

Gender & STEM Network Conference 5-6 September 2012, Haarlem, The Netherlands

Overview

VHTO, the Dutch national expert organisation on girls/women and science/technology makes an effort in many different ways to increase the involvement of women and girls in science and technology in The Netherlands. In 2007, Associate Professor Helen Watt from Monash University Australia was invited as a keynote speaker at a VHTO conference. Our discussions centred about the very many research studies and findings concerning gender and STEM participation, but also that different studies tend to focus on one or few aspects. We agreed it would have surplus value if relevant research results of the last few years could be interrelated, in order to be able to gain a more coherent view concerning gender and STEM (Science, Technology, Engineering, Mathematics) from childhood to labour market. With this in mind, together we have formed our Network on this subject with members who undertake related research.

Objectives of the Network are:

- to gain more insight into the various, closely connected aspects of career choices and professional careers of girls/women (and boys/men) in the direction of STEM;
- to detect new approaches to actually improve the underrepresentation of girls/women in STEM.

Introduction about the aims of the conference

The first Gender and STEM Educational and Occupational Pathways and Participation Network Conference was held on 5 & 6 September 2012. Professor Jacquelynne Eccles from the University of Michigan launched the Network at the conference. More than 80 researchers and policy makers who are concerned with the subject attended the Symposia and panel discussions. The conference brought together academics, teachers, policy makers, experts and the public to explore the missing pieces of the 'jigsaw puzzle': what do we not yet know that we need to, concerning girls/women and STEM. We aimed that the conference would bring us a clearer picture of the Gender & STEM puzzle: what we know and what we don't know yet, and which policies and interventions might be more effective than others.

Welcome by host VHTO

VHTO is the (Dutch) national expert organization on gender and STEM in The Netherlands since 1983, and one of the initiators of the Network.

Cocky Booy, managing director of VHTO gave a brief overview of the developments in VHTO's aims to increase the involvement of girls and women in STEM in The Netherlands. Back in the 1980s VHTO started with improving the public information about STEM-studies in higher education in co-operation with universities. At that time the underrepresentation of girls in STEM-courses was mainly attributed to a lack of information about STEM university programs. In the late 1980s there was an understanding that there was more to it. Together with universities VHTO developed alternative guidance, based on the minority position of female students. In the early 1990s new forms of learning and teaching, such as problem-oriented education and project-based learning were introduced at universities. VHTO worked with a number of Dutch universities to ensure that these educational innovations would increase the appeal of STEM study programs for potential female students. In the late

1990s 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, still declining. Therefore in 1998 the Dutch government launched the Axis Foundation. A broad strategy focusing on broadening and re-positioning technical study programs was adopted. VHTO was asked to fulfill an advisory role in this process. During this period VHTO was also tasked with introducing gender perspectives in the redesign of technical study programs and in the development of various multidisciplinary study programs. VHTO developed the 'gender scan tool', to identify and assess the current preconditions for attracting, retaining and ensuring the successful graduation of female students.

The Lisbon agreements of the leaders of the EU-countries, in the year 2000, led to Dutch government policy in respect to STEM (Delta Plan for STEM) and the introduction of the Dutch National Platform Science & Technology (2004-present) to implement this policy. 'Gender Balance' is an explicit aim of this STEM policy, and VHTO is involved in realizing its aims. The gender perspective has therefore been incorporated into all National Platform program 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 (in primary education, secondary education, senior secondary vocational education and higher education), and with success: the number of girls in STEM courses is increasing.

Keynote: *'Gender and STEM: Opting in versus dropping out'*

Professor Jacquelynn Eccles is Patron member of the Network Gender & STEM. She (and colleagues) has been working on the Expectancy-Value Theory for more than 30 years (Eccles et al., 1983). The model provides an integrated framework to approach the question of why girls and women make the choices they do, related to STEM (or other fields). Since she started her research there has been a tremendous change. History has shown that the participation of girls/women in STEM can be changed by policy. It is an area in which we can have a lot of influence.

What determines women's choices? Choices are made from a wide range of alternatives. Girls/women are interested in (future) jobs in which they can cooperate with others and can help people. Another important issue is that girls/women are concerned about the possibility to balance work and family. These views play an important role in making their career choices. Girls/women opt in to careers that fit their values and those values are influenced by gender stereotypical images (TV, media etc.). We need to change these stereotypical images, go into the classrooms and show children/students what an engineer really is/does/can do. We need to show that one can have fulfilling careers in STEM just as in biological sciences. We should do so from an early age, because stereotypical images already start to develop in infancy. We should postpone school career choices as long as we can, and in the meantime prepare children/students for making their choices.

Eccles pointed out that *within* STEM gender differences are even more important to study than STEM vs. non-STEM gender differences. It is important to first define clearly what STEM is. If, for example, STEM teacher training is included in our definition of what constitutes STEM (as a major), the numbers of girls participating in STEM increase dramatically. Different definitions of STEM lead to different interpretations and interventions. Girls place less value on math and they will only take the most advanced science and math courses if needed. At the end of high school young people have an image of what they are going to do. This implies that interventions will have to take place at an early age. Teachers are important, because they have substantial influence on the attitude of children and adolescents towards STEM. Math has been indicated as a critical

filter to inhibit girls from participating in STEM. More boys than girls take advanced math courses, because they need it for their major in engineering; girls more often major in math independent of a professional pathway requirement. So, the low level of participation of girls in STEM is linked to other factors. For effective interventions we should focus on the career choices that girls and women actually make and why. This is useful for interventions that aim at opting in, instead of focusing on why women are dropping out.

Motivations to work with others, to make a social contribution and for a family flexible career are key determinants for career choices of girls. When growing up children develop different – personal and social – identities. They want to be in a career that illustrates the person they want to be. For example: If one wants to help others, one is drawn to a career that is likely to make that possible. If an individual believes that an engineer is someone who helps people, it will fit with his/her expectations. But, if the person's image of an engineer is that of someone who is only 'being technical', there is a poor fit. So we need to change girls' view of what engineers do, with the help of inspiring role models. Engineers *do* work with others and *can* help. It is critical that in communicating with girls about what different kinds of STEM careers involve, how they can allow for making a social contribution should be highlighted. At the same time, attention should be paid to the workplace environments, to make them more cooperative and family-flexible.

Keynote: *'Sex differences: All in the brain?'*

Professor Lydia Krabbendam started her keynote by stating that sex differences in the brain exist and are relevant, but that they are not innate and not fixed. So it cannot be concluded that brain differences are the *cause* of gendered outcomes. Images of the brain are not real 'photographs' but representations. Male and female brains show differences, but the effect sizes and the behavioral relevance are small; people are more similar than they are different. The difference between boys and girls in STEM abilities appears to be very small. Since there are significant differences in subject choices, this must be mainly the effect of cultural conditioning. We learn from experiences. The key-mechanism is prediction. The brain adapts to our environment by the prediction, after an event, of a reward or a threat. What is good and what is bad differs in different cultures. One aspect is that cultures differ in their appreciation of masculinity and femininity. Expectations in social situations affect performance; they act like a self-fulfilling prophecy. If one believes one's intelligence can grow, one pays more attention to corrective feedback and performance improves. Teachers have expectations of their pupils/students, which affect their performance. Gender stereotypes about ability for STEM are still active. This influences school career choices of boys and girls. Educators should be aware of this and try to minimize gender stereotyping in their teaching. After that we can investigate how other cultural aspects influence the brain.

Keynote: *'Teacher and classroom characteristics of effective STEM education for boys and girls - recent findings and practical implications'*

Professor Angela Ittel linked up with what Jacquelynne Eccles said earlier about changing the images that girls (and boys) have of engineers and that a TV-series with an attractive, young, smart female engineer might help. The MINTiFF Network in Germany offers the opportunity to discuss with TV producers what stories, themes, backgrounds and charismatic figures MINT has to offer, in order to captivate a young audience beyond the usual science stereotypes.

Talking about possible 'missing pieces' of the Gender & STEM, one missing piece is: what is relevant for teachers in everyday practice? If we take a look at statistics about

freshmen in higher education in Germany, we see no gender gap in mathematics, only a small gap in chemistry, but huge – and growing – gaps in computer science, physics and astronomy. Gaps in the last mentioned studies are growing despite national policy measures, so these measures seem to be not successful at all. How can we develop strategic teaching methods for STEM? Teachers who followed an academic teaching track (general university) appeared to feel less prepared in competency areas of STEM schooling and teaching, than teachers who followed a professional track (university of applied science). The 'academic' teachers felt they couldn't do it. This is something we'll have to look into.

The most striking difference between boys and girls in the classroom is that girls' interest is related to social support, which is relevant for subject and future education decision making. Girls need more support to make a non-traditional subject or study choice. But teachers say there are no gender differences (although from earlier research we know that parents never would say there is no difference between their sons and daughters). Only off the record, teachers started talking about gender differences among their pupils. Although boys and girls appear not to be different in their STEM abilities, girls' values related to STEM differ from those of boys. Girls and boys could require a different approach; diverse teaching methods could be a solution. The evaluation of a recent program to foster girls' interest in math showed that after the program the interest and self-concept of girls was significantly lower than before, which could mean that raising girls' interest in STEM would not be the most relevant intervention. Professor Eccles commented on this conclusion by stating that interest and self-concept usually decline after such interventions. These findings require further examination.

STEM teachers need to be encouraged to combine theory and (innovative) applications. Evaluations showed that their teaching benefits from programs, if they are adequately supported. Teachers often appear to be tired of talking about gender. They think girls and boys are the same and that they treat them the same. It is our task to show them that the participation of girls in STEM is declining. Persistent gender stereotypes and increasing gender blindness, as many teachers assume that science is gender neutral, are part of this problem.

Keynote: *'Dimensional comparisons and their consequences for self-concept and motivation'*
Professor Jens Möller demonstrated that people assess their own skills by comparing their performances with those of other people *and* with their own performances across domains. A diary study among students about dimensional comparisons in everyday life showed that people compare different aspects within (academic/academic) and between (e.g., academic/friendship) domains. Most of them are upward comparisons with better-off domains. Dimensional comparisons also regulate mood.

To evaluate their own performance students use social and dimensional comparisons. In social comparisons (external frame) they compare their achievement in one subject with the achievement of their classmates in that subject. For example, if their verbal achievement is higher than that of their classmates, their verbal self-concept will also be higher. In dimensional comparisons (internal frame) they compare their own achievement in one subject with that in other subjects. Really high achievement in one domain leads to an underestimation of achievement in other domains. As a consequence a highly talented student could develop an average self-concept in her/his worst subject, even though her/his performance in that subject is well above average.

Research showed that math and verbal achievements correlate positively and substantively, whereas math and verbal self-concepts correlate only moderately. Math self-concept depends mostly on experiences at school, whereas verbal self-concept does not. Achievements in both domains affect the corresponding academic self-concepts

positively, but have a negative effect on the non-corresponding academic self-concepts due to dimensional comparisons. For example, a good math grade promotes a high math self-concept, but it is compared to achievements in other school subjects, for instance German. If a student is not good in math but worse in German, then his or her self-concept for math is higher than corresponds with his/her achievements. Accordingly, dimensional comparisons can lead to biased self-evaluations.

To conclude: Dimensional comparisons between domains occur in everyday life. They are useful to regulate (enhance, maintain) self-concept and mood, to detect strengths and weaknesses, and to facilitate some decisions. However, they sometimes lead to biased self-evaluations. The few available studies on gender and dimensional comparisons show that both girls and boys use dimensional comparisons. One difference is that girls have lower math self-concepts. In particular, girls with good achievements in both math and English, devalue their math abilities through upward comparison. It might help not to focus on domain *distinctiveness* but rather on domain *similarity*.

Keynote: *'The development of science learning from a psychological perspective'*

Professor Maartje Raijmakers argued that children usually learn about science in formal learning environments, such as primary and secondary school, but also in non-formal learning environments: by experiences at home or in a science center. Already in infancy we start to experience scientific phenomena, like how objects fall to the ground. After a while young children can predict fairly accurately how an object will fall to the ground: we 'understand' (right or wrong) the underlying law of physics and store this mental model in our brain. Many people can hardly express what they know about this phenomenon. The knowledge is implicit experiential (or intuitive or naive). Experiential learning can be an effective instrument to promote interest of children and adolescents in science. If we want to encourage them to make school career choices in favour of STEM, we need to fit this intuitive and formal science knowledge together. Formal (STEM) education aims at explicit (STEM) knowledge.

In her research, Raijmakers investigates what implicit experiential knowledge consists of and how it can be transformed into more explicit, conscious and formal knowledge about science. One of her research programs consists of preschool-aged children estimating the size of shadows. In the science center NEMO her research group made a set-up in which children had to make two equally large shadows of two fake rabbits of unequal size. They could experiment by placing the rabbits at different distances from the lamp. Earlier research showed that most preschool-aged children will predict that only the size of the object determines the size of the shadow, but in the experiment they find that the size of the shadow is also dependent on the distance between object and light source. Children appear to use multiple strategies and their strategies are mainly related to their age. In the shadow experiment, 5 year olds stated less often than 4 year olds, that the shadow size only depended on object size. The change depends on prior knowledge: 5 year olds have more prior knowledge of shadowing than 4 year olds. Exploration appeared to depend on observed evidence. When playing freely with the shadowing set-up children performed more and better after perceiving conflicting evidence. No gender differences were found in behavior.

Another project was about logical reasoning in primary school. 'Math Garden' is a computer game to practice math skills for primary school children. At this moment the game consists of 15 arithmetic games, 2 complex reasoning games and a clock game. The reasoning games can be played on a voluntary basis. They are meant to introduce the domain of logical reasoning into primary school. It appears that children can and do play the reasoning games – a kind of deductive Mastermind. In this program some gender differences are found. Boys play more frequently than girls; for school domains as well as voluntary domains.

Symposium: STEM socialization

Socialization influences play an important role in the shaping of girls' and women's attitudes and participation in STEM (Science, Technology, Engineering, Mathematics) advanced studies and fields of career. This raises questions like:

- (how) Do mothers and fathers transmit or shape sons' and daughters' STEM-related values?
- Do STEM teachers have gendered motivations and teaching behaviours?
- What views are held by the public these days about gender and STEM?
- Are there different learning styles in STEM for girls vs. boys?

In this symposium several researchers presented findings to address these questions in their countries, from Germany, Australia, and the Netherlands.

Gniewosz & Noack: Gendered patterns in parent-to-adolescent transmission of math task values

There are two types of students, in terms of preference pattern: to be affected by mothers' vs. fathers' mathematical values. Not because of the parent-child relationship quality, but due to the child's gender. The same gender parent is more salient. Boys are more affected by fathers' values, girls more by mothers' values. But a father being an engineer is an important factor for both sons and daughters to make a choice for STEM. Would it be the same in other domains than mathematics?

Richardson, Watt & Devos: (How) Does gender matter in the choice of a STEM teaching career and later teaching behaviours?

There is a shortage of STEM teachers. Teaching is a feminized profession, yet STEM are masculine disciplines. Do STEM teachers choose their profession for different reasons than other teachers? Main motivations to go into teaching across a general sample are to have an impact on the next generation, contribute to society, interest and enjoyment, perceived abilities. Differences for future STEM teachers:

- STEM teachers choose their career for family-flexible and 'fallback' reasons more so than other future secondary teachers; perhaps these future STEM teachers are people who are interested in STEM, but want to escape from STEM jobs constraints, such as working long hours.
- Higher scores among the women on motivations to 'work with youth', 'time for family'; higher scores for the men on fallback career, but this remains marginal. It will be important to see whether this has negative implications for the men future STEM teachers in terms of how they teach and outcomes for students.

Forgasz: Public views on the gendering of STEM: What has changed?

Public views gathered across diverse country contexts emphasize high social importance on studying mathematics. Where gender stereotypes were endorsed, they were in favour of boys being better in math. This seemed more evident in countries like China, Singapore and India. Whether respondent gender is a relevant factor would be an interesting next step, with additional sample information to know about cultural typicality.

Cottaar: Learning from mistakes; balancing masculine and feminine strategies in learning science

Among a very large sample of undergraduate science students, men's academic success was more strongly impacted by their efforts than was the case for women (although both relationships were positive). Men also exerted lower efforts. Conclusions were drawn that women try too hard and could work less. Alternative explanations were that the academic success measure (the final test) might not be the best measure, due to factors such as

stereotype threat and test-taking anxiety among women. The value of learning from mistakes was discussed, which relates partly to the 'mastery learning environments' emphasized in the educational psychology literature, for example by Pintrich, Kaplan, and others.

Symposium: Curious minds of boys and girls, differences in 'talent'?

The project *Curious Minds* is a Dutch national initiative to foster STEM talent in young children. Groningen University, one of the 7 participating universities, argues that the role of the teacher is essential in the children's scientific acting and thinking. The university mainly investigates the development of STEM talent within the interaction between teachers and children. Presentations in this symposium report about the Video Coaching for Teachers, that gives teachers (mostly women, many with anxiety for teaching science) the knowledge and skills to teach science to young children, age 5-8.

Wetzels: Science for the young: A challenge for the teachers

Two studies show that after VFC-t teachers reported a higher level of intrinsic motivation for teaching science. They enjoyed lessons more and had a better interaction with their pupils by asking more questions, in particular questions related to the empirical cycle and more follow-up questions. These results demonstrate that a relatively simple intervention based on video coaching, can stimulate (male and female) teachers to spark interest in STEM in preschool children.

Van Vondel: 'Girls lack mathematical and scientific abilities'; fact or myth?

Do girls lack STEM abilities? Results are mixed. Boys advantage on several domains, but there are many intertwining elements involved (topic, assessment, attitude, adult behavior).

Geveke: Gender differences in the Orion Program: A case study of the Science Center

Research by science center De Magneet (The Magnet) showed that schools associate science and technology more with men than with women. Educators have a moderate positive attitude, but men are more positive. Most of the time the educator is talking and not the child. Curious Mind teacher training pays attention to equal speaking time for girls and boys. Enthusiasm for science and technology in the science center is equally high for boys and girls.

Meindertma: Gender differences among preschoolers during a floating/sinking task

There are no clear differences between boys and girls considering their scientific reasoning. Girls more often don't give an answer when they are asked what happens in an experiment than boys. Teachers and parents should be aware that boys and girls have different prior experiences, behave differently, but are probably equally capable in scientific reasoning. We should be especially aware of girls' tendency not to give an answer (learned helplessness).

Symposium: STEM participation: individual motivations, perceptions, and cultural values

In many countries girls and women are underrepresented (or men are overrepresented) in STEM (Science, Technology, Engineering, Mathematics) advanced studies and fields of career. This raises questions like:

- What is the role of girls' and women's own motivations and self-beliefs?
- Are these self-beliefs accurate?
- What gender discrimination is encountered or perceived?
- How do different cultural values play a role?

In this symposium several researchers presented findings to address these questions in their countries, from the United States, Australia, Canada, and Spain.

Hayes & Bigler: The role of values, gender discrimination, and mentoring in men's and women's satisfaction with their STEM graduate training

Women and men enrolled in a STEM doctoral program in chemistry and biochemistry might show differing occupational values, perceptions of gender discrimination, and perceptions of mentor support. Hypotheses concerning the utility of these variables for predicting students' satisfaction with their graduate training were tested. Results revealed sex differences in students' occupational values. Specifically, women valued family flexibility in their future careers more than men, and men valued money and power in their future careers more than women. Additionally, women perceived a better fit between occupational values and teaching careers than men. Conversely, men perceived a better fit between their values and research careers than women. Women also perceived females to be the target of gender discrimination within the department more often than men. Importantly, factors that predicted satisfaction with graduate training differed by gender. Perceptions of gender discrimination and the fit of their values with research careers were significant predictors of women's (but not men's) satisfaction with their training.

Robnett & Leaper: Perceptions of sexism in STEM fields: A cross-sectional examination of students in high school, college, and graduate school

Research shows that girls and women become more poorly represented in STEM as they progress toward higher levels of educational and occupational prestige. The present study examines girls' and women's experiences with sexism in STEM at three phases of education: high school, college, and graduate school as well as boys' and men's perceptions of sexism in STEM. Quantitative analyses indicated that women and girls who had progressed further through the pipeline perceived more sexism in STEM than did women and girls who had not progressed as far. Specifically, female graduate students perceived more sexism than did female undergraduates, who in turn perceived more sexism than did female high-school students. Similar trends were observed in participants' responses to questions about the domains in which they experienced sexism. For instance, relative to other participants, female graduate students were more likely to report that others in their field made them feel like they needed to work harder than men to be respected. Across the age groups, male peers were the most common source of sexism. Qualitative analyses revealed that many participants characterized women's underrepresentation in STEM as both a cause and a consequence of sexism. Although women and men tended to share this sentiment, they differed in the extent to which they perceived it as a serious problem. Remarkably, many participants pointed out that women's isolation (or 'token status') in STEM fields is a more serious barrier than overt forms of sexism.

Watt, Shapka, Morris, Durik, Keating & Eccles: Gender, motivation and mathematics participation: A comparison of samples from Australia, Canada and the USA

Gender differences and relationships among mathematical motivations within the Eccles et al. expectancy-value framework, high school math participation and educational aspirations and career plans were explored. Participants were from Australia, Canada, and the USA. In the Australian sample, which provided for a high degree of early specialisation, boys had higher intrinsic value, enrolled in more advanced math, and aspired to more math-related careers. Intrinsic and importance values predicted both math and non-math outcomes, with more significant paths for girls. In the Canadian and USA samples, which require college-bound youth to take specific numbers of math courses, there were no significant gender differences in educational or occupational outcomes; boys had higher expectancies, perhaps related to a cultural emphasis on test regimes that focus attention on ability rather than interest. Intrinsic value did not predict

outcomes, but expectancies and importance value did. More for girls than boys. The 'pipeline' metaphor was generally supported, with consequences for math and non-math outcomes. The findings lead to the conclusion that contexts which promote early choice and specialisation may serve to amplify gender differences in stereotyped domains. Perhaps choice structured by topics as in North America, may enhance girls' interest. The test culture in North America may increase the risk of girls' lower ability beliefs. Further study of diverse settings is required to test these speculations. The greater role of values in girls' choices resonates with socialisation practices towards girls being happy, and boys successful. Mathematical motivations not only predicted math-related outcomes, but also level of aspired education and career prestige; long-term data are required to test whether and how aspirations become enacted.

Sáinz & Upadaya: Are male and female students accurate in the assessment of math abilities? To what extent does it influence the pursuit of technology and ICT-related studies?

Self-concept of domain ability is a strong motivational factor involved in different academic and career-choice related decisions. But to what extent are students realistic in the assessment of their math ability? Does self-concept of math ability reflect students' actual performance in math? To what extent does the accuracy or bias in students' self-concept of math ability predict their future STEM-related career plans? Inaccurate beliefs lead students to wrong-headed academic decisions and to subsequent low performance. Four groups of students were identified, according to the accuracy or bias in their math ability self-concept (e.g. high accurate, low accurate, optimistic, and pessimistic math ability self-concept). Analyses proved that the education of the parents predicted the accuracy in young people's perception of their math ability. Similarly, linear and logistic regression analyses demonstrated that the accuracy in students' math ability self-concept (at time 1=enrolment in the last course of junior education) predicted their self-concept of computer ability and the choice of technology-related studies (at time 2=one year later in the first course of high school).

Symposium: Gender & STEM policy considerations

In many countries policy makers of national governments, educational institutions, research foundations, associations of STEM scientists or professionals etc. make an effort to raise the participation of girls and women in STEM and foster professional careers of women in STEM. This raises questions like:

- How to design/choose interventions/approaches that can meet these aims?
- How to design/choose interventions/approaches which are likely to be effective?
- What are preconditions for effective interventions/approaches?
- What infrastructure is needed for effective interventions/approaches?
- What is preferred: interventions/approaches aimed at girls/women, gender mainstreaming of policies and actions, or both; and what is decisive to choose for one of these approaches?

Lin: Community awareness: A quality analysis of the working group on women in physics (WGWIP) of the Physical Society of the Republic of China (PSROC)

Since 1999 the physics community has initiated various programs to improve the situation for women in physics: The Working Group on Women in Physics within the Physical Society of the Republic of China is one of them. Numerous action items on recruitment, retention and promotion of female physicists have been identified. Execution does not always run smoothly. For example: career workshops for undergraduates; 2005-2007: debates about assumed insufficient manpower; 2007: successful launch; 2008-2009: expansions, 2010 downsized to one workshop per year; 2011-2012: shift to undergraduate recruitment. Women physicists valued their professional growth in the community. A discrepancy was found between male and female members when they envision possible changes of the current situation for female physicists.

Best: Structures and frameworks enhancing female participation and occupational pathways in STEM: A European perspective

In Germany, the Government and Ministries as well as the German Research Foundation (DFG) have set effective incentives to foster the share of women in science in recent years: Government and Ministries initiated a funding *Programme for Women Professors*, grant *achievement oriented funds* (10% depending on gender-equality) and have funded STEM campaigns, gender-equality publications and labels. At the same time, DFG has established *Research-Oriented Standards on Gender Equality* in 2008. These standards require gender-equality as a means to high quality research. Reports on the implementation of standards per research institution are mandatory and gender-equality is considered in DFG-funding.

Despite differences between theory and practice, the holistic approach seems to work: the share of women in STEM has been largely increased in recent years. Gender-equality has become more attractive for research institutions.

Furthermore, an in depth analysis of student data allows for a quite positive outlook: first, a retrospective analysis of 'science-oriented study paths' in STEM indicates only a slight decrease of women from STEM student (1992-1997) to STEM professor (appointed 2009-2011) of -6%, overall. So in Germany the STEM-pipeline is not that 'leaky'. Second, perspectives are good: more women opt for STEM study paths which are directed towards a research career. Taking the results of our retrospective analysis into account, there are good chances for gender-equality in future.

Ihsen, Sanwald & Schüle: Quality management for more sustainability of women-attracting measures in STEM

In Germany the Federal Ministry of Education and Research in 2001 initiated *Girls' Day* nationwide, for girls between 10 and 16 (*Girls' Day* is an international event). In 2008 the Ministry also launched *The National Pact for Women in MINT Careers* (MINT=STEM; komm-mach-mint.de/English-Information). It integrates all single activities to a linked offer to girls between 8 and 18. All projects/programs aim at raising the share of female students in STEM subjects at least to European level, and help to recruit women in science and engineering careers, from which at least as many as proportionally graduate in the relevant study programs. The number of women in science and engineering study programs grows, as well as the female engineering employee rate. This seems to be good news. On the other hand the '*Seeking Traces*' research project showed that students mainly decide for science and engineering because of the internet, teachers and family, and not so much because of the motivating and attracting projects/programs. The impact of measures is generally higher for women than men, and the impact is significantly higher regarding the reduction of insecurities. Most projects/programs take place on 'the outside' of regular engineering culture that is traditionally male dominated. These specific circumstances result in female engineering students and professionals leaving at each (career) stage. For a sustainable development in engineering we need a gender oriented quality management system, integrating the various measures within the system (not next to it), and fostering structural changes in higher STEM education and in STEM businesses and (research) institutions.

Szekeres, Nagy, Takács & Vicsek: Approaches to improve the underrepresentation of women in technology higher education programmes - Results from a Hungarian university study

A qualitative and quantitative study was initiated to investigate what possible barriers stand in the way of getting more female students to apply for academic technology programs and what is needed to raise the potential of girls for these programs. Results showed that most female students have friends or acquaintances who work in the field of technology. Obtaining personal impressions of an academic program or a profession in the process of making decision on a career is significant. Students dismissed non-

personal ways, such as poster advertisements, and the male-centered presentations of academic programs on the homepages of the faculties.

Professors didn't seem to consider the shortage of female students as a problem. In their view, different professional interest of men and women is 'natural'. Despite the traditional order of values, some female students are regarded as the best. Male students are praised for intellectual abilities and creativity; female students are considered to be more mature, persistent, purposeful, and to have good social abilities because of their future family responsibilities.

To widen the potential scope of talented applicants, it is vital to attract more women to the field of technology. It is important to work on the issues of combating gender stereotypes and promoting equal opportunity in education for teaching staff as well as students.

Symposium: Pathways to STEM studies and careers

In many countries girls and women are underrepresented (or men are overrepresented) in STEM (Science, Technology, Engineering, Mathematics) advanced studies and fields of career. This raises questions like:

- Which girls pursue advanced STEM studies and aspire to STEM fields of career?
- Do they come from different 'types' of learning environments?
- Do they have distinct motivational and self-concept profiles?
- What is the role of personality?

In this symposium several researchers presented findings to address these questions in their countries, from Germany, Australia, Belgium, and the Netherlands.

Lazarides & Ittel: Gender & STEM: Educational and occupational pathways and participation in a global context

Empirical studies repeatedly highlight the decline in students' mathematical self-concept during secondary school, with female students' reporting particularly lower self-concepts in mathematics compared to their male classmates. Studies examining teaching and learning factors which enhance motivational learning outcomes, revealed that indicators of mathematics classroom quality such as structuredness, teacher support, and participation opportunities are associated with students' self-concepts. The present analyses revealed four distinctly varying evaluation patterns: students who perceived an overall high quality in math class; students who perceived high structuredness; students who perceived high teachers' support; and students who perceived overall low quality in math class. Results further revealed gender differences in the proportions of latent classes. Subsequent single-group analyses showed that female students who perceived high stereotyping math-related attitudes of their teachers were significantly less likely to perceive high quality in their math classes than female students who perceived low stereotyping attitudes. Additionally, it was shown that the relation between perceived high stereotyping math-related attitudes of teachers and female students' self-concept differed across females' evaluation patterns. For female students who evaluated their classroom quality as high, teachers' high stereotype math-related attitudes were positively associated to their mathematics self-concept. Focusing on female students' self-perceptions in math, there are implications for educational practice such as self-concept-enhancing teaching strategies, because of the importance of girls' self-concepts to participation pathways.

Findlay, Watt & Kronborg: Socio-motivational determinants for girls' pathways of mathematical enrollment and career choice

A longitudinal study investigated how girls' plans for advanced mathematics changed from middle to upper secondary school, whether enrolment choices were associated with

mathematical career plans, what the impact of perceived mathematical talent and interest was, as well as perceived parents' and teachers' beliefs, beyond the impact of mathematical achievements. Four pathways were created, for each of educational and career choices. For enrolments, high-high were girls who at grade 9 aspired to, and at grade 11 undertook, advanced mathematics. High-low aspired to advanced mathematics, but at grade 11 undertook basic. Low-high aspired to basic, but later undertook advanced. Low-low maintained low mathematics course choices. For career pathways, four groups were similarly created, dependent on mathematics-relatedness of aspired career. Conclusions are that high interest and parental perceptions distinguish high-high school pathways; whereas low talent external distinguishes low-low, beyond effects of achievement. Talent external was additionally implicated in high-high career pathways, and low interest for low-low. Low-high exhibited high talent internal with low interest, but a clear perceived need for mathematics towards their future plans.

Van Soom & Donche: Gender, academic motivation and self-concept: Profiling of freshmen science and technology students

To better understand the factors that determine study success of S&T students, the relationship between autonomous motivation, academic self-concept and early academic achievement of male and female freshmen S&T students was explored. By means of person centered data analyses, the study examined how different motivational and academic self-concept profiles among freshmen S&T students are present and how these profiles are related with early academic achievement. Results show that within both male and female student groups positive correlations were found between autonomous motivation and academic self-concept, and between academic self-concept and early academic achievement. For male students, there was also a positive correlation between autonomous motivation and early academic achievement, while this was absent for female students. Four distinct profiles could be discerned, based on the dimensions of autonomous motivation and academic self-concept: two groups that scored respectively and relatively high or low on both dimensions, a group with a high autonomous motivation and low academic self-concept, and a group with a low autonomous motivation and high academic self-concept. Girls were overrepresented in the high autonomous motivation- low self-concept group, whereas boys were overrepresented in the low autonomous motivation- high self-concept group. Students who are more autonomously motivated and have a high academic self-concept obtained higher early academic achievement scores than students who are low autonomously motivated and have a low academic self-concept. The results confirm the expected associations between autonomous motivation and academic self-concept and early achievement. For practice, it seems that coaching interventions should take into account these distinctive student profiles. For female S&T students, raising more self-awareness through adequate feedback provision might be an effective approach.

Korpershoek: Who opts for STEM courses? Introverted and autonomous girls!

School motivation is an important determinant of educational outcomes. Low school motivation can lead to underperformance and school dropout. According to the achievement goal theory of motivation, students adopt different goals in learning situations. Research usually concentrates on two types of orientations: mastery orientation (girls!) and performance orientation (boys!). Research questions in the present study, based on a large sample of 9th grade pre-university students, were: What motivates pre-university students to put effort into their school work?, and: Do gender differences exist in pre-university students' school motivation? Pre-university students appear to be primarily 'task-motivated' (mastery). Performance and extrinsic motivation are much less prominent. Boys score higher than girls on competition (performance), social power (performance) and token (extrinsic), girls score higher on effort (mastery), social concern (social) and praise (extrinsic).

Van Breemen & Van Laar: Encouraging teachers to be gender aware

Girls are underrepresented in STEM partly because of the prevailing stereotypes of parents, peers and teachers of gender and of STEM.

Science center NEMO is partner in the European project TWIST. TWIST is raising awareness about the role and representation of women in science through ambitious programs and activities in science centers and museums. The project targets young people, their teachers and parents as well as the general public. It will focus on the outdated stereotypes and prejudices on societal roles for men and women and career paths. As part of this project science center NEMO developed a professional development program for teachers.

Making teachers aware of their own stereotypical behavior is a first step in changing a teacher's attitudes. Research shows that teachers need to attend many sessions in a professional Development Program in order to change their practice. However, one afternoon session in TWIST, if run well, enjoyable, challenging, and intriguing, appeared to be helpful to change teachers' attitudes and awareness which in turn may change practice for the better.

Concluding remarks

If we look over the Gender & STEM 'puzzle' as presented in this two days conference, the main point seems to be that the views of girls (and their parents), of what STEM professionals do, need to be adjusted from early on in education, and with the help of – women – role models. Apart from education, the media can play a very important role in adjusting girls' images of STEM jobs and courses, by showing female STEM professionals with whom girls would like to identify. Also STEM (research) institutions and the business community will have to meet women's needs of flexible careers. We should take into account that, so long as STEM work fields and STEM university programs are male dominated and have a masculine culture, there can be considerable 'costs' for girls when they make career choices towards STEM, in the sense that they may remain uncertain that their school career choices will lead them to desired future identities.