forensic Genetics,* W. Goodwin, A. Linacre e.a.
- *Essential Forensic Biology,* A. Gunn
- *Forensic Chemistry,* S. Bell
- *Fundamentals of General, Organic, and Biological Chemistry,* J.E. McMurry, D.S. Ballantine
- *Principles of Forensic Toxicology,* B.S. Levine, S. Karrigan
- *Shooting Incident Recontruction,* M.G. Haag
- *Forensic Science, A.R.W. Jackson,* J.M. Jackson
- *Introductory Statistics For Forensic Scientists,* D. Lucy
- *Seeley's Essentials of Anatomy and Physiology,* C. Vanputte, J. Regan e.a.

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Programme profile

	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	III	II	II	II	III	I	I	II

Forensic Science

KNOWLEDGE

Biology

- **Cell biology:** structure and functioning of micro-organisms and cells, metabolism, biomolecules
- **Molecular biology:** DNA, heredity, DNA sampling and analysis, operating DNA databases
- **Anatomy/physiology/pathology:** construction and function of skeleton, skin and organ systems, blood, hormone system, consequences of injuries, autopsy
- **Entomology:** decomposition phases, succession of species on human remains

Chemistry

- **Basic chemistry:** atomic engineering, reaction equations, chemical calculations, reactions in water, kinetics, chemical equilibrium
- **Analytical chemistry:** sample preparation, spectroscopy, chromatography, gunshot residue analysis techniques
- **Organic chemistry:** nomenclature, functional groups, reaction mechanisms, narcotics
- **Toxicology:** pharmacokinetics and toxins
- **Fire and explosion:** chemistry and physics of fire, fire accelerators, flammability limits, reaction heat

Physics

- **Mechanics:** laws of motion, braking, collision and deformation
- **Strength of materials:** strength, moment, load
- **Ballistics:** determination of range and position, comparative examination of cartridges and projectiles
- **Optics:** light, imaging, image analysis
- **Materials science:** strength, fracture, deformation
- **Heat transfer:** conduction, convection, radiation

Informatics

- Computer forensics, data management, networking, internet forensics, cybersecurity, cybercrime

Statistics

- Data processing, normal distribution, confidence intervals, testing
- Using statistics/calculation of probability when determining evidential value
- Determining the evidential value of DNA analyses (Bayesian statistics)

Legislation

- Principles of Dutch law, criminal proceedings, criminal evidence law and substantiation requirements
- Lawfulness and reliability of the evidence-gathering process (e.g. expert witness in criminal cases)

SKILLS

- **Research skills and systematic approach to problems:** problem analysis, preparing research questions / hypotheses / scenarios (including for establishing the truth), desk research, research planning and implementation
- **Social and communication skills:** empathy, interviewing, collaborating, meeting, written reporting, oral presentation
- **Information skills:** word processing, spreadsheets, drawing software, presentation techniques, digital information searches and research
- **Skills at scene of crime/scene of incident:** using an (objective) description to make a sketch and a photographic record, managing the securing of biological, chemical and physical evidence, interpreting it and investigating how it relates to hypotheses / scenarios
- **Forensic examination techniques:** e.g. dactyloscopy, hair and fibre examination, scratch, impression and shape marks, presumptive tests on biological evidence
- **Identifying, securing and interpreting digital evidence**
- **Bloodstain pattern analysis**
- **Performing or arranging analyses of traces and/or physical evidence in compliance with standards**
- **Using standard laboratory equipment:** performing simple chemical, physical or biological analyses in a laboratory.

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

Operational Specialist Jurgen van Eldik:

‘A crime scene is actually one big complicated jigsaw puzzle’

‘After completing higher secondary education (HAVO) (NT profile) I opted for the Forensic Science programme, because detective work seemed incredibly cool to me. Luckily, the programme turned out to be highly practice-oriented, so that you are well prepared and no day is actually boring – you feel like you are already solving crimes. I was determined to graduate with the police; I felt a clear affinity with the cold case team, so I did my graduation research there.

In my current job as an Operational Specialist, I participate in the forensic investigation, which means that we go to a crime scene – of a murder, for example, or a burglary or fire – and conduct an on-site investigation to establish the truth. At the moment, I’m still in the early stages of my career. Since this job is subject to a lot of rules and legislation, you have to do a lot of internal follow-up training before you can really participate in a call-out. This sometimes requires a lot of patience, because every day you are confronted with one fascinating situation after another, which you consider to be an ‘adventure’ in which you want to help out.

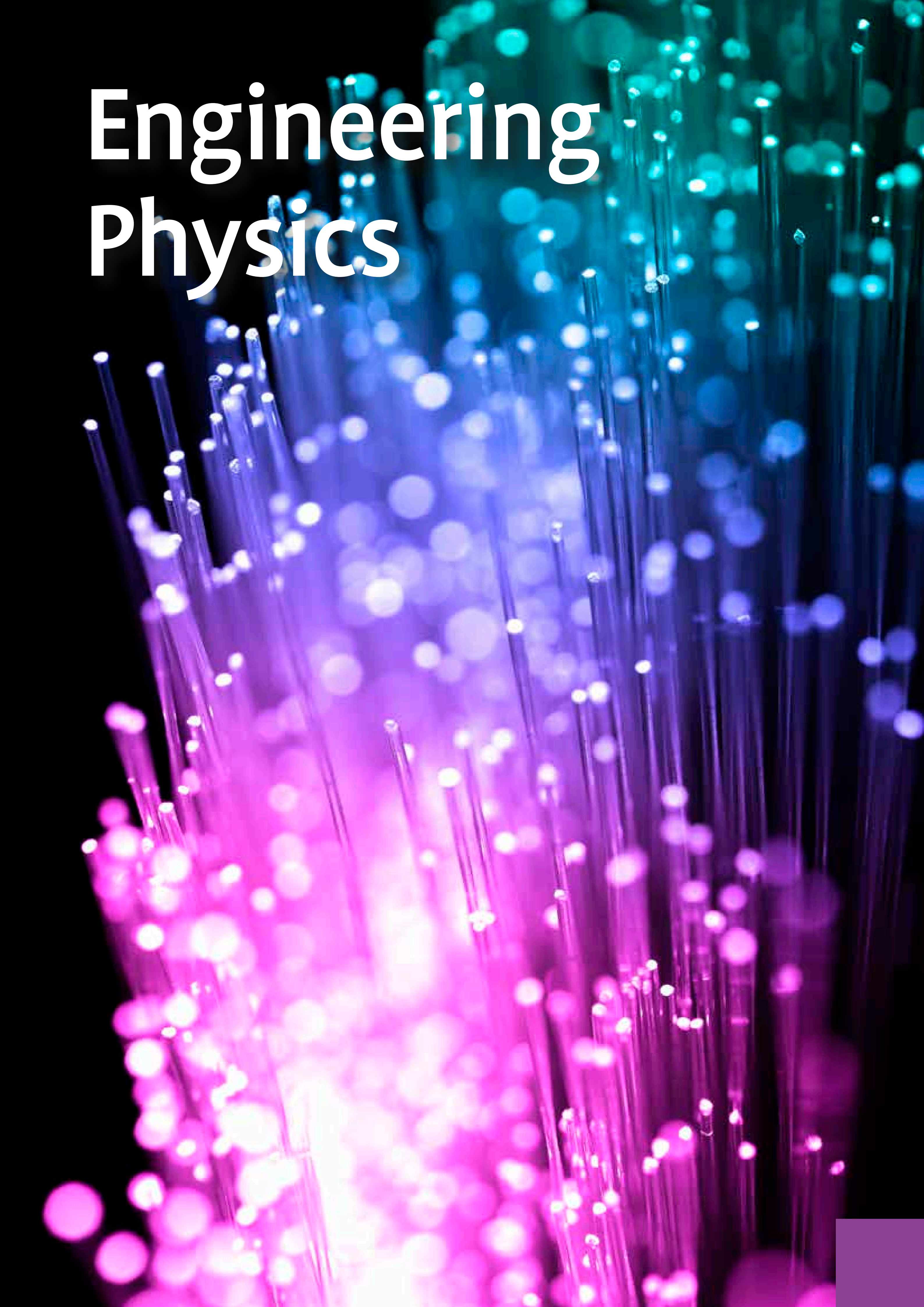
In principle, all facets of the work had been fully covered in the programme. The lessons were also always linked to a project, in the form of an actual investigation, which made the link with the real world very clear. In practice, the work is more clearly split between the call-out and the follow-up investigations in the lab. It is, of course, a higher professional (HBO) programme, so the emphasis is placed on the theory behind different methods and the investigations in the lab. In the lab, a graduate will be up to speed almost immediately, but at the crime scene you really need to gain experience to be able to participate. Of course, the knowledge you have obtained during the programme helps enormously.

The competences of **research**, **development** and **experimentation** are important in my job. A crime scene is actually one big complicated jigsaw puzzle that you try to solve through investigation. The job is constantly evolving – involving, for example, new techniques for finding and/or securing evidence. You have to stay curious all the time and be able to hang on in there. **Self-management** is important; the police is a large organisation which offers a lot of possibilities, but you have to be assertive and be able to stand your ground.

Over the next few years, I want to gain a lot of practical experience, which is very important in this job. My current position is the best fit for that at the moment, so for now I’m not thinking about anything else. It may not sound very ambitious but, actually, this is simply my dream job!’ ■

Name: Jurgen van Eldik
Age: 27
Course of study: Forensic Science
Place of employment: National Police, Forensic Investigation, East Netherlands Unit
Position and responsibilities: Operational Specialist A

Engineering Physics



The higher professional course in ENGINEERING PHYSICS leads to a job as an applied physicist. Through research and experimentation, this graduate amasses knowledge and information that contribute to solutions for technological problems and provide opportunities for new technological developments.

The working methods of applied physicists are characterised by the fact that they operate at the interface of theory, modelling and experimentation. They try to establish a link between the results of these approaches, verifying theories by means of experimentation wherever possible. Engineering physics as a professional field is continuously developing. A thorough knowledge and understanding of the theory of the basic sub-fields within physics is needed in order to operate in the field as an applied physicist. An applied physicist has an understanding of key physical concepts and can apply them in practical situations. The most important skills required of an applied physicist consist of the ability to carry out research, make model-based calculations and to set up, prepare and conduct experiments. Physics-related issues arise in a variety of fields of activity, including sensor technology, photonics, nanotechnology, sustainable energy and medical technology.

Institutions that offer the programme

- Fontys University of Applied Sciences, Eindhoven
- The Hague University of Applied Sciences, Delft
- Saxion University of Applied Sciences, Enschede

National programme profile

	Competence							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership	Self-management
Minimum national attainment target adopted for the programme	III	III	II	I	II	I	I	II

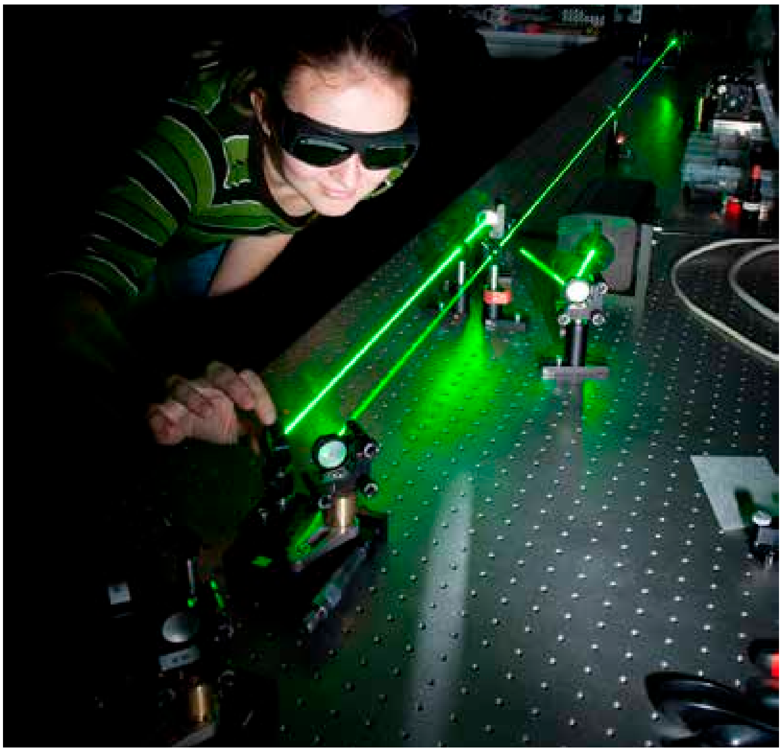


ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Research and development
- Engineering Physics researcher
- Project or development engineer
- Engineering Physics designer
- Photonician
- Metrologist

Engineering and manufacturing
- Metrologist/test engineer
- Product developer
- Process engineer
- Quality engineer

Commerce and customer service
- Medical physicist
- Service engineer
- Building physicist
- Radiation expert
- Audiologist
- Meteorologist
- Energy engineer
- Adviser/consultant

Engineering Physics

KNOWLEDGE

Physics

- Classical mechanics
- Electromagnetism
- Quantum mechanics
- Thermodynamics
- Waves and vibration
- Optics
- Properties of matter: elementary components and their interactions
- Atomic physics
- Nuclear and particle physics
- Acoustics
- Materials
- Fluid dynamics

Mathematics

- Calculus: elementary analysis and (linear) algebra
- Laplace and Fourier transforms
- Statistics and probability theory

Engineering

- Measurement and control technology
- Vacuum technology
- Energy engineering
- Electronics and signal processing
- Micro- and nanotechnology
- Laser technology
- Programming and data acquisition

SKILLS

- **General skills:** communication and collaboration, project-based work, systematic approach to problems
- **Skills relevant to the experimental approach:** building and managing test rigs and measurement systems, performing data acquisition for measurement system, programming, software including Labview, Excel, Matlab, programming languages
- **Skills relevant to the model-based approach:** using calculation and simulation software, designing a calculation or simulation program, programming, software including Matlab/Simulink, Maple, Comsol Multiphysics, Ansys

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

TYPICAL TEXTBOOKS

- *Physics for Scientists and Engineers with Modern Physic,* D.C. Giancoli
- *Optics,* E. Hecht
- *Warmteleer voor technici,* A.J.M. van Kimmenaede
- *Regeltechniek voor HTO,* J. Schrage, H. van Daal
- *Applied Statistics and Probability for Engineers,* D. C. Montgomery, G.C. Runger
- *Polymeren, van keten tot kunststof,* A.K. van der Vegt, L.E. Govaert
- *Multiphysics Modeling Using COMSOL 4,* R.W. Pryor
- *OPTO-electronics: An introduction,* J. Wilson, J.F.B. Hawkes
- *Introductory Digital Signal Processing with Computer Applications,* P.A. Lynn, W. Fuerst
- *Fundamentals of Thermal Fluid Sciences,* Y.A. Cengel, R.H. Turner e.a.

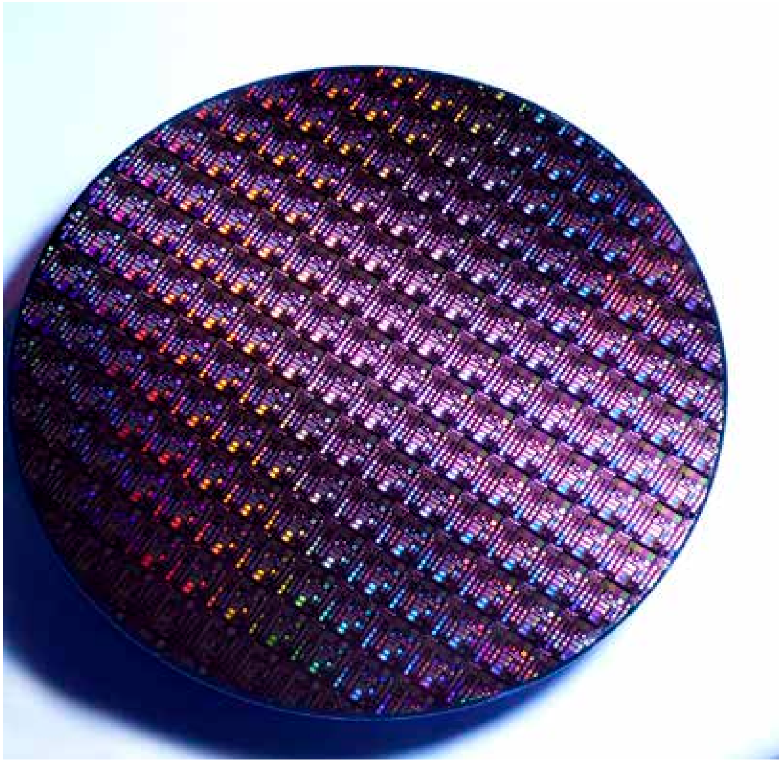
The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Operational coordinator Hans Beckers:

‘The programme leaves you with technical baggage’

Name: Hans Beckers
Age: 41
Course of study: Engineering Physics
Place of employment: ASML Veldhoven
Job: Operational coordinator First Line Support NXE

‘With my pre-university diploma, I initially decided to study Engineering Physics at Eindhoven University of Technology. I had a wide range of subjects, the exact sciences suited me and I thought it would be good to focus on complex issues. Thinking out of the box – that appealed to me. However, after nine months I realised that too little time was devoted to practical work, common-or-garden physics. I then switched to the higher professional course in Engineering Physics and this seemed to fit in much better with my need for everyday physics. The application of technology in the world of medicine came up during the programme. That appealed to me, so I did an internship at Verbeeten Institute in Tilburg, a specialist hospital which provides top clinical care in the area of oncology and nuclear medicine. Choosing a specialisation wasn’t difficult: Engineering Physics. I found my graduation project through my own network at Phillips, where I worked on “modelling for optical grooves”. My work has contributed to the fact that the DVD is as we know it today.



At AMSL we manufacture precision lithographic machines for the chip industry. In my current job, I am responsible for managing all failures in part of the production process of ASML’s most advanced machines. I make sure that the problems are solved to the internal or external customer’s satisfaction within the applicable time.

Commercial thinking

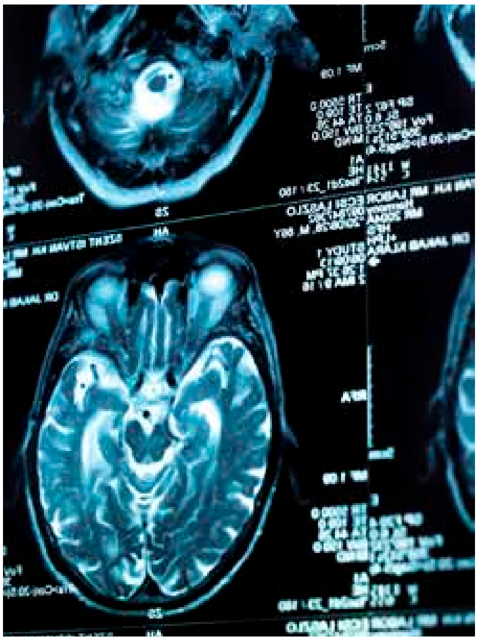
After spending a few years in “technology”, I am now more involved in guiding/coaching people, skills which I picked up through additional training. Another part of my job is to set up and standardise processes. This requires a more project-based approach. **Coordination | coaching | supervision** are things that I still use every day. At university, I feel, not enough attention was paid to working and thinking in a commercial way. You can come up with the most fantastic experiments or research, but they have to fit in with the customer’s time and cost frame.

The Engineering Physics course leaves you with a certain technical baggage, and from these foundations you start to specialise in specific subjects in industry. These are almost impossible to teach in the programme as it would be too specific. Structural thinking, analysing data and transferring knowledge are things to which attention was paid in the programme and which are useful in every organisation.

There are a lot of opportunities at ASML, it’s a large and diverse company. In the near future, the focus of my job will be shifting further towards the project-based delivery of processes, but my ambition still lies in the area of people management.’ ■

Clinical physics assistant Ruud Cools: 'I was looking for answers to my questions'

'When I got physics for the first time at secondary school, I discovered that I found it really interesting. But I still had questions and I therefore decided to choose a course of study that could possibly answer my questions. As my interests are so wide-ranging, a wide-ranging programme was a requirement. My physics teacher told me about the Engineering Physics programme and, after I had requested information, I quickly made my choice.



Name: Ruud Cools
Age: 26
Course of study: Engineering Physics
Place of employment: Erasmus MC
Job: Clinical physics assistant

The questions that I had at secondary school were of course answered. Fortunately, they were replaced by more questions. As well as learning answers during my programme, I also learned techniques that enabled me to answer my questions myself. I enjoyed research so much that I tried to find a subject that I could research for my graduation. I had always been fascinated by light and therefore choose a subject within photonics (physics subject that focuses on interaction between photons and electrons).

I'm currently working in the radiotherapy department of the Erasmus MC, where cancer patients are treated with radiation. The quality of their treatment is very important and, as a clinical physics assistant, you have an essential role to play in this regard. The work is extremely varied. For example, we take measurements of the accelerators to ensure that they are still working properly. Sometimes, in order to take measurements, you have to develop new measurement and analysis methods. In addition, radiotherapy involves a great deal of innovation. These innovations first have to be checked and tested before we can use them in the clinic. Sometimes they are software solutions for obtaining the optimum radiation level and sometimes hardware solutions are also involved. My colleagues and I then have to devise tests to be able to guarantee that everything will work properly. There are also opportunities for working on research and innovation yourself. For example, I am currently creating a software application that will enable us to control the operation of the accelerator when it is administering a very complicated radiation treatment.

First learn physics

Every day in my work, I need the analysis technique and way of thinking I learned during my programme. However, you do acquire technical knowledge at school that you only need sporadically, if at all. My personal opinion is that as little emphasis as possible should be placed on competences other than the competence of **development**. That may sound harsh, but more than anything it is essential that students are trained to become good physicists. If someone is interested in making progress in other competences, they will pursue this interest themselves. In addition, working in industry is a very good apprenticeship for learning these "secondary" competencies, but you definitely have to have sufficient knowledge of the subject first. So learn physics first – the other competences will follow.' ■

Environmental Science

The higher professional course in ENVIRONMENTAL SCIENCE leads to a job as an environmental engineer. Essentially, this involves sustainably improving the environment, ranging from clean air, soil and water to, for example, waste recycling. This is done from a foundation of applied science, bearing in mind what is achievable in terms of society.

Environmental engineers mainly work in consulting and engineering firms, where they are responsible for conducting research. They collect data (from field work, desk research, laboratory research), analyse and interpret this data and help to formulate and design solutions. It is very important that the work is customer-oriented and project-based. Similar advisory roles are also performed in the industrial domain, as a member of a staff department focusing on improving the sustainability, environment and safety of the company. Communication skills are essential as the role involves interaction with stakeholders.

Institution that offers the programme

- Avans University of Applied Sciences, Breda

In the role of environmental technologist, there is greater emphasis on improving technologies (e.g. for a water treatment plant); as a researcher or assistant researcher, graduates collect and interpret data on the quality of the environment. In the case of government bodies, such as environmental agencies, the environmental engineer has the role of enforcing regulations, granting permits or developing policy.

ILLUSTRATION OF PROFESSIONAL FIELD

Occupations, jobs and roles for graduates are mostly to be found in the following professional domains (for a full description of the professional domains, see Section 2). A few examples are given for each domain.

Research and development
- Environmental researcher (in research institutes)

Engineering and manufacturing
- Environmental technologist (optimising environmental technology)

Commerce and customer service
- Environmental consultant
- Sustainability (CSR) consultant
- Environmental (HSE) coordinator
- Inspector or enforcement officer
- Official responsible for issuing permits
- Policy adviser

Programme profile

	Competence							
	Research	Development	Experimentation	Management	Advice	Instruction	Leadership	Self-management
Minimum attainment target adopted for the programme	III	I	I	II	III	II	I	II

KNOWLEDGE

- **Sustainable development:** people, planet, prosperity, passing the burden in space and time, CSR, system-oriented thinking
- **Environment:** quality of the environment, sustainable design and planning, impact on our environment
- **Soil, water, air, noise:** sources of pollution, behaviour of substances, research, regulatory process, impact, measures, management
- **Nature/ecology:** basic natural principles (ecology), ecosystems, biodiversity, types of landscape, cultural heritage values
- **Climate change:** causes, effects, measures
- **Waste and raw materials:** cradle-to-cradle, circular economy (biobased and technical)
- **Energy:** sources, sustainable energy management
- **Safety:** sources, standards, risk assessment, measures, management
- **Legislation and environmental policy:** spatial planning, flora/fauna, environmental law, EIA, environmental policy (European, national, international, water, soil), policy instruments
- **Economics and management:** financial feasibility, SCBA, quality management/Deming circle, QHSE
- **Ethics:** moral dilemmas in professional practice

SKILLS

- **Research skills:** problem analysis, problem statement articulation, preparing research questions, research planning, reviewing, analysis, desk research, statistical methods, performing multi-criteria analyses
- **Consultancy skills:** holding intake and consultancy interviews, issuing quotations, carrying out stakeholder analyses, involving stakeholders in the implementation of assignments (environmental awareness, sensitivity regarding policy and political issues), effective collaboration with other disciplines, presenting recommendations
- **Specific ICT skills:** using geographical information systems, dispersion and sustainability models
- **General laboratory skills:** analysing soil, water, air in accordance with protocol
- **Fieldwork skills:** soil, water, flora/fauna, region

The Body of Knowledge and Skills is a summary of graduates' basic knowledge and basic skills which has been prepared by the HBO-programmes in consultation with the professional field. These are obtained during the first two years of education.

The Body of Knowledge and Skills for Environmental Science is laid down in the national consultative document covering all Environmental Science degree programmes. All other Environmental Science programmes are outside the scope of the Applied Science Domain and are not presented here. For more information, a detailed national document is available, see reference 2 on page 75.

TYPICAL TEXTBOOKS

- *Environmental Science, A Global Concern,* W.P. Cunningham, M. Cunningham
- *Introduction to Environmental Engineering and Science,* G.M. Masters, W.P. Ela
- *Campbell Biology,* L.A. Urry, M.L. Cain e.a.
- *Chemistry the Central Science,* T.E. Brown, H.E. LeMay e.a.
- *Brock Biology of Microorganisms,* M.T. Madigan, K.S. Bender e.a.
- *Foundations Maths,* A. Croft, R. Davison
- *Managing your competencies,* R. Grit
- *Project Management,* R. Grit
- *Praktisch Omgevingsrecht,* H.M. Liedekerken

The list of typical textbooks serves as an illustration to give an impression of the level at which the subject is taught in the study programme.

Process engineer Geert van Lith:

'The most challenging projects are those in other countries'

Name: Geert van Lith
Age: 25
Course of study: Environmental Science
Place of employment: Maris Projects
Job: Process engineer

'I chose this programme at the time because it fitted in well with my previous studies: I had already completed the senior secondary vocational land, water and environmental engineering programme. I therefore knew that I wanted to have something to do with the environment. The breadth of my course provides sufficient opportunities. Eventually, I ended up – through my programme – at Maris Projects, where I have progressed from environmental technologist to process engineer. This company's practical way of working really suits me, also because of my previous studies.

My job is difficult to describe in a couple of sentences. On the one hand, I'm involved in selling new and second-hand process equipment. These are machines or components for milling, crushing, pumping, extraction, etc. I help my boss in buying, selling, issuing quotes, supervising the workshop, etc. On the other hand, I work on projects: we develop technologies, machines and plants for re-using residues (e.g. culturing algae, fermenting biomass, drying residual products), using physical, thermal or biological treatments only. I manage and supervise the projects from start to finish. They often start in the laboratory, where we determine the properties of the residues. Once the options are clear, we build a scale model (from second-hand machinery) on which we test our idea. I then help to design or develop the final solution. After being successfully tested, the plants are built full-size. My responsibilities are to supervise the workshop, help to optimise the plants and start them on the customer's premises. There are also other aspects to take into consideration in projects, such as subsidy and financing processes in which I submit applications, reports and work plans. And the practical aspects, such as arranging transport for international projects, which I never learned about at university but which still has to be done.

International

The most challenging aspects of my job are the projects in other countries. As we are developing new technologies and most waste and residual flows are often in developing countries, it is easier to implement certain projects in these countries. I myself have been to India a number of times to help build a plant for extracting oil from waste meat residues from the leather industry.

Research and experimentation are very important competences in my professional field. The way I use them now is certainly different from the way we had them at university.
I definitely see my opportunities for advancement within the company, although that also depends of course on the growth of the business. There are great opportunities nationally and internationally and I'm sure I can progress internationally. For the time being, I'm still learning so much in practice every day that no university can compete!' ■

Project worker Bianca Peeters:

'I can now focus on specific competences'

'I did a job aptitude test just before completing my senior secondary vocational programme. This showed that my interest lay in the environment, society and technology. After visiting an open day for the environmental science programme, I became really enthusiastic: it looked like an enjoyable and interesting programme which would be sufficiently challenging and provide a choice of professional field.

My programme was wide-ranging and involved a combination of different environmental subjects, such as water, soil, air and noise, ecology, climate change, sustainable energy, sustainable development and legislation. The subject was taught in the form of courses, training sessions and project-based work. In the third and fourth years I did two internships and gained some practical experience. During my graduation project, I conducted research into a proposal for a new Nature Conservation Act and how it compared with current nature protection legislation. I was asked by the Environmental Law and Permits department of Witteveen+Bos whether I would like to do research into this as they had a lot to do with nature protection legislation and I was interested in nature.

I have now been working in the Environmental Law and Permits department for nine months. As a Project worker I check out which permits are required for different projects, prepare permit applications, give instructions for environmental and other investigations relating to the permit applications to be carried out and submit them to the relevant governing bodies.

Wide-ranging

I think my study programme fitted in well with my current job, thanks to the wide-ranging nature of the programme. While working with permits, I now find that I have some knowledge of a variety of environmental subjects. The project-based work that I learned during my programme also fits in well with my job. This is partly because Witteveen+Bos regularly work with environmental science students in supervising and implementing all kinds of projects. I was one of them myself in the third year of my programme!

Thanks to the competence-based approach in my programme, I learned which competences I was good at and which not so good. This means that I can now focus extra hard on specific competences, such as **instruction** and **management**, in order to develop further. My ambition is first of all to become an experienced consultant on permits. Later, I would like to become a project manager in order to keep the permit process and related matters on the right track for a project.
Eventually, I would like to work as the head or manager of a department. But that's an ambition for the long term!' ■

Name: Bianca Peeters
Age: 24
Course of study: Environmental Science
Place of employment: Consultancy and engineering firm Witteveen+Bos
Job: Project worker for environmental law and permits

Section 6

References/Acknowledgements

References

1. National Programme Profile for HBO/Bachelor in Engineering Physics, December 2016
2. Programme profile for Environmental Engineer (HBO), January 2014
3. Programme requirements for recognition as an Article-6 biotechnician at higher professional (HBO) level.

These documents are available in Dutch on the DAS website: www.appliedscience.nl

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and all the representatives of the following National Educational Committees
[*Landelijke Opleidingsoverleggen*].

LANDELIJK OVERLEG BIN BIO-INFORMATICA

LANDELIJK OVERLEG BML BIOLOGIE & MEDISCH LABORATORIUMONDERZOEK

LANDELIJK OVERLEG CH CHEMIE

LANDELIJK OVERLEG CT CHEMISCHE TECHNOLOGIE

LANDELIJK OVERLEG TN TECHNISCHE NATUURKUNDE

Appendix I

Definitions

Bachelor | degree that indicates that a student has successfully completed a study programme at a university of applied science.

BoKS | Body of Knowledge and Skills, a summary of graduates' basic knowledge and skills which has been prepared by the HBO programmes in consultation with the professional field.

BSc | Bachelor of Science.

Competence | a combination of knowledge, skills and attitude which is required to perform a specific professional task within a specific context. Competences can be measured and assessed, and improved by training and development.

Competence indicator | tool for making competences visible; students show that they have a specific competence by acting in a specific way.

Competence profile | the common competences that every new professional graduate in every bachelor-awarding domain must attain.

Context | the applied science setting in which companies and laboratories work.

CROHO | Central Register of Higher Education Study Programmes of the Dutch Ministry of Education, Culture and Science.

Domain | a group of study programmes related to each other in terms of content and career options; the professional context in the Applied Science domain is usually a laboratory, test or production environment or pilot plant.

Domain competences | all of the competences that a professional graduate must have at his disposal in order to be able to perform his profession/job properly. Programmes must develop these competences in students to the level of a new professional graduate.

Dublin descriptors | general descriptors for the attainment target of bachelor and master courses at European universities.

ECTS | the unit used to express the workload of a programme or part thereof. ECTS stands for European Credit Transfer System and is used by all the countries within the European Higher Education Area. One ECTS is equal to 28 hours of study.

Final qualification | a competence with a specific indication of the level that students must attain at the end of their higher professional or other course of study, as a new professional graduate.

Job | a set of activities performed by one or more persons who are employed in a specific context in order to contribute to a product or service, in which specific competences are used.

Occupational field | a collection of all the occupations/jobs in which graduate Bachelors of Science in the Applied Science domain are employed.

Professional domain | a collection of similar occupations.

Professional field | see Occupational field.

Professional profile | a compilation of possible occupations, jobs and relevant competences for a Bachelor of Science in the Applied Science domain.

Qualification | a competence which is graded and which students must fulfil at a specific time.

Appendix II

Competences, competence-based education and their relationship with the Body of Knowledge and Skills

There are various definitions of **competence**. Several are given in a document published by the Education Council of the Netherlands [*Onderwijsraad*]*.
Competence, as used by the Applied Science programmes, refers to the **ability to perform tasks within a context characteristic of the Applied Science professional environment**. They are known as professional competences and the professional field stipulates this as a requirement for its employees. The competences have been translated into competence indicators.

Professional competences require specific knowledge and skills which are essential to the correct performance of the professional task. The nature of the specific knowledge and skills required is almost always dictated by the context. The professional field of the Applied Science domain is very wide and so this context is also very wide. The wide diversity and range of professional tasks will therefore require extremely varied knowledge and experience.
Defining the Body of Knowledge and Skills as well as the set of professional competences makes the context of these professional competences explicit. The programme objectives therefore consist not only of the professional competences but also of elements of the BoKS.

The competence indicators which have been formulated for each level for each professional competence can also be used as assessment criteria in the programme. It is also possible to develop some competence criteria in isolation as a complex skill. By way of illustration, the competence indicator 'communicate with the client on the content of the assignment' will, in practice, only be used as an assessment criterion. But 'report orally and/or in writing on the assignment in accordance with specified guidelines' can exist in a programme as a separate course component entitled 'reporting'.

Moreover, 'skills' does not mean manual skills. They are complex skills which also require knowledge. Working safely in a laboratory, collaborating, performing a GC analysis, programming or writing a research report are examples of these complex skills.
Applying acquired knowledge is essential in a competence-oriented programme and could be referred to as a cognitive skill. Nevertheless, we have decided – for the sake of clarity – to refer to this as knowledge.

As well as competence, **competence-oriented education** also requires an explanation. The abovementioned document from the Education Council of the Netherlands explains what this term could refer to. In practice, the different interpretations appear to vary considerably, from innovation in teaching to strengthening the relationship with the labour market.
Within the Applied Science domain, each institution interprets the term in its own way but, to all of the institutions, it does at least mean strengthening the relationship with professional practice.

The main thing is that all the institutions that teach the Bachelor of Science degree use the professional competences as learning objectives. With the introduction of the professional competences as programme objectives, all the institutions had to innovate in their teaching. The extent to which today's teaching methods have departed from traditional educational practice differs greatly between the institutions. However, it is true for all the institutions that their relationship with the labour market has been strengthened by the introduction of the professional competences. This has also been helped by the introduction of the Body of Knowledge and Skills and the initiative to join forces as institutions and work in consultation with the leading industries to produce a national range of specialisations which is geared to the needs of the professional field.

**Studie van complicaties tot compromis. Over schuifjes en begrenzers*, J.J.G. van Merriënboer et al., Onderwijsraad, The Hague, 2002

Appendix III

Competence tables

In 2008, the Applied Science Domain drew up a common competence-oriented profile description of the Bachelor of Science (then still referred to as Bachelor of Applied Science) in consultation with the national professional field. This competence profile describes the competences and competence indicators for a professional with five years of work experience after graduating from one of the programmes in the Applied Science domain (Level IV).

In 2010, this profile description was revised on a number of points and reissued. In this version, the domain competences are supplemented with details of the intermediate levels (Levels I to III), intended to give the professional field insight into the possible level structure within the programmes. These details were provided after an exchange and comparison of details from the various universities. The elaboration per programme may vary within the various universities of applied science, based on the programme's own profiling and the application of the competences within the programme, as elaborated in the programme's own training policy and training competence profiles.

The Research, Experimentation and Development competences were completely revised between 2016 and 2019. The descriptions of the indicators were made more consistent, clearer and more compatible with educational practice. The professional field agreed to the changes made.

The level structure is cumulative: each successive level also includes the underlying levels.

1. COMPETENCE: RESEARCH

Within the Applied Science domain, the Bachelor of Science conducts research that either contributes to solving a problem or developing a method, or leads to greater insight into a subject within his professional environment.

	Level I	Level II	Level III	Level IV
	The student *performs simple research in response to a problem statement and setup provided.* He demonstrates this by:	The student *makes a major contribution to a research strategy provided and conducts the research.* He demonstrates this by:	The student *translates a problem provided into a research strategy and conducts the research.* He demonstrates this by:	Experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* He demonstrates this by:
a. Setting an objective for the research assignment	Communicating with the client about the problem and the objective of the research	Analysing a problem in consultation and in a coordinated way and translating it into the objectives of the research assignment.	Analysing, independently, a problem provided and translating it into the objective of the research assignment.	Analysing a problem independently and translating it into the objective of the research assignment.
b. Using literature or sources	Gaining an insight into the professional aspects of the research by studying the literature or sources provided.	Gaining an insight into the problem and the professional aspects of the research by studying the literature or sources the student has selected.	Selecting and obtaining, without assistance, scientific and other literature or sources in order to study the problem in greater depth, thereby validating the reliability of the different sources of information.	Selecting and obtaining, without assistance, scientific and other literature and/or sources in order to study the problem in full depth, thereby validating the reliability of the different sources of information.
c. Determining the research design	Explaining the relationship between the research question provided, sub-questions and research activities.	Formulating, under supervision, sub-questions and research activities regarding the research to be carried out.	Formulating, without assistance, sub-questions and research activities regarding the research to be carried out.	Formulating, without assistance, sub-questions and research activities regarding the research to be carried out.
d. Drawing up a work plan for research	Developing an approach to carrying out the research activities of a simple research assignment according to a format provided, including the planning of the work.	Preparing a work plan in consultation, drawing up the plan independently, taking account of any preconditions.	Preparing a work plan without assistance, taking into account the interdependencies of various research activities and preconditions.	Methodically drawing up a work plan, allowing time for evaluation and adjustment and taking account of preconditions and uncertainties.
e. Carrying out the research activities and obtaining the research results	Working in accordance with the work plan when carrying out the assignment and finding effective ways of achieving the intended results. Applying basic knowledge or skills.	Working in accordance with the work plan when carrying out the assignment. Implementing the work plan effectively and efficiently and determining whether interim adjustments are necessary on the basis of interim results. Applying relevant knowledge or skills.	Implementing a complex work plan effectively and efficiently and updating it as necessary in between times. Acquiring relevant knowledge and putting it into practice.	Implementing a complex work plan effectively and efficiently and working with dynamic scheduling as necessary. Acquiring relevant knowledge and putting it into practice.
f. Processing and checking data	Summarising the data from the research activities, structuring it in the light of the research question and presenting it clearly. Reflecting critically on the results to determine whether they are realistic.	Summarising and interpreting the full or partial results in relation to the assignment/ research question. Critically reflecting on the reliability of the results.	Logically and clearly combining the full or partial results and interpreting them in relation to the research question. Performing an analysis of the reliability of the results.	Summarising, structuring and interpreting the results in relation to the research question. Ensuring that the results are reliable.
g. Formulating research conclusions and recommendations	Using the research results to formulate conclusions relating to the research question and if necessary submitting a proposal for improving the implementation of the assignment/the research.	Using the research results to formulate conclusions relating to the research question and using these to make a proposal for follow-up steps.	Using the research results to formulate and interpret conclusions relating to the research question. Making proposals for follow-up research based on the conclusions.	Making proposals for follow-up research based on the conclusions and other insights. Continue on page 80 →

→ COMPETENCE: RESEARCH (CONTINUATION)

h. Reporting	Reporting orally and/or in writing on the assignment in accordance with specified guidelines.	Combining the results into one report in accordance with the applicable guidelines/ standard.	Reporting on the research in accordance with the standard applicable in the professional field.	Reporting on the results of the research in accordance with the standard applicable/valid in the professional field.
i. Cooperation and communication	Actively working as part of a team, processing the feedback on the work delivered to achieve better results. Being able to communicate concisely about goals and results as the work progresses.	Acting as a full team member in the student's working environment, where feedback and reflection lead to better results, reasoned choices and effective coordination in conducting the research. Being able to match communication on progress to the situation.	Acting as a full member and working as part of a team which also contains staff from other professional field(s). Communicating independently about the relevant substantive aspects of the progress.	Collaborating in a result-oriented way in a multidisciplinary setting. Communicating and reporting effectively on progress and coordination.

Definitions Competence Research

- Research involves working on an issue such as solving a problem, developing a method or gaining a greater understanding of a subject. Where the word '**problem**' is used in the competence indicators, it can also refer to a type of issue other than solving a problem. The word 'question' has deliberately not been used so as to avoid confusion with the term 'research question'.
- **Provided** indicates that there is a client who makes demands on, or has expectations of, the result. This is a higher level than a student who devises and conducts his or her own research in which the result or the quality of the result is of no importance.
- **Research strategy** concerns the objective, the research question and the design of the research.
- **Preconditions** relate to available resources (availability of resources in the widest sense), quality assurance (which also includes management measures), safety, health, welfare, the environment, sustainability and ethics.
- **Work plan** involves as a minimum the objectives, the design, the approach, the preconditions and the planning.
- **Complex work plan** is used when, for example, the plan is on a large scale in terms of duration and involves a multitude of substantive aspects, strict requirements for the quality of the results, multiple disciplines that need to be managed, a high risk factor or a lot of interaction and communication.
- **Follow-up steps** concern new objectives for solving the problem, developing a method, gaining insight into a subject or any other type of follow-up research.
- **The follow-up to a research assignment** may involve, for example: follow-up research, using a developed method, developing a product or ending work on a development.
- **Dynamic scheduling** produces a schedule that is not fixed in advance, but is constantly updated based on the results obtained.
- The **reliability** of the results can be derived from statistical calculations, but also from other calculations, literature or additional experiments.

2. COMPETENCE: EXPERIMENTATION

The Bachelor of Science conducts experiments within the Applied Science domain in order to obtain demonstrably reliable results.

	Level I	Level II	Level III	Level IV
	The student *conducts an experiment according to the approach/ protocol provided and obtains replicable results.* He demonstrates this by:	The student *chooses a protocol/approach, adjusts it if necessary, implements it and obtains reproducible and reliable results.* He demonstrates this by:	The student *sets up experiments under supervision and conducts them unsupervised in a systematic way and obtains reproducible and reliable results.* He demonstrates this by:	Experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* He demonstrates this by:
a. Objective and design	Explaining the objective of the experiment.	Choosing an approach and explaining why it is a suitable way of achieving the objective.	Formulating, without assistance, an approach to achieving the objective of the experiment.	Translating a research question into objectives by means of a suitable experimental design.
b. Methods and techniques (conceptual)	Explaining the principle of the method and technique provided.	Having sufficient knowledge and understanding of available methods and techniques to assess their suitability and choose the right equipment and/or device settings.	Choosing or developing suitable methods and techniques and anticipating possible experimental problems.	Demonstrating such knowledge, insight and skill as makes it possible to carry out the work in a responsible, safe and critical way using the correct methods, techniques and equipment.
c. Equipment/ setups/ instruments/ hardware and software* (use)	Becoming proficient in the correct handling of the equipment.	Becoming so skilled in operating the available equipment that adjusting the settings leads to desired effects.	Being capable of learning independently about the possibilities and limitations of the equipment to be used in order to recognise experimental problems and be able to act accordingly.	Being capable of learning about the possibilities and limitations of the equipment in order to be able to deal with experimental problems.
d. Preparation and implementation	Properly preparing an experiment on the basis of a protocol/approach provided, conducting it and obtaining replicable results within the specified time and maintaining accurate and clear documentation.	Preparing a schedule for implementing a protocol/ approach, conducting the experiment and obtaining reproducible results within the specified time and maintaining accurate and clear documentation.	Preparing a schedule for a number of experiments, conducting them and obtaining reproducible results within the specified time and maintaining accurate and clear documentation.	Drawing up and implementing work instructions so that demonstrably reliable and reproducible results can be obtained and maintaining accurate and clear documentation.
e. Health, safety, environment (HSE) and sustainability	Working according to HSE standards and taking ethical and sustainability standards into account when preparing and conducting the experiment.	Assessing whether the approach can be implemented according to HSE, ethical and sustainability standards.	Assessing the approach and adapting it if necessary in accordance with HSE, ethical and sustainability standards.	Designing an approach in accordance with HSE, ethical and sustainability standards, assuming responsibility for the local environment.
f. Reliability of results	Processing measurement results properly and correctly and estimating whether a result obtained is realistic.	Assessing the reliability of a result on the basis of an (e.g. statistical) analysis provided.	Choosing a statistical or other analysis for assessing the reliability and validity of the result obtained.	Using (statistical) techniques to process/validate the results and ensure their quality.
g. Critical review	Giving reasons to establish whether the approach to the experiment has been followed correctly.	Giving reasons to establish whether the approach to the experiment requires improvement.	Making proposals, where necessary, to improve the approach and propose additional experiments.	Taking a decision on the follow-up, based on the results.

* Where 'equipment' is mentioned in the level descriptions, this can be read as including setups/instruments/hardware and software.

Definitions Competence Experimentation (page 81)

- Where **documentation** is mentioned, this can also be read as: 'lab journal, logbook, technical manual or any other type of documentation used in the professional field'.
- Where **experiment** is mentioned, this can also be read as 'analysis'.
- Here, **replicability** means that the experiment produces the same results if it is carried out again by the same person under as equal conditions as possible.
- Here, **reproducibility** means that the experiment produces the same results if it is carried out again by another person under as equal conditions as possible.
- The **reliability** of the results can be derived from statistical calculations, but also from other calculations, literature or additional experiments.

Definitions Competence Development (page 83)

- **Developing** can also be 'designing', 'improving', 'optimising' or 'up- or downscaling' a process.
- We call it a **process** when a 'component' undergoes a treatment in a 'device' or other item of equipment, e.g. a distillation column, a reactor or a heat exchanger.
- An **instrument** is a 'device' or other item of equipment that has a physical, chemical or biological function, e.g. a magnet, an analytical instrument or a booster.
- A **component** is a material or intermediate product that undergoes a process.
- A situation is **complex** as a result of a large number of concepts, a significant correlation between concepts or a correlation with another discipline.
- **Or** is the 'inclusive or', that is 'and/or'.
- **Discipline-specific** is an adjective used within the context of Applied Science, e.g. relating to chemistry, physics, biology, engineering.
- A **discipline-specific concept** is a subject from the discipline for which a theory or models have been described, e.g. reaction kinetics (chemistry), distillation (physics), increase of biomass (biology) or electromagnetism (engineering).
- A **discipline-specific model** is a model of a discipline-specific concept or a combination thereof.
- **Discipline-specific feasibility** is feasibility in terms of chemistry, physics, biology or engineering, but not economic feasibility. Economic feasibility is defined separately.
- The **result** is the developed product, process, instrument or material or the scaled process.
- The **development** is the entire process undergone to achieve the result.

3. COMPETENCE: DEVELOPMENT

The Bachelor of Science develops or improves a process, instrument, product or material or scales a process up or down in the Applied Science domain.

	Level I	Level II	Level III	Level IV
	The student *develops or improves in accordance with a supplied approach.* He demonstrates this by:	The student *develops or improves by selecting or adapting an approach.* He demonstrates this by:	The student *develops or improves by independently creating an approach.* He demonstrates this by:	The experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* He demonstrates this by:
a. Criteria in specification of requirements (SoR)	Applying the criteria that the product, process, instrument or material must meet (SoR).	Adapting where necessary the criteria that the product, process, instrument or material must meet (SoR).	Setting the criteria that the product, process, instrument or material must meet, based on the client's requirements or wishes (SoR).	Setting the criteria with which the product, process, instrument or material must comply in a complex situation, based on the client's requirements or wishes (SoR).
b. Concepts	Identifying discipline-specific concepts supplied (assessing whether and where they can be identified), in the specification of requirements.	Choosing from a supplied set of discipline-specific concepts while identifying these concepts in the specification of requirements.	Identifying without assistance discipline-specific concepts in the specification of requirements.	Identifying without assistance, in a complex situation, discipline-specific concepts in the specification of requirements.
c. Parameters	Selecting the discipline-specific design parameters supplied that can affect the process, product, instrument or material.	Selecting the most suitable discipline-specific design parameters supplied that can affect the process, product, instrument or material.	Selecting the most suitable discipline-specific design parameters that can affect the process, product, instrument or material.	Selecting, in a complex situation, the most suitable discipline-specific design parameters that can affect the process, product, instrument or material
d. Models	Verifying whether discipline-specific models supplied are in accordance with the SoR, adjusting them and validating them.	Selecting suitable discipline-specific models supplied, verifying whether they are in accordance with the SoR, adjusting them and validating them.	Selecting, without assistance, suitable discipline-specific models, verifying whether they are in accordance with the SoR, adjusting them and validating them.	Selecting, in a complex situation, suitable discipline-specific models, verifying whether they are in accordance with the specification of requirements, applying and validating them.
e. Feasibility, sustainability	Using a supplied method to investigate the discipline-specific feasibility of the result.	Investigating the discipline-specific feasibility and sustainability of the result.	Investigating the discipline-specific and economic feasibility and sustainability of the result.	Investigating, in a complex situation, the discipline-specific and economic feasibility and sustainability of the result.
f. Feedstocks and unit operations	Determining the quantity of the feedstocks supplied and – if necessary – the dimensions of the unit operations.	Selecting the most suitable of the supplied feedstocks and unit operations in both qualitative (which) and quantitative (quantity, dimensions) terms.	Selecting, without assistance, the most suitable feedstocks and unit operations in both qualitative (which) and quantitative (quantity, dimensions) terms.	Selecting, in a complex situation, the most suitable feedstocks and unit operations in both qualitative (which) and quantitative (quantity, dimensions) terms.
g. Documentation	Preparing the documentation for the development and the result in a supplied format.	Preparing the documentation for the development and the result in accordance with detailed guidelines.	Preparing the documentation for the development and the result in accordance with the standard applicable in the professional field.	Preparing the documentation for the development and the result in accordance with the standard applicable in the professional field for a complex situation.

4. COMPETENCE: MANAGEMENT

The Bachelor of Science develops, implements and maintains a management system or parts thereof to ensure that the system conforms to the relevant legislation and quality standards and the the organisation's culture.

	Level I	**Level II**	**Level III**	**Level IV**
	The student *acts within the given frameworks and procedures described in relevant management systems.* This is demonstrated by:	The student *evaluates his own work activities or those of others in conformity with procedures described in relevant management systems.* This is demonstrated by:	The student *evaluates and maintains a management system.* This is demonstrated by:	Experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* This is demonstrated by:
a. Context	demonstrating overall knowledge of the context in which relevant management systems are set up.	explaining the relevance of procedures described in the management system within the context.	assessing the relevance of changes in context for the organisation.	translating changes in context into advice on upgrading a management system.
b. System design and content	complying with the guidelines of relevant management systems by acting appropriately when carrying out his own work.	ensuring compliance with the guidelines of relevant management systems.	evaluating a management system, making suggestions for improvement and implementing them (or ordering their implementation).	coordinating activities relating to the development, implementation and maintenance of the management system (or parts thereof).
c. Communication and reporting	communicating on (compliance with) the guidelines of the management systems used when carrying out his	reporting on (compliance with) the guidelines of the relevant management systems.	reporting on the usability of the management system.	communicating on maintenance, development and implementation of management systems.

Definitions Competence Management

- A **Management System** is a set of resources, agreements, procedures and data used to provide information, while ensuring that a particular topic is covered. Examples of management systems include QHSE (Quality, Health, Safety and Environment), HSE (Health, Safety and Environment), LIM (Laboratory Information Management), data management, inventory management and programming code management.
- **Context** indicates factors inside and outside the organisation that influence the type of management system used and its design. For example, relevant legislation and organisational culture.

5. COMPETENCE: ADVICE

The Bachelor of Science gives well-founded advice on the design, improvement or application of products, processes and methods within the Applied Science domain, taking into account technical, economic and social constraints, thereby contributing to technical and economic solutions with regard to products or services within the Applied Science domain.

	Level I	Level II	Level III	Level IV
	The student *familiarises himself with the client's problems and/or requirements.* *Helps to formulate advice according to a set method.* This is demonstrated by:	The student *Helps to solve a technical problem facing the client. Delivers advice, without assistance, in a non-complex situation.* This is demonstrated by:	The student *gives practical advice on a specific issue. Delivers advice, without assistance, in a complex situation.* This is demonstrated by:	Experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* This is demonstrated by:
a. Clarifying questions	listening to the client and restating the question in his own words.	actively listening and asking relevant questions to identify the client's requirements.	actively listening and asking relevant questions to summarise the client's requirements in a specific question.	actively listening, asking relevant questions and drawing on his own expertise to summarise the client's requirements in a specific question.
b. Understanding context	describing information provided on the context.	analysing information provided on the context and describing its impact.	gathering information on the context without assistance and evaluating its impact.	gathering information on the context without assistance and evaluating this information, based on experience and expertise.
c. Proposing a selection of possible solutions	using technical knowledge provided to propose a possible solution.	using technical, economic and social knowledge provided to propose possible solutions.	using technical, economic and social knowledge accumulated without assistance to propose possible solutions.	using technical, economic and social knowledge and expertise accumulated without assistance to propose possible solutions.
d. Substantiating the advice given	justifying the chosen solution to the question.	substantiating the advice given on possible solutions.	substantiating the advice given and informing the client which of the proposed solutions are to be preferred.	substantiating the advice given and, drawing on his expertise, convincing the client which of the proposed solutions are to be preferred.

Definitions Competence Advice

- Where **Client** is mentioned, this can also be read as: "customer" or "user".
- **Context** means, for example, market research, stakeholder analysis, social trends or constraints.
- For **Analysis**, we use the definition according to Bloom's Taxonomy: Breaking down a communication into its parts to examine connections and relations between them.
- For **Evaluation**, we use the definition according to Bloom's Taxonomy: Making judgements based on criteria and standards.
- A situation is **complex** as a result of there being a large number of concepts, a significant correlation between concepts or a correlation with another discipline.

6. COMPETENCE: INSTRUCTION | SUPERVISION | TEACHING | COACHING

The Bachelor of Science instructs and supervises employees and customers while teaching new knowledge and skills within the Applied Science domain.

	Level I	Level II	Level III	Level IV
	The student *passes his own knowledge and skills, on request, to employees (by demonstrating and explaining).* He demonstrates this by:	The student *takes the initiative to instruct employees who are lacking in knowledge and skills.* He demonstrates this by:	The student *transfers knowledge and skills to employees using appropriate teach-ing methods.* He demonstrates this by:	Experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* He demonstrates this by:
a	Helping to provide fellow em-ployees, students or trainees with instructions/demonstrations with regard to a practical test, etc.	Providing fellow employees, students or trainees with instruc-tions/ demonstrations with regard to a practical test, etc.	Independently providing fellow employees, students, trainees or course participants with a theoret-ical introduction incl. instructions/ demonstrations with regard to a practical test, etc.	Independently providing employ-ees, trainees, students or course participants with theoretical introductions, instructions and demonstrations with regard to practical experiments, the use of equipment, materials, etc.
b	Helping to supervise employees, trainees, students or course participants in the use of methods and equipment, etc.	Participating in the supervision of employees, trainees, students or course participants in the use of methods and equipment, etc.	Providing part of the supervision of employees, trainees, students or course participants in the use of methods and equipment, etc.	Supervising employees, trainees, students or course participants in the use of methods and equip-ment as well as in conducting desk research for practical assignments.
c	Explaining things clearly.	Transferring information tailored to the target group.	Transferring complex information tailored to the target group.	Applying teaching skills in different educational settings.
d	Being aware of the importance of continuously developing his expertise.	Initiating activities to develop his own expertise and that of others.	Helping to coach employees on the basis of his own experience.	Coaching employees and teams on the development of expertise.

7. COMPETENCE: LEADERSHIP | MANAGING PEOPLE

The Bachelor of Science provides direction and guidance for organisational processes and the employees involved in them in order to achieve the goals of the division/department or the project which he is managing.

	Level I	**Level II**	**Level III**	**Level IV**
	The student *provides employees with assistance and guidance when asked to do so.* He demonstrates this by:	The student *provides employees with assistance and guidance in order to improve performance.* He demonstrates this by:	The student *ensures that team members' goals and roles have been defined and helps the members to achieve the team goals.* He demonstrates this by:	Experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* He demonstrates this by:
a	Showing that he understands the place and role of his part of the organisation (internship/graduation project)	Bringing his own knowledge and understanding to bear in approaching new activities in the organisation.	Ensuring that employees are clear about what their role is in achieving the organisation's goals and supervising them in this regard.	Having a vision for his part of the organisation and communicating it.
b	Helping to allocate tasks and work.	Providing assistance in solving problems in scheduling and prioritising work.	Specifying how tasks should be allocated when scheduling work, as well as providing a timetable, setting priorities and listing other constraints in terms of time, money, quality, information and organisation.	Working on the basis of a project and according to a plan.
c	Being approachable and accessible for employees, fellow students and lecturers.	Motivating employees	Delegating tasks to employees according to their job and qualities.	Coaching employees by inspiring, persuading and motivating them, showing them respect, encouraging collaboration and delegating.
d	Being honest and reliable towards employees, fellow students and lecturers.	Calling employees to account for the way they deal with colleagues.	Being open and clear about his own position and helping to resolve conflicts.	Acting as a role model for employees.
e	Supporting others in their initiatives.	Encouraging employees to develop new initiatives themselves.	Helping employees to develop their initiatives.	Giving employees a feeling of shared responsibility.
f	Contributing to staff and progress meetings on the basis of his own work.	Sharing ideas with other employees at staff and progress meetings and taking the initiative to solve problems.	Allowing participants at the meeting to make a specific contribution based on their role in the team.	Chairing meetings, including progress meetings.
g	Giving a clear and unambiguous explanation or instructions about a task to be performed.	Consulting with other employees to reach a common goal.	Managing employees' progress to achieve the specified goals.	Communicating in a task- and process-oriented way.
h	Giving employees an insight into the importance of the constraints of the project.	Adjusting an existing schedule by agreement to remain within the stated constraints.	Allocating tasks to those participating in the project so as to achieve the best possible results within the constraints.	Managing a project in terms of time, money, quality, information and organisation.

8. COMPETENCE: SELF-MANAGEMENT

The Bachelor of Science manages himself in performing his duties and in his development and ensures that he is up to date with the latest developments in terms of knowledge and skills and in terms of ethical dilemmas and socially accepted norms and values.

	Level I	**Level II**	**Level III**	**Level IV**
	The student *reflects on his own performance.* He demonstrates this by:	The student *reflects on his own performance and development.* He demonstrates this by:	The student *manages himself in his own work.* He demonstrates this by:	Experienced professional *develops or improves independently, where the situation is complicated or transfer from a different discipline is involved.* He demonstrates this by:
a	Working towards an established learning objective. Discussing the learning strategy and the ensuing results; being aware of the function of a learning objective and how to use it in his learning strategy.	Determining his own learning objective and learning strategy in consultation/without assistance and reflecting on the result.	Making a career development plan and setting his own new learning objectives.	Setting and implementing a learning objective and a learning strategy without assistance and feeding the result back into the learning objective.
b	Identifying any need to adjust his own performance in the academic environment.	Using feedback on his own performance to adapt to the working environment.	Adjusting his performance to meet the requirements of the different working environments.	Quickly adapting to changing working environments.
c	Communicating with others about professional and ethical dilemmas and identifying professional and ethical dilemmas.	Taking note of any professional and ethical dilemmas and giving his opinion on them.	Taking a position based on socially accepted professional and ethical norms and values.	Weighing up professional and ethical dilemmas and taking a decision in accordance with socially accepted norms and values.
d	Seeking information in order to improve his own performance.	Taking on board criticism of work delivered and discussing his own performance with colleagues.	Adapting his own performance on the basis of experience.	Giving and receiving feedback.

Appendix IV

Relationship between programme profiles and the Dutch HBO-Bachelor qualification framework

The following text has been taken from documents issued by the NVAO*, the Dutch/Flemish accreditation body for higher education.

*www.nvao.net

The Dutch Qualification Framework for Higher Education at a glance

The Dutch framework consists of three levels, which qualify for Bachelor, Master and Doctor degrees. These levels correspond to the cycles of the overall framework for the European Higher Education Area. In addition, there is a 'short cycle' in the first cycle, which concludes with the Associate degree. The attainment target for each cycle is described by the **Dublin descriptors**, which are used in the Netherlands as reference points for the three levels.

The level that corresponds to the end of the first cycle concludes with a Bachelor degree, which provides access to the labour market and continuing education in the second cycle. Within the level structure, the Netherlands makes a distinction in terms of orientation; this is known as the binary system of education provided at universities of applied science [*hogescholen*] and traditional universities [*universiteiten*] (HBO and WO). In principle, the HBO trains students for an occupation, whereas the WO trains students for an academic career in a certain specialisation. The degrees are at the same level but differ in terms of orientation.

This difference in orientation means that, in the overwhelming majority of cases, holders of an HBO-Bachelor degree are not admitted directly to WO-Master programmes.

The final qualifications awarded by the programme must be consistent with general, internationally accepted descriptions of Bachelor qualifications. These are known as the Dublin descriptors and are the reference point for the attainment target of the Bachelor. The Dublin descriptors consist of the following items in each cycle:

- Knowledge and understanding
- Applying knowledge and understanding
- Making judgements
- Communication
- Learning skills

The Qualifications Framework for the European Higher Education Area, to which the National Qualifications Framework for higher education refers, was accepted by 46 European countries in 2005. Within the EU (25 countries), the European Qualifications Framework for Lifelong Learning (EQFLLL) has since been developed for all educational levels. The levels in the short cycle (Associate degree) and in the first, second and third cycle are defined in the European Qualifications Framework for Lifelong Learning as levels 5, 6, 7 and 8 respectively.

Information on the **Dublin descriptors** can be found on the NVAO website (www.nvao.net).

The Netherlands Association of Universities of Applied Sciences has drawn up national programme profiles (including this profile description) at programme level in consultation with its members and groups in the relevant professional field.

The professional competences described in the programme profile must specify the higher professional level as described by the Dublin descriptors and it is agreed that the programmes match these profiles.*

*www.vereniginghogescholen.nl/opleidingsprofielen

In the past, it was stated how each programme profile related to the Dublin descriptors. Because the intermediate levels of the professional competences I - III were worked out in 2011, these analyses were no longer relevant.

For this revision of the profile description, a generic link has been established between the professional competences of the BSc in the domain and the Dublin descriptors for the HBO/Bachelor level. To this end, the Dublin descriptors for the Associate degree (Ad, level 5) have been compared with the descriptors for the Bachelor degree (level 6). Each combination of Dublin descriptor and professional competence has been examined to ascertain in what respect the Bachelor differs from the Ad and then whether and from which intermediate level the skill is found in the indicators for the competence. The table below shows the comparison between the Dublin descriptors for the Associate degree and the Bachelor.

Dublin descriptors	**Associate degree** *The candidate:*	**Bachelor** *The candidate:*
Knowledge and understanding	has demonstrated knowledge and understanding of a field of study that builds upon general secondary education and is typically at a level supported by advanced textbooks; such knowledge provides an underpinning for a field of work or vocation, personal development, and further studies to complete the first cycle (Bachelor).	has demonstrated knowledge and understanding in a field of study that builds upon his/her general secondary education and is typically at a level that, while 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 his/her knowledge and understanding in occupational contexts.	can apply his/her 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	has the ability to identify and use data to formulate responses to well-defined concrete and abstract problems.	has the ability to gather and interpret relevant data (usually within his/her field of study) to inform judgements that include reflection on relevant social, scientific or ethical issues.
Communication	can communicate about his/her understanding, skills and activities with peers, supervisors and clients.	can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
Learning skills	has the learning skills to undertake further studies with some autonomy.	has developed those learning skills that are necessary for him/her to continue to undertake further study with a high degree of autonomy.

The resulting link is shown in the table on page 89. For each combination of Dublin descriptor and DAS competence, the figure indicates the intermediate level at which the competence matches the Bachelor level of the Dublin descriptors. Where a dash is shown, it has been concluded that the competence does not contribute to the Bachelor level of the descriptor concerned.

This matrix is used to check for each programme profile whether all the Dublin descriptors at Bachelor level are completed with the attainment target for the competences. This is the case for all the programme profiles included in this profile description, except for the Biology and Medical Laboratory Research programmes.
The reason for this is a difference in profiling at different universities, which results in two differ-

Dublin descriptors for Bachelor	DAS professional competences showing the minimum competence level at which an indicator contributes to the Dublin Bachelor level							
	Research	Experimentation	Development	Management	Advice	Instruction	Leadership | Managing people	Self-management
Knowledge and understanding*:	II	II	II	II	II	II	–	–
Applying knowledge and understanding:	III	III	III	III	III	III	–	–
Making judgements:	II	II	II	III	II	III	–	II
Communication:	III	–	III	III	II	III	–	III
Learning skills:	–	–	–	–	–	–	–	II

* In addition to the professional competences, the Body of Knowledge and Skills contributes to a considerable extent to the acquisition of knowledge and understanding at Bachelor level.

ent programme profiles being used. The resulting national programme profile shows a lower attainment target than the profiles for the individual programmes. All the individual programme profiles used are actually commensurate with the Bachelor level of the Dublin descriptors and can be requested from the universities that offer the programme.

The orientation must also be expressed in the final qualification, as well as the level. The orientation of the programme must guarantee the development of skills in the area of professional practice. The HBO standard was provided to make this core element of the HBO-Bachelor explicit.

Dedicated to quality

In the document 'Dedicated to Quality' [*Kwaliteit als opdracht**] the universities of applied sciences formulated the HBO standard for their Bachelor programmes. The standard lays down that a programme is responsible for ensuring – within both a national and international context – that students:

1. acquire a sound theoretical foundation;
2. acquire research capabilities to enable them to contribute to the development of the profession;
3.have sufficient professional expertise;
4. develop the professional ethics and social orientation fitting for a responsible professional.

**Kwaliteit als opdracht*, Uitgave HBO-Raad, www.vereniginghogescholen.nl, August 2009

The standard is the target for the development of national programme profiles and then for their implementation in the curriculums of the individual programmes.
The addition of the BoKS to the programme profiles during the last revision of this profile description explicitly provided the first characteristic of the HBO standard. The other three characteristics had already been implemented through the professional competences.

Appendix V

Consultation and validation by the professional field

This new version of the *Competence-oriented Profile Description of the Bachelor of Science in the Applied Science Domain* builds on the profile descriptions published in 2013 and 2016. The first profile description of 2013 was drawn up and approved after extensive consultation with the relevant professional field. With each new edition, the content of the profile description has been updated and expanded.

The Competence-Oriented Profile Description has been designed as a dynamic document. The consultation and validation by the professional field was therefore not a one-off action. Universities of applied sciences regularly compare their curriculum to the profile description in consultation with their regional professional field advisory committees. Annual meetings are also held at national level with a number of representatives from these regional professional field advisory committees and with the professional field organisations from the sector to discuss whether the competence profile should be amended or updated. Any improvements and new information will if necessary be published in an addendum to the current version of the profile description.

General consultation with the National Professional Field Consultative Committee

Following publication of the first version of the profile description in 2008, consultation with the National Professional Field Consultative Committee in 2010 resulted in a validated refinement of the competence indicators into intermediate levels. Until that time, the competences and competence indicators had been described for a professional with five years' work experience. The refinement gave the field representatives a better understanding of the level structure during the programme and at the time of graduation. The refinement was first published in 2011 and has been included in this profile description as Appendix III since 2013.

The second request of the National Professional Field Consultative Committee was to make the knowledge component of a programme transparent during the next update and also publish an illustrative bibliography to give an indication of the level of the material. A start was made in 2010, the result of which was that all programmes falling within the domain developed their own Body of Knowledge and Skills (BoKS). The professional field was consulted with regard to the design of the BoKS.

In 2012, the National Professional Field Consultative Committee confirmed and validated that the competence profile and the associated levels were still regarded as a good foundation from which to design the programmes within the domain. In response, a completely new competence-oriented profile description for the Bachelor of Applied Science was published in June 2013, with the refinement of the competence levels and the addition of the Body of Knowledge and Skills for each programme. This version was approved and validated by the National Professional Field Consultative Committee.

During the period following publication, the planning-neutral conversion of the CROHOs in the engineering domain brought about some changes in the programmes that fall within the Applied Science domain. Discussions were also held with the professional field about the benefits of concluding competences at level 1. It was jointly concluded that although a competence concluded at level 1 does not contribute to the HBO-Bachelor level, this competence does make it possible for the student to raise his profile and end up in different professional domains from those for which the programme was primarily intended. In addition, the universities believed that the full set of competences is a good reflection of the breadth of the domain. It was then decided to maintain the full set of competences and show all eight competences in the competence profile for each programme, even if not all of them are relevant.

The new competence profiles were approved by the National Professional Field Consultative Committee. Following interim publication in an addendum, these changes have now been included in the profile description of September 2016. The changes published in this version were approved in advance by the National Professional Field Consultative Committee.

The subsequent period was characterised by programme activity. For example, the National Programme Profile for Forensic Science was coordinated and the Bio-informatics and Chemical Engineering programmes revised their BoKS. All these changes were approved by the regional professional field committees of the universities in question and subsequently validated by the National Professional Field Consultative Committee. In addition, the competences Research and Experimentation were revised at national level. The revised versions were approved by the National Professional Field Consultative Committee. Any changes and corrections in future will also be published in an addendum in consultation with the professional field.

The representatives in the national consultative committee are from a variety of organisations and have different backgrounds and jobs that tie in with the different programmes in the domain. During the period 2016-2020, the National Professional Field Consultative Committee consisted of representatives from:

BASF
Bayer Crop Science
BEJO Zaden
Byondis
Charles River Laboratories
COAST
Delft Solids Solutions
Dow Benelux
ECN-TNO
HAS Den Bosch
Huwicon
IBOTA-Innologic
Interscience
Intertek
Leiden Universitair Medisch Centrum
Mercachem
Micreos
Nyrstar
Philips
QPS
Sensus
Synthon

Validation of Body of Knowledge and Skills for each programme

In order to create the widest possible support for the Body of Knowledge and Skills within the professional field, the BoKS with its associated bibliography for the publication of Version 1.0 of this profile description was validated in 2013 by representatives of the professional field in the regional professional field advisory committees of all the universities that offer the programme. The competence profile of the programmes included for the first time in the profile has also been validated.

APPLIED SCIENCE

ASML
Chemelot Innovation and Learning Labs (CHILL)
DSM
Huijbregts Groep
IAE
Intervet International
Intertek
Jeroen Bosch Ziekenhuis
Kamer van Koophandel
Leids Universitair Medisch Centrum
Maastricht Universitair Medisch Centrum
Maastricht University
Océ Technologies
Philips
Radboud UMC
Summa College Eindhoven
SABIC
St. Annaziekenhuis
TNO
TU Eindhoven
Vlisco

BIO-INFORMATICS

BaseClear
Centre for Molecular and Biomolecular Informatics
Keygene
Leids Universitair Medisch Centrum
Universitair Medisch Centrum Groningen
UMC St. Radboud, afdeling humane genetica

BIOLOGY AND MEDICAL LABORATORY RESEARCH

Amsterdam Medical Center (AMC)
Antoni van Leeuwenhoek Ziekenhuis – Nederlands Kanker Instituut
Canisius-Wilhelmina Ziekenhuis
DSM, Geleen
DSM Food Specialties
Erasmus Medisch Centrum
Groningen Biomolecular Sciences and Biotechnology Institute
HZPC Holland BV
IMEnz Bioengineering

Klinisch Chemisch Laboratorium Leeuwarden
Laboratorium Microbiologie Twente-Achterhoek
Laboratorium voor Infectieziekten
Leids Universitair Medisch Centrum
Maastricht Universitair Medisch Centrum
Meander Medisch Centrum
Medial
Mercachem
OctoPlus
Onze Lieve Vrouwe Gasthuis Amsterdam
Orbis Medisch Centrum
Organon/MSD
PathoFinder
Patholoog (zelfstandige)
Radboud Universiteit Nijmegen
Rijksuniversiteit Groningen
Sanquin Bloedvoorziening
St. Antonius Ziekenhuis Nieuwegein
Synthon
TNO
Trombosedienst Oostelijk Zuid-Limburg
Unilever Foods R & D
Universitair Medisch Centrum St. Radboud
Universitair Medisch Centrum Utrecht
Universitair Medisch Centrum Groningen
Universiteit Maastricht (Pathologie / Genetica en Celbiologie)
Universiteit Twente (Biomedische technologie)
Universiteit van Amsterdam
VU Medisch Centrum
Ziekenhuisgroep Twente

BIOTECHNOLOGY

Bejo Zaden
HZPC Holland BV R&D
International Security Partners
IZORE Centrum Infectieziekten Friesland
Monsanto
Seedvalley
Universitair Medisch Centrum Groningen (Reumatologie)
Universiteit Leiden (Industriële Biotechnologie)
Universiteit van Amsterdam (Moleculaire Plantenpathologie)
Van Haeringen Laboratorium
Wageningen UR Food & Biobased Research

CHEMISTRY

Agilent Technologies
API Institute Emmen
BaseClear
BASF
Capilix
COAST
Cosun
Danieli Corus
DCMR Milieudienst Rijnmond
Dow Benelux
DSM Innovative Synthesis
DSM Neoresins
DSM Pharmaceutical Products
DSM Resolve
ECN
Emmtec Services Emmen
Erasmus Medisch Centrum
Europese Commissie
FrieslandCampina
Givaudan
Imtech
INEOS Styrenics
Inspectie Leefomgeving en Transport
Intertek
Leveste Emmen
Lipid Nutrition BV
Leids Universitair Medisch Centrum
MercaChem
Nuplex Industries
Océ Technologies
OctoPlus
Organon/MSD
Provincie Noord-Brabant
Proxy Laboratories BV
Purac
Quaker Chemical
Radboud Universiteit Nijmegen
REDstack
Rijkswaterstaat
Royal Haskoning
SABIC, Geleen
SABIC Innovative Plastics, Bergen op Zoom
SGS Environmental Services
Shell Global Solutions
Spark Holland B.V. Emmen
Synbra
Tata Steel
Teijin Aramid BV
TNO
Unilever Research Centre
Universiteit Maastricht
Universiteit van Amsterdam
VU
Waternet

CHEMICAL ENGINEERING

Albemarle Catalysts Company B.V.
BaseClear

BASF
Capilix
Cosun
Danieli Corus
DCMR Milieudienst Rijnmond
DSM Neoresins
DSM Pharmaceutical Products
DSM Resolve
ECN
Europese Commissie
FrieslandCampina
Givaudan
Imtech
INEOS Styrenics
Inspectie Leefomgeving en Transport
Intertek
Leap Frog Technology Management
Nuplex
Organon / MSD
Océ Technologies
Provincie Noord-Brabant
Proxy Laboratories BV
Purac
Quaker Chemical
REDstack
Rijkswaterstaat
Royal Haskoning
SABIC
Sensus Roosendaal
Shell Global Solutions
Solanic
Synbra
Teijin Aramid BV
TNO Innovation for life
Unilever Research Centre
Universiteit Maastricht
Universiteit van Amsterdam
Waternet

FORENSIC SCIENCE

This programme has been included for the first time in the profile of Bachelor of Science in the Applied Science domain. The professional field representatives listed below have validated both the Body of Knowledge and Skills and the competence profile:

Delta Lloyd
Dienst Nationale Recherche
Kenniscentrum Brandweer Twente
Lectoraat Advanced Forensic Technology
Ministerie SZW, directoraat Major Hazard Control
Nationale Politie
Nationale Politie, Expertisecentrum Forensische Opsporing
Nederlands Forensisch Instituut
Nederlandse Voedsel- en Warenautoriteit
Onderzoeksbureau EMN-expertise
Onderzoeksraad voor Veiligheid
Politieacademie
Regionale Eenheid Oost-Nederland
Vrije Universiteit Amsterdam

ENGINEERING PHYSICS

Aalto University, Finland
EKO Instruments Europe B.V.
Erasmus Medisch Centrum
FME-CWM
Ocean Optics
Océ Technologies
Philips Research Laboratories
RISO
Sensata Technologies
Singulus Mastering
Syntens
Thales
TNO Industrie en Techniek
VanderHoekPhotonics
XTREME technologies GmbH, Aken

ENVIRONMENTAL SCIENCE

The Environmental Science programme has a programme profile which has been drawn up in association with all of the environmental science programmes offered at universities of applied sciences in the Netherlands. Only the programme of Avans University of Applied Sciences falls within the Applied Science Domain. The national programme profile containing the Body of Knowledge and Skills has been drawn up and validated by the professional field representatives of all the environmental science programmes (see reference 3, page 75) and therefore enjoys wide support in the relevant professional field. In addition, the compliance of the Avans University programme with the competence profile for the Bachelor of Science in the Applied Science domain has been validated by professional field representatives of the companies and organisations listed below:

DCMR Milieudienst Rijnmond
Europese Commissie, Directoraat-Generaal Milieu
Inspectie Leefomgeving en Transport
Provincie Noord-Brabant
Witteveen+Bos

Appendix VI

Applied Science Domain

* For a list of participating universities, programmes and research groups, see pages 96 and 97.

The Applied Science Domain Foundation (DAS, Domein Applied Science) is the national collaboration between higher professional educational institutions that award a Bachelor of Science degree in the applied sciences. As of mid-2020, the Domain consists of fifteen universities of applied sciences offering nine different programmes* attended by over 13,000 students. Forty-four research groups in the field of applied research are active within the Domain and four Master programmes are being offered.

DAS tries to provide a coherent range of high-quality education and research which is geared to the needs of the professional field and also to social developments. The emphasis is on the interests of the up-and-coming professional who is being trained. Collaboration within the Domain assists the programme directors to formulate their policy. Exchanging experiences is an important element of the collaboration. In addition, the Domain also develops joint activities that go beyond what is possible for individual universities. The priority areas are education, research, quality assurance and providing information on the programmes. Other important current issues are the positioning of the programmes, internationalisation and communication. Each year a major conference is organised at which staff members from the universities can meet to discuss education, research and the provision of information.

Examples of activities within the priority areas are listed below:

Education

- A common competence profile and Body of Knowledge and Skills for all Applied Science programmes (validated by the professional field).
- Exchange and support for programmes targeting 'data-skilled professionals'.
- Coordination of MBO-HBO-WO connection and transfer with national organisations.
- Reviewing developments in secondary education to promote the link with HBO.

Research

- Semi-annual meetings for professors, research group members, lecturers and students working in the research groups.
- PR and communication in the professional field and government concerning Applied Science research.
- Creating joint research projects and submitting funding applications.

Providing information on the programmes

- Providing information to raise awareness of the programmes among school students and allow them to discover whether a programme in the Applied Sciences is suitable for them with the aid of an app, leaflets, website: www.proef.info, learning materials and workshops at conferences for secondary school teachers and student counsellors.
- A smartphone app that helps school students choose a study course for an Applied Science programme.
- Learning materials about occupations in Applied Sciences for lower secondary levels.
- Realistic information material about higher professional programmes for senior secondary vocational students.
- Participation in national project 'Exactly what you're looking for', a collaboration between vocational, higher professional and university programmes and the business community.
- In terms of providing information, the domain is collaborating with Stichting C3, the communication centre.

Coordination with professional field

An important part of the collaboration within DAS is the national coordination of developments relating to priority areas and issues with the professional field. This is being done at different levels.

Regional professional field advisory committees

All of the universities and programmes participating in DAS are collaborating with regional professional field committees to match the design of the individual programmes to the actual occupations involved. These committees are made up of representatives from the professional field, often from the region in which the university is located. Topics for discussion include the curriculum for the programmes including minor subjects and specialisations, internships and graduate projects, guest lectureships, internships for lecturers and real-life research projects for students, lecturers and research groups. The nationally agreed competence profile and the Body of Knowledge and Skills are also validated by these professional field advisory committees and translated into the individual programmes.

National Professional Field Consultative Committee
By organising the National Professional Field Committee, DAS establishes the link between the regional developments on the one hand and the input from the individual professional field committees on the other.
This body is made up of representatives of the regional professional field advisory committees of the participating universities. The professional field representatives can look beyond the boundaries of the individual programme and university and observe trends in the sector. Topics and issues discussed in this National Professional Field Committee include professional development and trends in the professional field, national coordination of the competence-oriented profile descriptions, developments in the labour market, exchange of best practices with regional professional field committees and projects involving the professional field across regional boundaries.

Applied Science Advisory Board
Ongoing consultation is taking place among a number of top sectors and industry organisations to coordinate Applied Science education and research to meet the needs of the professional field, thereby deploying the available resources effectively and efficiently.

The Advisory Board is made up of representatives of the following organisations:

- Confederation of Netherlands Industry and Employers [VNO-NCW]/The Royal Association MKB-Nederland [MKB-Nederland] are kept informed of developments and, where relevant, involved and/or consulted.
- FENELAB, Association of Dutch Laboratories, Calibration and Inspection Institutes
- Leading players in the chemical sector
- Leading players in Life Sciences and Health (LSH)
- Association Innovative Medicines [Vereniging Innovatieve Geneesmiddelen]
- NIBI, Netherlands Institute of Biology
- NRK, Federation of Dutch Rubber and Plastic Industries
- NVML, Netherlands Association of Biomedical Laboratory Staff
- Platform for Professional Field of Medical Laboratory Education
- VNCI, Netherlands Chemical Industry Association

The DAS organisation
DAS is characterised by a high degree of organisation, with an extensive internal and external network. All participating universities have a role or function in its management and in the different working groups active within the domain. It is not only all of the programme directors who participate in working groups, national educational committees and/or project groups, a large number of programme coordinators, PR coordinators and lecturers from the participating universities are also involved. DAS has its own office facilities and is assisted by policy advisers.

Programmes and research groups at participating universities

Below is an updated version of the list of Bachelor programmes and research groups at participating universities.

PROGRAMMES AND RESEARCH GROUPS AT PARTICIPATING UNIVERSITIES

University of Applied Sciences (UAS)	Programme (CROHO)	Research groups and Master programmes
Amsterdam UAS	Forensic Science	■ Forensic Science
Avans UAS, Breda	Biology and Medical Laboratory Research	■ Analysis technologies in Life Sciences ■ Biobased Energy ■ Biobased Building Blocks & Products ■ Biobased Construction ■ Marine Biobased Specialties ■ New materials and their applications
	Chemical Engineering	
	Chemistry	
	Environmental Science	
Avans UAS, Den Bosch	Chemistry	
Fontys UAS, Eindhoven	Applied Science	■ Applied Natural Sciences
	Engineering Physics	
The Hague UAS, Delft	Engineering Physics	■ Energy in transition ■ Smart Sensor Systems ■ Technology for Health ■ Urban metabolism
The Hague UAS, The Hague	Chemical Engineering	
HAN UAS, Nijmegen	Bio-Informatics	■ Biodiscovery ■ Molecular Life Sciences (Master)
	Biology and Medical Laboratory Research	
	Chemistry	
Hanze UAS, Groningen	Bio-Informatics	■ Biobased Chemistry ■ Biobased Ingredients & Materials ■ Biorefinery ■ Sustainable Energy
	Biology and Medical Laboratory Research	
	Chemical Engineering	
	Chemistry	
HU UAS, Utrecht	Biology and Medical Laboratory Research	■ Innovative Testing in Life Science & Chemistry
	Chemical Engineering	
	Chemistry	

PROGRAMMES AND RESEARCH GROUPS AT PARTICIPATING UNIVERSITIES

University of Applied Sciences (UAS)	Programme (CROHO)	Research groups and Master programmes
HZ UAS, Vlissingen	Chemistry	■ Marine Biobased Specialties
Inholland UAS, Amsterdam	Biology and Medical Laboratory Research	■ Green Biotechnology ■ Sustainable Pollination of Crops
	Biotechnology	
	Chemistry	
NHL Stenden UAS, Emmen	Biology and Medical Laboratory Research	■ Polymer Engineering (Master) ■ Sustainable Plastics
	Chemistry	
NHL Stenden UAS | VHL UAS, Leeuwarden	Biology and Medical Laboratory Research	■ Biobased Proteins ■ Biomimicry ■ Circular Plastics ■ Dairy Process Technology ■ Food, Health & Safety ■ Food Physics ■ Healthy and Sustainable Food and Diseases of Affluence ■ Sustainable Water Systems ■ Water Technology
	Biotechnology	
	Chemical Engineering	
	Chemistry	
Rotterdam UAS	Biology and Medical Laboratory Research	■ Lab innovation and Point-of-Care Testing ■ Process optimisation and identification ■ Sustainable (Bio)Chemical Innovation
	Chemical Engineering	
	Chemistry	
Saxion UAS, Deventer	Biology and Medical Laboratory Research	■ Advanced Forensic Technology ■ Applied Nanotechnology (Master) ■ International Water Technology ■ NanoBioInterface ■ NanoPhysicsInterface ■ Sustainable Energy Supply
	Chemistry	
Saxion UAS, Enschede	Biology and Medical Laboratory Research	
	Chemical Engineering	
	Chemistry	
	Engineering Physics	
	Forensic Science	
UAS Leiden	Bio-Informatics	■ Biodiversity ■ Bio-Informatics ■ Genome-based Health ■ Innovative Molecular Diagnostics ■ Metabolomics
	Biology and Medical Laboratory Research	
	Chemistry	
Zuyd UAS, Heerlen	Applied Science	■ Materials Sciences ■ Nanostructured Materials