KNOWLEDGE INTO ACTION

INFORMING WHAT WORKS ... RAISING ATTAINMENT AND REDUCING INEQUITY

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Education Scotland
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RESEARCH BRIEFING

LOOKING AT GENDER BALANCE IN STEM SUBJECTS AT SCHOOL

Photo credit: Institute of Physics

ISSUES AT A GLANCE

Under-representation of girls in physics and technological subjects

In 2014, girls represented:

- 7% of entries for Higher in Technological Studies
- 20% of entries for Higher Computing
- 28% of entries for Higher Physics.

Gender balance levels have remained largely static for the last 30 years.

Under-representation of boys in the biological sciences

36% of entries for Higher Biology in 2014 were boys.

Under-representation of girls in STEM-related apprenticeships

Only 3% of engineering modern apprentices in 2014 were female.

1. INTRODUCTION

This briefing summarises research on the gender differences in participation and attainment in science, technology, engineering and mathematics (STEM) subjects, and explores some of the factors that may lead to these differences. The main focus for research selection was large scale, systematic or meta-analytical reviews and empirical research studies. However, some of the research intervention studies have a very small sample size; therefore generalisations cannot necessarily be made. The research studies include national and international settings. The briefing will describe the key findings and summaries of the emerging key areas of research which are: participation, attainment, key factors and intervention.

"Women make up nearly half of the UK workforce but only about a fifth of those working in science, technology and engineering industries."

WISE CAMPAIGN, 2014.

2. KEY FINDINGS

- There is wide-ranging evidence of gender differences in STEM participation and attainment but not ability, suggesting that internationally girls underperform relative to their ability. Performance gaps in mathematics can be seen as early as the pre-school years.
- Boys tend to perform better on standardised tests whilst girls do better in continuous assessments.
- Gaps in participation are wider in wealthier countries. Children and young people in wealthier countries are also less positive about science, technology and mathematics.
- Attitudes and perceptions of STEM subjects are already formed when children enter education as a result of early socialisation experiences.
- Girls can perceive science and technology as subjects that are incompatible with their ideas of femininity and lacking in the human-centred aspects important to their value systems.
- Relevance to their lives appears to be a key driver influencing whether girls are encouraged into sciences.

"Girls are less likely than boys to aspire to science careers, even though a higher percentage of girls than boys rate science as their favourite subject."

ASPIRES REPORT, KINGS COLLEGE LONDON

- There is evidence that some interventions can be successfully used to influence participation and perceptions of science.
- If more women are to be encouraged to view STEM careers as an attractive option, teachers, careers advisors, work experiences and families need to do more to counter gender differences from an early age.
- Girls often lack self-efficacy, or confidence in their own abilities, in science and STEM subjects even when their performance is equal to or better than that of boys.

3. DETAILED FINDINGS

Differences in participation and attainment in STEM subjects among pupils in Scotland

Scotland-specific research on the differences in participation and attainment in STEM subjects is limited. However, SQA evidence suggests that while overall entries across the STEM subjects at Higher level are fairly gender balanced, there are large differences in the gender balance within the individual subjects. From 2010 to 2014, female learners have been under represented in Higher Technological Studies, Computing, Physics, Graphic Communication and Information Systems, with male learners making up 60% and above of entries in these subjects. Similarly between 2010 and 2014, male learners have been under represented in Higher Biology and Human Biology, with the percentage of male learner entries being below 40%.

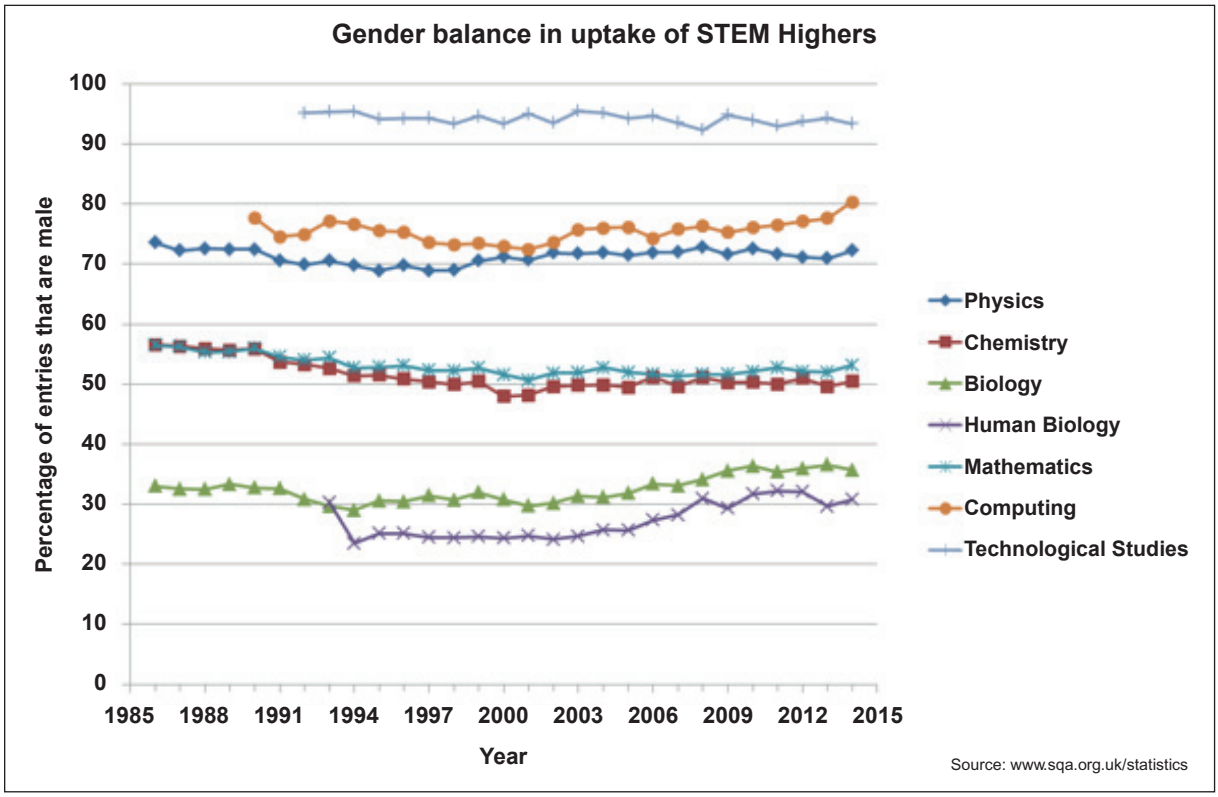

Figure 1: Uptake of STEM subjects. The data shown is an amalgamation of traditional and CfE Highers and in some instances English and Gaelic-medium Highers.

Differences across STEM have also been documented in other countries as highlighted below.

Attainment and ability

- PISA (2006) indicates that whilst gender differences in attitudes towards science are larger in the UK compared to other countries, there are no apparent differences in attainment. Girls who study physics in the UK at GCSE level often attain similarly or outperform boys (Silim and Cross, 2014; Mutjaba and Reiss, 2012).
- Research also indicates there is little difference in mathematics ability (Blickenstaff, 2005).
- International results show that boys often outperform girls at the highest levels on mathematics and science on standardised tests suggesting that girls are under-performing relative to their ability (Mosatche et al. 2013).
- Lubienski (2013) reported that in the USA, performance gaps in mathematics appeared soon after children began kindergarten and widened throughout elementary school.

Participation

- Analysis by Charles (2014) confirmed that gender gaps in participation in STEM careers are greater in wealthier countries.

"In a straitened economy where education is free, the failure to provide a workplace where skilled individuals – whether male or female – can progress and thrive is a wasted investment in human capital and represents a serious loss of potential for Scotland."

SCOTTISH GOVERNMENT, SUPPORTING SCOTLAND'S STEM EDUCATION CULTURE.

Key factors that lead to differences in the participation of STEM subjects and the influence of gender

The factors that lead to differences in the participation of STEM subjects are varied and suggest that:

- Homer, Ryder and Donnelly (2013) analysed long-term patterns of participation in science across England and confirmed that participation was associated with gender.
- Interest in science appears to decline from age 11 although within the UK some studies suggest it begins even earlier.
- Older learners, while believing science in general to be important, often fail to place the same importance on school science. Many fail to see the connection between science and their lives, or future career prospects beyond teaching science or being “a scientist”.
- According to Osborne (2003), role models e.g. teachers, parents, peers and wider society, have a significant influence on whether young people study STEM subjects post-16.

Photo credit: Skills Development Scotland

Attitudes and perceptions

- A study involving over 40 countries, including Scotland, found that most children agreed that science and technology are important. However young people and girls were less positive especially in the richest countries. Few young people were interested in a science career with girls being less interested overall (Sjøberg and Schreiner, 2010). Boys and girls in wealthier countries also tend to have less positive attitudes towards mathematics (Charles, 2014).
- Girls often see the relevance of subjects like biology to their lives, but links with physics appear more difficult to identify. Mujtaba and Reiss (2012) reported that when making choices about physics post-16 this lack of perceived relevance can lead to a decline in interest.
- Girls appear less confident in their abilities when studying physics with confidence levels decreasing as they get older. Similarly Lubienski (2013) found wider gaps in mathematical confidence than in mathematics interest or achievement as children moved through primary school in the USA, though other evidence suggests that confidence levels drop for both genders as they get older.
- Perceptions of science as 'clever', 'geeky' and 'not nurturing' were not consistent with girls' constructions of being feminine e.g. 'girly', 'caring', 'active' (Archer et al, 2013). Studies, such as one by Capobianco et al (2011), also indicate that some STEM subjects are viewed as 'male'. For instance, when young pupils were asked to draw pictures of engineers the majority drew a man.

"When it comes to good teaching, one must look at the children you are going to teach and know what will appeal. This means knowing your students and understanding why they are studying physics."

HEAD OF PHYSICS
IT'S DIFFERENT FOR GIRLS REPORT – INSTITUTE OF PHYSICS

- Silim and Crosse (2014) claimed 16 is the critical age at which women are lost to an engineering career as choices made at this stage are based on attitudes and perceptions that have developed in earlier years.
- The way STEM subjects are taught also appears to influence girls' experiences. Evidence suggests that girls may learn better in small groups or private study and do not enjoy approaches which include rote memorisation, and have little discussion. Similarly role allocation/rotation especially in practical work results in better learning for both girls and boys.

- Boaler, Altendorff and Kent (2011) highlighted that in three popular science textbooks females were shown cooking and working in professions such as singing. Men and boys were shown using complex equipment or working as scientists and doctors.

Role models

- A survey by Rodrigues, Jindal-Snape and Snape (2011) found that parents' wishes were a major factor influencing the career choice of 14 and 15 year olds studying science.
- Girls are often not aware of females working in the field and the examples of scientists they encounter are men.
- According to Yazilitas et al (2013) peers can influence stereotypes and punish non-conformity.
- Introducing positive role models as a stand-alone intervention has little effect on the uptake of sciences.

4. INCREASING THE PARTICIPATION OF GIRLS IN SCIENCE-BASED SUBJECTS, PARTICULARLY PHYSICS AND ENGINEERING

School initiatives

- Mosatche et al. (2013) reviewed out-of-school initiatives designed to engage secondary aged girls with science and mathematics. The most successful were those that connected science and mathematics to real-life experiences, were practical and hands-on, and had relevance to their lives.
- Holmes et al. (2012) paired female college engineering students with school-aged girls and found that having a mentor did have an impact but the quality of the relationship was the most significant factor influencing the girls' confidence.
- Harkness and Stallworth (2013) analysed the participation of high school girls struggling with mathematics. Two themes that emerged were: lack of connection to the knowledge; and lack of confidence in their own independence when doing mathematics. The authors suggested that schools could be more active in helping girls 're-perceive' mathematics.
- The Institute of Physics (2013) stated that physics classrooms and whole-school culture needed to change for progress in gender differences to be realised.

Recommendations to help change gender balance in STEM from the Institute of Physics (IOP):

- Whole-schools measures to counter gender stereotyping
- Reflection on curricular content and types of assessment in gendered subjects
- Care not to reinforce gender stereotypes even at primary school level.

5. REFLECTIVE QUESTIONS

- Is there a difference in the engagement, attainment and participation of boys and girls in STEM subjects in our establishment, or in their perception of STEM subjects? What evidence do we have to support this?
- How do the research findings reflect the experience of our establishment?
- What steps have we already taken to address gender issues in STEM subjects and how successful have they been?
- How can we engage with parents and the wider community to tackle the cultural issues that prevail around girls and STEM?
- How could we ensure a coherent whole-school or setting approach to gender in STEM?

6. SUGGESTED ACTIONS

Tackling gender issues in STEM is a complex problem that will require sustained action, commitment and monitoring. The following list provides suggestions to get you started:

- What is your starting point? Undertake a baseline assessment of the current situation in your school or setting in relation to gender balance in STEM subjects. Gather views and experiences from learners, teachers and parents. Secondary schools can use the Insight tool to track progress.
- Engage with further research in this area and find time to engage in dialogue with colleagues. GTCS registered teachers can access research through GTCS' Education hub: http://www.gtcs.org.uk/research-engagement/research.aspx. A full list of the references used to inform this briefing is available from: http://www.educationscotland.gov.uk/STEMgenderbalance.

- Pick one aspect of gender balance relevant to your school. Develop a small-scale intervention to address it. Evaluate the impact. If it proves effective, scale it up.
- Organise class observations or learning rounds to investigate unconscious bias.
- Review resources, contexts and examples used for learning and explore ways to make learning more relevant for all learners.

- Build positive practitioner-learner relationships and find ways to build the confidence of learners, especially girls. Make them feel valued and included and show you care about them and their future. Friendly advice and encouragement to pursue STEM careers, where appropriate, can be highly effective.
- Encourage parental engagement – emphasise the importance of careers in STEM and the opportunities for both girls and boys. Make parents aware of positive messaging they should be reinforcing in the home. Invite parents and former learners into your establishment to discuss their STEM career and the route they took to get there.
- Embed career awareness and progression routes to STEM careers in learning and teaching and the whole school environment.
- Review your curriculum, assessment and planning processes in light of findings and research.

Remember – getting 50% boys and 50% girls to choose a STEM subject or engage in a STEM club isn't necessarily the objective. The aim is to ensure that all gender barriers are removed. In some cases this will mean that on paper there is still the appearance of gender imbalance, but free and informed choice is important too.

"There are some very encouraging signs of progress. In the last two years, the number of women working as professional engineers in the UK has gone up by 13,255 – more than double the number in 2012."

WISE CAMPAIGN, 2014.

FURTHER READING AND RESOURCES

Girls in the Physics Classroom (2006) (http://bit.ly/girls_physics) Institute of Physics

Girl Friendly Physics (2015) (http://bit.ly/girl_friendly) Institute of Physics

Science: it's a people thing – discussion workshop for girls (2015) (http://bit.ly/People_thing) Institute of Physics

Aspires: Young people's science and career aspirations age 10 – 14 (http://bit.ly/Aspires) Department of Education and Professional Studies, King's College London, November 2013

Relevance of Science Education (ROSE) Project – Overview of key findings (http://bit.ly/Rose_project) University of OSLO, March 2010

Unconscious bias (http://bit.ly/Unconscious_bias) Shire Professional Charted Psychologists, 2010

Equality and Diversity Toolkit (http://bit.ly/E_D_toolkit) Centre for Science Education, Sheffield Hallam University, 2009

WISE (http://bit.ly/wisecampaign) A campaign to promote women in science, technology and engineering

Girls into STEM (http://bit.ly/girls_into_stem) Initiative providing STEM grants, robotics kits and competitions

Tapping all our Talents: Women in STEM, a strategy for Scotland (http://bit.ly/Tapping_Talents) Royal Society of Edinburgh, April 2012

NASA: Women of STEM (http://bit.ly/NASA_Women_STEM) Biographies of women past and present working at NASA

Further resources and advice on gender in STEM are available from:
Web: **www.educationscotland.gov.uk/STEMgenderbalance**
Email: **enquiries@educationscotland.gov.uk**

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