'Girls into STEM and Komm mach MINT': English and German approaches to support girls' STEM career-related learning

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European economies require STEM skilled people, yet compared with boys, girls demonstrate a tendency to reject some STEM study and STEM careers. This paper briefly reviews key factors that influence this phenomenon. It then introduces four examples of campaigns and initiatives that encourage girls to consider further participation in STEM in England and MINT in Germany as part of their career ambitions. Evidence of the impact of German initiatives is presented. It concludes that where there is a deliberate strategy linked with defined actions which tackle issues that are specific to girls, then gender imbalances can begin to change.

Introduction

Across Europe there are various degrees of skills needs and gaps in science, technology, engineering and maths (STEM). The importance of STEM skills to developed economies is widely recognised because of their association with innovation and economic growth (UKCES, 2013). At the same time, there are gender imbalances across Europe observed in choice of study and occupation. Practice in Germany is interesting, as employers experience the same difficulties in recruiting the skills that they need as those reported elsewhere, but, with a contracting youth demographic, low levels of unemployment and high levels of employment, they are seeking more active ways to encourage females to consider MINT (Mathematik, Informatik, Naturwissenschaften und Technik). This paper is based on two sources of evidence. Firstly, a review of research reports and literature from England and Germany (in English) was undertaken to establish a baseline for comparative exploration. Secondly, interviews and discussions with managers of two nationally significant projects in Germany were undertaken as part of a case study visit hosted by Osnabrück University of Applied Sciences and the Competence Center Bielefeld.

STEM in European economies

A recent review of STEM skills in the European economy (EU Skills Panorama, 2012) concluded that the current supply is insufficient and, when combined with forecast growth in demand, such shortages present a potentially significant constraint on future economic growth in Europe. BusinessEurope (2011) report that this is due to the changing needs of commerce and industry, an ageing workforce, and a lack of in-migration of STEM skills to plug the gap. In England, the Roberts Review (2002) reported general needs across all science, engineering and technology areas. This has subsequently been refined and challenged with some analysis questioning whether there are any STEM shortages at graduate level (Smith, 2011); others point to an adequacy of STEM graduates but amongst people with inadequate employability skills (Mellors-Bourne, Connor & Jackson, 2011). Meanwhile, Mason (2012) has investigated the need for technician level skills in the STEM industries, concluding that industrial restructuring alongside the impact of education policies create a need for better ways to support young people to develop technician skills. A different perspective again is offered by analysis which focuses on the importance of geography and the magnet effect of London, meaning that businesses outside of the south east face greater difficulty recruiting the skilled people they need (UKCES, 2013).

While the nature and extent of skills shortages are actively debated, there is a consistent message about the gendered pattern of participation. In England, for example, there are lower numbers of females than males studying all STEM subjects at A level (upper-secondary) except biology, and 85% of those studying engineering and technology degrees are male (WISE, 2012). The issue of gender segregation is also familiar in Germany. For example, 71% of girls who take apprenticeships choose those in only 20 out of 360 different types on offer. Furthermore they are in occupations where women already dominate the workforce. For example, 8% of female apprentices train to be managerial assistants, 7% sales clerks, 7% office administrators and 6% medical assistants (information provided by Girls' Day).

It follows that there are lower proportions of women working in STEM roles in industry (European Commission, 2012). For example, a report by VDI (2010) suggested that across Europe, one in every six engineers was female, but that the range extended from 30% of all engineers in Latvia and Bulgaria to 8.5% in England and 16% in Germany.

Girls therefore represent a significant untapped resource in the labour market, so addressing gender occupational segregation would be beneficial to industry. Indeed, according the House of Commons Science and Technology Committee (2014: paragraph 5), 'simply put, the UK economy needs more skilled scientists and engineers and this need will not be met unless greater efforts are made to recruit and retain women in STEM careers'. Furthermore, female participation in a broader range of STEM occupations and careers would open up opportunities in areas where pay and progression are better than in those occupations currently dominated by women. It should therefore enrich the working careers of some women.

Factors that deter girls from STEM

There are many reasons why girls reject STEM. These include the type of decision maker they are (Blenkinsop, McCrone, Wade & Morris, 2006), their family background and how this shapes the science capital that they use to shape their choices and behaviours (Archer, De Witt, Osborne, Dillon, Willis & Wong, 2010), and their general orientation towards STEM subject study (Motivaction and YoungWorks, 2010). In this paper, four further key factors are discussed that help explain relative lack of female participation in STEM. These are: lack of self-efficacy as a 'STEM' person; socialisation in a culture where femininity is antithetical to STEM careers; STEM curricula which use pedagogies that are better suited to male learners; and a lack of socially visible female scientists, engineers and mathematicians that limits girls' self-concept. Attempts to inform and motivate females about STEM need to recognise these issues if they are to be overcome.

Bandura's (1997: 37) concept of self-efficacy, 'a belief about what one can do under different sets of conditions with whatever skills one possesses' helps to explain why girls abandon STEM. If they believe that STEM skills will not be of use to them based on their knowledge of the study or employment conditions they see around them, then they will not invest in those skills. The mathematics results from the Programme for International Student Assessment (PISA) provides an example. PISA is a triennial international survey, undertaken by the Organisation for Economic Co-operation and Development (OECD) which aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students. Analysis of the 2012 PISA survey shows that boys outperform girls in maths in 38 countries. This is particularly the case for the more difficult mathematics questions in the PISA survey which were answered correctly by 13% of boys and 10% of girls in the UK. However, this was not the case in other countries where girls outperformed the boys, so this is not a question of biological determinism. Borgonovi (2014) suggests that the gender difference in mathematics performance mirrors the gender difference in students' drive, motivation and self-belief between different countries and cultures. In other words, if girls think that they are unlikely to use STEM skills in their lives, they will not be motivated to study hard at it. Similarly, if they think that they are not good at a subject (even if in fact they are equally as good as the boys) they will be less inclined to pursue it (Morris, 2006).

The second and related reason why girls discount STEM is that, whilst they might like science they simply don't see themselves as a scientist (Archer et al, 2010). Young people understand only a very narrow range of STEM related jobs and those tend to be associated with culturally defined stereotypical images. The prevailing images of scientists for example are 'white men in lab coats' who have to be 'brainy' (Archer et al, 2010), whilst engineers are associated with men driving white vans ready to fix washing machines (Moore & Hooley, 2012). These associations encourage girls to think that STEM is not for them. This perception is then perpetuated by families and social groups that also share this view and who emphasise the important role of females in the home. Girls may then reject STEM because it is associated with a lifestyle that is incompatible with their future social roles within families and communities (Duru-Bellat, 1994).

Classroom experiences of learning STEM subjects are also related to girls' enjoyment of and desire to continue learning and applying those subjects. Institute of Physics (2006) research demonstrates that girls are more likely to engage with curricula that emphasise the social applications of science whereas boys are more comfortable with abstract theoretical learning. They conclude that girls' preference for more social relevance can be linked to the higher recruitment and retention of girls to physics courses which emphasise real-life applications. They also explored the impact of single sex schooling. All girls schools generate higher proportions of girls who study STEM at a higher level (Institute of Physics, 2013). The Institute of Physics explored whether this was due to social factors (as, in England, single sex education is associated with fee-paying schools or those with an intake selected on the basis of high academic achievement) or to tailoring the curriculum to girls' needs. They found that 'girl friendly' interventions had some positive impact but it was limited and short lived, whereas single-sex learning environments can help give girls confidence before they move into a mixed group environment.

A final aspect of girls' decision making is the lack of awareness of career roles that can and are being performed by women. Visioning a future self is a challenge but even more so if there are no templates on which to base one's vision. The SESTEM project (a European Leonardo funded project) concluded that 'the existence of socially visible, scientific women is a powerful factor, allowing girls to project themselves into a different future' (SESTEM, 2011: 30). The impact that exposure to people who are in work can have on career exploration motivation is increasingly seen as significant, with a correlation being made between the number of people in employment that young people meet and subsequent positive career outcomes (Mann, 2012). Consequently, if young women meet women in STEM employment this should enhance their overall career awareness, and may provide them with experiences that challenge their self-concept alongside their views of what is a realistic ambition.

The factors presented here are closely inter-related. For example, role models can change the prevailing view of what girls can do. Furthermore these factors may interact in a different way with the different subject areas within the STEM acronym. Finally, there is as yet only limited empirical evaluation evidence of the impact of such interventions on young women's choices (Tripney, Newman, Bangpan, Niza, Mackintosh & Sinclair, 2010). Nevertheless, if career support interventions aim to provide impartial career learning opportunities to challenge stereotypes and raise aspirations, then they need to have regard to these types of issue.

Career interventions in England and Germany

There are a plethora of initiatives that seek to promote STEM subjects to pupils either to engage interest in STEM subjects among greater numbers of young people so that they continue to study them for longer, or to raise their awareness of the wide range of career opportunities that STEM study can lead to. A study of science education across Europe found that all countries have their own range of actions designed to enhance engagement in science, and some have national strategies in place with associated infrastructures. But they found that 'very few partnerships seem to focus their attention on raising girls' interest in science' and that 'only some countries provide specific initiatives which seek to encourage more girls to choose scientific careers' (Eurydice, 2011: 57).

In England for example, there are literally hundreds of opportunities that schools can engage with to support their pupils' STEM learning. These are compiled in the STEM Directories which are supported by the Department for Education and are searchable by several factors. However, while many seek to ensure that there is equality of access, only four of them are exclusively for girls.

There are examples of career programmes in England that have been designed in such a way that they are providing girls and young women with positive career-related learning experiences. The WISE campaign in England celebrates thirty years in 2014 and has been working with businesses, schools, young people and their parents to offer a range of activities such as a blog of inspiring women, a workshop and other learning materials which can be taken into schools and colleges, and discovery workshops for girls, parents and teachers. WISE is an independent community interest company whose aim is to increase the gender balance in the UK's STEM workforce from 13% female employees to 30% by 2020 (WISE, 2012: 3).

In addition to campaigns and resources, there have been programmes specifically aimed at exposing young people to STEM careers to achieve equality and diversity ambitions. One example is the London Engineering Project which managed a programme of activity across south and east London which attracted deep engagement from five large engineering employers. It ran a range of activities including STEM ambassador programmes, residentials, e-mentoring, support for school science and STEM clubs, and a range of taster days offered by a higher education institution. One core element was to develop training approaches to help colleagues working on the project to understand the issues around gender and cultural awareness. The evaluation concluded that this approach provided an invaluable way to help people build confidence to tackle issues around gender and challenging stereotypes as well as improving the promotion of engineering positively to young people (Harrison, 2009). The evaluation reported positively on the use of role models whose impact was deepened when mentor and mentee were actively engaged in a practical activity such as a STEM day or a design and build competition.

A second example is RAF WISE (Collins, 2013), which is a week-long work experience offered by the Royal Air Force. This provides young women with a residential experience which includes a programme of activities that engage them in science learning leading to a CREST Award[1]. It also provides opportunities to work with female mentors and encourages familiarisation with a STEM workplace. An evaluation of the first three years concluded that it has provided participants with employability skills and achievements that can be used to support their transition to further learning, and also that 'the messages that have been taken back into schools and the local community have been positive' (Collins, 2013: 45).

The English approach to challenging stereotypes and promoting equality of opportunity in STEM careers relies on the integration of this agenda within other actions. This is informed at a national level by organisations such as WISE and other national networks but at present, there is no single government funded organisation. The mainstreaming approach to embed gender issues within enhancement and engagement activities that occur in science and other STEM subjects can work well. According to the London Engineering Project, this can be a very effective and sustainable strategy. Similarly there are few projects or initiatives which are specifically targeted at females such as RAF-WISE but again this provides an example of an approach which brings benefits to both employer and the female participants.

Germany provides a contrasting example. It too has its share of initiatives but it also has national and regional infrastructures which provide a framework for their MINT engagement activities. It is worth highlighting the context in which young people are supported to make career choices in Germany as it contrasts with the current provision in England (Watts, 2013). Firstly, the dual system of academic and vocational education is very stable and well known – this is not to say that educational structures and qualifications are inert – but the overall architecture has changed little over decades. This contrasts with decades of

1 The British Science Association run a series of awards at bronze, silver and gold levels which recognise achievement in a scientific investigation. They are nationally recognised awards that can be used to provide evidence of achievement as part of a personal statement or curriculum vitae.

routine reformation of the English system which has seen changes to organisational infrastructure, funding routes, qualifications and teacher training across all aspects of education and training. Secondly, the career service in Germany is professionalised, well resourced, all-age and universally accessible, so most young people will have had contact with the service run by the Federal Employment Agency (Jenschke, Schober & Frübing, 2011). Finally, schools incorporate Arbeitslehre (learning about work) into the curriculum – either as a subject in its own right or integrated into other curriculum subjects. Together this means that all young people have had the opportunity to learn about core concepts associated with career whilst at school, including aspects of equal opportunities (Ihsen, Schneider, Wallhoff & Blume, 2011; Blättel-Mink, 2009). Consequently, enhancement activities can be more focused on specific elements of the labour market or transition process.

Go MINT – the National Pact for Women in MINT Careers[2], was developed to change the image of MINT professions in society. It is a network of more than 179 partners from politics, business, science and the media, including nine 'Länder' companies such as Siemens and Daimler and big research institutions including the Helmholtz Association. Go MINT is part of the federal government's qualification initiative and was launched in 2008 at the instigation of the Federal Ministry for Education and Research, with the aim of increasing young women's interest in scientific and technical degree courses and attracting female university graduates to careers in business and science. Within Go MINT the Federal Ministry of Education initiated a number of projects which may change in focus each year. These include:

- MINTalente – a network of female role models for girls
- echnik braucht Vielfalt (Technology Needs Diversity) – a project focusing on young female in-migrants
- CyberMentor: CyberMINT Communities – an e-mentoring and social media network
- Mädchen-Technik-Talente-Foren (Girls' technology talents forums) - with a focus on optical sciences.

All partners of Go MINT are providing numerous good practice projects. The Go MINT national agency undertakes internal evaluation of key aspects of their work and the management team therefore are able to state that key elements of successful activities are: practical career decision-making support, the contact with role models at an early stage, and the affirmation of one's own technical competences and interests. Together, the partners are committed to promoting and optimizing successful initiatives and activities, as well as developing new ideas and integrating them into existing structures. The Pact is always open for new partners and input.

The importance of 'MINT für mädchen' to Germany is demonstrated by federal support of the network that enjoys high level of employer engagement. In turn, Go MINT strengthens the public awareness of the issue. The information portal (www.komm-mach-mint.de) provides an overview of nationwide activities, including a national project map with information on more than 1,000 projects and provides a platform to share single actions and lessons learnt which would otherwise be dispersed across a local or regional level.

All of the initiatives together are gradually delivering change. In 2012 one in four female first year students opted for a scientific or technical degree course. A look at the absolute numbers of MINT-female first year students shows an above-average increase: in 2012 there were 67% more first year students in Engineering Sciences than in 2008 (from 21,400 to 35,700) and 52% more first year students in Natural Sciences and Mathematics than in 2008 (from 38,200 to 58,100).

An evaluation of Go-MINT has been undertaken by its core team (Haaf, 2013). Results from their research have summarised some of its key impacts, including that in total it has engaged 436,000 females since it started, and that 69% of Go-MINT participants chose a career in STEM. Perhaps just as significantly, 82% of Pact members have increased their activity in this area since signing the memorandum. The real strength of this approach is that it is employer driven and links key employers with learning providers and policy makers. This gives it authenticity, sustainability and credibility

2 Further information can be found at: http://www.komm-mach-mint.de/

with girls and with their parents and other employers.

A second example of an initiative designed to encourage further female participation in MINT by challenging their self-concept and providing positive role models is Girls' Day[3]. On one day every year business, research centres and other institutions put on simultaneous open day events for girls, mainly aged 13 – 15 years. Girls apply for places at companies directly through the scheme either independently or with the support of their school. In 2013, Girls' Day was held on 24th April and involved 108,000 girls and 9,200 events across Germany. Over 1 million girls have been involved since the initiative started 10 years ago. A wide range of partners are involved in organising these events, including employers, trade unions and trade associations as well as schools. It enjoys good media profile, assisted by the involvement of Angela Merkel, herself a physics graduate. Girls' Day has three core principles. Firstly, to be a single-sex event giving girls the chance to explore new professional territories without feeling like they are competing with boys and secondly, to provide hands on experience and gain self-efficacy by practical job-related activities. The third principle is for girls to meet role models. Each year a standardised evaluation tool is used to assess impact on girls, on companies and on schools. Findings are positive. For example, 36% of girls say that they can see themselves working in that type of organisation, and over 60% of the participating organisations use young female workers or students to mentor the visiting girls. Furthermore, the proportion of schools that focus career lessons to include gender-specific career orientation has doubled since 2004 (Girls' Day, 2013). For the past three years, there have also been Boys' Days to introduce boys to occupations such health and social care.

There are many projects in Germany which have the specific aim of focussing on girls. Other smaller examples include one run by Osnabrück University of Applied Sciences' Niedersachsen Technikum programme[4]. This places young women for six months in a technical company, with one day a week in the university where they can build friendships and share experiences. This occurs after Secondary Level 2 at the age of 18 or 19. Their expenses are covered by the company (about 350 Euro per month). Participants complete a project which is useful to the company and in doing so they gain confidence in their ability, a network of peers, and familiarity with the university and courses they could progress to. For the young women this provides a low-risk way to start technical studies without making a long-term commitment to an apprenticeship or university course. In 2013, 100 young women used this opportunity for a six month technical course. Of these, 92 opted for further MINT-related vocational courses afterwards.

Conclusions

The shortage of STEM skills is experienced across Europe as is the imbalance between the proportions of males and females studying STEM subjects and working in STEM jobs. There are factors that are specific to young women that conspire to push them away from STEM. Career interventions can play a part in helping to address those factors but there are social, cultural and pedagogical factors that need attention by other partners.

The examples covered in this paper have shown how partnership initiatives can begin to change girls' self-efficacy by demonstrating, in safe and structured environments, that they can do things they might have thought were beyond them, such as computer programming or completing a CREST Award. Moreover, the experience also teaches girls that these skills are and will be relevant to their future lives. The examples have shown the importance of role models and mentors in challenging girls' assumptions about what 'people like me' can do either through participation in work taster events such as Girls' Day or work placements such as RAF-WISE. These indicate how it is possible to change girls' world views through exposure to different people and places.

The projects also demonstrate either through participation in gender equality training (as in the London Engineering Project) or through awareness raising (by the Go-MINT pact) that teaching approaches and workforce development practices can be changed to make the learning and working

3 Further information can be found at http://www.girls-day.de/
4 Further information can be found at https://www.uni-osnabrueck.de/studieninteressierte/gaststudium/niedersachsen_technikum.html

experience better for girls and more productive for organisations. While the culturally embedded and socially acceptable norms that influence girls' choices underpinning STEM are profound, there is evidence emerging from the German experience that change can be effected. This will be important for careers practitioners and their strategic partners in England and elsewhere to both monitor and emulate.

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