

Trend analysis

gender

in higher

**STEM**

education



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**Cocky Booy**  
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- Drs. B.L.C. Kurver and A.F. Boerboom, *Vrouwen in bèta en techniek, tabellenrapportage* (Women in science, engineering and technology, table report), ResearchNed, October 2010.
- Drs. B.L.C. Kurver and A.F. Boerboom, *Vrouwen in bèta en techniek, tabellenrapportage (update)*, ResearchNed, July 2011.
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- Drs. E.J.M. Jansen, *Gender Radar 2, Wat vinden afgestudeerden belangrijk bij bèta/technische ho-opleidingen* (What do graduates consider to be important in higher science, engineering and technology education programmes), VHTO, August 2011.
- Prof. dr. J.J. Schippers, *De winst van bèta-vrouwen, kosten/baten-analyse van additionele instroom van meisjes in bètatechnische opleidingen* (The benefit of women in science, cost-benefit analysis of additional intake of girls onto science, engineering and technology study programmes), Utrecht University, Faculty of Law, Economics and Governance, May 2011.

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# Introduction

Since the early 1980s, VHTO, the Dutch National Expert Organisation on Girls/ Women and Science/Technology, has been building up knowledge and experience of the participation of girls and women in the world of science, technology, engineering and mathematics (STEM) and deploying this expertise in areas such as education.

As well as many activities in the field of secondary education, VHTO has in more recent years intensified its activities within higher STEM education. For instance, over the period 2005-2011 VHTO carried out gender activities focusing on STEM study programmes at universities of applied sciences and research universities in the context of the National Platform Science & Technology's Sprint Programme (with additional funding from the Ministry of Education, Culture and Science, Department of Equal Opportunities). The conclusion of this programme seemed a good time to examine the current state of affairs with regard to gender and STEM, and what is still needed in the future to improve the gender balance in STEM.

This *Trend analysis gender in higher science, engineering and technology education* addresses the following questions:

- 1 What do we currently know about gender and STEM?
- 2 Are more girls and women now choosing STEM?
- 3 What is the situation with regard to gender and STEM in other countries?
- 4 What have been recent developments in the focus on girls / women and STEM?
- 5 What have universities done over the last few years with regard to gender and STEM?
- 6 What do graduates consider to be important in a STEM study programme?
- 7 Does a greater focus on women and STEM provide any economic benefits?
- 8 Does the gender balance in STEM need to be improved further? How to proceed?

**Yonna Welschen**, Mechanical Engineering student, Delft University of Technology



# 1

## What do we currently **know** about **gender** and **STEM**?

**Girls and women are underrepresented in science, engineering, technology and (to a lesser degree) mathematics (STEM) compared to their male counterparts - not only in the Netherlands, but also in other countries. However, the situation in the Netherlands is somewhat exceptional in that we are often one of the lower ranking countries worldwide in this area. Research conducted at both a global and national level (also by VHTO itself) and VHTO's activities have revealed a number of interrelated aspects of this situation.**

Neuroscientific research has shown that there is no difference to speak of between girls and boys in terms of aptitude for STEM. Whether and to what extent talents that you are born with develop depends on the environment in which you grow up: society (economy, culture etc.), your family and parents, school (teachers and school careers advisers), your contemporaries and so on. During primary education, the learning areas of arithmetic and science, and during secondary education the subjects of mathematics and physics (and to a lesser extent chemistry) form a prelude to an academic and future career in STEM. This concerns not only performance, but also things like interest, motivation, how useful pupils find these subjects in terms of their future academic career and how much they enjoy these subjects. In the Netherlands, boys perform slightly better in mathematics and physics than girls. However, the differences are small. On the other hand girls, particularly in the Netherlands, have a significantly lower self-concept in relation to science subjects than boys.

This low self-concept could be to do with the fact that Dutch people score highly when it comes to gender-stereotypical associations compared to people in many other countries. This has been shown by a test that measures, amongst other things, the extent to which people associate science with masculinity. Such associations may often be subconscious, but have a strong impact on thoughts and actions. Gender stereotypes also influence all sorts of aspects of the curriculum for subjects such as science (content, teaching methods, examples

etc.), interaction between teacher and pupils, interaction amongst pupils and so on.

Also other aspects of Dutch culture, such as a lack of enthusiasm amongst the Dutch population towards STEM, help to create a situation in which Dutch girls (and boys) are rarely enthusiastic about a future in these fields of work. As female STEM professionals are still in a strong minority, they are almost 'invisible'. As a result, girls have few to no female role models in the fields of STEM. These aspects are set out in more detail below.

### Scientific performance compared at an international level

There are two major international data sets on pupil performance: *Trends in International Mathematics and Science Study* (every four years, 9 to 10-year-olds and 13 to 14-year-olds, arithmetic/mathematics and science) and the *Programme for International Student Assessment* (every three years, 15-year-olds, language, mathematics, science/natural sciences). US researchers have carried out a meta-analysis on the data sets from 2003 for 13 to 15-year-olds relating to mathematics (Else-Quest e.a. 2010). This revealed that on average, boys and girls around the world perform at around the same level in mathematics. Despite these similarities in performance between boys and girls, there are clear differences in terms of attitude towards mathematics (see also *Self-concept*, page 9).

If we look more closely at the dozens of countries that took part, we see that Dutch boys and girls performed at around the same level in mathematics in 2003. In the following research years the situation in the Netherlands appears to have deteriorated to some extent. The PISA data for 2006 and 2009 show a declining trend in the performance of Dutch pupils in mathematics and physics. This is true in both absolute (average scores) and relative terms (compared to other countries; lower position of the Netherlands in the international rankings). The decline in mathematics is mainly due to a poorer performance by girls. In the case of physics too, girls score significantly lower than boys. Further research into this revealed that, amongst other things, in the case of mathematics relatively little attention has been paid to the topic of insecurity (see also *Self-concept*, page 9). In the case of physics, too little attention has been paid to things like STEM professions and applications (SLO [Netherlands Institute for Curriculum Development]/Kuiper 2010), while girls in particular need more information about this (see also *Curriculum*, page 18).

These major international studies that are conducted every few years show that the 'gender gap' in science is not always the same everywhere: it is sometimes bigger, sometimes smaller, boys perform better at a given point in time in some countries and girls perform better in other countries. This therefore means that,

in principle, girls and boys can perform at the same level in science subjects. It is useful for teachers to be aware of international data on the performance and self-concept of boys and girls in the field of science subjects.

### **Self-concept in relation to science subjects**

The PISA and TIMMS studies also examine pupil's attitudes towards mathematics. The meta-analysis by Else-Quest e.a. (2010) reveals that in the case of mathematics, boys are on average more extrinsically and intrinsically motivated, have a more positive self-concept and have more self-confidence than girls. In both data sets from 2003 there is only one country where the self-concept gender gap in favour of boys is greater than in the Netherlands. In the case of PISA, only Switzerland has a greater gap than the Netherlands: in the 39 remaining countries the gap is smaller. In the case of TIMMS the gap is only bigger in Hong Kong, with smaller gaps in 14 other countries, no gap in 3 countries and a reverse gap in 6 countries (there girls have a more positive self-concept). The self-concept gender gap identified by PISA is significantly larger than that established by TIMMS. PISA 2003 also reveals that girls are much less likely than boys to believe that mathematics will become useful to them later on. Another study has also shown that girls are less likely than boys to see science subjects as being useful in their later academic and professional career and are therefore less motivated to make an effort in these subjects (see for instance Watt e.a. 2006, Alting 2003). International research has also revealed that girls start to turn away from science subjects around the age of 14, or drop these subjects as soon as the education system allows them to do so. It also appears that boys often overestimate their scientific ability (see for instance Watt 2006). On the other hand this makes it easier for them to join the 'STEM highway', whilst girls are hesitant to do so. The education sector is therefore faced with the task of bringing girls' self-concept in relation to STEM more in line with their abilities in this field.

### **Talent for STEM**

If we look at the PISA and TIMMS data from the start of these studies (PISA from 2000 and TIMMS from 1995), boys are generally better at mathematics and science than girls. Many people will feel that this confirms their belief that boys are 'naturally' better at science subjects than girls. However, there are huge differences between the countries. In some countries the boys are better, in other the girls. In some countries the gap is larger, in others smaller. For instance in the US, the gender gap for mathematics is pretty much non-existent, while the gap in the Netherlands appears to be growing. This indicates that the gender gap in science subjects is not caused by a difference in innate talent, but instead by

sociocultural factors, such as explicit or implicit gender-stereotypical beliefs and associations (see also *Gender stereotyping*, below).

There has been a boom in neuroscientific research over the last few years. Amongst other things, the results show that there are innate gender differences when it comes to behaviour, but at the level of cognition gender differences are minimal (Fine 2011, Eliot 2010). Differences within the group girls / women and within the group boys / men are much greater in the field of science than between the two groups (see for instance Hyde & Linn 2006). It has also emerged that, if there are gender differences in cognition, a short training programme (e.g. in spatial skills) is often sufficient to 'repair' gender gaps in aptitude (Tzuriel & Egozi 2010).

Based on recent neuroscientific research it is currently assumed that everyone is born with a 'blueprint' of abilities, and that the extent to which these abilities develop depends on environmental factors (see for instance Fine 2010). The brain can be moulded, particularly in youth: in other words it continues to develop under the influence of experiences (plasticity of the brain). For instance, a person who has a great deal of musical talent cannot learn to play a musical instrument without an instrument and lessons. On the other hand, a person who has average musical talent can learn to play an instrument to a reasonably high level by practicing a lot (particularly during childhood).

It is therefore important to ensure that a flair for STEM is also given the chance to develop in both girls and boys. Education plays a crucial role in this process. It can make it clear to pupils and students that hard work pays off. This is particularly important in the case of girls and women. They often see themselves as less talented in STEM than boys and men, and have the impression that they cannot do anything about this (you have a talent for these subjects or you do not) (see for instance Ceci & Williams 2007). Because hard work pays off, it is important that teachers expect the same level of achievement from female pupils and students as they do from their male counterparts.

### **Gender stereotyping**

It has already been mentioned briefly above that explicit, directly expressed, but also implicit or subconscious gender-stereotypical beliefs and associations can influence how girls and boys perform and to what men and women aspire with respect to STEM. Everyone has automatic and often less conscious preferences and beliefs that help to form a basis for their thoughts and emotions. An implicit stereotype (for instance the association between science and masculinity) is so strong that it influences the way that we judge situations in a way that we cannot consciously control (see for instance Banaji & Greenwald 1995).

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An analysis of the data generated by Harvard University's *Implicit Association Test* (US, gender section, more than half a million tests completed worldwide) reveals that more than 70% of the respondents, both male and female, implicitly associate science with masculinity and the arts and social sciences with femininity, even if they consider themselves to have egalitarian views. Of 34 nations around the world, Dutch people have highly gender-stereotypical associations: the most gender-stereotypical associations between gender and science were found in Tunisia, followed by, in tied second place, the Netherlands, Hungary and Romania (Nosek e.a. 2009).

These researchers also examined the relationship between the degree of implicit gender stereotyping and performance in mathematics and science for each country that took part in TIMMS 2003 and 1999. This relationship proved to be positive: the stronger the gender-stereotypical associations in relation to mathematics and science (= masculine) in a country, the greater the gender gap in performance (boys perform better). This can be extrapolated to other 'markers' of diversity in the labour potential for STEM, such as interest, participation and leadership (Nosek e.a. 2009).

Gender-stereotypical associations amongst the Dutch population could therefore be a major threat to how well Dutch girls perform in STEM subjects, to their interest in these subjects, to academic career choices that lead towards a future in these areas and to a professional career in the sector. The implicit or explicit gender-stereotypical views of parents cause boys to have a greater interest in and experience with STEM than girls at the start of secondary education. We have seen that the brain changes under the influence of experience (plasticity), particularly during youth. Toys, activities and encouragement place more boys than girls on the track towards STEM. The gender-stereotypical associations of teachers can then widen the gap. It is important for teachers to be aware of their implicit gender-stereotypical views and preferences. For teachers who took part in a VHTO teacher training course, filling in the gender&science section of the Harvard *Implicit Association Test* was in many cases an eye-opener. For their part, gender-sensitive teachers can convey to parents, for instance at parent evenings, that science, engineering and technology in itself are neither masculine nor feminine, and that their children can further develop their talent for STEM by working on subjects such as arithmetic/mathematics and science/physics.

Nosek e.a. (2009) advocate national policy that focuses on combating gender stereotypes while at the same time encouraging greater participation by girls and women in STEM, because these elements each have an impact on the other.

## Culture

Views on gender differences and stereotypes in relation to activities, school subjects, study programmes and careers are shaped by culture. Young people use these stereotypes as an aid to shape their identity. They have their own view of each stereotype, as well as being influenced by their parents, contemporaries and others. Culture and, within this, gender stereotypes cause boys and girls to develop in different ways: if you ask young people to make a list of their interests, preferences and goals, this list would look different for boys, in any event in terms of order, than for girls (Bøe e.a. 2011).

In many highly developed countries, interest amongst young people in STEM is on the decline. This situation hardly ever occurs in developing countries, and is probably related to a country's level of social development. Norwegian researchers point out that in highly developed countries, a great deal of value is attached to the principle of individuality. According to them, this means that young people in these countries tend to judge STEM study programmes based on the extent to which they can contribute towards their personal development (Schreiner & Sjøberg 2007). Girls (young women) in particular place an emphasis on self-realisation (Bøe 2011), and if they feel that STEM has less to contribute towards this than other study programmes and professional fields, they will also be less inclined to opt for STEM.

Not only parents, but also teachers play an important role in socialising children and young people. Both in the Netherlands and in many other developed countries, the majority of teachers in primary education are female. They have chosen to do 'something with children', generally have little affinity with STEM or have little confidence in these areas (see for instance Beilock 2010). Teachers in the Netherlands do not all have the same level of education. We have teachers who have followed higher professional education and academic higher education, and first-level and second-level qualified teachers. First-level qualified teachers, i.e. teachers who are qualified to teach certain subjects in the highest grades of secondary education, are less likely to suffer from a lack of confidence when it comes to STEM, as their command of the course material is much more developed than that of second-level qualified teachers, i.e. teachers who are qualified to teach certain subjects in lower grades of secondary education only (see also chapter 3, for example Finland).

One difference between the Netherlands and countries like the US is that there is an explicit focus on motivating pupils in the US. If a pupil in secondary education expresses a desire to work towards a STEM study programme, this

takes precedence and the pupil is assisted as much as possible in achieving his or her ambition (VHTO 2010). In the Netherlands, however, boys and girls who perform at the same level in mathematics and/or physics often receive different advice from teachers and careers advisers: boys who achieve a 7 for mathematics are encouraged to opt for a science subject cluster, while it is not rare for girls with the same grade to be discouraged from making such a choice (VHTO 2008). The reason behind this is that it is often assumed that girls who achieve a 7 (out of 10) for mathematics have earned this grade through hard work (diligence, dedication), while boys are believed to achieve the same grade for mathematics based on ability (talent, 'boys are simply better at science subjects', 'if this boy worked a bit harder he could achieve higher grades'). Americans, and therefore also American teachers, have significantly fewer gender-stereotypical associations in relation to STEM than the Dutch (Nosek 2009). However, the American culture of 'if you want something go for it' also means that girls are more likely to move on to a STEM study programme than in the Netherlands. This does not alter the fact that in the US too, people are not satisfied with the participation of girls and women in STEM.

Foreign STEM professionals and students who work or study in the Netherlands are often very surprised by the Dutch population's attitude towards their discipline. They find that in the Netherlands women who work in STEM fields are sometimes viewed with pity. Dutch people presume that they must not enjoy doing such boring or difficult work (see for instance VHTO 2007 and 2010). These foreign women also have the sense that Dutch girls and women view work more as something that is problematic than something that is challenging and in which you can apply your talents and develop yourself as a person.

When it comes to STEM, girls have much fewer role models to emulate than boys: after all, most girls have few to no female STEM professionals as an example in their immediate environment.

All in all, there are various cultural factors that give girls negative signals about a professional career in STEM, as well as doubts about their abilities in these areas. In this context, it is argued that female role models who excel in STEM and who clearly take pleasure in their work should have a higher profile (see for instance Else-Quest 2010, VHTO 2010). This has clearly proven fruitful over the past few years in secondary education: at senior general secondary education (HAVO) and university preparatory education (VWO) schools where VHTO organises speed dates with female role models, a significantly larger number of girls opt for a science subject cluster (see [chapter 3](#)). Incidentally, women who opt for a study programme or job in the field of STEM are not automatically effective role models. If despite being female they only give out gender-stereotypical

messages ('It's difficult', 'STEM studies take a lot of time and hard work', 'I'm just not like other women', 'I actually get on better with men than with women', and suchlike) then girls get the impression that these women are different to themselves and their actions will make little difference (Cheryan e.a. 2011).

### Women in a minority position

Because women who opt for STEM study programmes and jobs, or who work as a scientist or technical expert in the academic world, are still moderately to severely underrepresented, it is difficult for them to mould the culture within the study programme, the institution or the company so that they feel at home there. Feeling at home is key to integrating into the student or employee population, which in turn affects your performance and your enjoyment of your studies or work. According to Rosabeth Moss Kanter's (1977 amongst others) theory about 'critical mass', a 50-50 split is not essential, and a minority has full influence on the culture of the population as a whole once it has achieved a share of one third or more. In this case, the 'minority' no longer occupies a 'minority position' in the sense of less influence or power to mould the situation within the population. This 'one third' rule is a useful guideline for educational and other institutions and companies where the percentage of women is much smaller than one third. Nevertheless, for educational and other institutions and companies where the percentage of female STEM students or women in STEM positions is 33.3-50%, this is no foregone conclusion. Critics of Moss Kanter argue that she based her theory purely on numbers, and formulated it in a gender-neutral (and colour-neutral) way. According to Moss Kanter people who find themselves in a minority position based on certain significant characteristics must suffer from the same negative consequences. Ott (1985) has shown that such negative consequences do not apply to men in female professions and to women in male professions. For instance, men who were brought into nursing in the 1980s were advised and supported by their female colleagues and rapidly ascended in the hierarchy. However, women who went to work for the police had to prove themselves twice over and remained excluded. Ott concludes that it is not about numbers but rather the status of the minority in question. If this status is high, the minority position has a favourable impact, if it is low the effect is unfavourable. The latter is still the case for STEM. This demands constant vigilance on the part of STEM study programmes, companies and institutions with regard to the position of female students and employees.

Women who opt for masculine study programmes and professions are often faced with a dilemma: they want to be 'one of the guys', but instead stand out even more from all their male colleagues and often need to work extra hard

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to prove themselves ('tokenism', Moss Kanter 1977). A strong female network within the organisation can offer female students and/or staff a great deal of support. Representatives of the network can enter into discussions with managers and together work on the empowerment of female students/staff.

### Academic and professional career choices

Career choices are based on personal factors (mapping out your own route) and structural factors (opportunities and obstacles in mapping out this route). Jacquelynne Eccles has spent 30 years working on her *Expectancy value model of achievement-related choices*<sup>1</sup>, which analyses all possible influences on career choices (Eccles, 2007 amongst others). According to Eccles, academic and professional career choices are primarily based on the following two questions:

'Can I do this?' and: 'Do I want to do this?' The answer to the question 'Can I do this?' is closely connected to self-concept. We have previously seen that girls have a much lower self-concept in relation to STEM subjects than boys, and are therefore much more likely to doubt choosing a STEM career path than boys.

More girls than boys have the impression that STEM is difficult and that you can therefore only choose these paths if you excel in STEM subjects. This belief is often reinforced by the attitude and behaviour of parents, teachers and careers advisers.

The answer to the question 'Do I want to do this?' depends on things like whether girls enjoy STEM. We have seen that in our society, boys more than girls are encouraged to get involved with STEM. Boys have therefore generally had more opportunity to develop an affinity with STEM and to enjoy STEM than girls. What's more, boys can easily follow the example of (many) role models, which is rarely or never the case for girls.

In the Netherlands pupils are required to make academic career choices much earlier than in most other countries (see for instance Van Langen & Driessen 2006). At this age (14-15) young people are still at the height of their development. This makes it extremely difficult to make decisions that will determine a significant part of their lives (academic career and professional career) at such an early stage. It is even more difficult to make non-traditional choices this early, such as girls opting for STEM.

Pupils choose a type of education on the transition from primary to secondary education, at the age of just twelve. This is particularly disadvantageous for pupils in preparatory secondary vocational education (VMBO), because they also need to make their next choice very early (two years later) and this choice

1 A film clip with an explanation from Jacquelynne Eccles can be found at [www.vhto.nl](http://www.vhto.nl) > Internationaal.

is already more specifically aimed at a field of study than in senior general secondary education (HAVO) / university preparatory education (VWO); here, the next defining moment occurs three years after the transition from primary to secondary education and is somewhat less specific.

In addition to the fact that Dutch pupils are required to make choices early in their academic career, there are also extremely few opportunities to move up a level. For instance, once you have chosen a society subject cluster in HAVO and VWO there are practically no further options to switch to a science subject cluster. For the purpose of comparison: in the US, there is a free choice of subjects in secondary education. Pupils who drop certain subjects can take them up again later. In the US you do not commit yourself to a specific subject or course of study until the second year of university (see for instance VHTO 2008).

If it is still relatively 'easy' to choose science in secondary education in the sense that the male to female split in the science subject clusters is not yet so uneven and the culture is not yet so masculine, it becomes more difficult on choosing a course of study. In the case of many STEM study programmes men are still by far in the majority, and the learning environment, the culture and the curriculum are often still masculine. Moreover, many girls have a negative image of the job prospects. Consequently, girls stay on the safe side and choose an advanced programme and a professional field in which they can be more confident that they will feel at home. Girls are also less aware of STEM study programme and job prospects than boys. School careers advisers and teachers are more likely to advise boys to make academic career choices in the direction of STEM than girls, and sometimes even advise girls against such choices.

These factors combined cause many girls to consciously or subconsciously exclude STEM professions and study programmes at an early stage. It is important that, during career orientation and guidance in secondary education and during 'reach out' activities for STEM study programmes, female professionals and students in the field of STEM are brought in as role models, that an appealing and realistic picture is painted of the study programme and the professional options and that it is emphasised that a STEM study programme is not extra difficult, certainly not if you have reasonable to good grades for science subjects.

### Curriculum

In the *Self-concept* section (page 9) we saw that young people, particularly girls, start to turn away from STEM on average at around the age of 14. This is influenced by experience they have gained in the previous years. This self-concept in relation to science, but also the teaching skills of the teachers, the content of STEM subjects and the aspirations of and support from parents have at this point

already had a significant impact on their career expectations (see for instance Tai e.a. 2006).

The content and format of STEM programmes are not always effectively tailored to both male and female pupils and students. The content and context of STEM are often still more appealing to male than to female pupils and students. Boys find it interesting when physics content is presented in a technical, mechanical or electrical context and if it is spectacular, violent or explosive, while girls are more interested in health, the human body, medicine, ethics and aesthetics (Van Griethuijsen 2011, Sjøberg & Shreiner 2010). Approaching things like the principles of physics via formulas is also less appealing to girls than an approach based on situations in everyday life in which these principles manifest themselves (Boltjes 2004, VHTO 2010).

The link to professional practice is not always sufficiently clear in higher education, or cases (project-based learning) are not sufficiently up to date, true to life and attractive for female students in particular. Here too, there is often a lack of enthusiastic female role models who can demonstrate interesting job prospects to female students. Contact with role models can also keep female students' motivation for the study programme alive and help them to successfully complete their studies.

Further attention to the gender mainstreaming of the science curriculum in secondary education and of STEM study programmes, and to increasing gender sensitivity amongst teachers and secondary education careers advisers, is therefore essential.

## 2

# Are more **girls** and **women** now **choosing** STEM?

**In order to identify trends in women's participation in STEM study programmes and in the STEM labour market, and to examine whether efforts in the field of gender and STEM have helped to generate a more positive attitude on the part of girls and women towards STEM, it is interesting to look at how the intake, progression and outflow of (female) STEM students into/out of higher education has developed over the years based on quantitative data.**

ResearchNed, an independent research institute, has carried out a statistical analysis on behalf of the National Platform Science & Technology/VHTO to this end. Various sources were used for the analysis, including the data files of Statistics Netherlands (CBS), the Education Executive Agency (DUO), the National Platform Science & Technology (PBT) Knowledge Base and the Research Centre for Education and the Labour Market/Maastricht University School of Business and Economics (ROA).

### **Explanatory notes on classification into study programmes and study programme clusters**

The data from CBS, DUO, the PBT Knowledge Base and ROA are sometimes difficult to compare. For instance, no uniform classification into study programmes and study programme clusters is applied. In addition, intake into higher professional education has only been systematically recorded since the 1990s. The International Standard Classification of Education (ISCED) has provided a refined level-based classification since 1990. Since then all study programmes have been grouped within a specific sector in the Central Register of Higher Education Study Programmes (CROHO), and they have all been assigned a unique CROHO code. However, many study programmes that have a STEM curriculum do not fall within the (CROHO) STEM sectors. In 2000, the PBT therefore re-classified higher STEM education into four clusters:

- 1 higher education study programmes belonging to the CROHO STEM sectors (100% STEM) (cluster 1)

- 2 study programmes with more than 50% STEM content (for instance human movement science in academic higher education, biotechnology in higher professional education) (cluster 2)
- 3 STEM teacher-training programmes (cluster 3)
- 4 study programmes with less than 50% STEM content (for instance medicine in academic higher education, physiotherapy in higher professional education) (cluster 4)

ResearchNed has produced a table for converting ISCED codes into cluster 1 and cluster 2 study programmes. Different classifications will be used in this chapter, namely according to: STEM cluster (PBT) and HOOP sector (Higher Education and Research Plan). In a HOOP sector, study programmes are grouped together as recorded in the Central Register of Higher Education Study Programmes (CROHO).

### Pupils completing secondary education

Over the period 2002-2009 there was a sharp rise in the number of both male and female school-leaving examination candidates, both in senior general secondary education (HAVO) and in university preparatory education (VWO). The number of pupils per subject cluster has also risen since 2002 proportional to the overall increase in the number of pupils. The total number of HAVO and VWO pupils with a science subject cluster has more than doubled since 2000. This is mainly

**Table 1 Subject clusters chosen by 4havo pupils**

	NG			NT/NG			NT		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
2000-2001	2,880	3,831	6,711	299	159	458	5,366	606	5,972
2006-2007	4,872	5,359	10,231	1,004	270	1,274	4,745	477	5,222
2007-2008	4,393	6,027	10,420	1,546	874	2,420	5,869	740	6,609
2008-2009	4,199	6,202	10,401	1,719	1,006	2,725	6,057	944	7,001
2009-2010	4,425	6,334	10,759	1,995	1,058	3,053	5,945	908	6,853
2010-2011	4,594	6,556	11,150	2,086	1,163	3,249	5,629	856	6,485

Source: ResearchNed

**Table 2 Subjects clusters by 4vwo pupils**

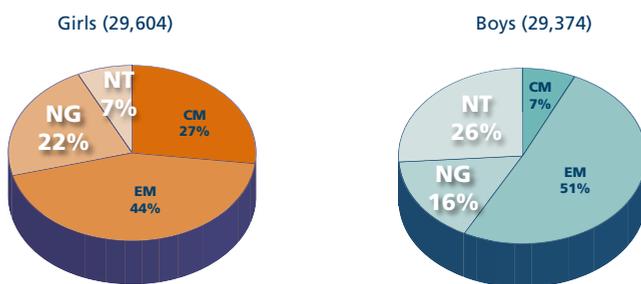
	NG			NT/NG			NT		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
2000-2001	2,010	3,452	5,462	2,914	2,389	5,303	2,975	723	3,698
2006-2007	3,376	5,821	9,197	4,706	3,876	8,582	3,381	812	4,193
2007-2008	3,325	6,293	9,618	3,404	3,427	6,831	5,283	1,719	7,002
2008-2009	3,401	6,247	9,648	3,655	3,527	7,182	5,283	1,913	7,196
2009-2010	3,426	6,198	9,624	3,662	3,563	7,225	5,280	2,023	7,303
2010-2011	3,481	5,945	9,426	3,837	3,580	7,417	4,901	1,889	6,790

Source: ResearchNed

due to the growth in the number of girls taking part in these subject clusters and the substantial increase in science subject clusters in HAVO. The science subject clusters include the following clusters: Science and Technology (Natuur en Techniek, NT), Science and Health (Natuur en Gezondheid, NG) and the 'dual subject cluster' (NT/NG). Tables 1 and 2 show the absolute numbers of 4HAVO and 4VWO pupils (i.e. at the time at which a subject cluster is chosen) over the past five years. The starting date here is the 2000/2001 academic year, and the data are then shown per year from 2006.

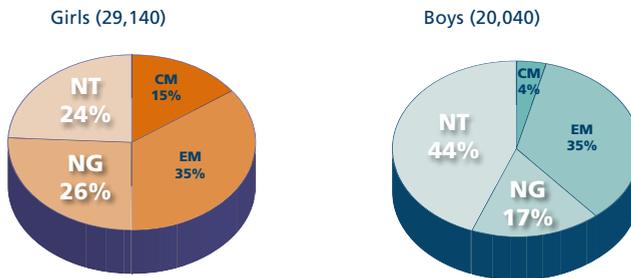
The absolute numbers show a very steady growth in the numbers of both boys and girls who opt for a science subject cluster. However, if we look at the subject

**Figure 1 Subject clusters chosen by 4havo pupils in 2010-2011**



Source: National Platform Science & Technology

**Figure 2 Subject clusters chosen by 4vwo pupils in 2010-2011**



Source: National Platform Science & Technology

clusters chosen by boys compared to those chosen by girls we still see an uneven distribution. More than one quarter of male 4HAVO pupils opt for the NT subject cluster compared to only 7% of their female counterparts.

In VWO, 24% of girls choose the NT subject cluster compared to 44% of boys.

Despite this uneven distribution, the number of girls opting for a science subject cluster has indeed risen in absolute terms. All these girls therefore have the correct subject cluster to move on to an advanced STEM programme.

#### From secondary education to higher education

More than 80% of male HAVO/VWO pupils with an NT subject cluster choose an advanced STEM programme. However, only around 60% of female pupils with this subject cluster choose an advanced STEM programme. Table 3 shows the percentage of pupils moving on to an advanced STEM programme per subject cluster and per gender.

**Table 3 Pupils moving on to an advanced STEM programme in higher education (2010-2011)**

	NG		NT/NG		NT	
	Male	Female	Male	Female	Male	Female
Havo	48.1%	15.1%	71.2%	31.7%	80.2%	56.1%
Vwo	47.5%	28.4%	72.4%	48.2%	80.5%	64.9%

Source: ResearchNed

In short, far from all girls who have the option to follow a STEM study programme actually choose to do so. So which study programmes do these girls choose instead? In higher professional education (HBO) they opt for subjects such as nursing, teacher training for primary education (PABO), physiotherapy and education. In academic higher education (WO), medicine, psychology, education and law are popular among female students with a science subject cluster. Of these study programmes, a science subject cluster (including physics and biology) is only a requirement for medicine. A large number of female students therefore consciously decide against an advanced STEM programme.

### **VHTO-effect on academic career choices**

Over the past few years, 183 HAVO/VWO schools have made an effort to boost pupil enthusiasm for the science subject cluster in the context of the National Platform Science & Technology's Universe Programme. These schools have worked hard to encourage pupils to move on to advanced STEM programmes. The statistics show that these schools have succeeded in increasing the number of pupils who choose a science subject cluster and who move on to an advanced STEM programme. The vast majority of these schools (145) collaborated with VHTO to focus specifically on the subject clusters and study programmes chosen by girls (see chapters 4 and 5 for more information on this approach). The National Platform PBT examined whether the science subject cluster scores and progression outcomes of schools that worked with VHTO to provide girls with careers guidance differ from those of other schools. It did indeed emerge that on average, the number of girls choosing a science subject cluster was highest at the 'VHTO schools'. This applies to both HAVO and VWO. Particularly in the case of VWO, the average and the success rate was significantly higher (National Platform Science & Technology 2011).

### **Intake for higher STEM education**

As described, a growing number of HAVO/VWO pupils are opting for a science subject cluster. This group of pupils is the prospective intake for higher STEM education. We should therefore see the growth in popularity of science subject clusters reflected in the intake statistics for higher STEM education. This section looks at the intake statistics for both higher professional education (HBO) and academic higher education (WO).

### **HBO intake**

The first half of the 1990s saw a sharp rise in the number of students enrolling in higher STEM professional education, with the growth in intake subsequently

**Table 4 Intake for STEM HBO study programmes by cluster and gender**

	'05-'06	'06-'07	'07-'08	'08-'09	'09-'10
<b>Cluster 1</b>					
Male	86.0%	85.7%	84.8%	84.2%	83.3%
Female	14.0%	14.3%	15.2%	15.8%	16.7%
Total (n=100%)	14,596	14,550	14,951	15,672	16,944
<b>Cluster 2</b>					
Male	55.6%	58.6%	54.9%	52.5%	52.6%
Female	44.4%	41.4%	45.1%	47.5%	47.4%
Total (n=100%)	1,365	1,242	1,315	1,319	1,520

Source: ResearchNed, National Platform Science & Technology Knowledge Base

levelling off. Table 4 shows the intake statistics for the past five years for HBO cluster 1 and HBO cluster 2 study programmes (see *Explanatory* notes on page 20).

The growth in female intake is stronger than the growth in male intake. However, there is a big difference between the two clusters. For instance in the first cluster in 2009 the percentage of female incoming students was 16.7%, whereas this percentage was almost half in cluster 2.

### WO intake

Intake in academic higher education has grown considerably since 1980, with a sharp rise in the percentage of women in all sectors. Male students are only still in the majority in the sectors Science, Technology and Economics.

The intake of students onto WO study programmes in clusters 1 and 2 (see *Explanatory* notes on page 20) has risen by 62% since 2000. This rise is largely attributable to female students, as this period saw a 73% rise in the intake of female students onto these programmes. The same period saw a 26% rise in the intake of female students onto non-STEM study programmes (source: National Platform Science & Technology).

The percentage of women in the Science sector is significantly higher than in the Technology sector: 39% versus 19% (2005-2009, table 5).

**Table 5 Intake for study programmes in the HOOP sectors (WO) STEM by gender**

		2000-2004	2005-2009
<b>Science</b>	Male	66%	61%
	Female	34%	39%
	<i>Total (n=100%)</i>	<i>13,494</i>	<i>18,701</i>
<hr/>			
<b>Technology</b>	Male	83%	81%
	Female	17%	19%
	<i>Total (n=100%)</i>	<i>23,597</i>	<i>28,157</i>

Source: Statistics Netherlands/Education Executive Agency; processed by ResearchNed

### Graduates from STEM study programmes entering the labour market

It is interesting to examine whether women who chose a STEM study programme in higher education also move on to a job or profession in these sectors. Research by Statistics Netherlands (CBS) and the Research Centre for Education and the Labour Market (ROA) shows that the percentage of unemployed women who hold a diploma for a STEM study programme from a research university of university of applied sciences has fluctuated between 1-6% over the past ten years. In the case of both higher professional education and academic higher education, most women find paid work within 18 months of graduating. On average, STEM graduates find paid employment within two months. Most graduates succeed in finding a job within their field of study. Female STEM graduates are more likely to find a job within their field of study than both male STEM graduates and women who have followed a non-STEM study programme. Female STEM graduates also perform well in terms of level of employment. Female STEM graduates are less likely to be employed below their educational level than their male counterparts. Women with a STEM qualification from a research university are more likely to be employed below their educational level than women with a STEM qualification from a university of applied sciences, but still less likely than male STEM graduates and much less likely than female non-STEM graduates (source: ResearchNed).

Although women are therefore less likely to be employed below their educational level than men, this does not have a positive effect on their income. Even if we take into account part-time employment, male STEM graduates from both

research universities and universities of applied sciences earn more than their female counterparts.

Research conducted amongst graduates by ROA shows that the professions of architect, structural engineer and project manager are popular among female STEM graduates, as is the post of academic researcher (source: ResearchNed). According to the Dutch Network of Women Professors (LNVH), the number of female academics is rising in all job categories, but despite this increase the male to female split among academic staff remains uneven, particularly in higher level positions.

**Table 6 Female STEM graduates entering the labour market (2008)**

	From HBO	From WO
Food, drink & tobacco industries	2.6%	2.1%
Chemistry	2.3%	2.1%
Metal industry	3.0%	2.3%
Other industries	1.3%	0.8%
Construction industry	1.4%	0.4%
Transport by road	0.5%	0.5%
Other transport	0.7%	0.2%
ICT	4.1%	2.4%
Technical consultancy	6.7%	13.0%
Automotive sector	0.4%	0.1%
Agriculture	1.3%	0.8%
Other technical	0.6%	0.3%
Non-technical	75.0%	74.9%
	N=1019	N=1556

Source: Statistics Netherlands Social Statistics Database; processed by ResearchNed (2010)

Statistics Netherlands' data files were analysed in order to provide an overview of the STEM labour market. Unfortunately, it is not possible to determine from this data which professions STEM graduates practice: Statistics Netherlands only reports how many women are employed in each branch of industry.

Consequently, we cannot see whether STEM graduates who are not employed in a STEM business sector have a STEM-based job or profession within another business sector.

If we look at the graduates who do end up in a STEM business sector, the technical consultancy sector is by far the most popular amongst women. ICT and the metal industry are also popular employment sectors.

### **On the right path, but 'vigorous action' is still needed**

The statistical analyses show that there is a growing number of prospective female STEM students, as more and more girls in secondary education (HAVO/VWO) are opting for a science subject cluster. This is also reflected in the growing intake statistics for higher STEM education. The efforts made within both secondary and higher education have therefore had a positive impact. Unfortunately, some girls with a science subject cluster are also deciding not to move on to an advanced STEM programme. More detailed research could be carried out into these girls' motives: more effective and more structured careers guidance during upper secondary education could probably encourage more girls to become interested in STEM programmes in higher education.

A second striking outcome is that far from all female STEM graduates can be found in a STEM sector in the labour market. This does not necessarily mean that these women are not or are no longer employed in a STEM-based position. They could be working in the service sector, at a hospital, for the government or suchlike. It would be highly interesting to study this in greater detail. Furthermore, it is distressing to find that women in the Netherlands also earn less than men in similar positions in the STEM sector.

# 3

## What is the situation with regard to **gender** and **STEM** in **other countries**?

**The Netherlands lags behind other countries in terms of the percentage of girls opting for STEM study programmes in higher education. What are the statistics and what insights have a number of study trips provided?**

Eurostat, the statistical office of the European Union, has carried out an international comparative analysis of students enrolled in tertiary education<sup>2</sup> (see table 7). Particularly in the case of science, the Netherlands features at the bottom of the scale with just 19% female students in 2009 (compared for example to Turkey with 41.5%, Finland with 39.1%, the UK with 36.8% and Spain with 34.9%; Italy has as much as 51.4% female science students). Also in terms of participation in technology study programmes, the Netherlands is close to last with 16.1%.

The strikingly low participation of women in higher STEM education in the Netherlands probably goes hand in hand with Dutch girls' considerably lower self-concept in relation to science subjects compared to boys (see figure 3), whilst these girls achieve practically the same results in science subjects as boys. This low self-concept could once again have to do with the fact that Dutch people score highly when it comes to associating gender stereotypes compared to people in many other countries (also see [chapter 1](#)).

### Study trips

Study trips<sup>3</sup> to three countries where the participation of female students in STEM programmes is higher than in the Netherlands (the UK, Turkey and Finland) revealed that a later final choice of school subjects or study programme has a particularly positive impact on the number of girls who choose STEM. It is also

- 2 Eurostat deems 'tertiary education' to include higher professional education, academic higher education, education provided by the Open University (study programme syllabuses) and other, often private, vocational training at this level.
- 3 VHTO organised three international study trips in 2010/2011 in the context of the National Platform Science & Technology Sprint Programme for representatives of higher education STEM study programmes.

**Table 7 Percentages of women in tertiary education (Eurostat, 2009)**

Tertiary education in generals		Engineering, manufacturing and construction		Science, mathematics and computing	
Iceland	64.3	Liechtenstein	43.7	Romania	52.1
Latvia	63.7	Denmark	34.5	Italy	51.4
Estonia	61.9	Iceland	33.7	Bulgaria	47.7
Norway	61.1	Macedonia	32.6	Portugal	46.6
Slovakia	60.5	Bulgaria	31.1	Sweden	43.1
Sweden	60.1	Romania	30.1	United States	43.0
Lithuania	59.2	Italy	30.0	Turkey	41.5
Denmark	58.2	Sweden	29.4	Ireland	40.1
Slovenia	58.0	Slovakia	29.1	Finland	39.1
Poland	57.9	Spain	28.1	Croatia	38.9
Italy	57.7	Poland	28.1	Estonia	38.7
United States	57.1	Malta	26.9	Macedonia	38.6
United Kingdom	57.0	Norway	26.9	Slovakia	38.4
Hungary	56.8	Croatia	26.8	European Union	37.7
Czech Republic	56.5	Estonia	25.3	Norway	37.2
Malta	56.5	France	25.3	Iceland	36.9
Romania	56.3	Portugal	25.3	United Kingdom	36.8
Bulgaria	55.6	Slovenia	25.3	Poland	36.7
European Union	55.5	European Union	24.9	Slovenia	36.1
France	55.2	Czech Republic	23.8	Cyprus	35.9
Croatia	55.0	Austria	23.2	France	35.8
Belgium	54.8	Belgium	23.0	Austria	35.7
Spain	54.1	Cyprus	22.6	Germany	35.5
Finland	54.0	Turkey	21.2	Czech Republic	35.4
Ireland	53.9	Lithuania	21.0	Denmark	35.0
Portugal	53.4	Finland	19.2	Spain	34.9
Austria	53.2	United Kingdom	19.1	Lithuania	33.8
Macedonia	53.0	Hungary	18.4	Latvia	31.9
Netherlands	51.8	Germany	18.1	Hungary	31.6
Germany	51.4	United States	17.4	Switzerland	31.2
Switzerland	49.7	Netherlands	16.1	Belgium	30.1
Cyprus	46.8	Switzerland	15.6	Malta	26.8
Japan	45.8	Ireland	15.5	Japan	25.0
Turkey	43.6	Japan	11.5	Netherlands	19.0

**Figure 3 Index of self-concept in mathematics for boys and girls in the OECD and partner countries**



Source: PISA 2003. The higher the index, the greater the difference between boys and girls. In all countries in this index, boys had a more positive self-concept in mathematics at the measurement moment than girls.

clear that a culture in which girls and boys are equally encouraged to strive to perform to the best of their ability and to develop career ambition, and where admission is subject to strict selection procedures, girls have just as much drive to secure a place on STEM study programmes as boys. This is the case in both the UK and Turkey.

### Finland

In Finland, which ranks top on the PISA list, girls in secondary education perform significantly better in natural sciences and on a par with boys in mathematics. The participation of girls in STEM study programmes is also relatively high in Finland. This is probably to do with the close collaboration between higher education institutions, secondary education schools and science centres, the Finnish emphasis on life-long learning and the academic educational background of all teachers. All teachers, including primary school teachers, have completed a first-level study programme at a research university. This means that they have a thorough grasp of the content of their field of study and that they have university-level skills, which enables them to develop their own teaching materials. This is also possible in Finland because teachers have greater freedom to determine the specific details of their lessons, within the legal frameworks. Finnish researchers (including Lavonen 2004) and teacher trainers emphasise the importance of interesting content *and* context for the natural sciences, to boost motivation amongst all pupils (specifically including girls). In addition to their subject matter knowledge, teachers are trained to teach a wide range of groups (with various learning styles) and to use a range of teaching strategies. As in the past few years in the Netherlands, vigorous efforts are being made in Finland to achieve an integrated approach: special activities for girls (including contact with female professionals/role models), teacher training, and a policy-based approach to gender mainstreaming.

### The UK

In the UK too, fewer women than men opt for a STEM study programme, job or profession. However, participation by women is significantly higher than in the Netherlands. For a long time now the UK government has taken measures to boost female participation in STEM. What is striking is that many initiatives in this area are managed centrally and directly by government. Nevertheless, the UK government has recently cut back on investment in this policy. UK culture may be similar to Dutch culture, but the higher education system is not. The student recruitment and selection processes in particular are very different to those in the Netherlands. This is because universities in the UK vary widely in terms of quality, status and image. The most prestigious universities

of technology can impose strict selection requirements and primarily attract top students. The status of these universities ensures that many students, both male and female, have the ambition to be admitted. In the UK too, the importance of female role models in STEM is emphasised. The universities therefore collaborate closely with the business sector in order to involve female professionals in teaching and therefore to provide a clear picture of the profession. In the UK the business sector is also involved in developing new curricula that respond more effectively to demands from the labour market. These bachelor's and master's degree programmes have also proven to be very popular amongst girls, possibly because they involve applied science to a significant degree.

### Turkey

The higher education system in Turkey differs greatly from the Dutch system. Not only are there both private and state universities, but the admission procedure is also very different to that in the Netherlands. Of the 1.9 million people who sat entrance examinations in 2002, around 33% were admitted to a university study programme. Admission to a university with a good reputation is subject to a strict selection procedure, and depends on the results obtained in a national test. The universities of technology are the most highly regarded and offer the best job prospects. This is also why this field of study is the first choice of the majority of students. It also means that high demands are placed on pupils (by their environment and family) to achieve as high results as possible at a cognitive level. Moreover, competition on the labour market is fierce. In short: all pupils, both male and female, strive to achieve the highest possible grades in order to access a study programme that offers the best job prospects, i.e. a technical study programme.

The universities of technology therefore do not need to boost enthusiasm amongst students by providing information. Turkish pupils do not choose their studies based on personal interest. On the contrary, girls and boys are equally instilled with an ambition to perform to the best of their ability at school from a young age.

Research has shown that there is a link between a country's level of development and the level of interest in STEM amongst young adults (Schreiner & Sjøberg 2006). The higher a country's level of development, the less interested young people are in practising a STEM profession. The lower a country's level of development, the higher the status of technology and the greater the enthusiasm amongst young people for jobs in the technology sector. Turkey does not appear in the list; however it is clear that in southern European countries (lower development level) the interest in STEM is greater than in northern European countries (higher development level).

In Turkey technology is a very popular degree programme amongst both boys and girls. This stands in contrast with the fact that in the Netherlands, boys and girls of Turkish origin are actually less likely than young people of native Dutch background to opt for a career in STEM.

# 4

## What have been recent **developments** in the **focus** on **girls** and **women** and **STEM**?

When the EU member states formulated the Lisbon objectives in 2000 with the aim of becoming a leading knowledge economy by 2010, they explicitly agreed to strive for a 'gender balance'. In the Netherlands, this ultimately led to a sound policy-based focus on boosting female intake in the field of STEM.

In order to achieve the desired 15% rise in STEM professionals, VHTO and the Education Inspectorate calculated that girls in secondary education form the largest potential source of new intake.

As part of a joint effort by the National Platform Science & Technology (PBT), the Ministry of Education, Culture and Science, Department of Equal Opportunities and VHTO, an effective strategy has been developed in recent years (2004-2011) designed to encourage more girls to opt on a large scale for the engineering and technology sector (in VMBO), the science subject clusters (N&G and N&T, in HAVO and VWO) and for advanced STEM programmes in senior secondary vocational education, higher professional education and academic higher education. This strategy has proven particularly effective in view of the huge increase in the number of girls who now choose science subject clusters (particularly at the secondary education schools that collaborate with VHTO) and in view of the higher female intake onto STEM study programmes in higher education (see [chapter 2](#)).

### Secondary education

The abovementioned secondary education strategy combines VHTO incentive activities that have proven successful in previous years (see below) with new insights. The strength of the current strategy lies in the combination of activities for girls, training programmes for teachers and careers advisers and consultations with school managers:

- *Specific information activities for girls at school*

Designed to introduce girls to the range of opportunities in STEM and to female professionals (role models) who enjoy working in this sector. This takes

the form of speed dates with female professionals (and female students) at defining moments, in other words on choosing a subject cluster in junior secondary education and when choosing an advanced programme in upper secondary education. The girls talk to various 'role models' (women with an educational background in STEM who are now employed in a STEM-based position, or female students following STEM study programmes, who have signed up as a role model in the VHTO 'Spiegelbeeld' database: [www.spiegelbeeld.net](http://www.spiegelbeeld.net)). In addition, these female professionals hold guest classes on their field of study at schools (to get both girls and boys used to the idea that women can also be experts in the field of STEM) and they take part in the annual Girls' Day at their company for girls in junior secondary education.

– *Training programmes for teachers and careers advisers*

Training in gender awareness (including international comparisons and research insights), in breaking down stereotypes within STEM, in gender-inclusive science teaching and in careers guidance.

– *Consultations with school managers*

On the embedding of gender and STEM in school policy (mainstreaming), monitoring both male and female pupils' results and choices, and the importance of systematic assessment (and adjustments where needed) of gender policy and activities.

An important precondition for this effective strategy is the fact that the National Platform Science & Technology has explicitly incorporated a focus on the decision-making process by girls and on the enshrining of the gender perspective in school policy in the targets of its STEM programme for secondary education (Universe Programme) and in the monitoring & auditing of secondary education schools.

### **Higher education**

Over the last policy period, the National Platform Science & Technology (Sprint Programme) has also helped universities to increase the numbers of incoming and graduating students. As the intake of female students onto higher education STEM study programmes has not kept pace with the huge rise in the prospective supply of female pupils in secondary education (namely the large number of girls with a science subject cluster), the universities have been explicitly encouraged over the past few years to do more in terms of 'reach out' activities, aimed at both boys and girls, and in terms of more intensive collaboration with HAVO and VWO schools as regards content. Universities have also been encouraged to

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critically examine the content, the educational structure of the study programmes and the study programmes on offer. In doing so, they were able to make use of VHTO's knowledge and experience (see also [chapter 5](#)).

### **Background**

The focus on gender in higher STEM education is nothing new<sup>4</sup>. Terms such as chain approach, integrated approach and gender mainstreaming have gradually become the common foundations of policy in relation to girls and STEM in higher education. However, views on girls and women and STEM in Dutch higher educational institutions have changed drastically since the 1980s. Whereas at the start of the 1980s efforts were still limited to the provision of better information to girls, by the end of the decade there were calls to reinforce information policy with a systematic guidance approach for female students. The 1990s saw a recognition of the fact that greater account also needs to be taken of differences between students (including gender differences) in the design and content of the learning process. In 1994 the Equal Opportunities Board called for a review of engineering and technology. Technology must again become a stronger tool to help people take control of their environment. Axis (1998-2004) subsequently gave this review tangible substance by encouraging the development of interface study programmes (between engineering / technology and other disciplines) and by adopting a chain approach. In the same period, VHTO called for a longitudinal, integrated approach to girls & engineering and technology and for the deployment of female professionals as role models in information provision. However, it was not until the introduction of the National Platform Science & Technology (2004) that it became a policy-based priority (with available financial resources) to carry out targeted activities on a large scale and throughout the entire education chain, and thus VHTO was able to use its knowledge and experience to the full. The gender perspective was also taken into account in educational innovation, such as in the review of upper secondary education, and in science subject reforms.

### **Mid 1980s: provision of information to female school-leaving examination candidates**

An awareness of the situation of female students (and of relevant gender differences) arose in the majority of universities of applied sciences offering engineering and technology study programmes and at the universities of technology in the mid 1980s. Female participation was pitifully low (1.7% female

4 This background is taken from the article 'Emancipatie in het hoger technisch onderwijs; verleden heden en toekomst' (Equal opportunities in higher technical education: past, present and future), in *Topics, Technóva; analyse en cases* (Technóva: analysis and cases), VHTO, 2000.

students at institutes of technology). In those days many universities of applied sciences had an equal opportunities coordinator and an equal opportunities working group, consisting of (female) lecturers, counsellors and in one case also students. VHTO was set up by the institutes of technology of the universities of applied sciences and acted back then as an 'equal opportunities umbrella organisation' for these technical study programmes. The equal opportunities coordinators and VHTO together mapped out policy lines and set up projects. The three universities of technology also each had an equal opportunities officer.

In the 1980s, the reasons behind the unequal participation of girls and boys in engineering and technology education were primarily sought within society (which reinforced traditional role patterns and choices) on the one hand and, on the other hand, within the girls themselves (who according to the institutions should have been better informed). The universities therefore actively took measures until far into the 1990s to improve information policy. Girls were recognised as a separate target group, and VHTO produced a guideline for activities for this target group: the *Anders voorlichten* (Alternative information provision) strategy. Institutions set up information activities specifically aimed at girls (school-leaving examination candidates). Little to no attention was still paid to culture, educational structure or the content of the STEM study programmes as potential obstacles to attracting larger numbers of female students.

### Late 1980s: guidance of female students

At the end of the 1980s there was a realisation that better information specifically aimed at girls on its own was not sufficient to boost the number of female students enrolling and progressing in, and graduating from, higher engineering and technology education. Research showed that there was a negative relationship between the performance and study motivation of female students on the one hand and the social study environment in higher engineering and technology education on the other hand. VHTO and the equal opportunities coordinators called for a systematic guidance approach (amongst other things in relation to work placements and the transition from study programme to employment), for policy in respect of sexual harassment, and for further teacher training to improve the atmosphere and teacher-student interaction. An increase in the number of female lecturers could also help to improve the atmosphere, and these professionals could also act as role models. The universities of applied sciences appeared to welcome these recommendations, and most developed policy specifically aimed at prospective female students in subsequent years. Following on from *Anders voorlichten* VHTO produced *Anders begeleiden* (Alternative guidance), based on the minority position of female students.

### Early 1990s: new forms of teaching

In higher professional engineering and technology education, a stronger focus on gender differences developed in the design and content of the learning process. New forms of teaching were also introduced, such as problem-oriented education and project-based learning. Experience abroad showed that these forms of teaching boost the appeal of technical education and have a positive effect on the intake and progression of young people who have not been fascinated by engineering and technology from a young age. VHTO research in a number of European countries also showed that, under specific conditions, these forms of teaching belong to the success factors that boost the appeal of technical education for both boys and girls in these countries. VHTO worked with a number of universities of applied sciences to develop methods and instruments (*Action, Loupe*) to ensure that these educational innovations would also increase the appeal of technical study programmes for potential female students in the Netherlands. VHTO also conducted research into differences in learning styles, into both male and female student drop-out rates and into the extent to which technical study programmes in higher education were aligned with related technical professions and jobs.

### Mid 1990s: role models and the nature of technology

In this period, five universities of applied sciences, Delft University of Technology and VHTO started to use female technical professionals as role models who young girls could identify with. This role model strategy proved to be a strong tool from the very outset, but it was not until 2005 that funds were found to introduce this strategy on a large scale throughout the Netherlands. VHTO and Delft University of Technology's international Mellow project (1995-1998) produced methodologies for providing girls in secondary education with information about technical study programmes and jobs via these role models, for supporting female technology students in entering the labour market and for supporting young female professionals in their career development.

A significant boost to views on the relationship between 'women and technology' was provided by the Equal Opportunities Board, which published a report entitled *Het mysterie van Thea* (The mystery of Thea) in 1994. In this report the Board identifies a number of fundamental obstacles that make it impossible to substantially improve the position of women in engineering and technology. For instance, according to the Board the very nature of technology, as reflected in the perception of this field of study, prevents girls from choosing engineering and technology. The Board called for a review of engineering and technology. A broad and emancipatory technology would hold greater appeal for more women, but also for more men.

### **Late 1990s, early 2000s: a broad strategy and chain approach**

Shortly after this, the education sector, the business community and the government jointly sounded the alarm. It became increasingly clear that traditional engineering and technology education had reached its limits. Not only were just a small number of girls opting for these fields, but male participation was also below the desired level and even declining. Only one in four young people were opting for a technical study programme. This percentage was higher in almost all other western countries. In 1998 the government launched 'Stichting Axis' (the Axis Foundation). A broad strategy was adopted, focusing on broadening and repositioning technical study programmes. Axis targeted the education world as a whole, from primary education to higher education, as well as the business sector, and emphasised the importance of a chain approach. The motto was: attractive choices, attractive study programmes, attractive jobs for boys and men and girls and women. VHTO was asked to fulfil an advisory role in this process. During this period VHTO was also tasked with introducing gender perspective in the redesign of technical study programmes and in the development of various technical interface study programmes. In the same period, VHTO worked together with the universities of applied sciences offering technical study programmes to identify the current preconditions for attracting, retaining and ensuring the successful graduation of female students (Project Technóva). VHTO developed the 'gender scan' tool for the purpose of this assessment. This tool was developed further over the years and has also been used in recent years. The set of preconditions that have emerged from the gender scans over the years all still apply (see page 68).

### **From 2004: gender perspective in all PBT policy lines**

As stated at the beginning of this chapter, the Lisbon agreements have led to government policy in respect of STEM (Delta Plan for STEM) and the introduction of the National Platform Science & Technology (2004-present) to implement this policy. 'Gender Balance' is an explicit aim of this STEM policy. Gender perspective has therefore been incorporated into all National Platform Science & Technology programme lines. Additional funding from the Ministry of Education, Culture and Science, Department of Equal Opportunities has subsequently made it possible to carry out targeted activities throughout the education chain (primary education, secondary education, senior secondary vocational education and higher education), as well as creating greater scope for the development and exchange of more knowledge.

# 5

## What have **universities** done over the last few years with regard to **girls** and **STEM**?

**Over the past few years, universities have invested large sums in improving the information provided about their STEM study programmes, particularly to girls. However, gender-inclusive educational innovation requires more than this.**

In their performance agreements with the National Platform Science & Technology (Sprint Programme), universities set themselves targets for the intake of female students onto their STEM study programmes. VHTO offered them support in achieving these targets.

As early as spring 2008, the *universities* of applied sciences collaborated with VHTO to perform a 'gender scan' to identify current and past developments at the institution (and within the different study programmes) in relation to girls and STEM, and opportunities (or desires) to optimise policy and activities. Based on the results of these gender scans VHTO produced an action plan for each university of applied sciences to ensure that more girls enrol and progress in, and graduate<sup>5</sup> from, the study programmes in question.

The research universities were also able to use this gender scan approach in the period 2008-2011. The universities then organised an in-house working conference with representatives of the various bodies within the institutions (and with partners in their own education chain) based on the action plans and in collaboration with VHTO. During these one-day working conferences gender aspects were discussed, information was provided, training courses were held in specific fields, result-oriented agreements were reached and the managers responsible for policy committed themselves to gender mainstreaming. 'Gender core teams' were subsequently formed at a number of universities and implementation plans were drawn up.

5 The booklet *Genderkennis.doc: inzetten op een brede doelgroep, meisjes en jongens, voor bèta/technische hbo-opleidingen* (Gender awareness.doc: focusing on a broader target group, girls and boys, for higher professional education STEM study programmes), VHTO, November 2008, provides a summary of the points for attention featured in all these action plans.

### Increased provision of information

Recent years have seen a huge rise in the number and professional standard of information activities offered by universities. Nevertheless, secondary education schools have, even recently, not always been satisfied with the 'reach out' efforts by universities. They would like to see greater collaboration in terms of subject matter content, particularly throughout upper secondary education. They are also calling for more realistic information about STEM study programmes, which also covers the breadth of the fields of study and professional options. Moreover, they rightly claim that the universities are not doing enough to boost enthusiasm in their study programmes, particularly amongst the growing supply of prospective female students.

In addition to intensive activities such as junior lectures and pre-university lectures (which have been set up for both boys and girls, but which have succeeded in attracting large numbers of girls) there is a wide range of different information activities, from guest classes to open days to taster sessions. This benefits pupils in secondary education; girls in particular, because many of them prefer to gather and compare lots of information, and to sample the atmosphere themselves.

Now that there are clear signs that there has been huge growth in the prospective supply of female students for higher education STEM study programmes, but that these girls do not automatically enrol on these programmes, support in higher education for targeted information activities aimed specifically at girls with a science subject cluster has increased. More and more universities are organising specific information activities for girls (and occasionally their mothers), often in collaboration with secondary education: Ladies nights, High Tech High Teas, girls' science camps, girls' days and promo teams. Most of these initiatives are devised by the information departments at the institutions, however the female students themselves are increasingly taking the initiative to interest more girls in their STEM study programmes. As well as first-hand realistic information about the study programmes, the ability to identify with the female students (role models) in particular makes these subjects more accessible.

These information activities appear to be effective, as the intake of female students in higher STEM education is rising (although this intake is still not

keeping pace with the increase in the prospective supply). The growth in the intake of girls in higher STEM education is greatest for study programmes that combine STEM with the fields of medicine, life sciences and design. The challenge is for the universities to continue these still fairly new information activities in the coming years if they want to take full advantage of the large number of prospective female students.

### **Gender-inclusive approach**

A gender-inclusive approach to educational innovation requires more from universities than simply providing more and a better quality of information. Actual gender mainstreaming of policy and other activities is also essential.

For instance, one of the things discussed during gender scan sessions was that STEM lecturers and project and seminar supervisors often have little to no knowledge of relevant gender differences. This should be a mandatory component of the teacher training received by these education providers. An example of another point for discussion is that female students in particular must be given the opportunity to form a positive image of the profession, to learn about interesting developments within their field of study and to develop career ambitions, amongst other things through contact with alumni and other female professionals, as early as in the bachelor's phase. This increases the likelihood that they will remain in the STEM sector long term after their studies and that they will no longer settle for a lower salary for the same work as their male colleagues. Another point for discussion, in addition to the structure and appeal of the curriculum, was the deterrent effect of communicating 'informal' additional admission requirements, such as an average grade of 7 (out of 10) for science in the school-leaving examination in the case of technical study programmes: for girls with an average grade of 7 or even 8 this highlights the 'extreme difficulty' of technical study programmes and reinforces their lack of confidence regarding their own performance.

### **State of affairs within universities**

During the gender scans and the subsequent working conferences and afternoon seminars, many topics were reviewed that contain elements that can help to promote the intake, progression and successful graduation of female students, or conversely where adjustments were found to be needed. The gender scans, working conferences and afternoon seminars were often eye-openers and led to new ideas about how to improve the intake, progression and outflow of female students. The following description of the state of affairs provides a summary of these topics, based on the themes in the National Platform Science & Technology's Sprint Compass:

- 1 Institution policy
- 2 Guidance on choosing a subject cluster and study programme
- 3 Education and educational innovation
- 4 Professional and practical orientation
- 5 Networks

VHTO has elaborated these themes according to gender aspects. The basic principle here is that a greater focus must be placed on gender in the long term, in other words on male and female (prospective) students instead of simply students, for as long as female students are severely underrepresented.

### Re 1 Institution policy

#### *Gender mainstreaming*

In recent years many universities have become more aware of the fact that they need to view their policy and activities from a gender perspective (gender mainstreaming) in order to make use of the available female potential. They have also become more aware that they cannot achieve any long-term changes through a small number of individual activities, but instead need to introduce longitudinal (long-range) policy in this area.

In the case of many higher education STEM study programmes in the Netherlands, gender has not yet been fully embedded as a quality feature in policy and activities. In order to achieve a gender balance (equal participation and success rates amongst both male and female students) within these specific study programmes it is essential to gender mainstream all policy intentions and the resulting activities, in other words to determine whether they will be just as effective for female as for male students. Some study programmes have made good progress in this direction in recent years, and this is certainly true of new or updated study programmes. However, there has also been a striking lack of attention to (and ex ante evaluation of) gender effects in recent new plans, such as the plans of the three universities of technology.

#### *Quantitative awareness and targets*

If during the gender scans in 2008 universities of applied sciences still doubted the existence of untapped female potential in the case of STEM study<sup>6</sup> programmes, all universities are now aware of the number of girls with science subject clusters sitting examinations at HAVO and VWO schools<sup>7</sup> and there is a much wider sense

6 See the booklet *Genderkennis.doc: inzetten op een brede doelgroep, meisjes en jongens, voor bètal technische hbo-opleidingen*, VHTO, November 2008.

7 See the statistics in chapter 2.

of urgency and a desire to boost interest in STEM study programmes among these potential students.

Many participants of the gender scans also acknowledged themselves that quantitative awareness as regards intake and the number of female students leaves something to be desired. Failure to break down these data by gender and to analyse differences could result in the loss of a great deal of valuable information. Information that could lead to policy adjustments and/or targeted activities that could increase student intake, success rates, and also the number of graduates moving on to programmes such as research master's. Periodically discussing this data during management consultations means that trends can be identified. This in turn makes it possible to identify (at least to some degree) which activities actually lead to a larger intake, and whether girls value these activities in the same way as boys. A male/female breakdown of the data also provides a great deal of insight into the effectiveness of the activities during the monitoring and evaluation of projects.

Many institutions have not expressed their desire to appeal to more girls in the form of a target. The arguments speak for themselves: with so few girls, even a very small absolute increase in the number of girls is a huge relative increase. Nevertheless, it also makes sense in such cases to formulate reasonable, but still ambitious targets. Targets can provide a common goal and trigger the raising of awareness.

### *Staff policy*

Many universities are attempting to recruit more female staff, particularly female subject teachers, for their STEM study programmes. Explicit efforts are being made to attract talented female staff and there is a stronger female presence within nomination committees. A number of research universities have also set up fellowship programmes<sup>8</sup> and are seeking to retain young female scientists at the university by means of tenure tracks.

Female university of applied sciences and research university lecturers themselves<sup>9</sup> acknowledge that not all lecturers are also suitable role models for young female students: many of these women have had to fight hard for their positions and are keen to distance themselves from the suggestion of 'positive discrimination'. At the majority of universities, the percentage of women becomes smaller the higher the position (academic/top management). Many universities have now

8 Such as the Rosalind Franklin Fellowships at the University of Groningen and the MacGillavry Fellowships at the University of Amsterdam.

9 As emerged from interviews and panel sessions held with female lecturers by Actis Advies in the context of this project.

**Lauke Ringens**, Molecular Life Sciences student, Radboud University Nijmegen



signed the 'Talent to the Top' charter, which sets a target of 20% women in top jobs by 2020. Subscribing to the charter will certainly help to raise gender awareness within selection procedures and acceptance policy.

### *Gender core teams*

To truly embed the theme of girls and STEM within an organisation it is important that there is someone who feels responsible for this theme, and who is also given the time and funds to do so. A working group, a gender core team including a number of people from various study programmes and services, would be a better option still. A number of universities have introduced gender core teams, who are responsible for implementing the action plans produced following the gender scans. The advantage of a gender core team is that gender mainstreaming (essential as long as female participation in STEM lags behind that of men) and specific gender policy (essential when there is a severe gender imbalance in STEM) thus becomes a shared responsibility and therefore gains more support within the organisation. It cannot be emphasised enough that attracting and retaining more girls and women in engineering and technology requires an integrated, long-term approach, instead of individual ad hoc activities.

### **Re 2 Guidance on choosing a subject cluster and study programme**

As stated at the beginning of this chapter, universities have started to pay more attention to 'reaching out' to potential students in recent years. Female students are actively involved in this process at many universities, increasingly on the initiative of the students themselves (role model, targeted source of information, accessible). These information activities appear to be effective, as the intake of female students into higher STEM education is increasing. The growth in the intake of girls in STEM education is greatest for study programmes that combine STEM with the fields of higher medicine, life sciences and design. The challenge is for the universities to continue these still fairly new information activities in the coming years if they want to take full advantage of the large number of prospective female students. It has also been shown that, if greater account is taken of girls as a target group, this also has a spin-off effect on boys, namely those boys who would not automatically opt for STEM.

VHTO's collaboration with schools of the Universe Programme (see page 24) has revealed that far from all parents support their daughter's choice of a science subject cluster. In many cases parents also do not have a realistic view of STEM study programmes and know little about what STEM has to offer. Some universities recognise this and also organise separate workshops or question times

for parents during open days, attend secondary education parents' evenings, and/or organise parents' evenings for the parents of prospective students.

Like parents, secondary education teachers and careers advisers sometimes also do not have a clear picture of the many academic and professional opportunities in STEM. To ensure that a more positive and up-to-date image is conveyed to these individuals, universities could organise information sessions for them that are also attended by male and female lecturers, male and female students and alumni (male and female professionals and small business owners/male and female science professionals who have started up their own businesses in the context of independent entrepreneurship).

Efforts to generate interest amongst girls for STEM need to start at an early stage, because otherwise these girls exclude the world of STEM prematurely (foreclosure) when making their academic career decisions. Collaboration between all relevant players throughout the entire education chain from primary education, secondary education and higher education to the labour market is vital to early intervention and structured information policy. In the context of the chain approach<sup>10</sup>, the following steps need to be taken in order to awaken and retain girls' interest in STEM:

- Step 1: awaken the interest of young girls, preferably in the last four years of primary education, in STEM fields of work (particularly those fields of work that correspond with the STEM study programmes offered by universities<sup>11</sup>).
- Step 2: retain the interest of girls, through company visits (annual Girls' Day<sup>12</sup> and interviews in junior secondary education<sup>13</sup>).
- Step 3: support girls in choosing a subject cluster, for example through speed dating with female professionals, and by providing parents with information on the possibilities offered by STEM.
- Step 4: support girls in choosing a study programme, for instance through speed dates with female students and professionals, and work shadowing or mentoring by female professionals.

10 The chain approach encompasses much more than generating and retaining interest amongst girls, namely also activities aimed at female students, education providers, education managers, parents and companies/institutions.

11 See the VHTO and Science Center NEMO primary education projects: *SpotJeTalent* and *Talentedkijker* ([www.talentedkijker.nl](http://www.talentedkijker.nl)).

12 VHTO organises an annual national Girls' Day on which companies open their doors to young girls (aged 10-15), see [www.girlsday.nl](http://www.girlsday.nl).

13 See also *TubeYour Future*, an initiative by Science Center NEMO ([www.tubeyourfuture.nl](http://www.tubeyourfuture.nl)).

### Role models

Female role models play an important role in boosting the involvement of girls and women in STEM. They show that there is a broad range of STEM study programmes, professions and jobs, and that they are both good at and enjoy their work. They also make it clear that a science subject cluster is a good choice, because it allows you to keep the most options open for an advanced programme. What is more, they can help to instil in girls greater self-confidence and interest in STEM-related subjects (see also [chapter 1](#)). Role models (students and professionals) in this sense play an essential role in providing guidance on choosing a subject cluster and study programme. Female role models can be an eye-opener for both girls and boys, while conversely, male role models are more likely to reinforce the idea that STEM is a man's world. As long as there are far more male than female role models present and 'visible', it is advisable to primarily use female role models in the context of education.

Female students at many universities play an active role in providing information, often on their own initiative. Female HAVO and VWO pupils are interested to hear what a day in the life of a female student is like, which subjects they follow, how difficult these subjects are, what they like to do in addition to their studies and with whom, and so on. For a number of years now VHTO has been organising speed dates for pupils who have not yet chosen a subject cluster in secondary education (HAVO, VWO), at which girls take turns to talk in small groups with female professionals and/or students with a STEM programme and/or job in the business sector or in academia. This activity generally provokes a very enthusiastic response from participating schools and pupils. At schools where speed dates are organised, the female intake for science subject clusters is considerably higher than at other schools (see [chapter 2](#)).

### Re 3 Education and educational innovation

Quality of education is a top priority for most universities. They are prepared to reorganise their courses and programmes where reviews show this to be necessary. Educational restructuring or innovation is often an excellent opportunity for gender mainstreaming, in other words to take into account both female and male students. For instance, during subject reviews it is important to break down the results according to male and female students to get a better idea of the perception, experience and perspective of female students. After all, when thinking in terms of 'students' it is easy to overlook the fact that:

- the student population for STEM study programmes is often largely male; students are then easily viewed as *male* instead of male/female;
- female students are less likely to have prior knowledge and experience of STEM than male students before starting the study programme.

The intention to reach out to and generate interest in STEM study programmes among more girls by means of restructuring is regularly expressed. For instance, a research university has recently restructured its physics curriculum. There is now greater integration between the subjects and the interrelationships are clear. In addition, there is a greater focus on social context and relevance. The study programme will also be promoted in this way within secondary education. The success of the restructuring can ultimately be assessed by means of carefully monitoring the impact of the change and its effects on intake, progression and outflow, broken down according to male and female students.

Relatively new degree programmes such as Earth and Economics in the case of Geography, and Medical Technology, in which factors such as coherence, contextual relevance and multidisciplinary have been taken into account, have seen a rise in intake of both girls and boys.

In many cases new study programmes, the updating of subject matter content and changes in the curriculum also help to motivate staff, which is certain to considerably boost enthusiasm amongst the prospective students who are provided with information.

When redesigning study programmes it is also vital to steer the expectations of potential students in the right direction. Once again, it is important that they have a realistic picture of the study programme. A good programme title also helps, for instance because it shows whether the study programme covers a wide range of engineering and technology or primarily focuses on developing capacity for innovation. Although a good title on its own, while the programme is actually still simply a traditional technical study programme, does not help. The title may temporarily generate a new intake, but the students will soon realise that this is not what they were looking for and drop out or switch to another study programme or sector.

University lecturers are becoming more aware of the different learning strategies used by boys and girls and the importance of linking examples and case studies to various fields of interest. This awareness helps lecturers to boost interest and motivation amongst girls within the study programme, to encourage them to progress to master's level and to ultimately enable them to gain a STEM qualification.

Universities still have a strong need for a checklist of 'dos & don'ts' when it comes to female students. Many lecturers have taken on board the following points identified by VHTO during working conferences and afternoon seminars:

- A focus on the usefulness, social relevance and practical value of STEM.
- Contextual relevance of STEM issues and problems.

- The option of teamwork.
- Multidisciplinary of fields of study and working together as part of a multidisciplinary team.
- Broad rather than narrow STEM-oriented topics.
- A clear picture of how scientific and technical knowledge is used in daily professional and research practice.
- The importance of establishing a link with professional and research practice through 'real' design and development assignments.
- Dual focus: attention to the product and the process.

Female students at Delft University of Technology have recommended that the subject matter content should focus more on:

- Social aspects of engineering and technology.
- The ethical side of design.
- Examples of medical, biomedical and biomechanical applications.
- A teaching method that is gender-inclusive, in other words: appealing and feasible for both female and male students.

#### Re 4 Professional and practical orientation

The scans, as well as the second Gender Radar study (see [chapter 6](#)), revealed that only few universities, particularly research universities, prepare their students for professional practice. Very little information is provided on the career prospects offered by the study programmes. Even in the information materials, career prospects are often described in general terms (policy officer or academic). The provision of this type of information plays an important role in recruiting and retaining female students, but also in encouraging a successful outflow of graduates onto the labour market (business sector or academic career), certainly in the case of girls. Girls like to have a concrete picture of the future and do not have a clear impression of the opportunities in the STEM sector. Greater attention is paid to this in higher professional education, although in many cases the primary focus is on traditional technical (male) professions and/or via work placements.

STEM study programmes at research universities essentially prepare their students for a career in academia, however only a small percentage of graduates actually follow this route; this is even more true of women than of men. Consequently, it is also important for students at research universities to familiarise themselves with the professional practice outside academic research.

Female students who took part in the gender scan sessions stated that they would like to have more contact with (female) professionals in order to gain a better

idea of the full breadth of the field of study and of the career prospects. Some emphatically stated that this type of contact would boost their study motivation. However, the scans did not reveal any examples of universities that explicitly stated a desire to improve and expand the image that (female) students have of the professional field in their policy. Nevertheless there are examples of methods of familiarising students, also in the bachelor's phase, with the professional practice:

- Group assignments using up-to-date, realistic case studies from professional practice that are developed in close collaboration with the companies and professionals (men and women) who work in the relevant field.
- Guest lectures or workshops held by professionals from the business sector.
- Field trips to companies and institutions where alumni of STEM study programmes work.

Female students, by their own account, profit from the deployment of female professionals as guest lecturers and during workshops. Female professionals then act as role models and help female students to feel confident in their choice. Female STEM professionals demonstrate that they enjoy their work and are good at it. The same applies to female academic staff. Contact with role models encourages female students to actually move on to STEM professions and jobs on graduating, instead of switching to a different field of work.

### Re 5 Networks

Teachers have now become key partners in the networks of more and more universities. Science teachers, mentors and careers advisers play an important role in the decision-making process by secondary education pupils, when choosing both a subject cluster and a study programme. Universities are collaborating with secondary education teachers more and more, in particular due to the need to coordinate subject matter content. The various institutions have invested heavily in recent years in collaborating to provide information about fields of study and advanced programmes, in designing science modules, in the provision of guest lectures, in the supervision of pupils' subject cluster projects and in the provision of continuing professional development of STEM subject teachers. Gender differences in STEM were a fairly regular topic of discussion within these networks. Secondary education teachers also attended the VHTO working conferences at the invitation of universities. Information activities specifically aimed at girls (such as Girls' Days and girls' camps) have been set up together with secondary education careers advisers and teachers. However, the loss of the extra funding from the Sprint Programme has led to concerns that these activities specifically aimed at girls may not continue.

The degree of collaboration with companies (in the region) varies per study programme and per university. Where institutions do collaborate closely with companies, particularly innovative companies within the region, this has a huge impact on student motivation. Female students state that this improves their career prospects and that the resulting contextually relevant subject assignments give them a greater insight into the usefulness and the social relevance of their study programme.

Alumni also play an important role, not just as suitable role models and as a link to the business sector but also as a sounding board when determining the structure of the study programme. They can establish links between the content of the study programme and the professional practice, for instance by describing the skills that are essential for the job that they perform. Amongst other things, a systematic alumni policy can provide universities with the following information:

- how the jobs and careers of alumni develop
- whether this warrants changes to the study programmes on offer, and if so, which
- whether there is a demand among alumni for post-master's degree programmes and/or flexible learning pathways, and if so, which
- whether there are differences between male and female alumni in terms of job details and career development, and if so, which
- whether this can be 'translated' into the curriculum to ensure that it holds more appeal for a broader group of young people (result: larger intake).

## What do **graduates** consider to be important in a **STEM** study programme?

In 2003 VHTO carried out the Gender Radar project which, amongst other things, included a career survey test among recent male and female STEM graduates. In 2010 VHTO conducted a new survey on the careers of university STEM alumni in order to analyse gender differences in their decision-making processes and to find out more about how satisfied alumni are with their study programme and career.

The aim of the Gender Radar 2003 was to boost the appeal of technical study programmes for a wider target group, including girls, in collaboration with a number of technical higher professional education study programmes in the Netherlands. To do this, the curriculum needed to be brought closer in line with developments in the technical sector. During this process male and female alumni from various study programmes acted as an important source of information on developments within the labour market (see VHTO 2003, the Gender Radar Method). To ensure that feedback from alumni is submitted, it is essential that the study programmes are able to establish strong ties with their graduates. A successful alumni policy is needed in order to achieve this. The Gender Radar 2003 revealed a number of interesting differences<sup>14</sup> between men and women in relation to technical higher professional education study programmes. For instance it emerged that:

- many women prefer to postpone their final choice of study and therefore prefer to opt for a technical study programme with a broad scope.
- women enjoy working on projects that involve realistic, up-to-date case studies.
- more women than men feel that they should have been taught more technical skills during the study programme.

14 More results can be found in the reports from the various study programmes that took part in the Gender Radar 2003.

### Gender Radar 2010

Following on from the Gender Radar in 2003, the decision was taken in 2010 to conduct a second survey among alumni of STEM study programmes. Like the Gender Radar 2003, Gender Radar 2010 was a survey on the careers of recent STEM graduates. The aim of the survey was to identify differences in decision-making processes and study programme and career satisfaction of men and women who followed a monodisciplinary or multidisciplinary<sup>15</sup> STEM study programme at a university of applied sciences or research university. The information from this survey would help university STEM study programmes to boost the appeal of such programmes for a broader target group, including women. In addition to gender differences, the Gender Radar 2010 also looked at differences between:

- graduates from universities
- graduates of monodisciplinary/traditional STEM study programmes (such as electrical engineering and physics), multidisciplinary/interface-based STEM study programmes (such as human technology, medical technology) and the teacher-training institutes (first-level and second-level).

The percentage of girls who enrol on and graduate from multidisciplinary STEM study programmes is usually much higher than for monodisciplinary study programmes. In the Gender Radar 2010 we tried to determine whether expectations and satisfaction with these study programmes are in line with what these programmes actually offer, and whether alumni of these study programmes are ultimately also more likely to end up in interface/multidisciplinary professions. We also wanted to know whether these groups differ in terms of their career as a STEM professional or in terms of the start of their career as a STEM professional. To find out we looked at things like differences in job, the size of the company and the sector in which alumni end up, salary, percentage of alumni in full-time and part-time employment and so on.

For the Gender Radar 2010, a questionnaire was completed by 92 men (41) and women (51) who graduated between 3 and 10 years ago from a monodisciplinary or multidisciplinary (45/47) STEM study programme at a university of applied sciences or research university (35/57).

<sup>15</sup> In this context, 'monodisciplinary study programmes' refers to the more traditional STEM study programmes such as physics, mathematics, information science, civil engineering, mechanical engineering, electrical engineering and motor vehicle mechanics. 'Multidisciplinary study programmes' refers to usually more recent study programmes that combine more than one discipline, partly within STEM, partly in combination with STEM, such as industrial design, human technology, medical technology and industrial engineering and management science.

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### Choice of study

The responses showed that men are more likely than women to follow advice received from a teacher or careers adviser when choosing a study programme and are more likely to be influenced by career prospects. This also applies to continued studies at a higher level. Women were more likely to be influenced by their experience of the information provided by the study programme (open days, taster sessions, guest lectures) and the variety offered by the study programme's subject combination. It is possible to conclude from this that women are more sensitive to the atmosphere of the study programme and how the programme is implemented, and that they place a greater focus on the range, breadth and variation of the subjects they will be taught.

One thing that stood out was that both male and female graduates of monodisciplinary study programmes were more likely to name broad career prospects as an important feature of the study programme than graduates of multidisciplinary study programmes. This could be because multidisciplinary study programmes are already pre-sorted according to a specific employment sector: for instance the medical world (medical technology), or industrial engineering and management science (management).

### Study programme satisfaction

Women and men with both a monodisciplinary and a multidisciplinary background (higher professional education/academic higher education) were generally satisfied with their study programme, however there are a number of essential differences worth mentioning. While men with a multidisciplinary background were most likely to feel that the curriculum could have been more strongly oriented towards STEM and that there could have been a greater focus on the basic subject matter content, female academic higher education graduates were found to have a greater need for non-subject matter-related professional skills (presentation and meeting skills, and so on) and would like to have seen a greater focus on the future professional practice. Academic higher education study programmes are essentially geared towards academic positions (researcher, teacher), while many graduates end up in a professional setting outside the university. Female academic higher education alumni would like to have received more information during their studies particularly regarding jobs outside the university world. Women who followed an academic higher education STEM study programme also felt that they could have received better guidance during their work placement.

We can conclude from all of the above that preparation for professional practice is more important to female STEM graduates than to their male counterparts. Women are less likely to automatically move on to a job in STEM than men, and

consequently may have a greater need to gain a better idea of the work and the professional settings after graduating during the study programme itself. Women may also have a greater need for information about the professional practice because as well as preparing for professions and jobs they also need to prepare for working in a 'man's world'.

Most participants felt very positive about project-based teaching, because this genuinely teaches students a lot about the professional practice.

### **The transition from studies to work**

With regard to the transition from study programme to work, monodisciplinary graduates were more likely to state that they felt ill-equipped in terms of non-subject matter-related skills, particularly presentation skills and working in multidisciplinary teams, but also communication, marketing, cost calculation and so on. All groups specified laws and regulations and entrepreneurship as neglected topics. In general, higher professional education graduates felt better equipped in terms of non-subject matter-related skills than academic higher education graduates.

### **Finding a first job**

Although all graduates managed to find a job relatively easily, women took longer to do so than men and ultimately earned less. Women were more likely to work part time than men, even those without children. Most respondents found their job via a media advertisement. Men were more likely to be headhunted for a job via their personal network or work placement organisation than women. Multidisciplinary graduates generally need to make more effort to explain their skills and added value during a job application. This is even more true for women than for men. In the group surveyed, the number of women who ran their own business was considerably higher than the number of men who ran their own business.

### **Professional field and job**

It is not surprising that monodisciplinary graduates were more likely to work in the more traditional technical sector (infrastructure, metals, mobility, chemistry and the processing industry) and multidisciplinary graduates were more likely to work in corporate services (consultancy and advice & management) and in R&D positions. In this survey, the metal industry was reserved for men. The majority of respondents worked within a large organisation (more than 1,000 employees) and were more likely to work for an organisation with more male than female employees. Core tasks differed somewhat between men and women: women were more likely to name advice and consultancy as their core tasks, as well

as production and manufacturing. It is striking that more women named the latter as a core task than men, certainly as these are highly qualified women. This could be to do with a combination of the discipline and the professional setting: for instance, an industrial designer (often a woman) with his or, in many cases, her own company is also required to produce his or her own scale models of designs. It is also suspected that some respondents found it difficult to distinguish between the response categories 'production and manufacturing' and 'development'.

Both male and female monodisciplinary graduates were more likely to be employed in a STEM position than multidisciplinary graduates. Although both genders were satisfied with the content of their work, slightly more women were dissatisfied with their job level. Naturally there is a link here between lower wages, a higher rate of part-time employment and job level.

### Career development

More men than women were satisfied with their career development. Both genders pointed out differences between the careers and career development of men and women. No or much fewer women progressed to senior management roles. The exact reasons behind these differences were unclear. Most respondents stated that all employees have the same opportunities, however women often remained in supporting roles for longer (for instance as project team member instead of project manager). Common explanations given were pregnancy, the fact that women appear to have less ambition to move up in the company hierarchy and the desire to work part time. Evidence of this can also be found in the requirements imposed on any future position. Men considered job level to be more important here, while women were keen to achieve a better work-life balance. This could perhaps also explain why women are relatively more likely to run their own business, as business owners have greater control over their work-life balance.

### Feedback to the study programmes

Alumni experiences play an important role in the continued, gender-inclusive innovation of higher STEM education. We can infer from statements by female alumni that 'seeing and experiencing in person' is an important criterion for girls in secondary education when choosing a study programme. As opting for STEM is still not an automatic process for girls, their information needs differ to those of boys, for whom this is indeed a natural choice.

Another important point is effective preparation for professional practice during the study programme. Female alumni feel that this could be improved. The alumni state that project-based learning makes up for this to some extent:

after all, projects and case studies ideally deal with 'real', up-to-date issues from the professional practice. Female alumni also feel that they would be better equipped for the professional practice if a greater focus was placed during the study programme on personal, non-subject matter-related skills (such as presenting, multidisciplinary teamwork and communication). Incidentally, one female graduate stated that she believed a greater focus on these skills would have been more useful for her male colleagues than for herself. Conversely, some male alumni would have preferred a greater focus on subject matter content, particularly those who followed a multidisciplinary study programme. It is therefore important that STEM study programmes offer students the opportunity through elective courses both to undergo further training in personal professional skills and to study the subject matter content in greater depth.

## Does a greater focus on women and STEM provide any economic benefits?

**What would happen if more girls opted for a STEM study programme and if more women with a STEM qualification entered the related employment sectors? Do the benefits outweigh the costs? And if so, for whom?**

As it has become clear from the previous chapters, women are underrepresented on STEM study programmes in the Netherlands compared to both Dutch men and to the European average.

In an ideal world, all female HAVO and VWO pupils with a science subject cluster would opt for a STEM study programme in higher education. Looking at the statistics in chapter 2, if we group the science clusters together, this would concern 29% of girls currently at 4HAVO level and 50% of girls at 4VWO level. Perhaps a goal of ensuring that all girls with a science subject cluster move on to an advanced STEM study programme is somewhat too ambitious, however a percentage that is around the same as that for boys must be feasible.

In the labour market, the percentage of female STEM graduates who ultimately end up in a STEM-related profession or job is considerably lower than the potential supply: only 15% of female STEM graduates opt for a profession or job in the Engineering and Technology Sector or in Industry (WO Monitor 2007). In addition to the fact that more girls could progress from science subject clusters to higher STEM education, more female STEM graduates could therefore also opt for a STEM profession or job in a STEM sector within Engineering / Technology / Industry. As mentioned in chapter 2, far from all female STEM graduates end up in directly related employment sectors. Consequently, it would be interesting to look in greater depth at whether these women are indeed employed in STEM roles within different sectors.

### Scenario analysis

The question is: *why* should more women opt for STEM? How would a larger percentage of women in higher STEM education and/or in STEM positions in Engineering / Technology / Industry benefit Dutch society? There is no simple answer to this question. Professor Joop Schippers, equal opportunities economist

at Utrecht University, has tried to find an easy way of illuminating the costs and benefits if girls and women were to change their current decision-making behaviour in relation to STEM. Schippers starts from a simple scenario analysis of the path that women could follow from HAVO or VWO to higher professional education or academic higher education and ultimately to the labour market. The model that forms the basis for the scenario analysis features two defining moments: the transition from HAVO/VWO to higher education and the transition from higher education to an employment sector.

The following examples provide a cost-benefit calculation for the professional sectors Engineering, Technology and Industry. These professional sectors do not give the most positive picture when it comes to analysing where female STEM graduates ultimately end up, as we find that many of these female students 'opt' for a job outside of these sectors. The most popular sectors among this group are Economics and the Services Industry (academic higher education) and Healthcare and Welfare (higher professional education). Including all sectors in which female graduates end up (in STEM or another type of position) in the analysis is not useful for the purpose of this study. Moreover, it would be almost impossible to find out in which positions women and men ultimately end up within other sectors. It is more obvious to concentrate on the Engineering, Technology and Industry sectors.

In his analysis, Schippers makes variations on the percentage of girls with a science subject cluster who choose a higher education STEM study programme and the percentage of female graduates who then move on to the Engineering, Technology and Industry sectors. The first variation concerns an equal percentage of boys and girls. The second variation, which is perhaps more realistic in the near future, uses a percentage of girls that amounts to the average of the current percentage of boys and girls. These variations are applied in the different scenarios on the transition from secondary education (HAVO/VWO) to higher education and from higher education to an employment sector.

### **Greatest benefits for STEM companies, branches of industry and sectors**

The scenario analysis reveals that, based on the limited data available for this study, the companies, branches of industry and sectors in which female STEM graduates would find employment would profit most from a change in the

decision-making behaviour of girls and women. The annual profit generated would be at least 6 million euro.

It is less easy to express the benefits for universities in monetary terms. In the first instance, it appears that they would profit most if more girls at 5HAVO level were to opt for a STEM study programme at a university of applied sciences. This is because girls who have opted for STEM in higher professional education appear (even now) to be just as likely to choose a profession in the Engineering, Technology or Industry sectors as men. The situation in academic higher education is somewhat more complex. Here it would be considerably more beneficial if a change in decision-making behaviour on the transition to academic higher education were accompanied by a change in decision-making behaviour in transition to the labour market. Female STEM graduates from research universities are less likely than female graduates from universities of applied sciences and less likely than men to opt for a profession in the Industry, Engineering and Technology sectors.

### Implications

Put briefly, this would mean that society would benefit most if female HAVO and VWO pupils were encouraged to choose an advanced STEM programme in higher professional education. After all, female and male higher professional education graduates are most likely to opt for the standard transition to employment sectors that are directly related to their study programme. With regard to VWO, influencing both decision-making behaviour on the transition from VWO to a STEM study programme in academic higher education and on choosing a profession or job in the Industry, Engineering and Technology sectors would provide the most benefit.

Furthermore, it would be interesting to examine the extent to which women and men in sectors other than Engineering, Technology and Industry are employed in STEM-related positions and why they chose this option. This could provide a more realistic picture of the potential costs and benefits for society of a rise in the number of girls and women in STEM. After all, some STEM graduates take on a STEM position in areas other than the Engineering, Technology and Industry sectors, such as hospitals and central government (including provincial authorities and municipal authorities). Statistics on these groups are difficult to come by, however it has been clear for some time now that female STEM graduates look for jobs and professional fields which offer them appealing job content, working culture and employment conditions.

## Does the gender balance in STEM need to be improved further? How to proceed?

The answer is yes: as long as girls and women remain severely underrepresented in STEM, this situation requires further attention.

Read on for the key arguments in favour of this approach, as well as the short-term and medium-term points for attention arising from this trend analysis.

The main arguments in favour of a continued focus on women and girls in STEM are as follows:

- It has become clear in recent years that girls and women are no less *capable* in STEM than boys and men. It is rather implicit gender-stereotypical associations from their environment (parents, teachers) that encourage boys to join the STEM highway and that discourage girls (particularly in the Netherlands) from taking this route. The problem is therefore not a lack of ability.
- In recent years more girls in secondary education have started to make *academic career choices* in favour of STEM, particularly in VWO and HAVO. However, girls are still underrepresented in these subjects within secondary education.
- Moreover, intake onto advanced STEM programmes is not yet keeping pace with the rising percentage of girls choosing STEM in secondary education (particularly HAVO/VWO).
- A relatively large number of female STEM graduates (higher professional education and academic higher education) are not moving on to *STEM positions* in the Engineering, Technology and Industry employment sectors. It is still unclear whether they are indeed employed in STEM positions in another sector or whether they have switched to a non-STEM position.

The fact that women are still underrepresented in STEM is an undesirable situation for all parties. After all:

- Society needs more STEM specialists in order to face up to current and future challenges. What is more, the Netherlands has occupied a hardly prestigious position in various international rankings relating to women in STEM for a number of years now. Although women are underrepresented in STEM in

- many countries, the Netherlands often features near the bottom of such lists.
- STEM companies and institutions benefit from employing a wider range of professionals, including women, because this provides more ideas and lines of approach when it comes to tackling social issues.
  - Everyone should have the opportunity to develop their abilities, including girls and women with a flair for STEM. Freedom of choice exists in principle, but as long as social norms, gender stereotypes and expectations form a barrier between women and STEM, there is no real freedom of choice.

### Current points for attention

This trend analysis has shown that the following key points require attention in the short and medium term:

- The transition from secondary to higher education is not yet optimal. Many prospective female students are lost at an early stage because pupils graduating from HAVO and VWO schools with a science subject cluster are deciding against an advanced STEM programme. Of the women who do choose these programmes, a number also drop out during the first phase of their studies. Universities are faced with the task of providing an honest, clear picture of the possibilities that their STEM programmes offer, the social impact of these programmes, the professional field and research areas (particularly in upper secondary education). Account must be taken here of the fact that when girls in secondary education are looking for an advanced programme they want to see with their own eyes what STEM study programmes actually involve, what the atmosphere is like, what type of people they will meet, and preferably also: what type of work graduates, women in particular, do.
- Contact with female STEM professionals is essential to the decision-making process of female HAVO and VWO pupils. They can have a positive impact on the main questions that influence the decision-making process, namely: 'Can I do this and do I want to do this?' Female role models can help to improve girls' negative self-concept in relation to STEM by setting girls positive examples in these areas. Moreover, bringing girls into contact with role models from a range of STEM positions and careers gives them an idea of the full range of possibilities within STEM. Particularly at defining moments (when choosing a subject cluster or an advanced programme), contact with role models can encourage girls to investigate or to opt for STEM. Incidentally, women who opt for a study programme or job in STEM are not automatically effective role models. If despite being female they only give out gender-stereotypical messages about STEM (it's difficult, studies take a lot of time and hard work, I'm just not like other women, I actually get on better with men than with women, and suchlike) then their input will probably produce the opposite effect.

- High-quality education is education that is equally accessible and feasible for everyone (at a specific level). Gender equality is one of the quality criteria. This means that it must be natural for pupils graduating from HAVO and VWO schools with a science subject cluster to be able to enrol on an advanced STEM programme and also to successfully complete this programme, regardless of whether they are male or female. Gender awareness must form part of the basic knowledge of every teacher, and must therefore be embedded in the curriculum for teacher-training courses and teaching refresher courses. Teachers must be able to independently use research results in the field of gender and STEM. They must also be able to interpret quantitative data (for instance on intake, dropout rates, graduation, performance) in a way that provides an insight into any gender differences within their study programme, study programme cluster or faculty, as well as in relation to other, similar study programmes, study programme clusters or faculties. For as long as women are underrepresented within STEM study programmes, an individual or team (for instance a gender core team) within the university must be responsible for gender equality as a quality criterion and further gender mainstreaming of educational policy. It is important for female STEM students to regularly come into contact with the professional practice during their study programme. Female STEM graduates from research universities in particular stated that this contact was lacking during their programme. The ideal situation would be if this contact with the professional practice were always to take place via alumni of the study programme in question.
- The experiences of alumni (both women and men) could play a more prominent role in educational innovation.
- Within the potential supply of pupils graduating with a science subject cluster, there are many girls who consciously decide against an advanced STEM programme. More targeted research into these girls' motives is desirable. Are they not attracted by the excellent labour market prospects for STEM specialists? Do these girls consider 'enjoyable' to be a primary selection criterion when choosing a study programme, or do they make a decision based on desired personal and social development, both in the short term? Do they take into account the long-term implications of their choice of study? For instance, are they aware that female STEM graduates find a job faster and are more likely to be employed at their educational level than female graduates in other sectors? Or are they aware of this, but also aware that these women earn less for carrying out the same work? Or do they perhaps have a narrow view of how useful STEM is to society? Are they simply unaware of the wide range of possibilities? Or do they prefer to choose professions that enjoy a high status in our society, such as doctors and lawyers?

- Girls and young women in the Netherlands should be encouraged more to develop ambition to build up an interesting professional career. They need to become more aware that enjoyable and interesting work and everything that goes with it (working environment, colleagues and so on) can lead to a sense of fulfilment and happiness in life. They need to learn to make targeted career decisions and not to be deterred by setbacks they encounter along the way.
- It is not clear whether all female and male STEM graduates move onto and remain in a STEM-related position. Only a percentage of these graduates can be found in the statistics on the STEM employment sectors of Engineering, Technology and Industry. The remainder are either employed in a STEM position elsewhere (provincial and municipal authorities, hospitals and so on), or are not, or no longer, employed in a STEM position. Further research, also into the factors that attract these graduates to STEM positions in non-STEM sectors, could shed more light on this situation.

### Preconditions

When developing policy and activities designed to successfully attract, retain and ensure the graduation of both female and male students, universities will have to take into account a number of preconditions:

- *Chain approach*  
Collaboration with all relevant parties: secondary education, the STEM business community and other partners within the region.
- *Integrated approach*  
An approach that simultaneously tackles all fronts, designed to attract and retain female students and ensure the successful progression onto the STEM labour market. An individual focus on either intake, or progression, or graduating students is not effective in the long term.
- *Longitudinal approach*  
Not a collection of one-off uncoordinated activities, but instead a sound long-range strategy which is regularly evaluated in terms of effect and process, and adjusted in the interim where necessary.
- *Gender expertise*  
The appointment of a ‘gender expert’ with specific tasks or a gender core team within the STEM study programmes. Reorganisations have meant that many STEM faculties no longer have staff officers who are responsible for

and have expertise in equal opportunities, however the period in which equal opportunities coordinators were indeed active within universities was highly productive: there was a gradual increase in the percentage of female students over this time.

– *Gender mainstreaming of policy and activities*

It is important that STEM study programmes examine for all policy intentions and resulting activities whether these are equally effective for both female and male students. Embedding gender as a quality feature is highly beneficial for institutions: if lecturers and other parties involved see that a study programme is becoming more interesting and feasible for a wider group of students – men, women, students of native Dutch background, students of non-Dutch background, with a broad range of interests and competencies – the quality of teaching will also improve.

– *Specific gender policy*

Where there is a severe gender imbalance in the student population, additional measures to redress the balance must be taken for as long as this situation persists. An explicit focus must temporarily be placed on the target group, for instance information activities specifically aimed at girls in secondary education who are the potential next generation of female STEM students, and separate activities or provisions for female students.

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