

# Careers in Science and Technology in the Netherlands

## Summary

The Platform Bèta Techniek (the Platform Science and Technology), together with the Royal Institution of Engineers in the Netherlands and the publisher of Technisch Weekblad (Technical Weekly) commissioned the University of Maastricht to examine the current status of science and technology (S&T) careers in the Netherlands. This first report is based on a sample of engineers, members of the Royal Institution, and subscribers to the Technisch Weekblad surveyed early 2007.

There are clear differences in the careers of engineers with a university (wo, master/doctoral degree) or higher professional educational (hbo, bachelor equivalent degree) background. Recent graduates from professional education are more likely to start out in a career that is closely related to their own area of study while they earn more money than recent university graduates. Later in their career these professionals retain their head start on the salary scale, making more than others with similar but non technical degrees. This salary advantage is often the result of a career move towards less technical careers, the salary for technical jobs is lower than for management. On the other hand, technical professionals often need their technical expertise in their new career. For university graduates in S&T the picture is slightly different. While recent graduates also often work in careers closely related to their study, their start salaries are lower than average (but still higher than that of professional graduates). This salary disadvantage relative to e.g. economy graduates is true even after correction for relatively low paid post-graduate and research positions and continues throughout their career. In particular those choosing a career outside management make relatively less money.

On average S&T graduates make between 14.14 Euro to 14.26 Euro gross per hour. In Table 2.1 (p. 7) gross salaries are given for technology, economy, healthcare (and law for university) graduates at 1.5 years after graduation and 5 years. In Table 2.2 and 2.3 (p. 8) average gross hourly salaries are given respectively by educational degree and level, and career type. Over the years, the gap between professional and university S&T graduate salaries increase (Figure 2.1). Highest salaries are paid in the Financial as well as in the Oil, Gas and Mineral Industry, and lowest salaries can be found in Education and Research, and Healthcare. Management and marketing jobs pay better than those education and quality control. Many S&T workers' salaries contain a performance based component and a regular expense compensation, the likelihood of which increases with career length and is associated with management and marketing related tasks (see Table 2.7, p. 15).

Engineers and S&T graduates are relatively loyal to their employers, with average tenure of eleven years (see Figure 3.3, p. 25), and they are more satisfied with their current job due to their own intrinsic interest in their area of work. Job satisfaction increases over time. Status and salary are less important to Dutch S&T graduates than opportunities to learn new things, experience new challenges in their work, which is reflected in the higher than average participation in training (60 hrs/yr, Table 5.1 and 5.2, pp. 42 and 44) and time spent on individual study (74 hrs/yr, Figure 5.1, P. 44). Approximately half of all S&T workers are employed in large organizations (1000 employees or more) and about 10% works in much smaller companies (less than 10 employees). About 6% is government employed. S&T workers in large companies spend more time on training within working hours than those working in smaller companies. Recent science graduates are more often employed through temporary contracts, in part this is due to post-graduate research posts etc. As their career progresses, temporary contracts become less frequent. Working part time is not common in S&T careers at all, but is most common in university Industrial Design, Chemistry and Technological careers.

More often than non-S&T, S&T graduates perform management tasks, and those with university degrees more often than professionals. On average S&T professionals are as often independently employed as other professionals, university S&T workers are less often independently employed.

# Management Summary

How well are school-leavers and graduates in the sciences and technology prepared for the labour market? How well is technical education rewarded in terms of employment opportunities, salaries and career prospects? Is success in the labour market dependent on the region where one has completed one's studies?

These and other questions will be answered in this report, using a large-scale survey of school-leavers and graduates that was conducted from late 2006 to early 2007. The data covers people who graduated in the school year 2005/2006 from all levels of education in the Netherlands: pre-vocational secondary education (vmbo), secondary vocational education (mbo-bol), higher professional education (hbo) and university education (wo). For each level of education, we will compare the outcomes for (science and) technical school-leavers and graduates with those for school-leavers and graduates in other fields of education at the same level. In total, almost 110,000 school-leavers and graduates were approached. The overall response rate was 42%.

In order to gain further insights into the transition from education to the labour market, we will discuss the following aspects for each of the four levels of education:

- The qualifications of school-leavers and graduates
- Allocation of school-leavers and graduates to jobs
- Individual return on education
- Job satisfaction
- Career prospects

Finally, for school-leavers who completed the intermediate mbo-bol level 3/4 and graduates at hbo level, we will discuss regional differences.

## The qualifications of school-leavers and graduates: How well are they prepared?

With regard to the qualifications of school-leavers and graduates, the question is whether education has provided school-leavers and graduates with the skills (type and level) needed for success in the labour market. This does not simply refer to the question of whether the school-leavers and graduates have been sufficiently prepared for starting out in the labour market, but also whether education has succeeded in providing the school-leavers and graduates with a basis for continuously adapting their skills to changes in the labour market and acquiring the new skills for which there is a demand.

In comparison with school-leavers and graduates from other educational sectors, those in technical disciplines are generally more satisfied with the way in which their study has prepared them for the labour market. Exceptions are school-leavers who have completed technical education at mbo-bol level 1/2 and natural sciences graduates at university level. Although technical education seems to do relatively well in this sense, certain improvements are still needed, in particular at mbo-bol level. In fact, less than 50% of school-leavers who have completed technical courses at mbo-bol level 3/4 and only 33% of school-leavers who have completed technical courses at mbo-bol level 1/2 indicated that their education has provided them with a good basis for starting out in the labour market. In other words, the relatively good position of mbo-bol technical education in comparison to other sectors disguises the fact that in absolute terms the outcomes are not particularly good.

## Allocation: What kind of jobs do they find?

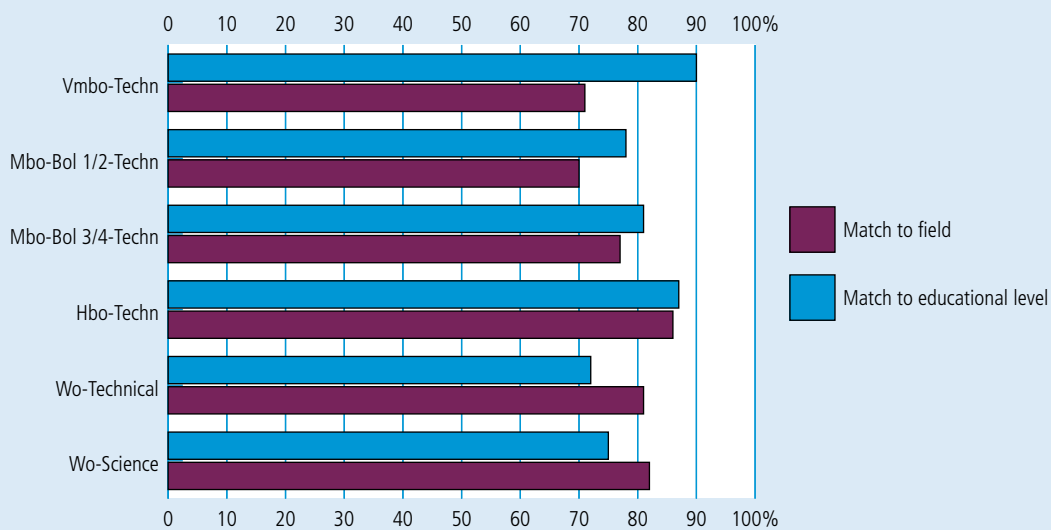
Allocation concerns the extent to which school-leavers and graduates find a job that matches their education. In addition

to a general impression of this match as given by school-leavers and graduates, we will consider the specific match between the level and field of education and the occupational level and field.

Firstly, we find that Dutch school-leavers and graduates from technical education courses are generally satisfied with the match between their education and their job. The lowest level of satisfaction is found among school-leavers who have completed technical courses at mbo-bol level 1/2. However, even among these school-leavers a clear majority (68%) indicate that the match between job and education is at least satisfactory. The highest level of satisfaction is found among those who graduated in technical subjects from universities: 86% find the match at least satisfactory.

Secondly, we find that Dutch school-leavers and graduates who have completed a technical course easily find a job that matches their education in terms of both level and field (see Figure S.1). 72% (university technical education graduates) against 90% (vmbo school-leavers who have completed a technical education) report that their job matches their educational level, whereas 70% (mbo-bol level 1/2) to 86% (hbo) of school-leavers and graduates from technical courses report that their job is a good match with their field of study. Only school-leavers and graduates from courses training people for a particular profession (e.g. health sciences or teaching sciences) outperform the technical school-leavers and graduates in this respect.

Figure S.1 Match between job and educational level and field



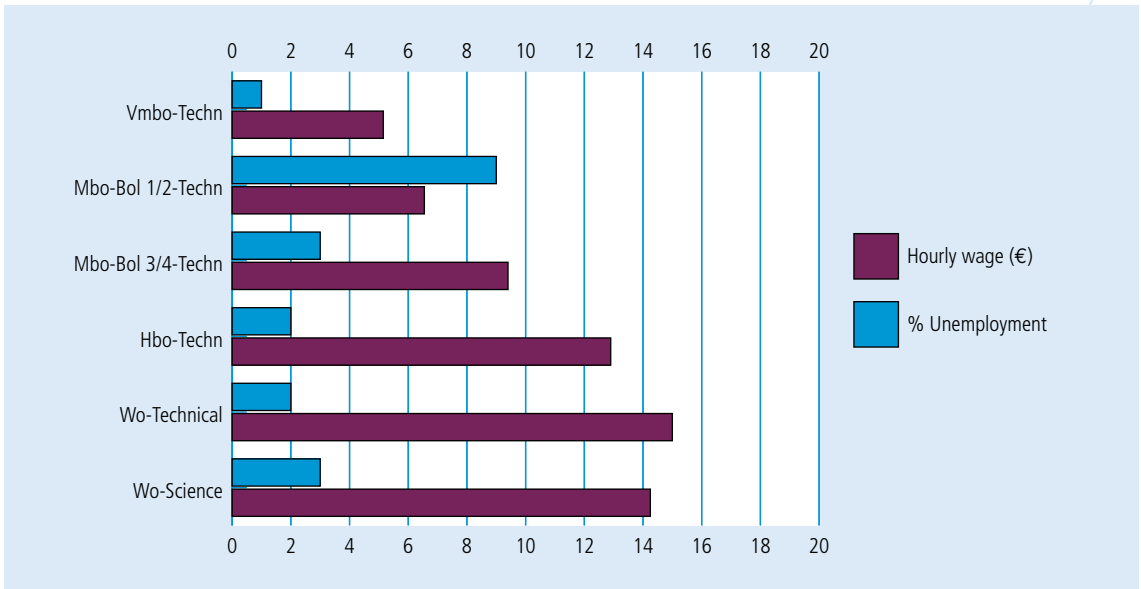
Bron: ROA (SIS)

### Return on education: What is gained?

The return on education refers to the question of what individuals gain from completing technical courses. We will analyse short term gains in terms of the unemployment rate and gross salary (both 1.5 years after graduation). The main results are presented in Figure S.2.

In 2004/2005, school-leavers and graduates who had completed technical courses certainly benefited from the economic recovery that started in the Netherlands around 2004. With the exception of mbo-bol level 1/2, the unemployment rate among school-leavers and graduates who have completed technical courses is very low. Moreover, the unemployment rate among school-leavers and graduates in technical disciplines is low in comparison to those in other fields of study.

Figure S.2 Unemployment rate and wages



Bron: ROA (SIS)

Interestingly, these relatively low rates of unemployment for school-leavers and graduates in technical subjects are not straightforwardly reflected in relatively high gross hourly wages. Whereas school-leavers and graduates who have completed technical courses at vmbo, mbo-bol and hbo level actually earn above-average wages, we find that the gross hourly wages of university graduates in technical subjects are just slightly above the average wages of university graduates, whereas the wages paid to natural sciences graduates clearly lags behind<sup>2</sup>.

### Job satisfaction and career prospects

On average, school-leavers and graduates who have completed technical courses are as satisfied with their job and with their career prospects as school-leavers and graduates in other fields of study. On average, 73% of Dutch school-leavers and graduates are satisfied with their job and 60% believe that they have good or very good career prospects.

### Regional differences

Finally, this PlatformPocket discusses the extent to which the match between technical education and the labour market differs between the four main regions in the Netherlands (North, West, South and East). The available data only allows such a regional approach for school-leavers who have completed technical courses at secondary vocational (mbo-bol) levels 3 and 4 and for graduates from higher professional education (hbo). Not surprisingly, we find that regional mobility after completion of courses is greater for technical graduates from hbo than for school-leavers at mbo-bol level. As a

2. The figures presented here for the gross hourly wage rate exclude university graduates who continued their education as PhD students.

consequence, regional differences are relatively smaller among hbo graduates than among school-leavers who have completed courses at mbo-bol level.

Among school-leavers who have completed technical courses at mbo-bol level, we find that in the Eastern part of the Netherlands 91% find a job that is a good match with their technical education. This percentage is significantly higher than in the other regions of the Netherlands. In the South only 81% of these school-leavers report having a job that matches their technical education. In the North only 74% report such a match and in the West of the Netherlands only 68% do so.

With respect to the gross hourly wage, we find that school-leavers who have completed a technical course at mbo-bol level in the West of the Netherlands earn almost 9% more than their peers in the Eastern part and 7.5% more than school-leavers with technical qualifications in the North of the Netherlands. Moreover, we find significant regional differences in job satisfaction and career prospects among school-leavers who have completed technical courses at mbo-bol level. In the Eastern part of the Netherlands, 75% are satisfied with their job compared with only 60% in the North. With regard to career prospects, school-leavers who have completed technical courses at mbo-bol level in the South are most satisfied: 71% indicate that they have good career prospects, compared with only 52% in the West of the Netherlands.

Among graduates in technical disciplines from hbo, we find regional differences, particularly with respect to the unemployment rate. In the North of the Netherlands, 4.4% of technical hbo graduates report that they are unemployed one and a half years after graduation. This is significantly higher than the unemployment rates in the West (1.5%) and the East (2.2%). The relatively high unemployment rate in the North might be one of the reasons why a relatively large percentage of technical graduates (26%) in this part of the Netherlands continue their educational career after completing their higher professional studies.

# A teaching approach for science and technology in havo (pre-professional secondary school)

## Summary

The Platform Bèta Techniek was entrusted by the government with the task of ensuring there are enough well-educated science and technology students by 2010. The Platform has developed the Universum Programme, an incentive programme for secondary pre-university (vwo) and pre-professional schools with the aim to provide more attractive and interesting science education, so that more young people than at present will choose science and technology subjects at higher professional and university level. A number of the Universum schools approached the Platform indicating that they were less sure about how to go about reforming their science education in Havo classes. They found that what worked at vwo level did not necessarily work well in havo classes. The Platform commissioned Oberon to carry out a comprehensive study surveying current best practice regarding a didactical approach specifically for havo, with an emphasis on science and technology subjects. Although we have not specifically focused on the two upper years of the havo, the emphasis of this study is indeed on these years as the problems perceived by schools manifest themselves more powerfully in the upper years compared to the lower years. We have formulated four main research questions for this study:

1. what are the characteristics of havo pupils?
2. what competences should havo pupils possess to progress successfully to hbo education?
3. what are the relevant parts of a havo-oriented didactical approach for science and technology education?
4. what other options are there for schools to do greater justice to the specific character of havo education?

The third research question is the central question of the study. The answers to questions one and two identify what needs to be taken into account in a havo-oriented didactical approach for science and technology education. Questions one to three have been explicitly dealt with in our study. In order to answer them, we carried out two main activities:

- literature research and a limited consultation of experts;
- group interviews with representatives of the Universum schools and with experts in the field of havo-oriented didactical approach and/or science and technology education.

In answering the fourth study question, we limited ourselves to information we came across 'spontaneously' in our research activities on the other three questions.

### Characteristics of havo pupils

There is considerable overlap in the characteristics of havo pupils that emerged from the literature study and those mentioned by the representatives of Universum schools. Even so, a number of subtle differences can be observed. We will first briefly describe these differences, and then conclude with a summarising overview of the characteristics of havo pupils. It is important to consider havo pupils in terms of their own qualities, and not always compare them with vwo pupils. We therefore aim to leave out such comparisons as much as possible in the summarising overview. Although we summarise the characteristics, we want to emphasise that there is no such thing as a typical havo pupil. On the contrary, the heterogeneity of havo classes, certainly in the upper years, is an important given.

The representatives of the Universum schools identify the sociable and spontaneous nature of havo pupils as an important characteristic. The literature hardly refers to this characteristic at all. In addition, the discussion partners place much more emphasis on the openness of havo pupils to the outside world than can be found in the literature.

**Tabel 7 Summarising overview of characteristics of Havo pupils**

<b>motivation, school perception and interest</b>
<ul style="list-style-type: none"><li>• Motivation of havo and vwo pupils to succeed is the same</li><li>• Havo pupils are more product-oriented and want results in the short term</li><li>• Havo pupils are motivated by positive confirmation and reward</li><li>• Havo pupils are more sensitive than vwo pupils to the attitude of teachers</li><li>• Havo pupils are slightly more positive about school than vwo pupils</li><li>• Havo pupils are interested above all in practical and application-oriented subjects</li><li>• Havo pupils are strongly focused on the world outside school</li></ul>
<b>Learning style and study skills</b>
<ul style="list-style-type: none"><li>• Havo pupils are largely 'do-ers' and (to a lesser extent) 'deciders' (Kolb learning styles)</li><li>• Havo pupils have a preference for the concrete strategy</li><li>• Havo pupils need freedom of choice, within clear boundaries</li></ul>
<b>Background characteristics and performance</b>
<ul style="list-style-type: none"><li>• Havo pupils are sociable and spontaneous</li><li>• Havo pupils are slightly less intelligent and have greater difficulty with the transfer of knowledge than vwo pupils</li></ul>
<b>Other characteristics</b>
<ul style="list-style-type: none"><li>• Havo pupils play truant slightly more often than vwo pupils</li><li>• Havo pupils already have a clearer idea than vwo pupils of what type of work they want to do</li></ul>

### **Competences for successfully progressing to higher professional education (hbo)**

We looked not only at the competences that havo pupils must possess in order to progress successfully to hbo, but also at a number of facts and opinions about progression, drop-out rates and transition. The main conclusions on this are:

- A large majority of havo pupils, after obtaining their diploma, progress on to hbo education. This progression is the greatest among havo pupils with an Science and Technology profile.
- The drop-out rate in hbo around eighteen months after commencement is about 16 per cent.
- Most pupils are satisfied with the transition from havo to hbo. Pupils with a science profile are relatively the least satisfied.

In order to identify which competences pupils must possess to enable them to progress successfully to hbo, we examined the competence profile of the Havisten Competent ('Competent havo students') project and the draft examinations programme for the science and technology subjects. Some 40 havo schools and hbo institutions are working together within Havisten Competent on improving the transition from secondary to higher professional education. They have identified five competence areas that can be regarded as the final attainment level for Havo. For the science and technology subjects, a reform committee has been set up for each subject. These committees have drawn up their draft examination programmes for the examinations from 2010 onwards. In these drafts, the examination requirements are organised in domains. The domain of skills comprises two subdomains that apply across all science subjects: general skills and mathematical, physical and technical competences. The latter domain is specific to the science and technology subjects, whereas the general skills are for all profiles. The table below gives a comparison between the competence areas of Havisten Competent and the general skills in the draft examination programmes. There is clearly a significant overlap between the two; there would appear to be agreement on the general skills that havo pupils must have to progress to hbo. The same applies to the mathematical, physical and technical skills in view of the fact that they apply across all science subjects. In addition, in order to progress successfully to hbo, not only is subject knowledge required, but general and profile-wide skills are important too.

**Table 8 Comparison of ‘Havisten Competent’ competence areas and general skills from the draft examination programmes of the science and technology subjects**

<b>Competence areas Havisten Competent</b>	<b>General skills from the draft examination programmes in science and technology subjects</b>
search, select and prepare information for own use	information skills
review behaviour and results	review one’s learning
develop professional attitude	study and occupation
training in skills, behaviour and application of knowledge to develop and automate consistent working methods	included in mathematical, physical and technical skills under: <ul style="list-style-type: none"> <li>• numerical and mathematical skills</li> <li>• application of knowledge</li> </ul>
problem-solving cooperation in a group of varying size	-
-	communication

### **A have-oriented didactical approach for science and technology education**

The question of what elements of Havo didactics are relevant to science and technology subjects is one we have approached from several angles:

- literature on didactics for science and technology subjects;
- literature and didactics for Havo pupils;
- opinions of representatives of Universum schools;
- opinions of experts.

The findings resulting from these four angles largely point in the same direction and complement each other well in a number of areas. Nowhere do the differing angles of approach lead to conflicting insights on what elements of a have-oriented didactical approach are relevant to science and technology subjects. This, however, does not mean that all the findings point in the same direction. The observed differences in insight are the result of fundamental differences within each angle of approach. For example, we see that both within the literature on a didactical approach for science and technology subjects and in the discussions with school representatives and experts, there is no consensus on the draft context approach that is fundamental to the new didactical approach. On the one hand we have the ‘proponents’ who believe that this approach is suitable for making education more meaningful to have pupils. On the other hand we have the ‘opponents’, who believe that the use of contexts through the limited transfer of knowledge leads to an inadequate understanding of principles, or that it is impossible to use contexts that are meaningful to all pupils. A second point about which there is a difference of opinion is the extent to which learning as a team is suitable for have pupils. The representatives of the Universum schools believe that group work is a welcome change from other forms of work. Some of the representatives, however, doubt whether have pupils really can work as a team.

If we consider the findings from the four angles of approach together, four teaching competences would appear to be the most important for a have science and technology teacher. Naturally other elements are important too, such as the didactic work form, the syllabus and the lesson structure. Teachers are largely responsible, whether or not together, for the way these elements are structured. We therefore summarise the main conclusions below, indicating at the same time which other elements are relevant.

### **Didactic competence**

A teacher must be able to accommodate the various learning styles of pupils. This can be done, for example, by using a variety of work forms, adopting several problem solving methods, or varying the lesson structure. In addition, teachers may use the differing learning styles of their pupils constructively by encouraging these pupils to learn from each other.

A prerequisite is that teachers know what learning styles there are, how they can recognise them among their pupils and how they can use them in a practical teaching situation. Often not all of these conditions are met in practice. In addition, teachers must use activating work forms. Finally, a teacher must provide a clear structure. This applies not only to the structure of the lesson, but also the work forms used and the teaching materials.

Variety in work forms and activating work forms are not only important in order to accommodate the pupils' learning styles, but also appear to be important for teaching the general and profile-wide skills that havo pupils will need to progress successfully to hbo.

### **Subject expertise**

Teachers must make the curriculum meaningful for pupils. One way of doing this is to use the concept-context approach. For havo pupils it is the social and the vocational context in particular that is relevant. Education can also be made more meaningful by creating links between the different subjects (projects involving more than one subject). Furthermore, such projects offer good opportunities for giving general and profile-wide skills their own place in education. In addition, teachers who are competent in their subjects could work together on developing continuing teaching guidelines. Finally, it is important for teachers to recognise misconceptions and 'erroneous' reasoning by students, and to know how they could respond to this.

### **Interpersonal competence**

It is extremely important for havo teachers to be able to get on well with their pupils. The most important aspects in this context are to demonstrate involvement with and an interest in pupils and have positive expectations of pupils.

### **Pedagogic competence**

Pedagogically competent teachers are aware of their pupils' perception of their environment, and have sympathy and understanding for their struggles with puberty. In addition, they can create a safe learning climate in which all pupils feel valued and are not afraid to express themselves.

### **Other options to strengthen a specific havo-identity**

In the course of the literature study and during the group discussions, a few other options were briefly considered in order to do greater justice to the desired specific character of the Havo. We wish to stress that the description of these other options is not comprehensive. Since the didactical approach was the central theme of our study, when examining the other solutions we limited ourselves to solutions that we came across 'spontaneously' in our literature study and the group discussions. These other solutions are:

- the use of teaching guidelines at school level;
- new forms of assessment geared to the reformed range of study materials;
- cooperation with the business sector and civic society;
- considering the upper years of havo (3, 4 and 5) as a single entity.

# Management Summary

This report describes the secondary analyses that have been carried out on a database with information on more than 1800 pre-professional secondary school (havo) students who entered higher education in 1999/2000 and were monitored for a number of years (Van Langen, 2005). The central theme of the report is the relationship between the science talents of these pre-professional secondary school pupils on the one hand, as indicated by their average score for three subjects maths, physics and chemistry in the spring report in Year 3, and their chosen profile after Year 3 on the other hand.<sup>2</sup> This survey uses the term utilised science talent when pupils make a profile choice that matches their science abilities, and underutilised science talent when these pupils who do indeed demonstrate scientific talent do not go on to choose a science profile. Finally, there is also a group of pupils who in fact choose a science profile that is more difficult than what their school marks would indicate they would be able to manage; pupils we refer to as the 'overutilisers'. Within this tripartite division, the boys and girls were analysed separately, with specific attention also being given to pre-professional secondary school pupils from ethnic minorities. A comparative study has been previously carried out on pre-university (vwo) underutilisers and utilisers of science talent (Van Langen & Vierke, 2006) and comparisons are made with this study. The lack of interest in science and technology among pre-professional secondary school pupils is in fact even more marked than among pre-university pupils. Since the threatened shortage of science students is found not only among university graduates but also graduates of higher professional education, it is relevant to know whether pre-professional and pre-university secondary school pupils differ from each other in this respect, and therefore require a different policy approach.

Before discussing the results, terms such as 'underutilised' and 'overutilised' science talent require some clarification. These terms have been chosen based on the policy decision that more scientists need to be trained. Pupils who make a different choice to that which would be logical based on their school performance, also have other talents that may perhaps be very well utilised in their chosen profile. Although at an individual level the underutilisation is therefore usually relative, from an economic perspective such underutilisation is undesirable. Furthermore, the current extreme underutilisation of science talent among women is also socially undesirable, because this creates the basis for a form of labour market segregation and unequal opportunities between the sexes to obtain a good position in the labour market. Moreover, for the 'overutilisers' it is certainly not the case that they have made a too difficult choice and that by definition they will experience problems. After all, the course of their further educational career cannot be predicted with any certainty based on this information. Finally, using the school marks in the third year of pre-professional secondary education as an indication of scientific talent is not without controversy, since it probably serves as an indication not only of the scientific talent present, but also the diligence and motivation of the pupil, as well as the relationship between the teacher and the pupil.

The pupils are divided into the categories of underutilisers, utilisers or overutilisers, based on their marks (their science talent) and their chosen profile, whereby three profiles can be distinguished; Science and Technology (S&T), Science and Health (S&H) and a Social profile (Economics and Society and Culture and Society together). This categorisation is important for moving on to further education in science: pre-professional secondary school pupils who progress to higher professional education hardly ever choose science and technology if they have taken their final school exams in a social profile, whereas 30% of those with an S&H profile and 82% of those with a S&T profile choose this sector. Analogous to this, a second division into three groups is used for science talent: with an average score of 6 or less (on a scale from 1 to

2 Each of the four profiles for the upper grades of secondary school consist of compulsory and elective subjects. The two Social profiles focus on languages and humanities, in the Science profiles sciences and mathematics are compulsory.

10) it is assumed that pupils have performed in accordance with a social profile; with an average of more than 6 but not higher than 7 they have performed in accordance with an S&H profile, and with an average higher than 7 in accordance with an S&T profile.

## The results

The table below shows how many of the 1636 pre-professional secondary school pupils in the sample studied belong to each group. The white cells in Table 1 show the overutilisers and the dark blue cells show the underutilisers of science talent. The unshaded cells are the utilisers.

Table 1 Relationship between actual profile choice and profile performance level based on the school marks for the science subjects. Study sample of pre-professional secondary school pupils, by gender.

		Performs in accordance with an:			Total
		Social profile	S&H profile	S&T profile	
<b>Chooses a:</b>					
Boys	Social profile	225	176	52	453 (62%)
	S&H profile	16	56	37	109 (15%)
	S&T profile	11	66	97	174 (24%)
	Total	252 (34%)	298 (40%)	186 (25%)	736 (100%)
Girls	Social profile	391	267	70	728 (81%)
	S&H profile	27	77	55	159 (18%)
	S&T profile	2	4	7	13 (1%)
	Total	420 (47%)	348 (39%)	132 (15%)	900 (100%)

The table shows that 65% of pre-professional secondary school boys and 54% of pre-professional secondary school girls possess some or considerable science talent (as derived from the school marks) whereas 39% of boys and only 19% of girls opt for a science profile. This means that there are differences between the sexes to the disadvantage of the girls both in terms of the science profile choice and science talent, but the differences in talent are smaller than the differences in choice. Moreover, the differences between the sexes concentrate entirely on the S&T profile. Among both the girls and boys, there is a substantial group of underutilisers: 44% of the girls and 36% of the boys. In relative terms, with regard to the pupils with science talent the picture is even clearer, with 55% of boys and 82% of girls with science talent not making optimal use of their talent: taken together this is 68%.

The number of overutilisers is much smaller: of the total number of pupils this is 13% among boys and only 4% among girls. In this category too, the boys differ from the girls by tending more often to choose S&T.

Analysis shows that the differences in profile choice between native Dutch and ethnic minority pre-professional secondary school pupils are fairly limited. Of the pupils with science talent, about 24% opt for an appropriate science profile. But since the percentage of ethnic minority pupils with a science talent is lower than that of native Dutch pupils, this means that ethnic minority pupils underutilise their science talent relatively less often (33%) than native Dutch pupils (41%). Within the group of pupils with science talent, the differences in underutilisation between ethnic minorities and native Dutch pupils are therefore minimal. The percentage of overutilisers is also the same in both groups (8%). Among the ethnic minority pupils too, more boys than girls have science talent (52% versus 42%) and among these talented pupils, once again it is more often the girls rather than the boys who tend not to utilise this talent optimally (71% versus 53%).

Comparisons between the underutilisers and utilisers of science talent on the one hand, as well as between the overutilisers and utilisers of science talent on the other hand, produce the following picture.

- The main explanation for both underutilisation and overutilisation is the pupils' interest in courses and occupational aspects. Those who feel attracted to studies and occupations in the science and technology sector utilise or overutilise their science talent; those who do not feel this attraction, do not. This underlines the importance of providing information on a wide range of attractive science and technology studies and careers.
- The advice from parents and the school on the choice of subjects and profile prove to have a significant influence on the degree of underutilisation, utilisation and overutilisation of science talent. This advice is not always unanimous for pupils with the same marks and may make the difference between underutilisation, utilisation and overutilisation. If these persons lack knowledge about studies and occupations, particularly in the sciences, providing good information to them could be useful as well.
- The pupil's own assessment of his or her skills in and enjoyment of physics and its usefulness for his or her own future and the general usefulness of this subject shows clear differences between the underutilisers and utilisers as well as between the utilisers and overutilisers. This indicates the need to improve the image of physics as a subject, on the one hand by ensuring that pupils (certainly those who obviously demonstrate a talent in this direction) enjoy the subject more, and on the other hand by devoting more attention to the usefulness of this subject for their future. It is not known to what extent this image problem is also an issue for the other science subjects that have not been studied.

### **Differences between boys and girls**

Although it is indeed the case that fewer pre-professional secondary school girls demonstrate considerable science talent compared to their male peers, the differences between the sexes in their choices are even greater than may be expected based on gender: 39% of the pre-professional secondary school boys choose a science profile compared to 19% of their female peers; only 1% of the pre-professional secondary school girls choose the Science and Technology profile compared to 24% of their male peers. Gender is therefore an important predictor of underutilisation, even though this did not emerge as such from the analyses because the boys and girls were studied separately. Among the overutilisers too, incidentally, there are far fewer pre-professional secondary school girls (4%) than boys (13%); furthermore the overutilising girls also nearly always choose the S&H profile, whereas overutilising boys often also choose the S&T profile.

Although the same factors that give rise to the underutilisation of science talent play a role with both boys and girls, it is important to realise that these determinants play a role among many more girls than boys. There are more underutilising girls than boys, because their preference for courses and occupations tends not to be aimed towards the sciences. Even with the same school report marks their parents and the school are more likely to recommend they pursue a different profile and on top of this they have a lower appreciation of the subject of physics.

All the above-mentioned conclusions on predicting the utilisation compared to the underutilisation of science talent proved to apply to a lesser or greater extent to pre-university pupils as well. Even so, two striking differences were observed. Firstly, fewer pre-professional secondary school pupils choose science profiles compared to pre-university pupils; 28% compared to 46%. Secondly, the percentage of pupils with higher school marks for the science subjects in Year 3 is much lower among the pre-professional secondary school pupils than pre-university pupils. The Education Inspectorate argued in 2003 that the difference between pre-professional and pre-university secondary education for most subjects can be classified as a difference in level. This could be the reason why there are far fewer pre-professional secondary school pupils than pre-university pupils with high school marks. If pre-professional secondary education were to have its own stronger individual identity, this would probably produce a clearer, normal distribution of the school marks, including a greater share of pre-professional secondary school pupils with high marks.

### **Ethnic minority pre-professional secondary school pupils**

The explanations for the underutilisation of science talent among ethnic minority pre-professional secondary school pupils appear not to differ from that among all (predominantly native Dutch) pre-professional secondary school pupils. From a policy point of view, the conclusion is therefore that reducing the underutilisation of science talent among ethnic minorities and native Dutch pupils must be aimed for based on the same interventions, and that no specific measures for ethnic minorities are needed. The small number of ethnic minorities in the science profiles is therefore not the result of a greater underutilisation among ethnic minorities compared to native Dutch pre-professional secondary school pupils, but rather the under-representation of ethnic minority pupils in pre-professional secondary education in general, as has often been observed in previous studies.

# Management Summary

Organisational networks appear to drive innovation, as is acknowledged in (policy) theory and practice. The Universum Programme (UP) is an example of this: based on the principle of backing the winners this programme stimulates the development of a network of secondary schools with the aim of exchanging innovations and expertise regarding science and mathematics education. This report shows two sides of network formation between Universum schools:

1. The network level: the overall network structure of UP. How has the network developed since before the programme and what is the current structure? In what way has UP contributed to the network, and to what extent?
2. The actor level: to what extent are the separate Universum schools embedded in the network structures, how are a school's network position and its science performance related and in what way?<sup>3</sup> It is assumed that a higher degree of network centrality correlates with better science performance.

This study did not only look at collaborations between Universum schools and other secondary schools. It also investigated to which degree Universum schools seek collaboration or connection to institutes of higher education and business. For each of these three points of departure, secondary and higher education and business, the study established to what extent collaborations existed with regard to the development of teaching materials and exchange of expertise regarding organisational aspects of science innovations (cross-cutting subjects, school rotas, etc.).

		Before UP	Now
Secondary	Collaborative development of science material	X	X
	Exchange of expertise regarding organisation of science innovation (i.e. subject integration)	X	X
Higher	Collaborative development of science material	X	X
	Collaboration regarding connection/flow between educational levels	X	X
Business	Collaborative development of science material	X	X
	Collaboration regarding providing career and professional information	X	X

To answer the question about "who does what with whom?" the UP coordinator or each of the 100 Universum schools was sent a questionnaire, and 96 questionnaires were returned.

## What is network analysis?

Network analysis - a rapidly emerging analysis method within sociometry and mathematical sociology - focuses on the actors (here the secondary schools, institutes of higher education and businesses) and their mutual relationships. The relationships are based on content (in this study: development of teaching material, organisational collaborations, activities regarding connections or flow, and providing professional and career information). Besides network visualisation (graphs of networks) the analysis results in a number of measures that facilitate quantitative statements regarding network formation in a more general sense and the network position of individual schools in the network. The main measures are degree (a school's number of direct connections within the network), closeness centrality (based on the total path length from each school to all other actors in the network, taking into account indirect connections), betweenness centrality (to which extent a school functions as a linking pin between clusters), density (the extent to which the network is tied together), and sub group/cluster (a set of closely connected schools that are more loosely related to the rest of the network).

<sup>3</sup> As measured by the share of science profiles in the upper cycle. In the fourth grade pupils must choose between four profiles, two of which focus on combinations of maths and sciences. The two remaining profiles focus on economics or languages and humanities

## To what extent did a Universum network develop?

The network analysis established that for all six dimensions studied (see Table S.1 below) powerful and integral network formation occurred. After the inception of UP, the Universum schools are more closely interconnected than before. The increased interconnection is clearly visible in the network visualisations (see Figure 4, secondary school and materials; Figure 7, secondary schools and organisation; Figure 8, secondary-higher education and materials; Figure 13, secondary-higher education and organisation; Figure 15, secondary-business and materials; Figure 17, secondary-business and organisation). The similarity between before and after visualisations indicates that the increased network formation grew out of existing relationships: existing ties become closer and 'friends of friends' come into contact. Almost all pre-existing relationships continue.

In addition to the quantitative network indicators (number of actors involved, number of relationships and density) the network quality (P) was calculated (i.e. the average density of relationships). The P-value after inception of the programme is much higher than before and the difference is traceable to the number of actors within each network and the number and intensity of relationships per network.<sup>4</sup>

Network quality (P)	After UP	Change (%)
Secondary - development of material	903	281%
Secondary- organisational innovation	969	206%
Higher - development of material	599	126%
Higher - flow/connection	570	84%
Business - development of material	450	347%
Business - professional and career information	396	236%

Conclusion: since the start of the UP a substantial and powerful network formation has occurred. The increase in network formation not only occurs between secondary schools; also institutes of higher education and businesses more often form relationships with schools.

## Are network position and the science performance related?

Is network embeddedness beneficial? In other words, is there a relationship between the network position of a school and its science performance? Network analysis has - for now - not been able to confirm this assumption. On the other hand, the more Universum schools collaborate with other secondary schools with regard to developing teaching materials, the more science oriented profile distributions for pre-professional pupils these schools have. With regard to secondary-higher education collaborations we see a significantly higher through flow. Overall - for now - not many convincing connections can be found between science performance and network embeddedness. However, there is a logical explanation for this result: to measure the science performance we had to use somewhat outdated statistics. Given the availability of data, a (time-wise) skewed correlation is unavoidable: connecting current network performance with past science performances. Furthermore we assume the existence of an UP incubation period: presumably it will take a few years before evident second order effects are measurable. Based on the network analysis we can reach the following additional conclusions.

### Material vis-à-vis organisational collaboration

The current network formation between secondary schools is stronger (in an absolute sense) than for material

<sup>4</sup> The theoretical maximum P is defined by the number of actors. The secondary school network consists of more actors than the higher education network. Therefore the values of various network foci (secondary or higher education or business) cannot be compared simply. It is possible to compare networks with regard to average intensity (see chapters 3, 4 and 5).

collaborations. The number of actors, of relationships, the density of the network and the network quality (P) are at a higher level for organisational collaborations. We do observe a considerable growth in the network formation regarding development of material. It seems this network is catching up.

With regard to collaborations between secondary schools and higher education, all network indicators show a more impressive growth for material development than for collaborations with regard to flow. Schools seem to perceive through flow issues as less of a network activity.

Universum schools that collaborate with businesses, tend to focus on developing teaching materials. This is not surprising, as professional and career information are usually already provided on - often more or less standardised - induction or information days.

### **Regional attraction: 'distance matters'**

The network visualisations show clearly that collaboration between secondary schools often is of a regional nature (schools in the same province are colour coded; See figures 4 and 7). Universum schools in North Brabant usually collaborate with schools in the same province, and the same goes for schools for instance in Limburg. In terms of improved network formation the Bètapartner network in the North Holland province is a powerful example of a regional sub-network. Collaborations with institutes of higher education or businesses are also often region oriented. Geographical proximity may already play a role in the selection of a partner. In particular in the frequent contacts between Universum schools, institutes of higher education and businesses, the regional attraction proved to be very strong. A possible explanation may lie in the transaction costs involved with choosing contact and collaboration partners in the region (travel time, travel costs etc.) as well as the inclusion of contacts from the informal network.

### **Formalising collaborations**

The results in chapters 3, 4 and 5 show that in particular for sub groups, formalisation of collaborative contacts contributes to increased density (on network level) and intensity (on relationship level). In this way the most closely connected sub group evolved around the Bètapartner network. Jet-Net relationships (which can be seen as formalised collaborations) prove to be as successful in network terms.

Furthermore, the Universum Programme itself can be seen as an approach to formalising collaborations. Fact is that all networks examined have developed considerably during the programme. To gather a better understanding of the effect of formalised collaborations, we examined whether the more formal networks, such as Technasium, Bètapartners and Beter Bèta, play a role in an increased embeddedness. Almost half (46.9 percent) of the Universum schools in this study indicate they are also member of another science initiative. It seems that there is a substantial overlap between science initiatives mentioned (chapter 6).

### **Linking pin constructions: the broker in the process of knowledge exchange**

Before the Universum Programme started, some regions were completely isolated from other science initiatives, with the obvious negative effects on the exchange of knowledge and expertise regarding science innovation. Currently we see a number of linking pin schools: brokers within the Universum network connecting various sub networks and facilitating broader exchanges of knowledge. Considering the power of regional attraction, it is not surprising that these schools are very often situated on the border of two regions. Besides these between-group linking pins, there are also within-group linking pin schools.

### **Network formation school types: from soloist to all-round networker**

Some schools focus on intensifying relationships with other secondary schools, other schools invest more in relationships with higher education or businesses. Considering the current secondary, higher education and business works we have distinguished eight network roles for Universum schools:

Type	Description
Soloist (1)	Below average embedded in secondary, higher education and business networks.
Higher Education networker (2)	Less embedded in networks with secondary schools and businesses, but connected excellently with higher education institutes.
Business networker (3)	Above average connected to businesses, but below average embedded in networks with other secondary schools and higher education.
Heterogeneous networker (4)	Lower investment in collaboration with similar actors (secondary school), but above average with regard to collaboration with other organisations (higher education and businesses).
Homogeneous networker (5)	In contrast to type 4, these networkers have above average connections to other secondary schools, but they lack concrete collaborations with higher education or businesses.
Education oriented networker (6)	Above average embedded in networks with secondary and higher education. Collaboration with business is below average.
Secondary and business networker (7)	Less connected in the higher education network, but above average performance with regard to secondary and business networks.
All-round networker (8)	These "winners" in terms of network embeddedness perform above average with regard to collaboration with secondary and higher education as well as businesses.

Comparing network roles before and after the Universum Programme, it is remarkable that almost half of the Universum schools do not change their networker type. Perhaps the nature of a school's 'networking behaviour' is fairly stable. The other Universum schools do develop in their networking role, with about equally sized groups of schools choosing either to "broaden" or to "narrow" (narrowing can be interpreted as specialisation as well; see Table 17). There is no relationship between network typology and science profile performance. This means that soloists do not necessarily have a smaller share of NG/NT pupils than all-round networkers.

### Network strategies for businesses and higher education: breadth against depth

Regarding higher education, we have found a number of network strategies (chapter 4). There are institutes who have many connections with Universum schools, but limit these contacts to one or two meeting per year. We would refer to this as a breadth strategy: many Universum schools are provided with information to their needs regarding science teaching material, usually through more or less standardised products. The advantage of this strategy is reach: a comparatively great number of schools and therefore a great number of pupils that may choose a science profile as well as future science students come into contact with the institute. Other universities seem to follow more of a depth strategy: these institutes work (very) closely together with a smaller number of Universum schools. This strategic dichotomy is less apparent in the business networks. This finding might be related to the dominance of JetNet businesses in the school-business network. Differentiation with regard to the types of collaborations between schools and businesses (depth vis-à-vis breadth) is less common.

### Collaboration with business: looking for the usual suspects

For now, Universum schools collaborate most with businesses with a very strong science aspect: the "usual suspects" (Bilderbeek et al., 2007). The most centrally networked businesses are Shell Research & Technology Centre, Philips (Consumer Electronics, Medical Systems, Lighting), Akzo Nobel, Unilever R&D, DSM Research, European Space Agency, Corus, the Dutch Royal Navy, Royal Haskoning, IBM and the Royal Dutch Meteorological Institute (KNMI). This shows remarkable embeddedness of Jet-Net companies. Currently, some 167 businesses/non-profit organisations collaborate with Universum schools regarding the development of teaching materials for science education; "only" 53 of these are Jet-Net companies. More remarkable is the fact that there are hardly any non-Jet-Net companies that prove central in the network. There are many other businesses (outside Jet-Net) that Universum schools collaborate with, but in those cases the collaboration is usually one-on-one.

# Labour market forecasts 2007-2012: Trends and figures for science and technical studies

## Management Summary

From 2004 onward, the Dutch economy has shown signs of economic recovery. This revival in economic activities has induced a drop in the unemployment rates and an increase in the number of vacancies for graduates of science and technical studies. As a result, as of 2006 labour market shortages returned. Moreover, it is expected that also in the coming years the economic growth will be substantial. Which in turn is expected to have a large impact on the labour market position of graduates of science and technical studies and on the expected recruitment problems for the firms at the demand side of this segment of the labour market.

This study provides an outline of the expected labour market perspectives for Dutch graduates of science and technical studies in the period 2007-2012. These perspectives are based on the bi-annual labour market forecasts of the Research Centre for Education and the Labour Market (ROA) of Maastricht University. The forecasts give an overview of the future labour market situation for 37 technical and science studies on four different levels: lower vocational, intermediate vocational, higher vocational and university education. The labour market perspectives for graduates with a particular educational background depend on both demand and supply factors. The expected demand for workers with a particular educational background depends on the expected employment development (expansion demand) and the replacement demand which arises due to the fact that employees retire, become disabled, or temporarily withdraw from the labour market. Outside those who are already employed, to a large extent labour market supply is determined by the inflow of school leavers and graduates into the labour market.

The labour market forecasts up to 2012 show that we may expect good labour market perspectives for graduates of technical and science studies in the Netherlands. These good perspectives are due to both labour demand and supply factors. On the one hand, there will be a large expansion demand for higher educated scientists and engineers, and a high replacement demand for technical workers with a lower vocational or an intermediate vocational education background. On the other hand, the labour market inflow of school leavers into the labour market from technical and science studies is relatively small. Most prospective students decide to enter business administration or commercial studies instead of technical and science studies. Consequently, the labour market perspectives of the former students are significantly less positive than the perspectives of students choosing a technical study. This holds especially for school leavers of lower vocational education and those with an intermediate vocational educational background.

At all levels of education, labour demand for science and technical studies will be larger than labour supply in the coming years, implying a shortage of science and engineering graduates as well as a shortage of school leavers of technical studies at the lower and intermediate level. Employers who expect a demand for these workers may therefore experience severe difficulties in finding technical personnel.

The study includes forecasts of expected expansion and replacement demand as well as inflow from school leavers and graduates and sensitivity to the business cycle are given for 37 fields of study on four levels of education, leading to a fairly detailed insight into the labour market expectations with regard to science and technology studies. Particularly remarkable is the excellent labour market perspective at the lower vocational level, with the best perspectives for school leavers in Construction and Metal Technique. However, at this level the labour market is sensitive to the business cycle

in combination with few labour alternatives, implying that especially these school leavers need to invest in improving their skills. At intermediate level the differences between fields is largest, with a very good labour market perspective for Process Technology, and good to fair perspectives for Laboratory, Mechanical Engineering, and Food. With regard to higher professional science and technology the best perspectives are expected for Civil Engineering, Transport and Logistics, and Chemical Technology graduates. Right through to 2012 it will prove difficult for employers to attract these students. On university level the largest shortage is foreseen for Electro Technique and Building Engineering graduates, and a considerable shortage is expected in the fields Agriculture and Environment, Mathematics and Natural Sciences.

Evidently, the extent of the shortage of science and technology graduates depends on adjustment processes that will take place within the labour market in the coming years. Such processes could include increased salaries, attracting non-science and technology graduates to certain positions that employers initially prefer filled by a science and technology trained employee, discouraging early retirement, attracting foreign labour and outsourcing economic activity to other countries. Leaving these adjustment processes that occasionally incur high societal costs aside, we can forecast the gravity of the expected shortages. In total we expect a shortage of about 125,000 science and technology graduates by 2012, approximately 81,000 of which at an intermediate level, some 31,000 on tertiary professional level and 13,000 at university level.

More in general, however, employment for graduates with a technical education is more sensitive to the business cycle. This particularly holds for higher educated scientists and engineers. However, not all graduates of science and technical studies will be affected to the same extent. Moreover, the replacement demand for workers with science or technical studies will remain high in the years after 2012 due to the greying of the labour force. Therefore, we may expect that the labour market perspectives for those with a science or technical study will probably remain good in the longer run

# Careers of Science and Technology teachers

## A survey among graduates from teacher education 1970-2006

### Management Summary

This report analyses and describes the careers of teacher-training graduates in science and technology for secondary education. The data comes from the Education Career Monitor (ECM, Loopbaanmonitor Onderwijs), which ECORYS has performed yearly since 2003 for the Ministry of Education, Culture and Science. Since 2006 this study is undertaken in cooperation with RISBO. The Education Career Monitor consists of an annual employment market survey among qualified teachers in primary and secondary education. The results in this report are based on secondary analyses of the available career information about more than 2000 science and technology teachers who graduated as secondary school teachers during the period 1970-2007.

#### Number of science and technology teachers among teacher-training graduates

- About 30 percent of the qualified teachers surveyed are qualified to teach science or technology.
- About two-thirds of the population of science and technology teachers are qualified to teach a science subject, while the remainder are qualified to teach a technology subject.
- Among the teachers who teach one of the science subjects, mathematics is the most common; 9 percent of teacher-training graduates are qualified to teach maths.

#### Science teachers are more often university graduates

To the extent that an average science/technology teacher exists, there are a number of clear differences between science teachers and technology teachers.

- Whereas teacher-training graduates for secondary education generally have a pre-professional secondary education (havo), the number of science teachers with a previous university education is higher than average. On the other hand, a higher than average number of technology teachers have an intermediate vocational education (mbo) background.
- Not unexpectedly, teacher-training graduates in science and technology subjects tend more often to be men compared to teacher-training graduates in other subjects. This is the case above all in technology subjects, where the majority of teacher-training graduates are male.
- Teacher-training graduates in science and technology are on average one year older when graduating, compared to teacher-training graduates in the other subjects. This difference is entirely due to the teacher-training graduates in technology subjects.

#### Knowledge transfer is the principal motive

Qualified science and technology teachers generally have, or had, the same motives to enter teacher training as those who graduated as secondary school teachers in other, non-science and technology subjects. For the majority of teacher-training graduates, a combination of teaching/social and subject-oriented motives underlie the decision to train as a teacher.

- For 75 percent of teacher-training graduates in science and technology, "learning to transfer knowledge" was an influencing factor for their decision to train as a teacher.
- The more intrinsic motive "I found the subjects interesting" comes second, with a share of 68 percent.

## Finding a teaching position is relatively easy

Qualified science and technology teachers usually find a teaching job fairly readily after graduating.

- 66 percent of science and technology teachers find a teaching job immediately after graduation. This is higher than the proportion of teacher-training graduates in other subjects (59 percent).
- It is the science teachers above all who go on to take up a teaching job immediately after graduating. For the technology subjects, the proportion of teachers varies from subject to subject.

Even after a few years, a higher proportion of science and technology teachers are still working in education compared to the other teacher-training graduates. Of the science and technology teachers surveyed, at the time of the survey 64 percent had a teaching job, whereas this was 58 percent among the other teacher-training graduates. The older the cohort, the greater the difference.

- Of those working in education, it is striking that a higher than average number of teacher-training graduates in technology subjects are working in lower professional secondary education (vmbo) or at a regional training centre (Regionale Opleidingen Centrum, or ROC).
- Teacher-training graduates in science subjects work above all in schools of pre-professional and pre-university education (havo/vwo), including at atheneum and gymnasium (modern and traditional schools of pre-university education respectively).

## Greater job security for science and technology teachers

- Of the qualified science and technology teachers with a teaching job, 91 percent have a permanent contract, while of the teacher-training graduates in other subjects who are working in education, 87 percent have a permanent contract.
- The differences are the greatest among the newer graduates; evidently science and technology teachers are able to find a permanent teaching job more quickly. It may possibly be that a relatively greater shortage of science and technology teachers plays a role here.
- Science and technology teachers also tend more often to have a full-time job. This is because men are over-represented in science and technology subjects, and more of them tend to work full-time compared to women.

## Science and technology teachers are more 'loyal' to education

The survey shows that most of the career steps of individuals with a job in education are career steps within education itself. Teacher-training graduates who are qualified to teach science or technology are even slightly more 'loyal' than teacher-training graduates in other subjects (significant). On the other hand, science and technology teachers are no more inclined to switch from a job outside education to one within education. For the group with a first job outside education, one in three of the career steps is a switch toward education. There is no difference here between teacher-training graduates in science and technology subjects and those in other subjects.

## Reasons for seeking a job outside education

Science and technology teachers who decide not to take up a teaching job after qualifying, cite as a reason the fact that another occupation is more appealing and that occupations outside education offer better career opportunities and more variety. For about one-third of the group who do not work in education, the inability to find a teaching job plays a role. This group is smaller compared to other subjects in teacher-training courses.

## Utilising the silent reserve

The silent reserve in education consists of qualified teachers who are currently not working in education, but who could possibly (at least in theory) be persuaded to do so. About two in three graduates with a current job outside education are willing, under certain conditions, to switch to a job within education ('certainly', and 'possibly' better together). This percentage is higher among the youngest cohorts and declines gradually to a willingness of one in three among the oldest cohorts. There is hardly any difference here between qualified science and technology teachers and qualified teachers in other subjects.

## Autonomy and progression to management are important in a teaching job

The conditions under which graduates in education with a job outside education consider making the change to a job in education are largely to do with employment conditions such as a 'permanent contract' and 'no drop in salary' or 'better salary prospects'. There are differences on this point between qualified science and technology teachers and those in other subjects:

- a full-time job is important for 44 percent of the science and technology teachers (11 percentage points higher than teachers in other subjects);
- independent working is important for 51 percent (7 percentage points higher than teachers in other subjects);
- qualified science and technology teachers state more often that 'opportunities to progress into management' influence any decision to make the switch to education;
- extra training and reduced travelling times, on the other hand, are less of an influence for qualified science and technology teachers.

## Competing sectors outside science and technology education

Qualified teachers who do not work in education often work in business services, the building industry, mineral extraction, industry and energy and water companies, where they generally have a technical or scientific job. There is often a direct relationship among science and technology graduates between their specialist subject and the sector and/or job in which they work.

# Career learning and career guidance in higher professional education

## Management Summary

Career guidance is a hot topic in higher professional education. It is being implemented in all higher education institutions as the most important tool in helping students to become more proactive in determining their own career direction. In recent years, a great deal has therefore been invested in career guidance, but until now, it seems as though these investments have barely paid off. Students do not view the career guidance on offer positively. Qualitative research has shown that students are barely aware of what it means to reflect on their careers. They do not make any connection between the material covered in their course and themselves, and they regard reflection simply as a compulsory part of their studies. This is reason enough to investigate how career guidance in higher professional education works at the present time, what the outcomes are in terms of career competencies and which learning environments are most effective for career learning.

This Platform Pocket gives an account of research which has been carried out into career learning among 4820 students and 371 career counsellors from various subject areas across 11 higher education institutions. We have defined career learning as the learning process in which students gradually find their own direction within their (study) career. In this piece of research, we have attempted to answer six research questions, while also testing two hypotheses. Each of these six questions will be answered individually below and the main conclusions with regard to both of our hypotheses will be discussed.

### 1. To what extent is the learning environment within higher professional education practice and demand oriented?

Overall, higher professional education is not very practice oriented and to a lesser extent demand oriented. The Technology and Economics departments have significantly lower scores for practice and demand orientation than other departments. Higher professional education appears to be still extremely 'internally focused'. Experiences gained outside of education do not count towards the courses (according to 75% of students) and 58% of those asked felt that their education did not encourage them to gain experience outside of the school. The content of students' work placements are to a great extent determined by the placement which they are assigned to (42%) or by the assignments that they are required to complete (23%). With regard to the question as to whether they could make their own choices for their programme of study or to be able to choose from various assignments, 64% and 49% respectively of students provided a negative response. Only 11% of students indicated that they were given assistance in the school in choosing the assignments that suited them best. The conclusion speaks for itself: higher professional education is to a large extent still based on the traditional model (theory and supply oriented), despite a great deal of rhetoric that places emphasis on the students having their own responsibility. Many students (37%) are aware that their course or their tutors respectively give them responsibility, but the students feel they are left to manage by themselves. 34% of students indicated that their tutors continue to prescribe how they must approach their responsibilities.

Career counsellors feel that the courses of study in which they work are somewhat practice oriented while only being demand oriented to a very limited extent and the students are of the same opinion. Career counsellors working within the Technology and Economics departments find that this department is significantly less practice oriented than the counsellors working in other departments. Career counsellors working within the Economics department find that this

department is significantly less demand oriented than study career counsellors working in other departments. When asked how the course teaches students to build up a network of professional contacts, 60% of career counsellors responded saying that little or no attention is given to this aspect.

## **2. What does career guidance counselling that takes place within higher professional education between students and their tutors consist of and what form does it take?**

Students talk about their own study career by far the most often with other students on their course, while this is discussed a great deal less with course tutors and career counsellors. This is likely to be due to the fact that discussions between career counsellors and the student only take place 1 to 4 times per year. If discussions are held with students, it is predominantly with those who are likely to drop out. Half of the students asked indicated that the content of the career guidance counselling session with the career counsellor was chiefly determined by the latter and just 26% of students stated that they themselves determine the content of the career guidance counselling session. Students from Economics and Technology departments felt that they have less opportunity to make their own contribution in a career guidance counselling session with a career counsellor than students from other departments. The career guidance counselling sessions with the career counsellor are more geared towards help than reflection and are oriented towards specific action with regard to the (study) career. In other words: it is more often the case that career counsellors provide information rather than helping the student to consider their own career and to take action with regard to this. Furthermore, the majority of students feel that the career counsellor hardly ever provides relevant information about (follow-on) courses (according to 68%) and also hardly ever discusses the various options (55%). Students from Technology and Economics departments gave the least positive responses with regard to the extent to which their career guidance counselling sessions with the career counsellor are helpful and reflective/encourage action. The counselling sessions with the career counsellor chiefly cover the study success and either never or hardly ever focus on the students' self-image and possible plans for the future and the specific actions that students need to or could undertake in terms of their work and course of study. Within the Technology and Economics departments, the students' self-image and possible plans for the future as well as specific actions are discussed significantly less than in other departments. It is not the case that there is lack of trust between students and their career counsellors, yet the majority of students (64%) still do not talk to them about aspects of life that truly concern them. Technology and Economics departments also score lower on this issue than other departments.

The majority of career counsellors (81%) likewise have indicated that counselling sessions with students take place on an individual basis 1-4 times per year on average. In broad terms, they agree with the students concerning their judgement of the extent to which the counselling sessions are conducted. When asked who determines the content of the career guidance counselling session, 50% of career counsellors stated that they do so, while 25% said that this is done to an equal degree by themselves and the student, whilst 25% stated that the student chiefly determines the content of the session. Career counsellors and students also agree on the fact that their sessions focus mainly on the progress within the course of study. It is a more common opinion among career counsellors than among students that the students' own view of their progress, possible plans for the future and specific actions that should or could be undertaken by the student in relation to the (study) career are also discussed.

## **3. How do career counsellors in higher professional education perceive their own career development and the opportunities to hold career guidance counselling sessions, and how does this relate to the actual content of career guidance counselling sessions?**

Career counsellors rate their own career success highly (the average score was 3.34 on a scale of 1-4). They feel competent as career counsellors but they also believe that little support is available for career counselling. In their experience, there is little support on the part of the subject tutors and from management.

The greater the extent to which career counsellors feel they have support and backing and the greater the extent to which they work in a practice-oriented situation, the more they tend to hold career guidance counselling sessions with students that are more reflective and encourage action. Whether the focus within a career guidance counselling session primarily lies upon the study success depends upon the gender of the career counsellor (women place greater emphasis on study success than men) and whether the course of study is demand oriented (the greater the presence of a demand-oriented learning environment, the less dominant the subject of 'study success'). The counsellor's own work situation and particularly the professional competence significantly determine whether the focus is particularly on the students' self-image and possible plans for the future. In other words, the more competent a career counsellor believes him/herself to be, the greater the emphasis he/she will place on the students' self-image and possible plans for the future during the session.

#### **4. What form does the cooperation between the tutor and the business world take on, and how does this relate to the actual content of career guidance counselling?**

As many as 77% of career counsellors feel that the cooperation with the business world in terms of career counselling is unsatisfactory and 44% of them even stated that there is no cooperation at all. In Economics departments, there is significantly less cooperation, closely followed by agricultural courses and the Health and Welfare departments. The most cooperation can be found in the Education departments (but even this score ranks under the average score on the scale of 2.5, which suggests that there is hardly any cooperation). If there is cooperation, it is particularly related to arranging meetings with people from the business world about providing guidance for the students. But even this was reported to occur by only half of the counsellors.

There is a link between speaking to students about specific actions in relation to work and their career and the experience of cooperation with the business world. What this means is that the greater the cooperation that exists with the business world, the more the specific actions that students can and perhaps need to take in relation to work and their career will be covered in career guidance counselling sessions.

#### **5. To what extent do students in higher professional education possess career competencies and what role does the learning environment play in this?**

Students in higher professional education scarcely develop career competencies. The average score ranks above the average on the scale only in terms of reflection on their career, while the scores concerning exploring work, career guidance and networking rank below the average score on the scale. The second part of the question relates to the learning environment. The hypothesis is as follows: A practice- and demand-oriented learning environment in which a dialogue relating to the career takes place has a positive effect on the development of career competencies, and also if personal and educational factors are taken into account.

The outcomes of the analyses have confirmed this hypothesis. There is a positive correlation between all career competencies on the one hand and a practice- and demand-oriented environment on the other. There is also a positive correlation between the contribution made by students in the session with the career counsellor (which forms the necessary characteristic for the existence of a dialogue) and all career competencies. In other words, the greater the presence of a practice- and demand-oriented learning environment and the greater the extent to which the career guidance counselling session takes the form of a dialogue (i.e. a career guidance counselling session with a career counsellor in which the student can make a clear contribution), the more there is evidence of career competencies. What is interesting is that a helpful form of counselling session has a negative effect on the development of career competencies, while a form of session that is reflective and that encourages action has a positive effect. A discussion about the course does not affect the implementation of career competencies, but discussing the students' self-image and

possible plans for the future as well as working and actions relating to their careers do. Therefore, there is a link between the programme of education as well as the interpretation of the career guidance counselling and the extent to which students work on their personal career development.

## **6. What is the relationship between the career competencies of students in higher professional education on the one hand and their motivation to learn, work identity, certainty in making choices and the likelihood of dropping out on the other hand?**

Notwithstanding the fact that the students who were questioned have a moderately developed work identity (an average score of 2.75 on a scale of 1-4), they were for the most part quite certain about their study choices. Yet, simultaneously, they have a moderate level of motivation for their studies. Even so, only few are considering terminating their studies prematurely.

The following hypothesis has been formulated on the relationship between these 'output factors' with career competencies: The possession of career competencies has a positive effect on the motivation to learn, work identity and certainty in making choices and has a negative effect on the likelihood of dropping out, even if personal and educational factors and the learning environment are taken into account. Only part of this hypothesis has been proven (and therefore part of it has been rejected). Exploring work and career guidance have a positive effect on the motivation to learn, work identity and certainty in making choices, but they do not have an effect on limiting the likelihood of dropping out. In other words: the more students research work opportunities and the more they make well-considered choices and take action to link their work and learning to their own qualities and motives and to the challenges they will face in work, the more motivated they feel about their education. In addition, they have a more highly developed work identity and they possess a greater feeling of certainty in terms of the choices they make in the course of their studies. Networking has an equally positive effect on work identity and certainty in making choices, but not on the motivation to learn and the likelihood of dropping out.

Finally, reflecting on a career has a positive effect on the likelihood of dropping out, but there is no evidence of an effect on the motivation to learn, and it has a negative effect on work identity and certainty in making choices. Students who spend more time reflecting on their career are more likely to consider whether they should cease their course prematurely. Their work identity is less developed and they are also less certain of the choices they have made in their study career than students who have reflected on their careers to a lesser extent. This can be explained by the fact that individuals only reflect on their career whenever they feel uncertain about the choices they have made up until now in relation to work and their studies. If a student reflects in such a way, this causes uncertainty, and the purpose of reflection is, after all, to question what has previously been regarded as a matter of course. Further follow-up research is required in order to ascertain whether the negative relationship between reflecting on one's career on the one hand and work identity and certainty in making choices on the other can be explained. For the time being, we must acknowledge that our hypothesis that more reflection on a career will result in greater certainty about work and study has not been proven.

# Management Samenvatting

De arbeidsmarkt houdt niet op bij de landsgrenzen. De internationale dimensie van de arbeidsmarkt wordt voor veel werkgevers steeds belangrijker. Het is echter de vraag of Nederland voor buitenlandse kenniswerkers wel aantrekkelijk genoeg is. De beslissing om al dan niet te migreren naar een ander land is op te vatten als het resultaat van een kosten-baten analyse. In deze kosten-baten analyse worden de verschillende voor- en nadelen van arbeidsmigratie tegen elkaar afgewogen. Zowel push als pull factoren kunnen in deze beslissing een rol spelen.

In dit rapport wordt ingegaan op de ontwikkeling in het aantal allochtone bètatechnici in Nederland, de internationale arbeidsmobiliteit onder bètatechnici zowel in het begin als later in hun loopbaan en welke factoren daarop van invloed lijken te zijn. Tenslotte wordt besproken in hoeverre buitenlandse kenniswerkers de toekomstige tekorten aan bètatechnici op de Nederlandse arbeidsmarkt zouden kunnen opvangen.

In de laatste 10 jaar is het aantal Westerse allochtonen dat in de bètatechniek werkt stabiel gebleven. De meeste van hen werken in de industrie, bouw en agrarische sector. Westerse allochtone bètatechnici zijn vooral ook van belang voor de beroepen op universitair niveau en op dat niveau is vooral de commerciële (en in mindere mate de niet-commerciële) dienstensector populair. Niet-Westerse allochtonen – waaronder ook veel tweede generatie migranten die de Nederlandse nationaliteit bezitten – zijn in toenemende mate de Nederlandse bètatechnische onderwijs- en arbeidsmarkt opgestroomd, met name op mbo niveau. In de komende vijf jaar zal het in absolute termen grootste tekort optreden op mbo niveau. Relatief gezien echter zal het grootste tekort ontstaan voor hbo opgeleiden. Zelfs bij een gemiddelde groei van ca. 5% per jaar, zal het tekort op mbo niveau en hoger niet door de instroom gecompenseerd worden.

De internationale arbeidsmobiliteit in Europa blijft op een relatief laag niveau steken: slechts 6,8% van de Europese beroepsbevolking heeft in het verleden in een ander land gewoond dan het land waar het momenteel verblijft. Nederland scoort wat stage en werk in het buitenland betreft relatief laag vergeleken bij verschillende andere Europese landen en dit geldt in het bijzonder voor exacte wetenschappers (4,6%) en technici (6,1%). Een semester in het buitenland studeren komt vaker voor dan een stage, Nederlandse studenten in de natuurwetenschappen behoren met 35% met een “buitenlands semester” zelfs tot de koplopers in Europa. Toch gaat een veel kleiner percentage van de afgestudeerden daadwerkelijk in het buitenland werken, waarbij hoger opgeleiden, zowel in Nederland als in de andere EU lidstaten, veel vaker in een ander land hebben bewoond dan middelbaar en lager opgeleide bètatechnici. Hierin wijken bètatechnisch hoogopgeleiden niet af van de overige hoogopgeleiden. Een voorlopige conclusie zou kunnen zijn dat de tekorten aan bètatechnici in kwantitatieve zin de komende jaren niet groter zullen worden als gevolg van emigratie vanuit Nederland en dat er mogelijk wat te winnen valt bij het aantrekken van bètatechnici uit de nieuwe lidstaten zoals de Baltische staten en Polen omdat daar de migratie intentie hoog is. Overigens staat Nederland op de vierde plaats van voorkeurslanden samen met Noorwegen en de Verenigde Staten van Amerika en vooraf gegaan door het Verenigd Koninkrijk, Ierland en Duitsland.

Belangrijke pull-factor for migratie zijn arbeidsvoorwaarden. In dit rapport is vooral gekeken naar hoogte van het salaris, aandeel vaste arbeidscontracten en de duur voor het vinden van een eerste baan. Nederland scoort niet erg goed op beide eerste criteria, de lonen liggen hier relatief laag, waarbij binnen de EU Tsjechië, Estland, Spanje en Italië nog minder betalen.

# Careers in Science, Technology Engineering and Mathematics in the Netherlands

## Summary

- Use of 'Loonwijzer' ('WageIndicator') data enables comparison between science, technology, engineering and mathematics (STEM)/non STEM graduates in STEM/non-STEM jobs
- Almost half of higher-trained STEM graduates not in STEM job
- Many differences between STEM and non-STEM graduates are due to the high male prevalence among STEM graduates
- Salaries of university STEM graduates in STEM jobs lag behind
- Not all STEM graduates are alike; there are big differences between degree programmes and sectors

### 'Loonwijzer' ('WageIndicator')

This is not the first study into STEM graduate careers, but it is nevertheless unique. Platform Bèta Techniek (Platform Science and Technology) and partners previously commissioned a study of STEM graduate careers (Smits and Sieben, 2008)<sup>5</sup>, but this gathered no information on non-STEM graduates and did not examine whether the employees worked in STEM jobs or not. The present study does draw on information about the precise degree programme and job (STEM or non-STEM). STEM graduates in STEM jobs can thus be distinguished from STEM graduates in non-STEM jobs. In addition, data were collected on non-STEM graduates in STEM and non-STEM jobs. This makes it possible to compare these groups and put the STEM graduates in perspective.

The information was gathered in the 'Loonwijzer', a long-running survey. Since the end of 2006 about 30 thousand employees with an intermediate or (mainly) higher vocational degree or university degree filled in the questionnaire. This report describes the careers of STEM graduates based on remuneration & benefits, career progression, job satisfaction and training and competence development.

### Diverse careers for STEM graduates

By no means all STEM graduates opt for a career in STEM. Almost half of the higher-trained STEM graduates end up in a non-STEM job. This percentage is markedly lower, namely 20 per cent, at intermediate level. The cross-over from non-STEM to STEM is much less frequent: non-STEM graduates are rarely employed in STEM jobs. What differences can we see in the careers of these diverse groups?

In general employees with an STEM degree are more often men and older than non-STEM graduates. Higher-trained STEM graduates also tend to work more frequently for large corporations. STEM graduates therefore earn more, on average, than non-STEM graduates: on average, men and older employees earn more – irrespective of their training – than women and young people. After an adjustment for background characteristics, the differences in remuneration disappear. In this case, only STEM graduates at intermediate level still earn more. However, STEM graduates do seem to make bigger wage jumps during their career. In addition, higher-trained STEM graduates more frequently occupy manager positions than higher-trained non-STEM graduates. Higher vocational STEM graduates are therefore more satisfied with their career opportunities than higher vocational non-STEM graduates.

<sup>5</sup> Smits, Wendy en Inge Sieben (2008), *Loopbanen in de bètatechniek 2007*. Maastricht: ROA.

Looking at other employment benefits, STEM graduates less often receive a fixed financial bonus such as a thirteenth month, but more often receive a performance bonus, lease car and reimbursement of telephone expenses. In addition, they more often have a permanent contract and work full-time than non-STEM graduates. This partly explains why higher-trained STEM graduates are less satisfied with their free time than higher-trained non-STEM graduates. In general higher-trained STEM graduates are just as satisfied with their job as higher-trained non-STEM graduates. However, higher-trained STEM graduates more often have a job commensurate with their degree. In addition, higher-trained STEM graduates stay longer in the same job and are less inclined to change jobs. At intermediate level, STEM graduates are less satisfied than non-STEM graduates, partly because they experience more stress in their work.

STEM graduates in non-STEM work are mainly women and STEM graduates with a 'less hard' STEM degree. These STEM graduates are not worse off than STEM graduates who opt for an STEM job. Higher brained STEM graduates in non-STEM work earn more and more often receive a fixed financial bonus – partly because they more often fulfil management positions. Despite their STEM background, they need less training to become fully proficient at their non-STEM work. They also receive employer-paid training less often than STEM graduates in an STEM job. Finally, higher-trained STEM graduates in non-STEM jobs are just as satisfied with their work as higher-trained STEM graduates in STEM jobs. However, STEM graduates in non-STEM work do change jobs more often.

Non-STEM graduates in STEM work make up a specific select group. These non-STEM graduates are mainly men and many work in the IT sector. They earn less and receive a fixed financial bonus less often than non-STEM graduates in non-STEM work. However, partly because they often work in IT, they are more likely to get a mobile phone and a lease car. This group appears to be less satisfied with their work and are definitely less satisfied than non-STEM graduates in non-STEM work. In addition, non-STEM university graduates in an STEM job are more inclined to change jobs.

### **High male prevalence among STEM graduates leads to other careers than non-STEM graduates**

Many differences between STEM graduates and non-STEM graduates stem from the large male prevalence among STEM graduates. One good example is the small percentage of part-timers among STEM graduates. The number of non-STEM graduates working part-time is some 25 percentage points higher at every training level. However, the percentage of part-timers among only women and only men shows virtually no difference between STEM graduates and non-STEM graduates. The difference between part-time female non-STEM graduates and part-time female STEM graduates is less than five percentage points. So the difference in the proportion of part-timers is probably due to differences between men and women rather than to differences in the type of jobs held by STEM and non-STEM graduates.

The difference in the proportion of men also largely explains why STEM graduates more often have a permanent contract, hold a management position and receive a performance bonus, lease car and a reimbursement of telephone expenses. The lower job satisfaction of intermediate vocational STEM graduates versus intermediate vocational non-STEM graduates also relates to the larger proportion of men in the first group, because women generally tend to be more satisfied with their work. Gender also explains the lower job satisfaction of non-STEM graduates in STEM jobs versus non-STEM graduates in non-STEM jobs.

Indirectly too, the difference in male prevalence leads to disparities between STEM and non-STEM graduates. As noted, this explains the higher number of STEM graduates working full-time – which, in turn, largely explains why higher-trained

STEM graduates are less satisfied with their free time. It also explains the greater frequency of employer-paid training: employers are more inclined to pay the training of a full-time employee than that of a part-timer.

### Remuneration of university graduates lags behind

After adjusting for differences in background characteristics such as gender, intermediate vocational STEM graduates earn more than intermediate vocational non-STEM graduates. At higher vocational and university level no differences exist – after adjustments – between STEM and non-STEM graduates. The remuneration obviously not only depends on the training but also on the nature of the occupation. STEM graduates regularly end up in non-STEM jobs. Occasionally, non-STEM graduates work in STEM jobs. What consequences does this have for the remuneration?

Among intermediate and higher vocational students, there is, respectively, no and not much difference between STEM jobs and non-STEM jobs. The differences among university graduates are much greater: they clearly earn less in STEM jobs. This is partly because the number of PhD positions is much greater in STEM disciplines than in non-STEM disciplines. On average, PhD candidates earn less than first-time employees in other jobs; see for instance De Graaf et al. (2007).<sup>6</sup> But among academics not involved in a PhD track, too, there is a difference in remuneration between STEM and non-STEM jobs. The nature of the STEM degree makes a difference here. Those with a 'less hard' STEM degree earn less in an STEM job than those who have studied science or technical subjects. This is probably related to the tasks performed by employees with a 'less hard' STEM degree. They tend to have operational positions, whereas STEM graduates with a 'hard' STEM degree more often have higher-earning managerial positions.

### Not all STEM graduates are alike

STEM graduates come in many shapes and sizes. Physicists and civil engineers are not alike, and electrical engineers have a totally different training from laboratory technicians. Moreover, an intermediate vocational graduate is not a university graduate. Differences even occur within disciplines: some IT graduates work in the business sector, others in industry. Therefore, at various places, this report zooms in on the exact nature of the STEM degree and the sectors in which employees work in STEM jobs.

The differences in remuneration of intermediate vocational graduates with different STEM degrees is small (after adjustments for differences in background characteristics). The biggest discrepancy occurs between 'transport & logistics' (e.g. 'road transport planner'), which earns the least, and process technology, which earns by far the most. The variance in remunerations between higher vocational and university graduates is similarly small (after adjustments). At both levels, employees with computer and information STEM degrees earn less than average. Disciplines that command high salaries at both levels are mechanical engineering, industrial engineering and the 'less hard' STEM subjects such as 'econometrics, actuarial science and information management'. Also striking are the high salaries in shipping courses at higher vocational level and technical chemistry at university level.

The various degrees also display (occasionally large) differences in relation to other job characteristics such as type of contract, the percentage in management and executive positions, job satisfaction and employer-paid training.

Regarding the (STEM jobs in) sectors, the report looks at five different job characteristics for higher-trained graduates: salary, extra employment benefits (fixed financial bonus and lease car), career opportunities, job satisfaction and employer-paid training. Mineral extraction is among the best sectors for every job characteristic except for extra employment benefits. Utilities and transport & communication also have high average scores on these characteristics.

<sup>6</sup> De Graaf, Djoerd, Arjan Heyma and Chris van Klaveren (2007), *De arbeidsmarkt van hoger opgeleide bèta's*. SEO report number 992. Amsterdam: SEO Economic Research.

Education, by contrast, performs poor across the board, except for the fixed financial bonus (thirteenth month). Between 2004 and 2007/2008 the construction industry climbed up the table of high-earning sectors (for higher vocational graduates), possibly due to the shortages facing the sector in recent years. In those same years, the chemical industry rose on the job satisfaction table (of higher vocational graduates).

In short, there is a great diversity of STEM graduates. In general, however, the group of STEM graduates appears to have lots of options after their training. Many opt for a non-STEM job and – partly due to self-selection – are equally satisfied with this choice. This leads to a large diversity in the careers of STEM graduates.

# Summary

## Research outline

During the 2007/08 school year, ITS was commissioned by Platform Science and Technology (Platform Bèta Techniek) to carry out large-scale study into the choice of pupils in the third year of pre-professional (havo) and pre-university (vwo) education for a science profile<sup>1</sup>. Within this context 7535 pupils in the third year in eighty schools across the Netherlands responded to a web-based questionnaire both at the beginning and at the end of the school year. Class mentors, study counsellors, science and mathematics teachers and parents also completed web-based questionnaires. This made it possible to construct an extensive data file containing information relating to the pupils themselves and the people in their surroundings who can potentially influence which profiles pupils opted for.

Statistical analyses were used to examine this data file more closely, the objective being to ascertain the factors that determine whether pupils choose a science and health profile or a science and technology profile. Pupils who choose these profiles are more likely to progress into study or employment in the fields of science, technology, engineering and mathematics than those pupils who choose a society profile, and it is precisely this choice of study and career that Platform Science and Technology is promoting. In the Netherlands, there is a shortage of highly educated professionals in the field of science, technology, engineering and mathematics and their numbers are expected to decrease further in the coming years.

## The profile choice of the participating pupils

The pupils who took part in the study belong to the second year affected by the New Second Phase (VTF)<sup>2</sup> which was introduced in August 2007. The profile content in the New Second Phase changed significantly when compared to the situation that previously existed. The subdivision within subjects were abolished and elective subjects (profile elective subjects) were introduced alongside the compulsory subjects. Schools also enjoy greater powers to make certain subject combinations compulsory or forbidden for their pupils. The entry requirements in higher education were adapted in accordance with the New Second Phase, which resulted in those pupils completing pre-university education with a science and health profile only having access to medicine and veterinary science courses if they successfully passed final exams in physics.

The profiles chosen by the pupils participating in the study appear to differ significantly from those of pupils in pre-professional and pre-university education from previous years (see Table 1). The extent to which pupils are opting for science profiles has increased by 5-10% both in pre-professional and pre-university education and both among boys and girls. Furthermore, there is evidence of a considerable shift from the science and health profile towards the combined profile (science and health with science and technology) within the group of pupils choosing a science profile. This applies particularly to girls; when compared with female pupils who completed pre-professional and pre-university education in 2007, the number of girls in our random sample with a science and technology profile or a combined profile is almost six times greater.

These differences could perhaps partly be explained by the selective composition of the sample. In view of the nature of the client and the schools' investment in time necessary to participate in the study, it is quite possible that schools taking

1 Each of the four profiles for the upper grades of secondary school consist of compulsory and elective subjects. The two society profiles focus on languages and humanities, in the science profiles sciences and mathematics are compulsory.

2 This is the upper cycle of pre-university education and pre-professional education.

part are much more science-oriented than on average nationwide. Also, it must be taken into consideration that the pupils in our study have some years to go before they take their final exams and that some of them may possibly change their profile in the coming years.

**Table 1 Profiles chosen by pupils questioned and the national population of pupils who completed pre-university or pre-professional education in 2007**

<b>Random sample of 3<sup>rd</sup> year pupils 2007/08 (n = 7535)</b>	<b>Boys in pre-professional education</b>	<b>Girls in pre-professional education</b>	<b>Total in pre-professional education</b>	<b>Boys in pre-university education</b>	<b>Girls in pre-university education</b>	<b>Total in pre-university education</b>
Society profile	54	69	62	38	49	44
Science profile of which:	46	31	39	62	51	56
- Science & Health						
- Science & Technology or Science & Health/Science & Technology	11	18	15	10	16	14
	36	13	24	52	35	43
<b>National population of graduated pupils in 2007</b>	<b>Boys in pre-professional education</b>	<b>Girls in pre-professional education</b>	<b>Total in pre-professional education</b>	<b>Boys in pre-university education</b>	<b>Girls in pre-university education</b>	<b>Total in pre-university education</b>
Society profile	63	80	72	44	59	52
Science profile of which:	37	20	28	56	41	48
- Science & Health						
- Science & Technology or Science & Health/Science & Technology	17	18	17	26	35	31
	21	2	11	31	6	17

However, the observed shift from a science and health profile towards the combined profile of science and health/science and technology is so marked that this will undoubtedly soon become noticeable among the student population on the national level. Furthermore, this shift had been predicted by the Tweede Fase Adviespunt, while giving the particular reasons namely that 1) within the New Second Phase it is easier to create a combined profile than it had been previously, 2) the entry requirements for popular courses such as medicine may give rise to many pupils combining science and health with physics and 3) many schools are using their larger policy freedom to make mathematics B compulsory in combination with physics, meaning many pupils effectively end up with a combined science profile.

It was also particularly evident from our research data that many pupils seemed unaware that they had chosen a combined profile. They had stated themselves that they had chosen a science and health profile. In such cases, it only becomes clear that they in fact have chosen subjects consisting a combined profile when we take the elective subjects into account as well. In addition, a substantial number of the pupils who themselves stated that they chose an exclusively science and technology-based profile had chosen biology, meaning that they had also actually chosen a combination science profile. As schools do not always register the pupils as having chosen a combined profile, this phenomenon is also underestimated in the national statistics, compiled by Statistics Netherlands (CBS).

Nevertheless, we regard this shift to be significant in terms of its content. The science and technology profile is the most science and mathematics-based of the two science profiles and, therefore, it offers the best preparation for a subsequent science-oriented career. The number of pupils entering science-oriented courses in past years was significantly greater among pupils completing their secondary education in a science and technology profile than among those who completed secondary education in a science and health profile. The question remains, of course, as to whether pupils who are themselves unaware that they have chosen a science and technology profile will make the same study choices as their predecessors who were well aware of this fact.

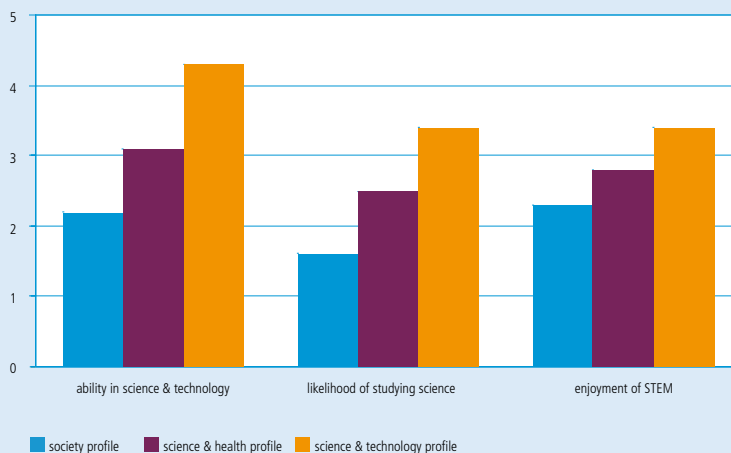
## The effect of peers, classes and schools influence a student's science profile choice

We used statistical analyses to examine which of the collective factors relating to pupils significantly influenced the likelihood that pupils chose a society profile, a science and health profile or a science and technology profile, and the measure to which these variables affect the choice for a science profile. We also followed the same procedure to examine the collective factors of the pupils' school and their year group. The factors with regard to the school also included the details that were gathered by the study counsellor relating to the school's background, its approach to profile choice guidance, etc.. Factors relating to classes include the details gathered by the teachers that relate to the teachers of science and mathematics, the class mentor and fellow pupils (peer group).

### Factors relating to pupils

We identified a number of student-related factors that correlate significantly with the likelihood of a science profile choice and each of these in its own right accounts for a significant percentage of the science profile choice. The greater the levels of self-confidence, perceived usefulness and enjoyment that pupils feel towards science and mathematics, science profiles and science-oriented subjects in general, the greater the likelihood is that they chose one of the science-related profiles (see Figure 1). The fact that a student is considering pursuing a course of study in the fields of science or technology is also significant.

Figure 1 Average scores on a scale of 1 to 5 for each profile group relating to 1) perceived talent for science & technology, 2) likelihood of study in science sector and 3) general enjoyment of science, technology, engineering and mathematics



In addition, the advice that pupils received from parents with regard their profile choice appeared to be of especially significant influence, even more so than the advice offered by the school or from friends, which also formed an important factor. Other student-related factors that increase the likelihood of a science profile choice to a greater or lesser degree include high term results for science and mathematics, whether the student is following a course of education that includes classical languages (in this case, a greater number of pupils opt for science and technology than they would when following pre-professional education or a course without classical studies), how the student perceives the teachers of physics and chemistry, the intended (provisional) profile choice at the beginning of the third school year and the choice made by the student's best friend.

### **Factors relating to school and study counsellors**

A number of factors relating to school and study counsellors significantly affect the likelihood that (certain) pupils will chose a science and health or a science and technology profile, although the extent of the school's influence is generally less than that of most of the student-related factors mentioned above. The science profile choice of pupils in pre-professional education is particularly affected by whether or not the school is taking part in the Universum programme of the Platform Science and Technology. Pupils in pre-university education benefit far more if the school is part of Jet-Net (Youth and Technology Network [Jongeren en Technologie Netwerk]). A school's share of science and technology profiles in previous years is a significant factor for all pupils. In addition, we found that there were significant effects that are the result of the school's policy. By making mathematics B compulsory in a science and health profile when combined with physics and by offering mathematics D as a profile elective subject in the science and technology profile, for example, both resulted in a significantly higher number of girls opting for science and technology. Setting minimum requirements with regard to term results for physics and chemistry for science and technology profile choice actually discourages the choice for science and technology.

The study counsellor's background and his/her attitude towards science-oriented subjects are also influencing factors to some extent. Boys who are counselled by a male study counsellor or an older one tend to opt for science and health more often than other boys. Conversely, girls tend to opt for science and health more often if their study counsellor harbours stereotypical views with regard to gender and judges the economic importance of science, technology, engineering and mathematics or the career prospects of a career in these fields to be relatively low.

Girls appear to be somewhat more affected than boys by the activities that are organised by their study counsellors in collaboration with other school staff concerned in the context of profile choice guidance. For example, they tend to opt significantly more frequently for a science and technology profile if their tutor is joined by upper-cycle pupils with a science profile when providing information relating to that profile, or if their school organises a camp/study week with themes relating to science, technology, engineering and mathematics or a trip to a business working in one of these fields. Particularly in the case of girls studying in pre-university education, a trip of this kind can have an effect. The involvement of VHTO (national expert organisation girls/women and science/technology [landelijk expertisebureau voor meisjes in de bètatechniek]) in profile choice guidance results in pre-university girls choosing science profiles more often or choosing subjects of a more scientific and mathematical nature than is the case of girls in pre-professional education. The schools and study counsellors involved in the study differ significantly from one another in terms of other aspects, such as in organising other activities than those mentioned above relating to providing guidance for pupils making choices, for example, but these do not appear to influence the extent to which their pupils will opt for a science profile.

### **Factors relating to pupils' classes**

There is a great deal of variation among teachers of mathematics, physics and chemistry in terms of gender, teaching experience, their views on science, technology, engineering and mathematics and ratios of men to women, didactic approaches and the extent to which they attempt to make their subject more appealing. All these factors, however, appear to have little effect on the extent to which their pupils opt for a science profile. Only a small number of factors relating to teachers form an exception in this case. For example, the greater the extent to which science teachers bring in pupils from the final years to act as tutor, the more that girls in particular are likely to opt for a science and technology profile. Pupils in pre-university education are more likely to opt for a science subject if their science teachers also teach pupils in the final years. It is also more frequently the case that pupils opt for a science and technology profile rather than a science and health profile, if their science teachers place greater importance upon pupils' autonomy in their advice regarding their own subject. These effects are significant, but they only provide a limited explanation as to the variation in their pupils' profile choice. These conclusions can also be drawn if we study the effect of teacher characteristics on the share of pupils opting for a science and technology profile.

There is also considerable variation among all class mentors, in terms of subject background, views with regard to gender stereotypes and many other kinds of (functional) factors. Only few of these differences appear to influence whether their pupils opt for a science profile to some extent. Pupils in pre-university education with a male class mentor are somewhat more likely to opt for a science and health profile than those who have a female class mentor. The fewer number of years of teaching experience that a class mentor has, the more likely pupils are to opt for science or mathematics-related profile. Furthermore, the more difficult their mentor regards science, technology, engineering and mathematics to be, the less likely boys are to opt for science and technology.

On a class level, it is not only the behaviour and the attitude of the teachers and class mentors which exerts an influence, but also the fellow pupils in the student's class, which we understand to be (part of) his/her peer group. The average perception of this peer group appears to have greater importance for pupils opting for a particular profile than the factors relating to the science teacher and mentor mentioned previously. For example, the more that fellow pupils hold positive views on average with regard to science and mathematics, science profiles and science, technology, engineering and mathematics in general, the greater the likelihood that the student will opt for a science and mathematics-related profile. The larger the percentage of fellow pupils who opt for science and technology, the more likely pupils are to do the same. The percentage of girls in the class who opt for science and technology even has a noticeable effect on the extent to which individual boys choose this profile. The greater the extent to which the views among fellow male pupils and female pupils in particular correspond to gender stereotypes, the less likely individual girls are to opt for subjects that are less science and mathematics based.

### **Predicting pupils' profile choice considering combined student, class and school related factors**

All significant variables that were identified among pupils, classes and schools were put in a discriminant analysis simultaneously in order to examine their collective effect on pupils' choice of profile and to ascertain the smallest possible set of variables sufficient to predict pupils' profile choice effectively. A model of 34 variables was compiled from the results, and by using this model we were able to successfully predict almost 88% of profiles chosen by the participating pupils.

One section of the 34 variables mainly distinguished those pupils who opted for science and technology from those who chose a society profile (Function 1). The higher the pupils' scores for these variables, the greater the likelihood that they will opt for a science and technology profile, while the lower the scores, the greater the likelihood that pupils choose a society profile. The most significant variables within Function 1 are the student's own assessment of his/her ability in a science and technology profile and a science and health profile. In other words, the extent of a student's confidence with regard to science profiles is the most important indicator as to whether a student opts for a science and technology profile, or conversely (if lacking in confidence), a society profile.

The rest of the 34 variables mainly distinguished those pupils who opted for science and health from other pupils (Function 2). The lower the scores for these variables, the greater the likelihood that pupils will choose a science and health profile, while the higher the scores, the smaller the likelihood of doing so. The most significant variable in this case is the advice provided by parents with regard to choosing a science profile. If the parents had recommended the science and health profile but not the science and technology profile, the likelihood of the student actually opting for the science and health profile is greater.

Considering these major predicting factors, it is obvious why girls and pupils in pre-professional education opt less frequently for science and technology profiles and more frequently for society profiles than boys and pupils in pre-university education. Girls and pupils in pre-professional education perceive their ability in the science profiles as significantly lower than boys and pupils in pre-university education do. Furthermore, it is parents more often recommend girls to study science and health, as opposed to science and technology.

The complete model of 34 variables which can be used to most successfully predict the pupils' profile choice consists, for the most part, of student variables, while the variables at higher levels (namely class and school) make little difference in predicting the student's choice. We must note, however, that as many as 13 of the 34 variables in the model relate to advice that is dispensed by third parties (namely, parents, the school and friends). These are regarded as student variables due to the fact that the student states that the advice is dispensed by third parties (that is, this is judged to be the case by the student), yet they also give reliable evidence to suggest the student's environment is of considerable influence. This influence is all the greater if we consider that these variables act relatively independently of each other, which is namely apparent in the fact that they all occur within the final model, in spite of the parsimony principle in the discriminant analysis. In function 2, for example, there is a strong correlation between the recommendations for science and health-related courses by the parents, friends and the school and each of these variables individually affects the likelihood that the student will opt for a profile within the science and health profile.

The other variables in the model that do not relate to the student, and that therefore independently affect which profile a student opts for in addition to or alongside the relevant student characteristics, can be described as follows: The greater the extent of the opinion on average among the student's fellow pupils (peer group) that mathematics, physics and IT are useful subjects, the greater the likelihood that a student will opt for a science and technology profile. There are also other effects that apply in the case of girls, namely, if female science teachers at their school are involved in providing information to assist pupils in choosing a profile, the likelihood of opting for a science and health profile increases and this is also the case if the school does not make it compulsory for pupils to replace mathematics A with mathematics B if they take science and health with physics.

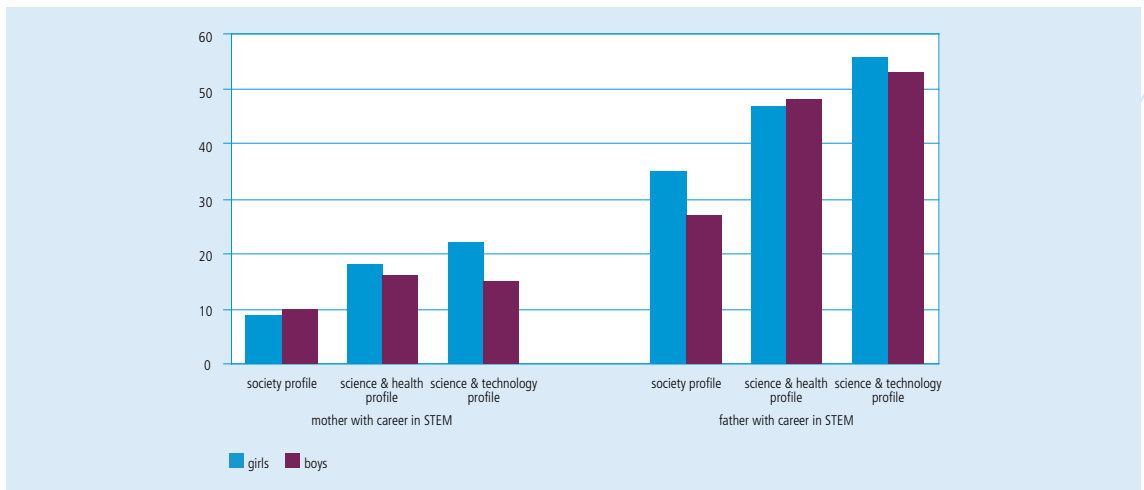
### **The influence of the parents and the opinions of mentors with regard to individual pupils**

Due to the poor and somewhat selective response to the parent questionnaire, the results could not be taken into account in the discriminant analysis that was prepared for this purpose. Instead, data from the parents was examined separately in terms of how they related to the pupils' choices of profile. This also applied to the results gained from the class mentors by giving their opinions with regard to a specific student from the class on forms known as student forms.

Some of the questions that were put to the parents and mentors related to their assessment with regard to the ability and suitability of their child or their student respectively, for certain subjects, profiles and courses. The same questions were also put to the pupils themselves and therefore we were able to examine to what extent the answers provided by the parents and their children, and those of the mentors and their pupils matched. It appeared from this study that the opinion of the parents corresponded far more closely with that of their children than was the case for the opinions of mentors and their pupils. It was also observed that the opinions of both parents and their children as well as mentors and their pupils all matched closely with regard to the suitability of the student to opt for science and mathematics, science profiles and studies in science, technology, engineering and mathematics. These opinions corresponded far more than was the case for other subjects, courses and society profiles.

Furthermore, it was evident that, if parents had studied or been employed in science, technology, engineering and mathematics, the likelihood that their children would choose a science profile increased considerably (see Figure 2). In the case of girls, the influence of the mother with a background in science, technology, engineering and mathematics was almost as much of an important factor as that of the father, while for boys, the father's background is of more relevance. The greater the extent of enjoyment that parents feel towards science, technology, engineering and mathematics and the more they feel that these subjects are important in terms of the economy, the more likely their children are to opt for science and mathematics-related subjects.

Figure 2 Percentage of mothers and fathers with a career in science, technology, engineering or mathematics compared with profile chosen by girls and boys



## Gender-based differences relating to advice and expectations

The study counsellors, mentors and science teachers included in the study gave answers to a number of questions, known as vignette questions, which involved a brief description of a fictitious student in terms of achievements and future plans. Following this, the respondent was asked what kind of advice he/she would give to student with regard to a profile or subject. In approximately half the cases of respondents questioned, the fictitious student had a boy's name while the others had been given a girl's name. This meant we were able to examine whether the respondents gave differing advice for girls than boys. However, there was hardly any evidence to suggest that this was the case. The advice that was given differed among the respondents, yet their types of answers were distributed evenly for the fictitious boys and girls respectively.

In order to investigate the potential gender differences in the advice that is given, we used a second method which involved 'real' pupils from our own research. Pupils were selected from the entire random sample who had achieved top marks in their latest report (in the spring of their third year) for the three science and mathematics-related subjects and therefore seemed to possess a reasonable level of ability in the sciences. For this homogeneous group of high-achievers (the average report mark was exactly the same among boys and girls), we subsequently investigated the nature of the profile choice advice they received from the school, parents and friends. This study showed that the science and health profile was recommended more frequently to girls with top report marks in science and mathematics. The science and technology profile was recommended less frequently and the girls were even advised against it more frequently than in the case of boys who have a similar level of achievement. This significant gender divide is made by schools and parents as well as friends and is more prevalent in pre-professional education than in pre-university education.

The difference between a fictitious and a 'real' student is likely to be that, in the case of the latter, the advisers also make a judgement with regard to the 'actual' (perceived) ability underlying the report marks. It does seem to be the case that, in addition to the established gender-based differences in the advice given to high-achievers, there is also evidence of noticeable gender differences in how this ability is assessed. The male high-achievers themselves as well as their parents and their class mentors assessed their ability for science and mathematics and the science and technology profile to be higher than the girls who have a similar level of achievement, their parents and their class mentor believed their ability to

be. This trend is also more prominent in pre-professional education than in pre-university education. It appears that a certain extent of gender-stereotyping forms the reason for these variations in the assessments and advice given to boys versus girls, even if they achieve comparably high report marks.