WOMEN IN STEM

MATRIX Position Paper, May 2018

MATRIX
NORTHERN IRELAND SCIENCE INDUSTRY PANEL

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Acknowledgements

This report is the outcome of a stakeholder engagement exercise conducted by MATRIX, the Northern Ireland Science Industry panel. The aim of the engagement has been to identify the issues that are prevalent within STEM sectors from across academia and industry, and bring together the latest thinking on activities that will positively influence broader STEM participation, in particular the issue of gender diversity in STEM in Northern Ireland.

MATRIX would like to thank the many willing stakeholders who took part in the consultative phase of this study. Without your contributions, we would not have been able to capture the full extent of the challenges we need to overcome and the action we now need to take if we are to make real progress in the months and years ahead.

We are indebted to the many contributors to our workshop, case studies and points of focus within this document. It is clear that we already have truly inspirational role models and exceptional initiatives which, with effective leadership, could go a long way to support our mutual aim; to maximise Northern Ireland's social and economic potential.

In November 2017 MATRIX hosted a Women in STEM workshop at the Titanic Belfast and had the pleasure of welcoming students, and their teachers, from four local schools. The insight garnered from each of the students was incredibly valuable, reinforcing and enhancing key messages that were developed during the day. Thank you to Ashfield Girls High School, Belfast Royal Academy, Strathearn School and Wellington College Belfast, your students were an inspiration to us all.

MATRIX would like to particularly thank Professor Eileen Harkin-Jones OBE, Bombardier-Royal Academy of Engineering, Chair in Composites Engineering at Ulster University and Dr. Bryan Keating OBE, Matrix Ambassador and former MATRIX Chair.

Foreword

Prof. Cathy Gormley-Heenan

I am delighted on behalf of MATRIX to present a report examining the participation and progression of girls and women in STEM in Northern Ireland. Over the course of this study we have engaged with industry, academia, government and associated education liaison bodies, third party organisations involved in STEM initiatives and outreach activities, post-primary students, teachers and women working in STEM roles. We have listened carefully to the views of all.

Competitiveness and productivity is an absolute economic imperative and Northern Ireland must commit to supporting the engagement of all of our resources in that competition. To do this we must work in partnership, combining resources to ensure a much greater, collective impact - we have the same objective after all, to support women in STEM education and in their careers.

Engaged leadership is key to progressing the STEM agenda in Northern Ireland and the development of an effective regional STEM strategy is crucial. With a complex landscape of skills provision, education, careers, outreach and supporting initiatives, coordination and liaison are essential activities. If we are to develop a more cohesive and impactful approach to delivering on much needed STEM skills and tackling diversity challenges, then the whole area of coordination under effective leadership needs to be addressed as a priority.

It is not the intention of this report or its recommendations to burden young girls with the pressure of choosing STEM as their career because that is where they are needed. Instead, it is to ensure that the next generation have been equipped to make better informed choices, to be aware of all of the opportunities and pathways available to them and for them to decide what they believe is the right fit for them.

Furthermore, to ensure that if they do chose STEM as a career path, that they will be supported in an inclusive environment and to have the same opportunities for career development, progression and reward as any other employee.

Executive Summary

With every MATRIX report published to date the issue of STEM skills shortages[1] has been prioritised as a barrier to growth in Northern Ireland's (NI) science & technology sectors. A major contributing factor to which is the significant gender imbalance across the STEM skills pipeline. The 2016 Advanced Manufacturing, Materials & Engineering (AMME)[2] and Digital ICT[3] reports documented continued, poor representation of women in their respective sectors, in particular.

Northern Ireland faces a significant STEM shortfall in the immediate term and that shortfall is set only to increase as future demand for STEM skills increases. Encouraging more women into STEM and subsequently supporting them to remain in this skills pipeline, could go a long way to solving those skills shortages. In examining the issue, MATRIX points to the persistent disengagement of girls in core STEM subjects between GCSE and A Level/FE as being absolutely critical:

In 1999, 11,943 boys and 11,104 girls were born in Northern Ireland.

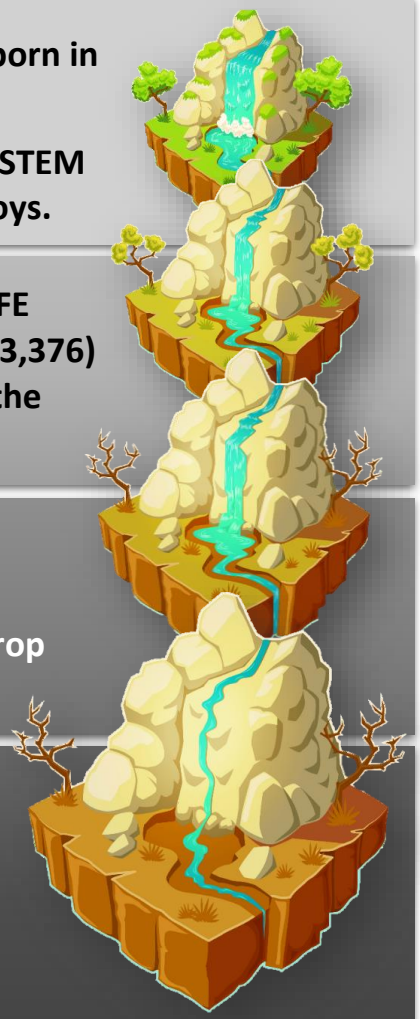
In 2014/15, 87.6%* of the girls (9,647) took STEM GCSEs, compared to 91%* (10,873) of the boys.

But when it came to Core STEM A levels or FE vocational exams in 2016/17, only 30.7%* (3,376) of girls took one. That compares starkly to the 85%* (10,221) of boys who did so.

So the decline in girls participating in Core STEM between GCSE & A Level/FE is anticipated to be 65%, compared to a 6% drop off for boys.

The gender imbalance in Core STEM participants can never recover from this catastrophic decline, so to understand the imbalance we must understand what puts girls off Core STEM at GCSE/A level/FE.

*Projections based on UK WISE rates of qualifiers.



[1] MATRIX Reports

[2] AMME Report. MATRIX. 2016

[3] Digital ICT Report. MATRIX. 2016

It follows therefore, unhappily, that not nearly enough of NI's young people go on to pursue a future career in STEM. By age 18, 83% of the region's total future workforce have turned their back on a career in those very priority sectors expected to deliver growth and prosperity for all. But the fact that so many girls in particular opt out makes this the single biggest challenge facing NI's government and employers today.

Only 7.8% girls currently pursue STEM to the point of employment in a STEM role.

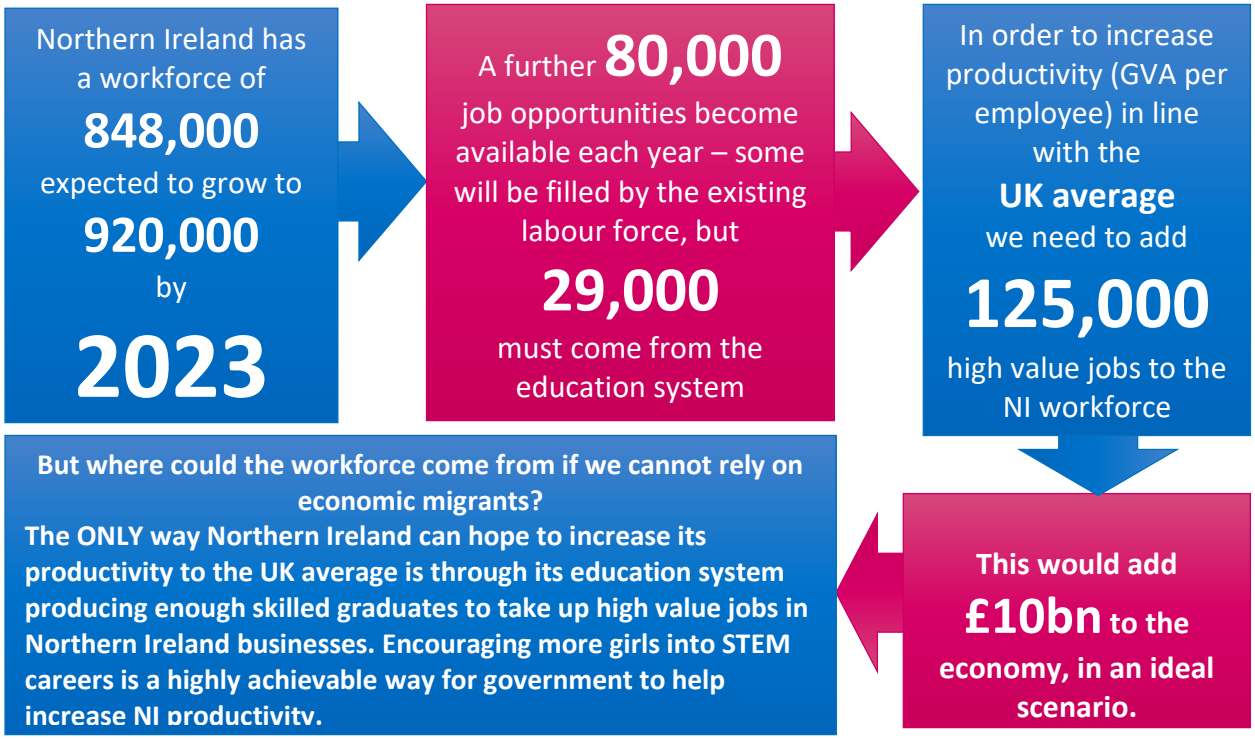
That's the same % as in 2008 and in the modern vibrant economy that Northern Ireland aspires to be, that's a shocking supply chain failure. It is difficult to imagine a manufacturer running a production line where around 40% of the resource at the beginning never makes it to the end of the line, never mind onto the market, but that's what happens with girls in STEM.

We must prepare for the economy we need to become

In an era where high growth in technology investment and industry is regarded globally as a key driver for productivity, it is those knowledge-intensive industries with the greatest potential to sell high value goods and services globally upon which a sustainable and resilient economy must be built.

The addition of higher value-adding jobs to the workforce is essential if overall competitiveness and the ever-widening' NI productivity gap' (NI now 17% behind UK average, 10% in 1997) is to improve.

Figure 1: Productivity - The Scale of the Problem[4]



[4] Sources: Box 1, NISRA; Box2, The NI Skills Barometer (UUEPC, 2017), Boxes 3 & 4, Understanding Productivity in NI (UUEPC, 2017)

Why are girls persistently disengaging with STEM?

A girl's motivation to pursue a Core STEM career can be influenced by self-confidence, stereotypes, educational environment, the perceived attractiveness of the sector and social factors including peers, parents, the presence of role models and media. Girls have lower levels of self- confidence in their ability than boys in mathematics and science and are less likely to continue in STEM education or pursue STEM careers, even within the context where they outperform boys.

Interviews with women in STEM careers across NI found that resilience and determination to succeed, despite the potential barriers, are key. However, the interviewees recorded a supportive home environment where STEM experiences were the norm and the presence of strong role models and mentors as being every bit as important.

At Primary School level

- A shortage of science expertise within primary schools across NI means just 12% of NI pupils in year 5 (age 9) are taught by teachers who have a science specialism and 18% by teachers who have a maths specialism (international averages, 38% and 41% respectively). A 2017 NI assembly research paper identified broader STEM issues in NI's primary schools:-
- The science and technology elements were underdeveloped in 54% of schools inspected;
- While 91% of teachers surveyed felt very prepared to teach maths (above international average), only 54% felt as ready to teach science (below international average).

At Secondary School level

- Gender dynamics in the classroom and school environment are critical. Teachers must be equipped to be proactive in STEM classes, to be aware that boys can easily take over in mixed classes, and to encourage girls to engage in the full breadth of STEM learning.
- Girls' learning outcomes in STEM can also be compromised by psychological factors such as maths or test anxiety and stereotype threat about their ability in STEM;
- Education providers are not adequately equipped with up-to-date knowledge of the various pathways to further study, STEM roles and careers.

At Tertiary level

- Only 14.8% of women pursue further study of core STEM to tertiary level, compared to 35.6% of men with women particularly underrepresented in engineering (14%) and computer science (16%).
- Both male and female staff in tertiary institutes have been found to present behaviours which subtly favour male students (staff more likely to respond to emails from male students, spend more time mentoring and more likely to seek participation from males in class). The presence of a female lecturer has a positive impact on women's participation.
- Careful consideration of course titles may contribute to more women enrolling on core STEM (traditionally male-dominated) courses e.g. greater cognisance of girls' career ambitions to bring solutions to the world for greater societal benefit.

In employment

- Despite women comprising almost half (48%) of the entire workforce in NI their representation in non-traditional, STEM occupations remains low.

- Women in STEM leadership roles, i.e. management, directorships and as senior officials remain underrepresented across all STEM fields (17% average).
- A critical point in the STEM women's career path arises during their mid-late 40s: representation at higher levels drop by 6% from 22% ; and continues to shrink until by retirement only 6% of science, research, engineering and technology professionals in NI are women.
- A recent Royal Academy of Engineering (RAE) report highlighted: "The perception that there is no 'crisis of inclusion' or burning platform, to drive action (rather a consistent pattern of low levels of inclusion with regard to women engineers)", as a potential barrier in addressing the fact that only 11% of UK engineering professionals being female.

Creating a more inclusive, respectful and meritocratic employment culture is fundamental to driving diversity in the workplace. Employers committed to proactively addressing gender gaps by embedding diversity strategies, will in turn secure increased growth and prosperity for all.

Conclusion

MATRIX isn't denying the need to attend to other important diversity challenges across the STEM workforce. Absolutely not - more can and should be done. However, as an economy facing ever increasing STEM skills and competitiveness challenges the biggest 'potential win' is indisputably engaging the untapped potential of half of the total workforce, NI's talented girls.

Who knows? In tackling the issues preventing girls from pursuing STEM, it may become more accessible and attractive to more boys too – and all to the good. But we must be clear - if we only promote STEM as an exciting and attractive education or career prospect without first tackling the gender issues set out above; then, at this point in 2018, as with the decade before, we are accepting that we are facing another 10 years of STEM supply stagnation – a further 10 years where the number of girls studying STEM between GCSE and A Levels drops by 65%, year-in, year-out.

And in real terms what that means for society is another generation of girls unable to fulfil their potential, unable to explore the world and wonder of engineering, as it touches every part of our lives - from spaceships to ice skates, the bubbles in chocolate bars to life saving cancer treatment. We are denying our young girls – some of the brightest and most creative talent at our disposal - the chance to make a positive difference to the future of the world around us.

The Prize? NI 2030: STEM READY

- Government commitment to strike out on an ambitious and confident footing could establish Northern Ireland as an **exemplar STEM region.**
- By 2030, **33%** of young people moving into STEM careers are girls
- Every child leaving primary school knows what an engineer does
- Girls can see themselves in **any STEM role**
- Senior management teams in STEM are **fully inclusive** and representative of a diverse workforce

Next Steps

Establishment of a DfE led, cross-departmental working group to develop (by year-end) a STEM action plan fit to deliver NI STEM-ready by 2030.

Recommendations

Leadership & Coordination

Encompassing government, industry and 3rd party representation, with authority to put in place:

- Transformative vision and commitment – challenge the status quo (based on the improvement of science capital to secure future economic and broader societal benefit)
- Address issues identified in relation to existing 'cluttered and complex' support landscape
- Coordination – to support collaboration and share best practice learning
- Key metrics
- Impact measurement

Visibility of STEM

The need to promote awareness of STEM careers is vital, in particular the promotion of:-

- STEM roles to children, parents, subject teachers and careers teachers – at all levels: primary, secondary and tertiary.
- All viable education and career pathways and visibility of earning potential.
- Development of resources to reflect future work opportunities – e.g:
    - Inspirational role models and celebration of women in STEM in NI campaign.
    - NI mentorship programmes (industry – schools; 3rd level students to secondary schools; secondary level pupils to primary schools).
    - Kitchen table skills barometer.
    - NI STEM businesses – case studies.

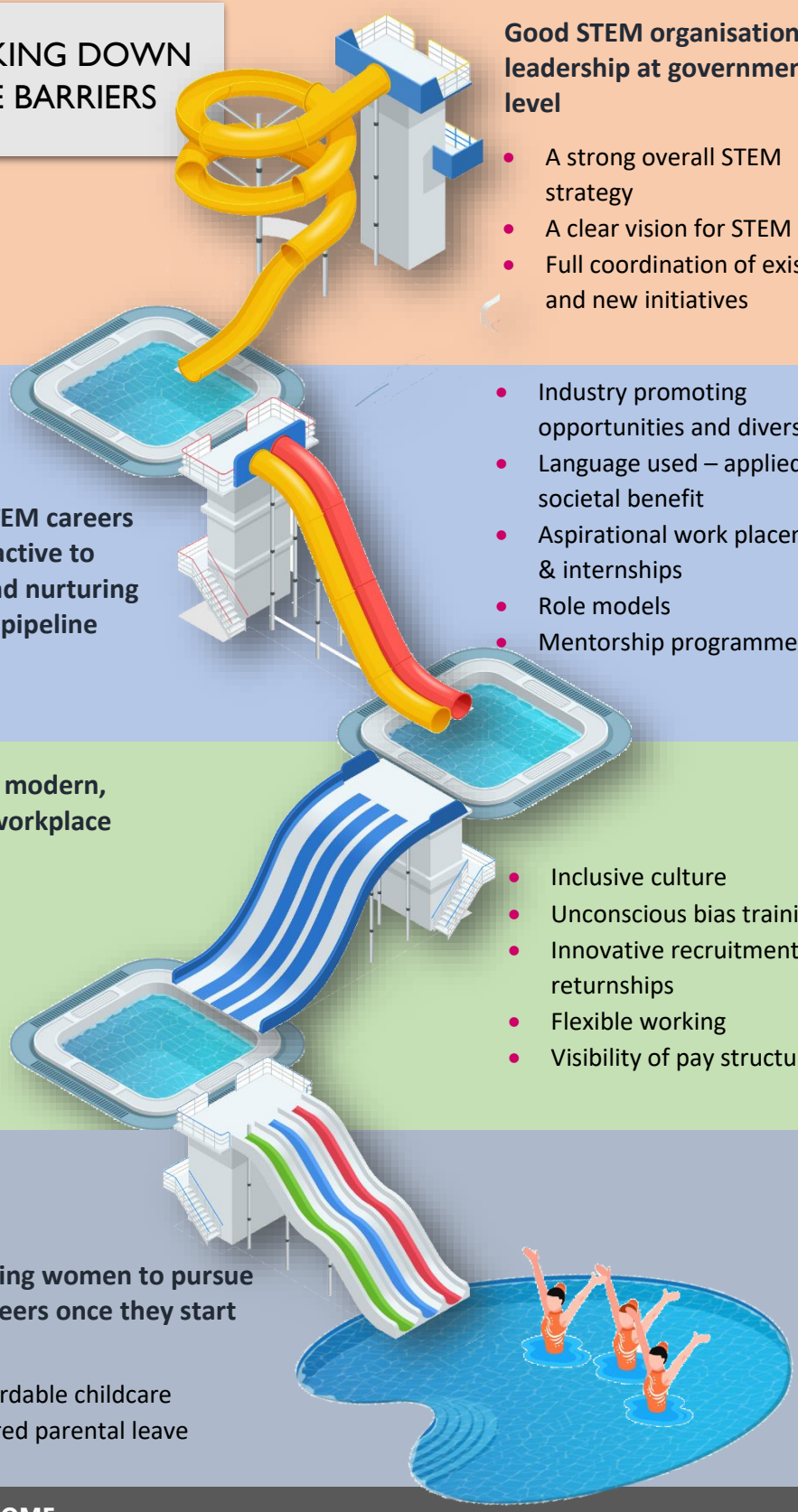
STEM Teaching

- Promotion of gender-neutral learning environments -teacher training to include STEM-specific focus on gender awareness and removal of stereotypes / unconscious bias training.
- STEM areas (e.g. engineering) embedded in initial teacher training and primary curriculum.
- Review need for STEM qualifications beyond GCSE for primary teacher training (explore incentives/use of quotas) and PGCE applicants.
- Time-tabled STEM-specific CPD for teachers, led by industry, with applied industry experience; and STEM-specific industry engagement for pupils.
- Review of metrics at policy level (realign grading towards employability measures). Provide an effective alternative to current league tables to incentivise / drive behaviour.
- Explore incentives to pursue courses in demand by industry (e.g. bursaries/fee reductions) – promoted alongside aspirational career pathways showcasing earning potential and real-world application of learning.

Workplace

- Inclusion and diversity education programme – articulate the return on investment.
- Promotion of benefits / celebration of pro-active employers.
- Re-setting the modern workplace – educate employers around needs of "millennials".
- STEM quality 'award' within the Gender Diversity Charter Mark NI (e.g. Athena Swann adapted /applied to business).

BREAKING DOWN THE BARRIERS



Good STEM organisation and leadership at government level

- A strong overall STEM strategy
- A clear vision for STEM in NI
- Full coordination of existing and new initiatives

Making STEM careers more attractive to women and nurturing the talent pipeline

- Industry promoting opportunities and diversity
- Language used – applied to societal benefit
- Aspirational work placements & internships
- Role models
- Mentorship programmes

Creating a modern, inclusive workplace

- Inclusive culture
- Unconscious bias training
- Innovative recruitment - returnships
- Flexible working
- Visibility of pay structures

Encouraging women to pursue STEM careers once they start a family

- Affordable childcare
- Shared parental leave

THE OUTCOME:
The potential of the entire population to embrace STEM is realized, driving innovation and economic growth, building a better place to live.
33% of core STEM workforce is female

Introduction

Every MATRIX report published to date has highlighted the issue of STEM skills shortages[5] as a barrier to growth in Northern Ireland's science & technology sectors. In addition, a significant gender imbalance across the STEM skills pipeline has been identified as being a major contributing factor. The 2016 Advanced Manufacturing, Materials & Engineering (AMME)[6] and Digital ICT[7] reports documented continued, poor representation of women in their respective sectors, an issue which the MATRIX panel believed merited further examination and which this report sets out to address.

As a region, we face a significant STEM shortfall in the immediate term and that shortfall is set only to increase as future demand for STEM skills increases. Encouraging more women into STEM and subsequently supporting them to remain in this skills pipeline, could go a long way to solving those skills shortages. The persistent disengagement of girls in core STEM subjects between GCSE and A Level/FE is absolutely critical:

In 1999, 11,943 boys and 11,104 girls were born in Northern Ireland.

In 2014/15, 87.6%* of the girls (9,647) took STEM GCSEs, compared to 91%* (10,873) of the boys.

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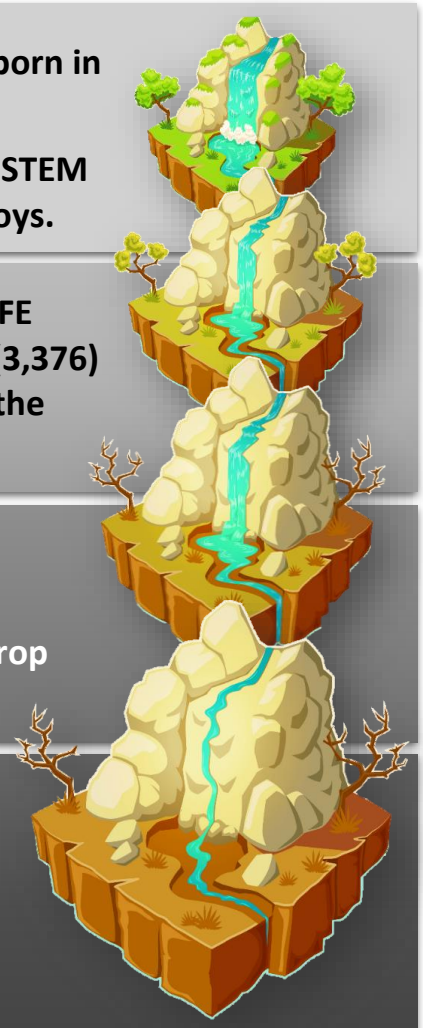


[5] MATRIX Reports

[6] AMME Report. MATRIX. 2016

[7] Digital ICT Report. MATRIX. 2016

Time for action

In commissioning this study in 2017, the MATRIX Panel set out to:

- develop recommendations to government regarding future policies and interventions necessary to address the challenges facing girls in NI when considering a career in a STEM-related area
- advise government on policies which would support women in, or wishing to return to STEM careers

The publication of this report is timely and MATRIX will work to progress its recommendations with the relevant government departments.

From the MATRIX AMME report, 2016:

"…the proportion of women in AMME careers **has remained unchanged at 16% since the 2008 Matrix report** (% of women in manufacturing static at 22%; women in all industries static at 52%). Median gross earnings in AMME are 26.7% higher for males (£28,253) than for females (£20,717)".

From the MATRIX Digital ICT Report, 2016:

"…women make up around 30% of employees in ICT businesses according to NISRA. **Just 18% of IT specialists in Northern Ireland are female**".

STEM skills are fundamental to the future prosperity of Northern Ireland.

In 2018, in Northern Ireland, we find a region starved of the STEM skills employers need to remain competitive and grow. Yet government, academia and STEM employers all share a determination to grow a future economy which will see demand for those skills only ever increase. The need to grow the STEM skill supply base is imperative – and there is an obvious solution. That is not to say it is a simple or straightforward solution - on the contrary, the whole area is challenging and complex.

Not nearly enough of the region's younger generation pursue a future in STEM. By the age of 18, 83% of the region's total future workforce have turned their back on a career in those very priority sectors which are expected to deliver growth and prosperity for all. But **the fact that so many girls in particular opt out makes this the single biggest challenge facing NI's government and employers today**.

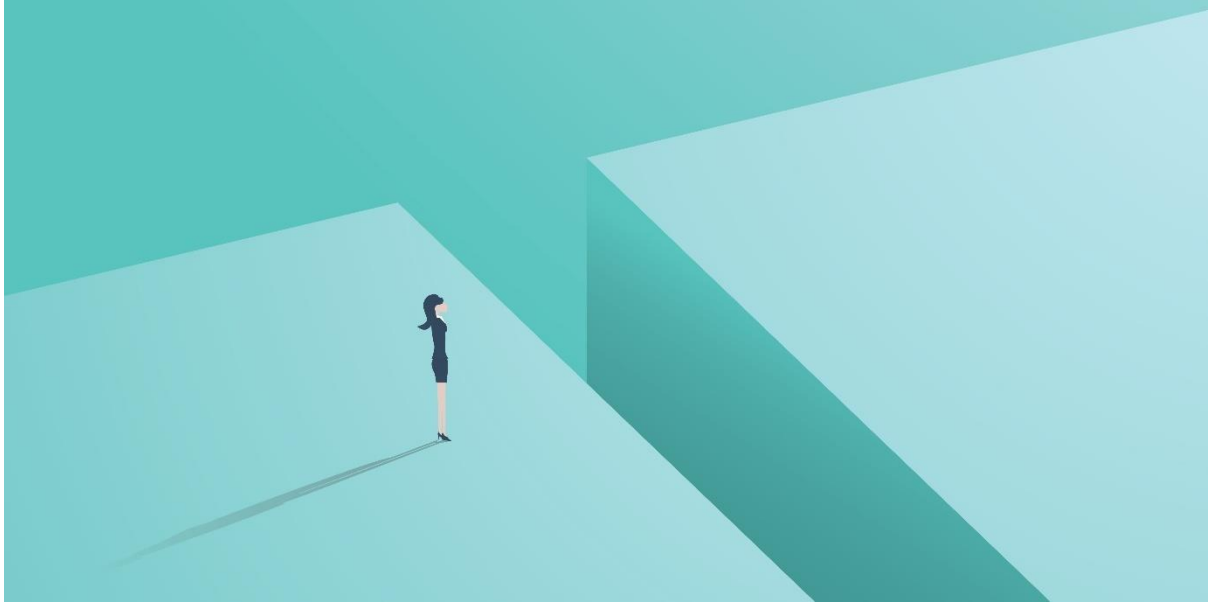
Supply Chain Failure: From Source to Science

Only 7.8% girls currently pursue STEM to the point of employment in a STEM role.

That's the same % as in 2008. In the modern vibrant economy that Northern Ireland aspires to be, whether today or by 2030, that's a shocking supply chain failure. **It is difficult to imagine a manufacturer running a production line where around 40% of the resource at the beginning never makes it to the end of the line, never mind onto the market.**

Yet, as a society, a government, an education system, as potential employers and as parents for the past 10 years that is exactly what we have continued to allow.

Girls in NI leave education disengaged from STEM while, at the same time, early and mid-career women don't pursue or don't return to STEM employment.



What's stopping girls in their tracks?

At every level there are hurdles and barriers, some blatant, some subtle, but all making STEM more difficult for girls. That is, more difficult relative to other subject choices; more difficult relative to boys; more difficult to remain; more difficult to return; more difficult to progress….

By the same token these difficulties are neither new nor novel. Northern Ireland is not unique, this is a multi-national problem (unless of course you are China and then 40% of engineers are women… or India, where women account for 30% of engineering undergraduates).

The root causes at each stage of disengagement are many, varied and without doubt or exception, complex.

But they **are** known.

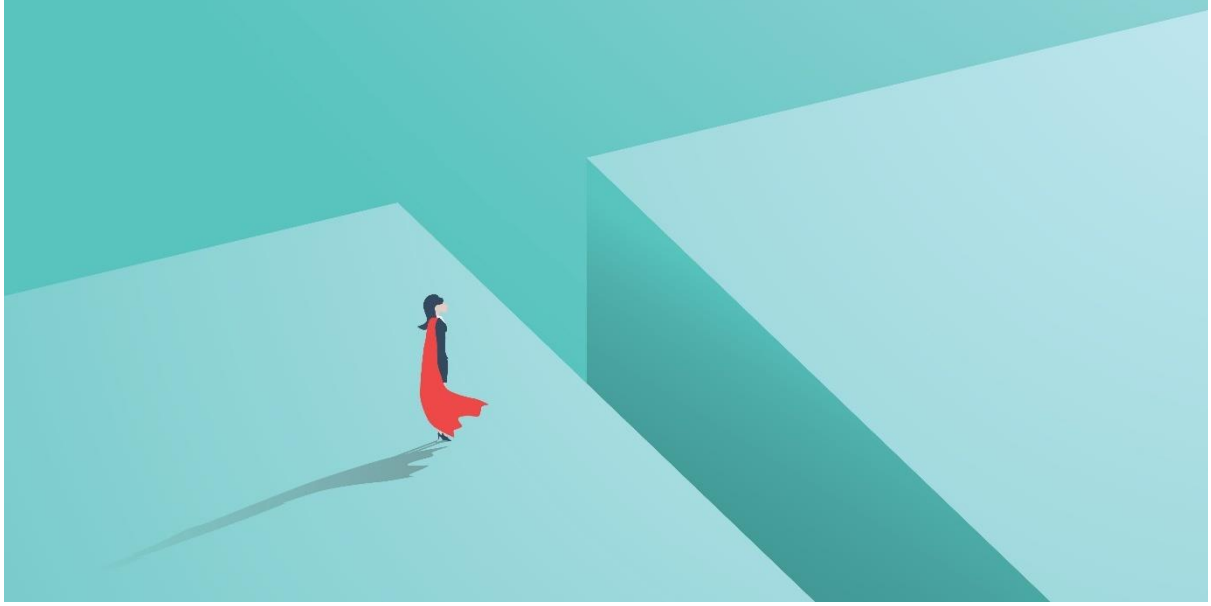
So they **can** be fixed.

What can we do to build confidence in young girls?

How can we convince them that a career in a STEM subject offers opportunities to travel, build solutions to real world problems and work on exciting projects as part of a team?

STEM careers are well paid, with a wide range of professions to choose from. Most importantly, a degree in a broad STEM subject equips students with a flexible and analytical approach to their work which will be valued throughout their career.

So how do we encourage girls to study and remain in STEM?



The position in 2018

As a region, we face a significant STEM shortfall in the immediate term and that shortfall is set only to increase as future demand for STEM skills increases.

Northern Ireland: Economy 2030

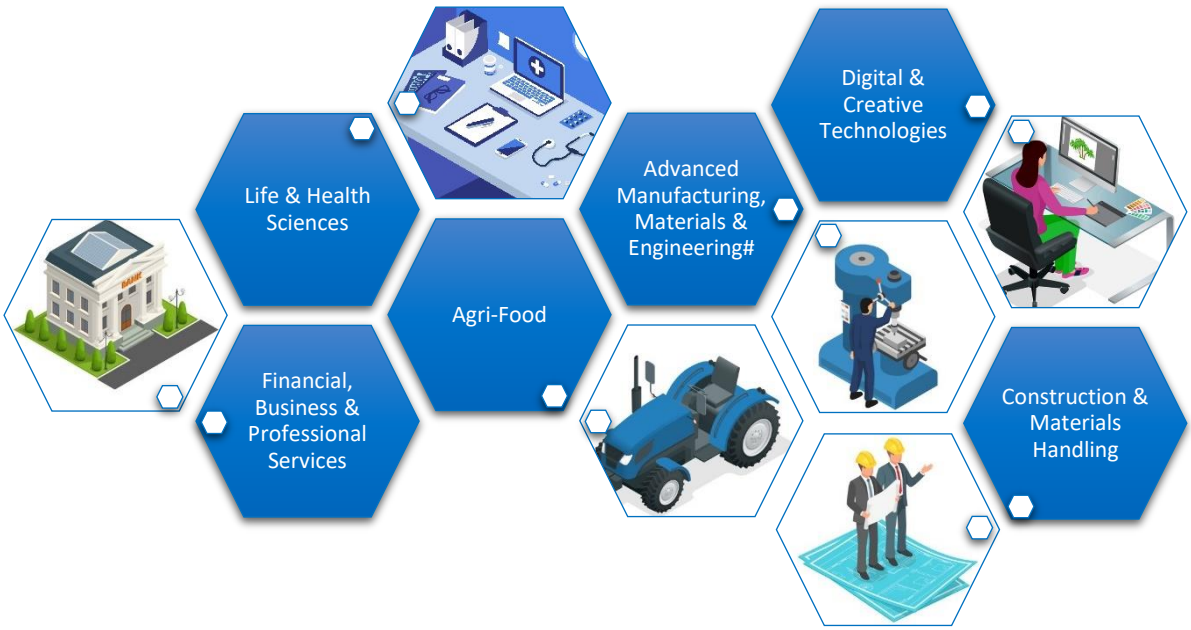
The Draft Northern Ireland Economic Strategy (published in 2017) set out the following vision:

"To be a globally competitive economy that works for everyone"

It also set out the ambition to build:

"An economy built on talent, which delivers excellence and relevance in education and skills and where **everyone** is supported to achieve their full potential".

Strong growth in the following sectors will be required for Northern Ireland to achieve the economic ambition Economy 2030 presents. All of which points to a clear demand for STEM skills to satisfy the growth of indigenous and existing multi-nationals located in the region and also to attract potential future inward investment in STEM sectors.



"To enable sustainable growth, NI must develop policy to drive real, transformative improvement in Education and Skills." (EAG)[8]

[8] NI Economic Advisory Group, Summary Competitiveness Report, July 2016 www.eagni.com

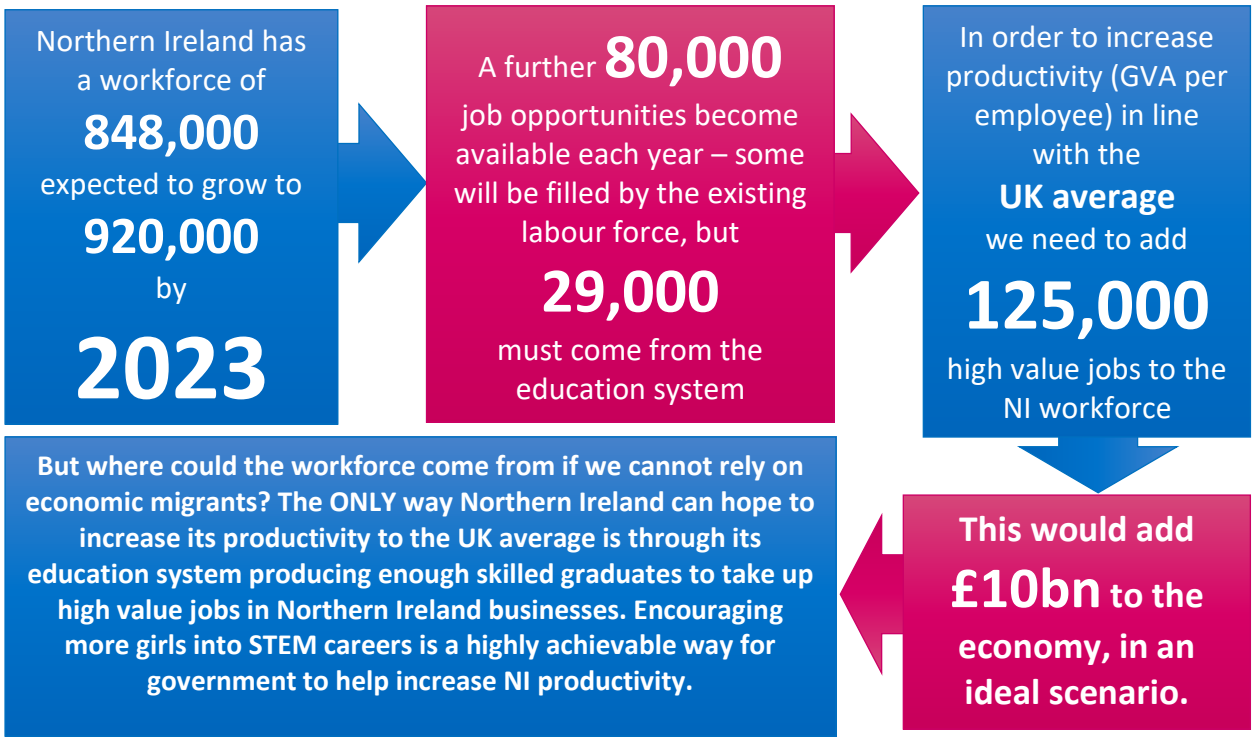
We must make preparations for the economy we need to become

In an era where high growth in technology investment and industry is regarded globally as a key driver for productivity, it is those knowledge-intensive industries with the greatest potential to sell high value goods and services globally upon which a sustainable and resilient economy must be built.

Productivity

The addition of higher value-adding jobs to the NI workforce are essential if overall competitiveness and the ever-widening' NI productivity gap' (NI is now 17% behind UK average, 10% in 1997) is to improve.

Figure 2: The Scale of the Problem[9]

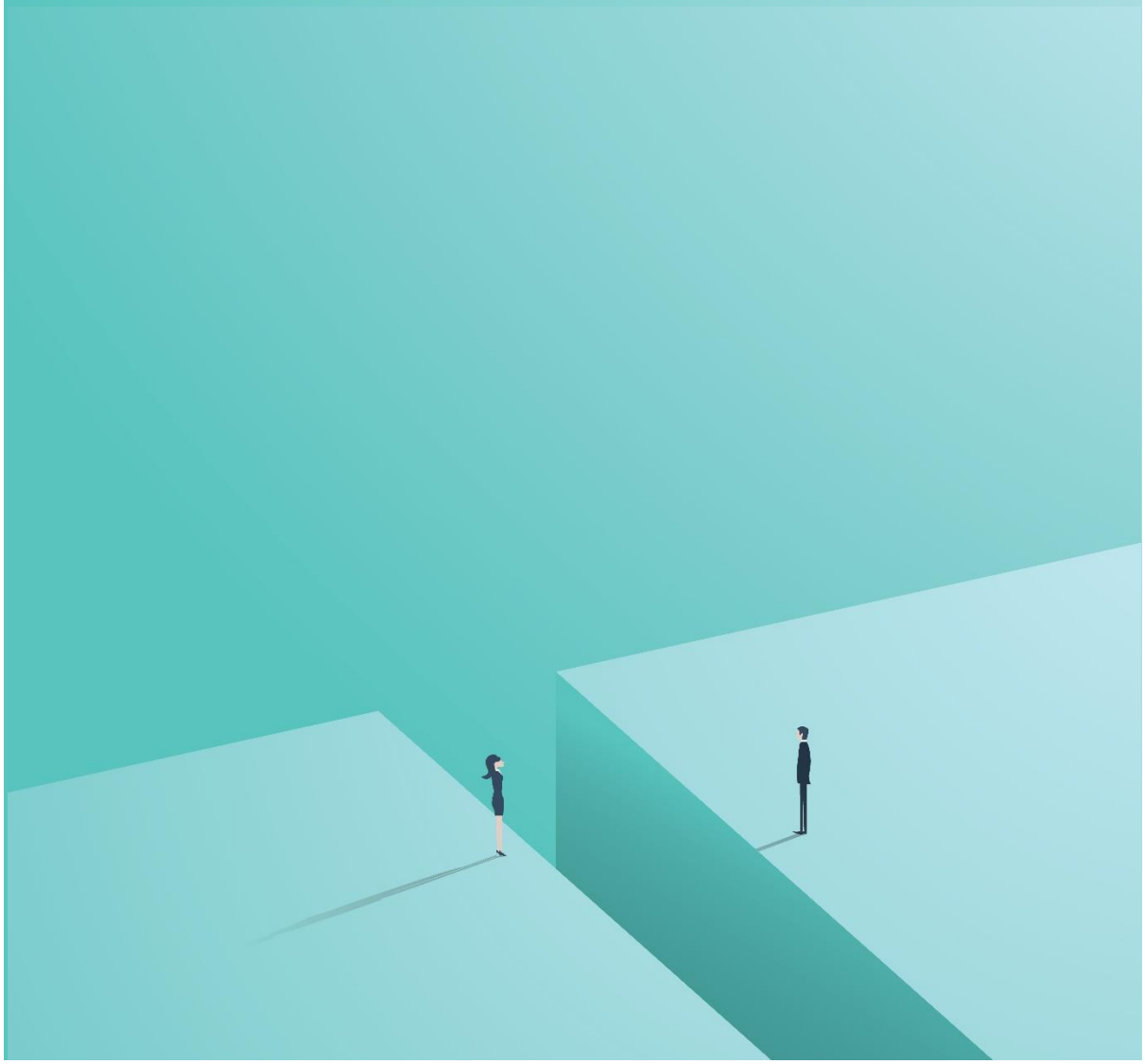


Sources: Box 1, NISRA; Box 2, The NI Skills Barometer (UUEPC, 2017), Boxes 3 & 4, Understanding Productivity in NI (UUEPC, 2017)

[9] Understanding Productivity in Northern Ireland, UUEPC, 2017 and the NI Skills Barometer (UUEPC, 2017)

"all sectors need to increase diversity within their talent pools and their leadership to benefit from the range of perspectives, creative thinking and skills needed…the current moment thus offers a strategic win-win opportunity to proactively enhance gender equality and prevent widening gender and skills gaps"

The Global Gender Gap Report, World Economic Forum, 2017



The substantial and persistent disengagement of **girls** studying STEM disciplines has been a particular concern for policy makers, striving to restore the balance through a multitude of interventions over many years, with little impact.

In all OECD countries, while girls envisage themselves as health professionals and are almost three times as likely as boys to expect to work as doctors, veterinarians or nurses; Boys are more than twice as likely as girls to expect to work as engineers or scientists. On average only 0.4% of girls, but 4.8% of boys, expect to work as ICT professionals. (PISA). We also know that by age 14, most young people's attitudes to science and considerations for future careers are fairly fixed. "The majority of young people have high aspirations – just not in science" (Aspire, King's College London).

Interestingly, the vast majority of NI pupils view school science as relevant to their future with a third of pupils expecting to work in a science-related occupation in the future, more than any other country in the UK. Furthermore, they held these views irrespective of their gender, socioeconomic status or aptitude for science. However this is not reflected in NI performance nor does it translate into personal choices to study science further. It is this **persistent disengagement** of so many pupils in science and other STEM subjects that is a major contributor to the skills shortages NI faces today.

What is putting girls off subjects like engineering, computer science and physics?

At what specific points do they become disengaged, and why?

According to a study by UNESCO, "Gender differences have little or no influence on academic or cognitive ability, including in STEM subjects".

In any case, the issue is not one of performance - on the contrary, girls regularly outperform boys in STEM exams. The issue is that **very few girls are choosing to study STEM beyond GCSE level in the first place**.

Why are girls persistently disengaging with STEM?

Psychological factors

Several studies have shown that stereotyped ideas of gender roles develop very early in life. For example it has been observed that boys and girls develop preferences for different types of toys by the end of their first year. Furthermore, girls' perceptions of intellectual brilliance in early years has received some research focus[10] and a major theme from stakeholder engagement in NI is girls' apparent lack of confidence in core STEM learning as these disciplines are perceived as being more difficult and are still identified as very much 'male domains'. This supports the 2015 PISA data and UNESCO findings that girls have lower levels of self- confidence in their ability than boys in mathematics and science and are less likely to continue in STEM education or pursue STEM careers, even within the context where they outperform boys.

> "*6-year-old girls are less likely than boys to believe that members of their gender are* ***really, really smart.***"
>
> Also at age 6, girls begin to avoid activities said to be for children who are "***really, really smart.***"
>
> These findings suggest that gendered notions of brilliance are acquired early and have an immediate effect on children's interests.

When students are more self-confident, they give themselves the freedom to fail, to engage in the trial-and-error processes and these are fundamental skills to lowering anxiety and acquiring knowledge in mathematics and science.

A girl's motivation to pursue a STEM career can be influenced by self-confidence, stereotypes, educational environment, the perceived attractiveness of the sector and social factors including peers, parents, the presence of role models and media.

Interviews with women in STEM careers across NI found that resilience and determination to succeed, despite the potential barriers, are key. However, the interviewees recorded a supportive home environment where STEM experiences were the norm and the presence of strong role models and mentors as being every bit as important.

[10] Bian et al., Science 355, 389–391 (2017) 27 January 2017.

"Self-selection bias is the main reason for girls' disengagement in STEM and this is influenced heavily by prevailing social norms and stereotyped ideas about gender roles within STEM disciplines"

UNESCO review of over fifty research papers

2015 PISA data and UNESCO findings both show that girls have lower levels of self-confidence in their ability than boys in mathematics and science and are less likely to continue in STEM education or pursue STEM careers, **even within the context where they outperform boys.**

The importance of role models and mentors

Girls in particular are believed to be more risk averse and the adage, "you can't be what you can't see", is true for most. Visibility of inspirational role models in STEM subjects (with whom girls can identify) can mitigate negative stereotypes, enhance perceptions of STEM and boost girls' enrolment in further study. Likewise, mentors can build girls' self-confidence, increase STEM aspirations, encourage inclusion and ultimately motivate girls to pursue STEM careers.

Family and peer influences

Whether intentional or not, parents with traditional views of education and careers will often discourage daughters from pursuing non-traditional routes; this includes the routes through education e.g. further education versus higher education and ultimately course choices e.g. healthcare versus ICT or engineering. The UNESCO review shows that mothers in particular can have a significant impact on their daughters' beliefs in their own ability and a greater influence than fathers on daughters' decisions to study STEM.

Societal factors

It is well known that cultural and social norms influence girls' perceptions about their abilities, their role in society, career and life aspirations. In the UK, the vast under-representation of females in non-traditional, core STEM roles further exacerbates the impact of societal perceptions. Stakeholders in NI agree that greater visibility of existing female role models in industry and academia would help with this aspect locally.

Stereotypes around 'expected to be good at' numeracy –v- literacy are also unhelpful, with many children labelled by both family and teachers as being stronger in either one or the other. This has the potential to influence girls' attitudes to STEM. For example, when *relative* strengths are considered research finds that in almost all countries (Romania and Lebanon being the exceptions), boys' best subject was science and girls' was reading – i.e. even if an average girl was as good as an average boy at science, she was still likely to be even better at reading. By default then, girls from an early age arguably are identified with being 'better' at English. They are then likely to assume that means they are not so good at maths. Without reassurance, they are also likely to believe that their 'not as good at' is just not good enough.

This particular research goes further to suggest that perhaps girls just aren't that interested – and that the gender STEM gap occurs "not because girls can't do science, but because they have other alternatives, based on their strengths in verbal skills….in wealthy nations, they (girls) believe that they have the freedom to pursue those alternatives and not worry so much that they pay less".

Impact of media

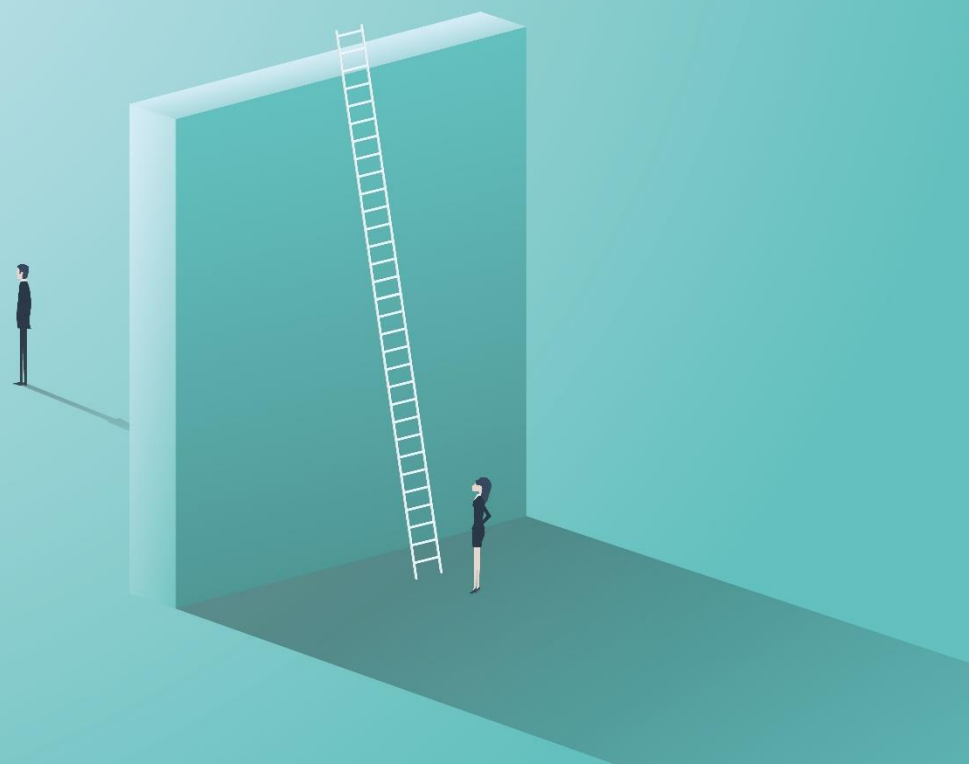
The impact of media and the portrayal of gender stereotypes in all aspects of media are naturally adopted by children and adults and affect the way they see themselves and others. Media can perpetuate or challenge gender stereotypes about STEM abilities and careers.

For example, the BBC recently acknowledged that its network animations had been male-dominated for too long and admitted that gender imbalance was often worse in cartoons than mainstream television. They have taken positive steps to redress the balance on their pre-school channel.

Stereotypes around expectations of being 'good at' numeracy –v- literacy are unhelpful, with many children labelled by both family and teachers as being stronger in either one or the other. This has the potential to influence girls' attitudes to STEM.

For example, when relative strengths are considered, research finds that in almost all countries the boys' best subject was science and the girls' was reading – i.e. even if an average girl was as good as an average boy at science, she was still likely to be even better at reading.

By default then, girls from an early age arguably are identified with being 'better' at English. They are then likely to assume that means they are not so good at maths. Without reassurance, they are also likely to believe that their 'not as good at' is just not good enough.



Promoting STEM success

Another consistent theme from NI consultations was the fact that NI fails to adequately promote or celebrate its successes and achievements in STEM, business or otherwise.

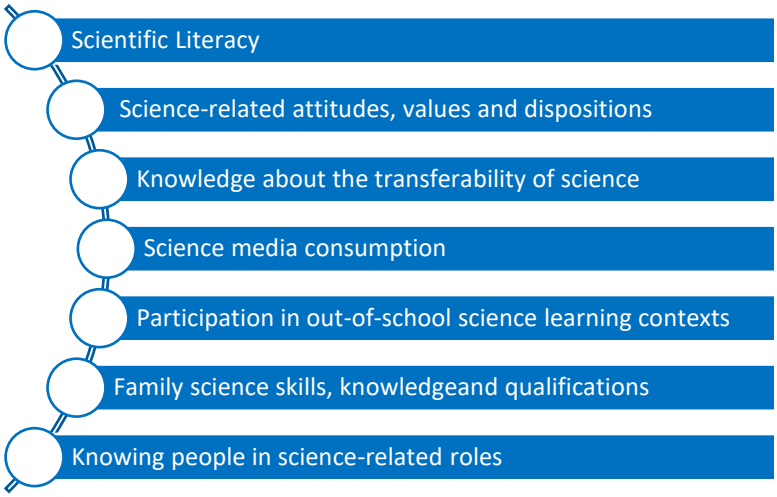
If we don't celebrate our STEM talent, our important scientists, engineers, inventors and entrepreneurs and our rich STEM heritage, then not only are we restricting our reputation on a number of industry and economic fronts e.g. attracting inward investment, opening up to new markets, and collaboration opportunities, but we are also damaging the next generation of STEM students and employees by denying them an understanding of the strengths and capabilities right here in NI.

'Science Capital'

King's College London has carried out research[11] which shows that the more science capital a young person has, the more likely they are to study STEM subjects.

Figure 3: King's College London's Science Capital Dimensions

All of these factors can impact on girls' motivation and feeling of belonging in STEM education.



[11] https://www.kcl.ac.uk/sspp/departments/education/research/Research-Centres/cppr/Research/currentpro/Enterprising-Science/03Research-Outputs.aspx

Primary School – What Happens?

Teaching science for girls

The quality and confidence of teachers teaching STEM subjects is critical, across all levels of education, with their attitudes, beliefs and interactions impacting on girls' enjoyment, motivation and ultimately their choice of further study and career. There is a shortage of science expertise generally within primary schools across NI with just 12% of NI pupils in year 5 (age 9) taught by teachers who have a specialisation in science (compared to international average of 38%) and 18% taught by teachers who have a specialisation in mathematics (compared to international average of 41%).

Gender awareness; gender bias training; language and participation

Creating a classroom environment that treats girls and boys equally is important for the educational success of students. However gender equality does not stop with the teacher. It is also important that the materials used do not contain gender bias in activities, photos, or words. Textbooks, images, reading materials, written assignments, or even test materials used on a daily basis in the classroom can reinforce stereotypes about gender roles in society and influence girls' perception of STEM related areas and where they fit in those areas.

NI Primary Curriculum

A major concern voiced by many stakeholders to date is the lack of exposure to practical, inquiry based science in the region's primary (and secondary school) curricula, with many stating there are fundamental challenges to overcome if we are to provide adequate STEM learning. Furthermore, industry is concerned that the curricula fail to reflect the future skills needs of the NI economy.

A 2017 NI assembly research paper found important broader STEM issues in NI's primary schools:-

- The science and technology elements were underdeveloped in 54% of schools inspected;
- While 91% of teachers surveyed felt very prepared to teach maths, only 54% felt as ready to teach science; and
- Teaching time was higher than the international average for maths, but below average for science.

Science and digital skills are not standalone subjects in the NI primary curriculum; the 'World Around Us' is an area of learning within the curriculum (Key Stages 1 & 2) that comprises science, technology geography and history. Countries that have demonstrable success in primary science do not take this approach and have a greater focus on science and digital skills in primary level education. Furthermore, the lack of statutory assessment of science and technology teaching within our primary schools is of concern. Whilst the issues found above are not specific to girls-only, they do compound the gender-specific problems which stakeholders identify. Namely, transitions from primary to secondary and from GCSE to A-level in terms of science and technology. The consensus being that a too-wide skills gaps exists at each transition which further exacerbates girls' perceptions that STEM is too difficult. Boys on the other hand are considered to be naturally less averse to risk than girls, with the added draw of men visible in core STEM roles providing boys with a platform from which they go on to choose STEM for further study.

We know that girls in particular are risk averse to non-traditional pathways and in order to develop their own STEM identity, they require a supportive environment and encouragement to explore all of the options available to them. It will be important to better support the development of positive STEM identities in girls and this can be achieved by increasing girls' exposure to STEM experiences from the early years of education through to post-primary and beyond. Experiences should include those outside of formal education and include those in the home, with family (through conversation or additional resources e.g. 'kitchen table' version of the NI Skills Barometer) and informal STEM learning programmes and initiatives (I'm Happy, CoderDojo, science clubs, W5, Girl Guides). Successful interventions will go a long way to improving the desirability of non-traditional sectors to girls.

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Furthermore, the lack of statutory assessment of science and technology teaching within our primary schools is of concern.

Whilst these issues are not specific to girls-only, they do compound the gender-specific problems which stakeholders identify – particularly at the transition from primary to secondary and from GCSE to A-level in terms of science and technology.

Secondary Level – What Happens?

Female STEM teachers in secondary level education can have an immensely positive impact on girls' STEM uptake and outcomes as they serve as role models and help dispel the myth that STEM is just for boys[12, 13]. Unfortunately, NI does not maintain records of its subject-specialist teachers or the gender composition, nor is there an agreed definition of a subject specialist.

Building teachers' awareness of role stereotypes

It is important that teachers understand the key factors that impact on girls' interest and motivation to engage in STEM learning:-

- A lack of encouragement, support and reinforcement can be detrimental to girls' intention to study STEM and;
- The need to dilute girls' anxiety and misconceptions about gender-based ability in STEM fields.

Attention to gender dynamics in the classroom and school environment is critical. Teachers must be equipped to be proactive in STEM classes, to be aware that boys can easily take over in mixed classes, and to encourage girls to participate and engage in the full breadth of STEM learning experiences.

Observing A-Level achievements of girls over the last 4 academic years shows that girls in all-girls schools continue to do better on average than girls in co-education settings and this is also true for six out of the eight STEM subjects studied at A-level (Computer Studies/Computer Science and Information Technology are the exceptions). However, girls studying in co-educational environments are more likely to choose STEM subjects (exceptions to this were enrolments for Physics and Design and Technology A-Levels). Further investigation of the reasons for lower STEM enrolments in single sex environments is required but possible causes could include even deeper engendered stereotypes within single sex schools, peer influence, reduced provision of STEM resources (expertise and materials), timetabling, and focus on non-STEM subject areas. For example, there were no enrolments for Computer studies/Computer science at A-Level in all girls' schools in NI until the 2015/2016 academic year.

Assessment anxiety

Additionally, assessment processes and tools that are gender-biased or include gender stereotypes may negatively affect girls' performance in STEM. Girls' learning outcomes in STEM can also be compromised by psychological factors such as mathematics or test anxiety and stereotype threat about their ability in STEM; In a population of 15 year olds surveyed, around 64% of girls and 47% of boys reported that they agree or strongly agree that they feel very anxious even if they are well prepared for a test.[14] This was a pattern observed across all OECD countries bar only one - Japan. The UK (including NI) does not fare well in relative terms to other OECD countries, with school-work related anxiety among 15 year olds well above the OECD average.

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[12] Unesco GEM 2016: Education for People and Planet, Creating Sustainable Future for All. Paris, UNESCO

[13] TIMMS 2011

[14] OECD (2017), PISA 2015 Results (Volume III): Students' Well-Being, PISA, OECD Publishing, Paris.

Relative attractiveness of STEM sectors to girls

Research tells us that girls aspire to hold careers that are creative and have ambitions to bring solutions to the world for greater societal benefit, but they have difficulty visualising themselves in core STEM roles as they struggle to see the link from the career (often male dominated) to their own personal interests or aspirations and also to their learning experiences. Good, inclusive and female targeted STEM initiatives should be promoted more effectively(e.g. 'People Like Me" from WISE and the IGNITE programme).

Feedback from post-primary school pupils highlighted their concern about 'general science' classes and that they would prefer to have separate classes so that they could better identify competencies and learning topics for each. Girls expressed feelings of confusion and anxiety over subject choices at GCSE and subsequently A-level as they didn't feel they knew what those subjects would involve, nor importantly, where they might lead to.

Sight to Career Pathways : Industry and Academia as partners

Education providers are not adequately equipped with up-to-date knowledge of the various pathways to further study, STEM roles and careers. Links with academia, industry and third party organisations are vitally important in what is now a rapidly changing landscape to help teachers gain the knowledge and experience to begin to overcome these barriers.

The incorporation of applied, topic based learning and experiences to teacher training and continuous professional development is therefore crucial.

An alternative option would be to remove careers teaching and guidance from the school environment. Free up the resource currently invested at individual school level in delivering fragmented, sub - optimal support and create a regional careers specialist unit (mobile / fixed point). Professionally staffed and refreshed by industry on a rolling basis, this would not only provide meaningful, industry-relevant insight to the careers of the future, but it would do so on an equal basis across the regional school network.

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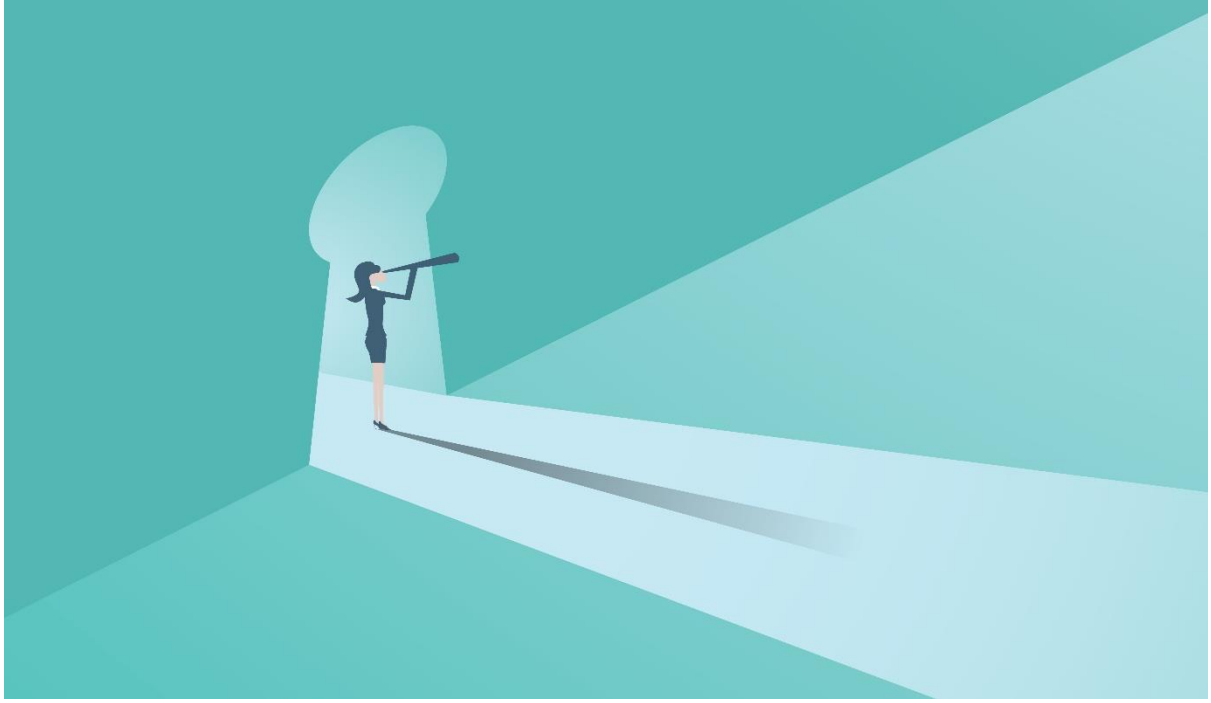

Tertiary Level – What Happens?

We know that few women pursue further study of core STEM to tertiary level, 14.8% compared to 35.6% of men and are specifically underrepresented in disciplines of engineering (14%) and computer science (16%). Having an interest in STEM and being motivated to pursue study and ultimately a career are important factors for girls' retention in STEM education beyond secondary level. However interest and motivation can be influenced by self-confidence, stereotypes, the educational environment, perceived attractiveness of the sector and social factors including interactions with peers and the teaching staff in tertiary institutions.

Subtle biases impact on women's retention in core STEM fields of study

Research into the causes of underrepresentation and attrition of women in core STEM study at tertiary level suggests that it is **"(not) a matter of outright discrimination, but rather the accumulation of smaller experiences that determine whether a female student identifies with and persists in a scientific field"[15].**

Unconscious bias - staff awareness

International research has looked at the impact that staff/student interactions in tertiary institutions can have on female students. Both male and female staff have been found to present behaviours which subtly favour male students e.g. staff more likely to respond to emails from male students, spend more time mentoring males on average, and more likely to seek participation from males in class. The presence of a female lecturer has a positive impact on women's participation in STEM.

Peer interactions are also important and it has been shown in recent research that male students hold a bias against their female peers' competence in STEM furthermore, that this bias progresses throughout the academic year whereas female students are equitable[11].

The study also suggests that the gender dynamics of the teaching environment, males being more out-spoken, strengthens this bias by reaffirming the stereotypes held by peers and staff alike. Teaching staff should be aware of these interactions in the peer group and use mechanisms to mitigate negative impacts e.g. avoid whole of class discussions in favour of small group work sessions or use a randomised class list.

All of these experiences undoubtedly impact on women's self-confidence in male-dominated fields. The presence of an influential person, perhaps a mentor, who can encourage and endorse a female student's abilities is crucial in reinforcing confidence and instilling a sense of belonging.

Use of language and attractiveness of core STEM sectors

The science of naming courses is gaining more and more attention and not least because of the potential for positive influence on gender diversity[16]. Interviews with NI HEIs also suggests that careful consideration of course titles may contribute to more women enrolling on core STEM courses at tertiary level e.g. greater cognisance of girls' career ambitions (i.e. to bring solutions to

[15] Males Under-Estimate Academic Performance of Their Female Peers. Grunspan et al., PLoS ONE 11(2) 2016

[16] Whats in a name? the impact of different course titles on student enrollment. PLoS ONE Blog. 2016

the world for greater societal benefit), when naming course titles could be a major factor in attracting girls to traditionally male-dominated courses.

Another important consideration is the possible negative impact of gendered course material in male-dominated fields of study. Similar to gender bias in recruitment adverts, the language used in course resources and materials, which are more likely prepared by men, could have a negative impact and compound women's lack of self-confidence and sense of belonging within their male-dominated peer group.

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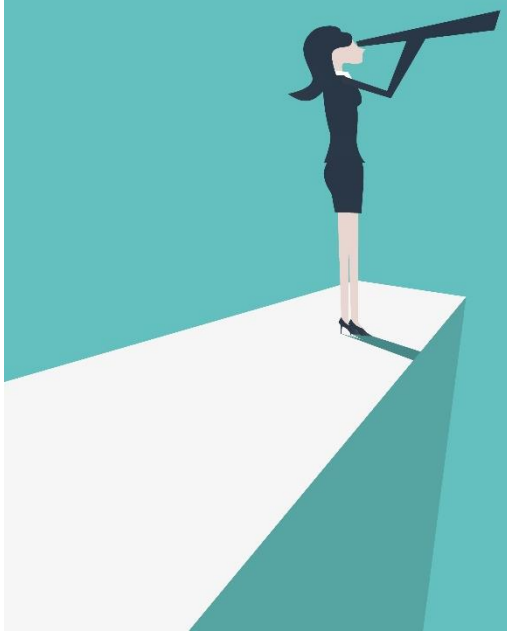
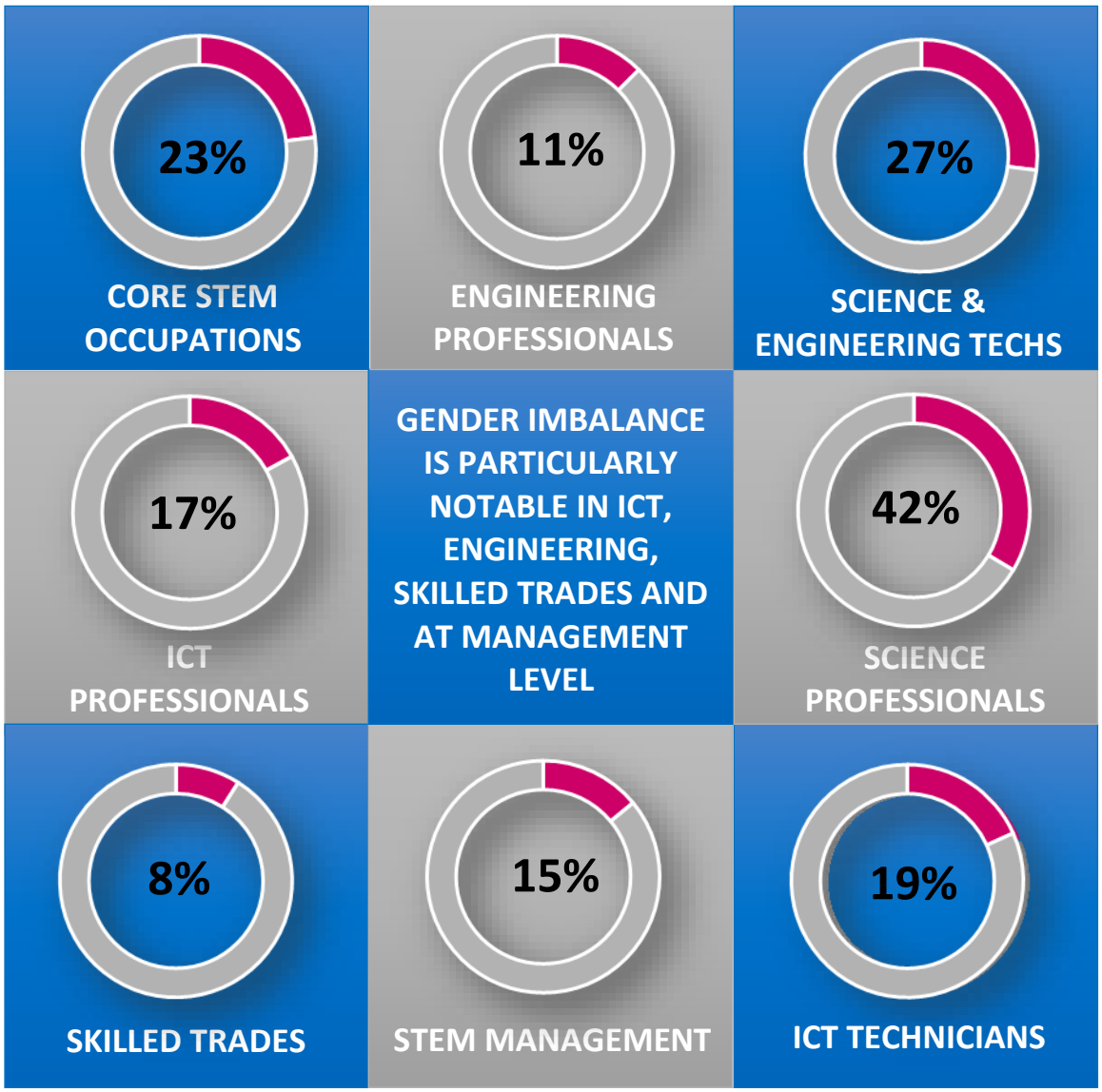
A better understanding of what girls want from a career (for example, solving societal issues) when naming course titles could be a major factor in attracting girls to traditionally male-dominated courses.



Employment Level – What Happens?

Despite the many well intentioned efforts to encourage women into non-traditional STEM occupations, considerable gender gaps remain and particularly within engineering and senior leadership roles. A UNESCO report finds that alongside fewer women entering STEM disciplines, women also leave STEM occupations in disproportionate numbers[17] exacerbating the situation further. The NI Employment survey December 2017 confirms that despite women comprising almost half (48%) of the entire workforce in NI, their representation in non-traditional, STEM occupations remains low. Rather, women dominate the caring, health, education and service sectors in NI. Detailed analysis of the STEM occupations at a regional level isn't available, however UK level data paints a clear picture.

Figure 4: 2017 UK level data on women in STEM jobs



Source: ONS Labour Force Survey

[17] http://unesdoc.unesco.org/images/0025/002534/253479e.pdf

Women in Engineering - "less likely to enter, more likely to leave"

All STEM careers are not pursued – or declined – in equal measure. Rather, the position differs significantly across distinct STEM fields. In the absence of NI-only data, the recent WES Women in Engineering report, based on the State of Engineering in the UK in 2017 survey, highlights:

- 11% of the UK engineering workforce is female. Whilst this is an increase of 2% from 2015, the number of women registered engineers and technicians (i.e. CEng, IEng, EngTech) has dropped from 6% to 5% of the total.
- The UK retains its unenviable position of having the lowest % of female engineering professionals in Europe.
- 15% of engineering undergraduates in the UK in 2017 are women - virtually static since 2012 (this compares to over 30% in India).
- At only 13% in 2014 the number of women in computing degree programmes appears to be falling (down from 14% in 2010).
- Women account for only 6.8% of engineering apprenticeship starts in 2015/16.
- The proportion of women apprentices in engineering is now lower than a decade ago. For ever female apprentice working within engineering there are 25 male apprentices and is possibly in decline (4.6% 2002 to 3.8% in 2014). In construction, male:female ratio is 56:1.
- In 2017, only 11% of engineering companies offer flexible working. Only 15% make any particular efforts to attract and retain – compared to 34% in 2016/18 This evidence of decline should serve as a stark reminder that progress cannot be taken for granted

All this, despite the fact that:

- In a survey of 300 female engineers 84% indicated they were "happy" or "extremely happy" with their career choice;
- Engineering students are 2nd only to medics in securing full time jobs and earning good salaries;
- We know that engineering is an important sector, contributing 26% of UK GDP – i.e. £127,580,000,000.

Inclusion and diversity matters.

The Royal Academy of Engineering (RAE) has undertaken extensive research in relation to inclusion and underlying barriers to progress on inclusion in engineering as part of its Diversity and Inclusion Programme Strategy 2016–2020. In the recently published "Creating cultures where all engineers thrive – a unique study of inclusion across UK engineering"[19], perhaps one of the most striking observations is that a significant barrier may be :

> "The perception that there is no "crisis of inclusion" or burning platform, to drive action (rather a consistent pattern of low levels of inclusion with regard to women engineers)."

[18] Skills and demand from Industry – 2017 survey, IET

[19] "Creating cultures where all engineers thrive – a unique study of inclusion across UK engineering", RAE, Nov 2017

The study clearly shows that how engineers perceive the culture of engineering is influenced by their gender and ethnicity. Being in a minority in the engineering profession gives women and black, Asian and minority ethnic (BAME) engineers a consistently different perspective on its culture, in significant ways. Seven indicators of inclusion in engineering were identified:- openness, respect, relationships, flexibility, career support, leadership and diversity.

The RAE found a direct correlation between engineers feeling more included and them being able to see a future for themselves in the profession and to remain in engineering. The % of engineers who say their gender is irrelevant to how they are perceived at work differs to a significant extent (82% of male, only 43% of women).

A number of recommendations with suggested actions, necessary to improve maturity of approach to addressing inclusion in engineering, were identified. These included particular challenges around culture which may well apply across other STEM disciplines: e.g.

"the benefits of a more inclusive culture must be articulated in ways that are much more compelling, convincing and engaging for engineers. The benefits to white and male engineers (the 'what's in it for me') are not clear enough to drive action and they must be articulated more clearly to enable stronger connections between inclusion and benefits to the profession".

"women and BAME engineers only comprise 9% and 6% of the engineering profession respectively. It is just not enough of a critical mass to drive change. *Without more white and male engineers engaging in change, the sector will simply be unable to create a more inclusive engineering culture.* "

Culture within sectors

Awareness of how different groups of engineers perceive engineering culture and inclusion. Engineers who already feel included enjoy an 'inclusion privilege', which means that they are least likely to see either the barriers to inclusion faced by other engineers, or the need for action to remove them.

Future approaches to creating an inclusive engineering culture need to leverage the specific strengths of engineering culture to maximise the likelihood of progress.

In terms of barriers, the culture of engineering is geared towards clear solutions and tangible outcomes, but addressing the 'problem' of inclusion is about complex change and often about achieving intangible outcomes, related to perception and experience. It is a proud culture, ambivalent about the personal, with a strong attachment to tradition. However, **creating a more inclusive culture requires humility, and is very much about the 'personal', and about doing things differently for the future. Making progress on inclusion requires that engineering try out behaviours that may be perceived as at odds with current culture.** This may feel uncomfortable but is necessary for change to happen. (The Royal Academy of Engineering, Nov 2017).

The inclusion dividend

Inclusion benefits the performance of individual engineers with 80% of those surveyed reporting increased motivation, 68% increased performance and 52% increased commitment to their organisation, when it is believed to be pro-actively inclusive. This re-affirms earlier findings across the workforce in broader STEM disciplines:

As far back as 2002 a US study concluded that "with a more diverse workforce, scientific and technological products, services and solutions are likely to be better designed and more likely to represent all users.[20] In addition, attracting and retaining more women within the STEM workforce will maximise innovation, creativity and competitiveness. That study illustrated the absolute need for a diverse workforce as follows;

"Engineers design many of the things we use daily- buildings, bridges, computers, cars, wheelchairs and x-ray machines. When women are not involved in the design of these products, needs and desires unique to women (half of the population) may be overlooked. E.g. some early voice-recognition systems were calibrated to typical male voices. As a result women's voices were literally unheard… or …. a predominantly male group of engineers tailored the first generation of automotive airbags to adult male bodies, resulting in avoidable deaths for women and children".

Later in 2011 Forbes Insights concluded that "diversity (by encouraging different perspectives and ideas) is a key driver of innovation and is a critical component of being successful on a global scale". Deloitte in 2013 went on to report that "when employees feel their organisation is committed to diversity and they feel included, the ability to innovate is increased by more than 80%, responsiveness to changing customer needs is increased by 30% and team collaboration is increased by more than 40%.

Innovation, customisation and collaboration – the backbone of engineering for the future.

And more recently McKinsey reasserted in their "Why diversity matters" that more diverse companies are better able to win top talent and improve their customer orientation, employee satisfaction and decision making…and all that leads to a virtuous cycle of increasing returns".

> "The unequal performance of companies in the same industry and the same country implies that diversity is a competitive differentiator shifting market share toward more diverse companies."[21]

Yet, despite this compelling business case, diversity within and across engineering remains stubbornly constrained.

[20] Margolis & Fisher, 2002, pp2-3
[21] Why diversity Matters, McKinsey, January 2015

Awareness must be raised on how different groups of engineers perceive engineering culture and inclusion.

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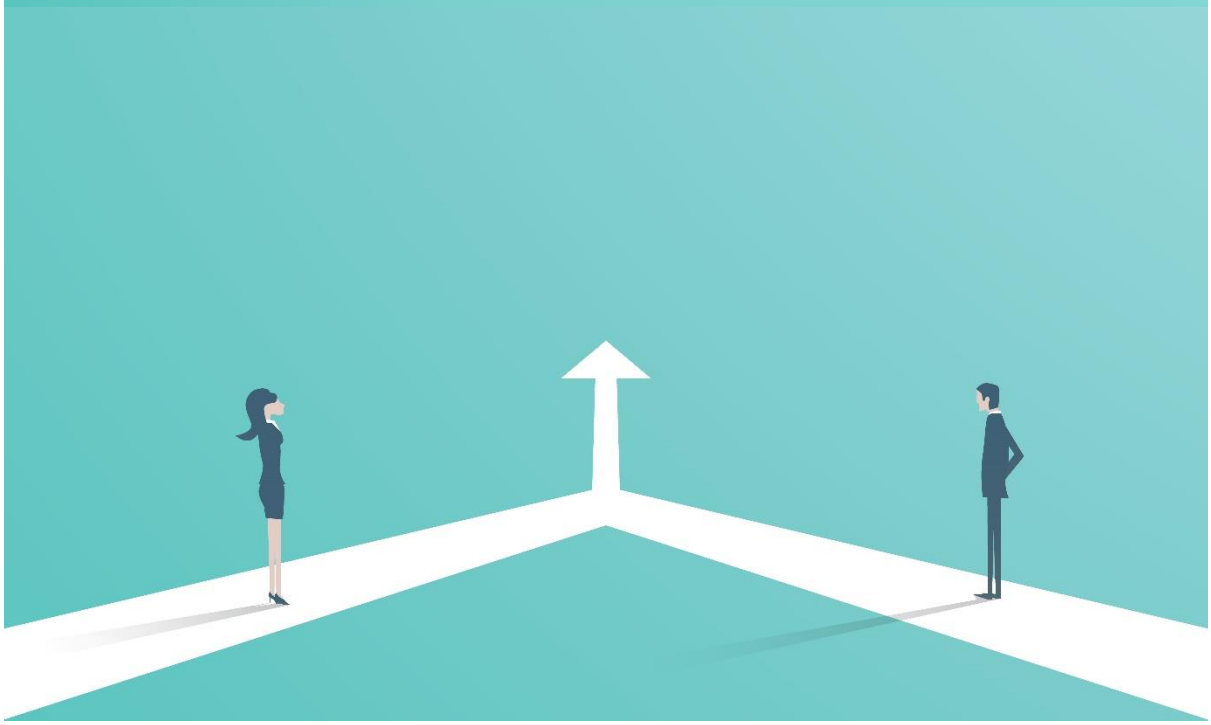
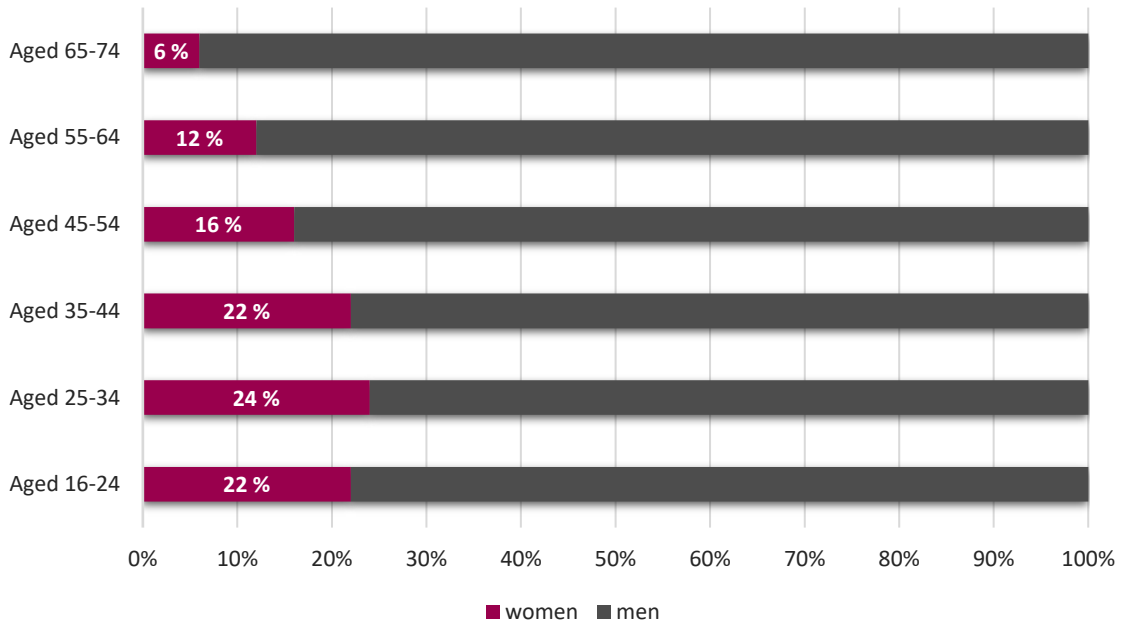


Progression of women in STEM careers

- Women in STEM leadership roles, i.e. management, directorships and as senior officials remain underrepresented across all STEM fields (17% average).
- There is a critical point in the STEM women's career path when, during their mid to late 40s, representation at higher levels drop by 6% from 22% ; From this point their representation continues to shrink until retirement, by which stage only 6% of science, research, engineering and technology professionals in Northern Ireland are women.

Figure 5: Science, research, engineering & technology professionals



(Source: 2011 NI Census)

Women in Academia – a similar pattern

Analysis of STEM cost centres reveals that the proportion of women varies greatly between disciplines; e.g. 61% of full-time academic staff employed within medicine, dentistry & health disciplines were women compared to **just 22% in engineering and technology disciplines**.

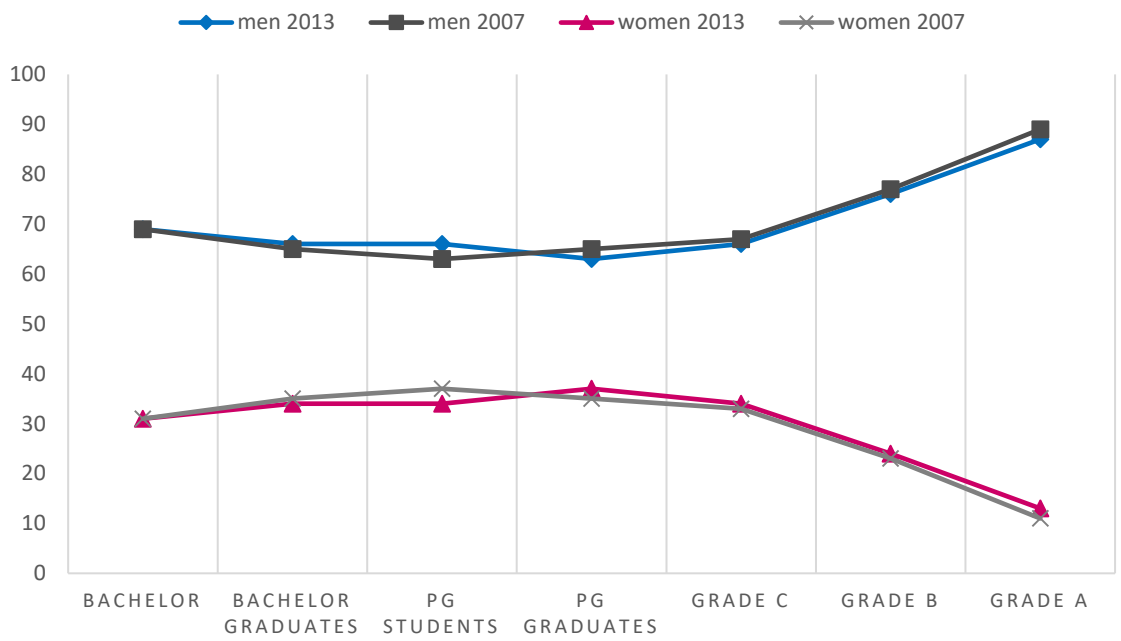
Across STEM, women are vastly underrepresented at senior academic levels. The significance of the leaks of female STEM talent in academia is exemplified best in the biosciences**; gender balance at entry level and early career research is reversed in favour of women or relatively equitable in the biological and biomedical sciences however, just 14% of professorships across biosciences are women.**

Funding structure for post-doctoral research

The post-doctoral research environment is perceived to be particularly challenging for women and the main reason for this is that research fellow posts are predominantly fixed-term (3 year) contracts and their funding structure is relatively inflexible. Women, in the main, transfer from their PhDs to academia from the age of 24 or 25, at a time when many women may be planning ahead for a family. Stakeholders agree that the demands on time, the expectation to travel and the temporary

nature of the posts are major factors that women consider when considering their future career in academia. Furthermore, difficulties arise with some Research Councils not having flexibility of funding for maternity leave.

Figure 6: Proportions (%) of women & men in a typical academic career in science and engineering, students and academic staff



(Source: Women in Science database, DG research & Innovation & Eurostat – Education statistics)

Funding gap in research grant

International research has also revealed fundamental funding challenges faced by women in research. Researchers must demonstrate scientific impact when applying for research grant. However women as a whole lag behind men in demonstrating impact indicators, e.g. the number of publications, co-authorship, citations, and peer review. Women are also less likely to collaborate with colleagues in other countries (travel to external sites). All of these factors impact on the bibliometric statistics for grant evaluation and creates a vicious cycle: less funding reducing their capacity to produce as many scientific papers and increase citations, in turn limiting career progression.

There are initiatives within, and involving, universities that may help. The Athena Swan programme encourages institutions to consider inequalities and disadvantaged groups, and often focuses on the issues surrounding women in science. There is some evidence to suggest it is having a positive effect.[22]

[22] Advancing gender equality through the Athena SWAN Charter for Women in Science: an exploratory study of women's and men's perceptions. Health Research Policy and Systems 15:12 2017

STEM occupations attract higher salaries, but are traditionally viewed as inflexible in terms of working patterns. Flexible working conditions when recruiting for skilled roles will appeal to the whole available talent pool.

The view of stakeholders within STEM, and particularly within the IT professions, is that in 2018 and beyond, if employers want talented people then they must think outside traditional working patterns.

Indeed, it could be argued that all jobs should be flexible by default, unless there is a good business reason for them not to be.

This is not just within the context of parents or those with caring responsibilities; it is part of a wider societal shift.

What needs to happen?

A Modern Workplace

Creating a more inclusive, respectful and meritocratic employment culture is fundamental to driving diversity in the workplace. Employers committed to addressing gender gaps will need to be proactive in developing and embedding inclusion and diversity strategies, if they are to reap the benefits of an inclusive and diverse workforce.

Flexible working arrangements

A move away from confusing presence with performance towards results-driven management and flexibility would be a good starting point, where employees have the flexibility to manage their own time productively, to the ultimate benefit of the employer.

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Talented millennials are keen to work on their own projects, and therefore look to employers who offer flexible working patterns and not the traditional 9-5 shift.

Removal of gender bias from selection

Processes that help to eliminate implicit bias in recruitment, opportunity, progression and pay are fundamental to this goal.

Opportunity and progression to leadership

Throughout the course of this study, stakeholders expressed the need for more flexible career trajectories, through mechanisms such as better provision for career interruptions, returning schemes and gender aware conditions.

As part of the drive to encourage diversity within organisations, diversity within leadership teams is essential. The low proportion of women in STEM skills and talent pipelines is a major and inevitable contributor to lower women representation on STEM boards. Valuing female talent and supporting women to remain in STEM careers will ensure a healthy pipeline that will facilitate progress in this respect. Again, mentorship programmes can be important to support change.

While women continue to have the largest share of parental or caring responsibilities in the home, challenges that pull against inclusivity and equality of opportunity will remain. The local policy environment could be a way of alleviating these challenges; family friendly and flexible policies such as shared parental leave and access to affordable childcare have been shown to be important tools in the drive to gender parity in other countries worldwide.

The 'motherhood penalty'

A survey by the Women's Engineering Society (WES)[23] reveals that a high proportion (60%) of women found that there were barriers which prevented them returning to careers in STEM after a career break and many had left STEM after maternity breaks. The barriers cited included financial challenges (including the cost of childcare), lack of flexibility in the workplace (including not enough opportunity for flexi time, job sharing, compressed hours, part time opportunities), and not enough training, guidance, and support offered.

Shared Parental Leave

One way to address the 'motherhood penalty' would be to encourage parents to share caring responsibility for their children to a greater extent. Since April 2015, parents in the UK have been able to share parental leave following the birth or adoption of a child. Around 285,000 couples every year qualify for shared parental leave, but take up can be as low as 2%[24]. For couples who earn differing salaries, it can be an impossible financial sacrifice for the higher-earning partner to take more leave. And as we know, on average men still get paid more than women, so consequently the status quo is perpetuated.

As part of the modern Industrial Strategy and Good Work Plan[25], the UK government has recently (February 2018) launched a campaign to reinvigorate the shared parental leave scheme. 'Share the Joy' shows parents how they can share childcare in their baby's first year, while maintaining their careers. It aims to raise awareness of employment rights, in a drive to boost job satisfaction and productivity.

Paternity leave incentives: 'use-it-or-lose-it'

Policy could go further in order to incentivise men to use paternity leave and share childcare responsibilities to a greater degree.

Some countries have a 'use-it-or-lose-it' policy on paternity leave. Back in 1974, Sweden was the first country to replace maternity leave with parental leave. In Sweden today, fathers get eight weeks of non-transferable paternity leave and it has become a strong tradition that both mothers and fathers take parental leave. In Norway, fathers receive twelve weeks of paternity leave that is non-transferable to the mother. In Iceland men get at least three months' paternity leave, and 90% of them take it. In the UK, including NI, fathers can take two weeks paternity leave.

Access to affordable childcare

A key driver for the gender gap (and the gender pay gap) in STEM is the lack of flexibility in working patterns for men and women, which is further exacerbated by the cost of childcare. Analysis of the costs of childcare across OECD countries has shown that there is a positive correlation with career progression and the gender pay gap. Increasing the availability of affordable childcare could enable greater participation of women in the labour market.

In NI, parents of all three and four year-olds can apply to receive 12.5 hours per week (475 per year) of free, preschool education. The rigidity of this provision and the limited hours provided mean that

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[23] Return: Project for Professional Engineering Institutions. Women Engineering Society. 2014

[24] Share the Joy Campaign: promoting shared parental leave rights for parents

[25] https://www.gov.uk/government/news/millions-to-benefit-from-enhanced-rights-as-government-responds-to-taylor-review-of-modern-working-practices

parents here do not have the same degree of flexibility as, parents in other UK regions (e.g. England).

A move within NI that would give working parents access to additional hours of funded preschool education, and enhanced flexibility in how this provision can be accessed, so that it can be used as a viable childcare option for full time workers, would be welcomed by many.

Returnships

Although the obvious long term mechanism for addressing the growing STEM skills shortages and gender diversity in the NI workforce is to find ways to retain women, a shorter term solution is to attract back those women who have already left. Some of the challenges are specific to STEM - for example, research has shown that women with young children stay home longer if they have a STEM background. The relative inflexibility of working patterns and lack of part-time roles across STEM occupations contributes to this. Women with a STEM background are also more likely to lack confidence returning to the workplace from a career break. Women quickly begin to feel that their skills are no longer relevant in a rapidly changing environment and therefore perceive that they would be unable to do a particular role. The loss of so many women scientists is a significant waste of expertise, talent and investment. Traditional recruitment methods are a barrier to STEM professionals wishing to return to the workforce following a career break or period of part-time work.

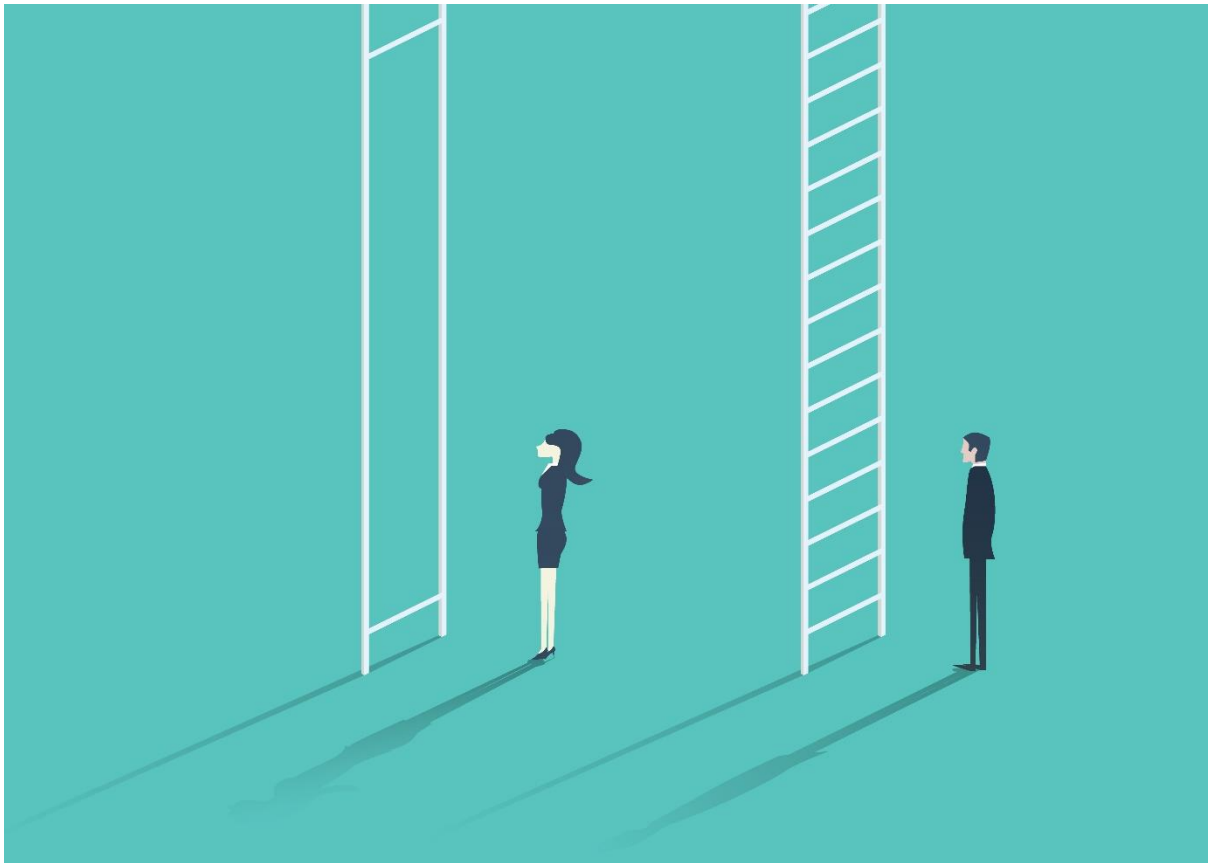
A recommendation voiced by stakeholders in NI was that STEM industry as a whole needs to be more flexible and innovative in its approach to recruitment to highly skilled roles, particularly if it is committed to tackling the issues of skills shortages within the sector. A gap in a résumé shouldn't mean the end of a career and industry should acknowledge that returners can contribute significantly to business and the economy. With 61% of employers reporting difficulties in recruiting experienced technical staff for their highly skilled vacant roles[26], it makes sound business sense to target those who are already qualified and skilled. Randox is one example of a NI business that recognises this and has put in place STEM returner programme[27].

Likewise, The Open University offers a 'Returning to STEM' course [28] which is designed for men and women who are about to embark on their hunt for their STEM role. It supports participants to get back to basics in terms of job searching, CV presentation, online visibility, networking and identifying a mentor, retraining and goal setting.

[26] Helping the UK Thrive, CBI and Pearson Education and Skills Survey, 2017

[27] www.randox.com/randox-returners/

[28] www.open.edu/openlearn/stemreboot



A recent report from the Institute of Fiscal Studies concludes that the arrival of children and subsequent differences in career patterns have a key role to play in explaining the evolution of the gender wage gap across the life-cycle of a career in the UK. **The analysis illustrates that there is a critical point in women's careers (late 20s to early 30s) when competing responsibilities come into play, usually the birth of a first child and/or onset of a caring role.**

This is mirrored in a recent study in Denmark which demonstrates the impact of the arrival of children. **The arrival of the first child creates a gender gap in career earnings of around 20%, driven by roughly equal proportions by labour force participation, hours of work, and wage rates.** The arrival of additional children increases this impact progressively – however, not to the same degree as the arrival of the first child.

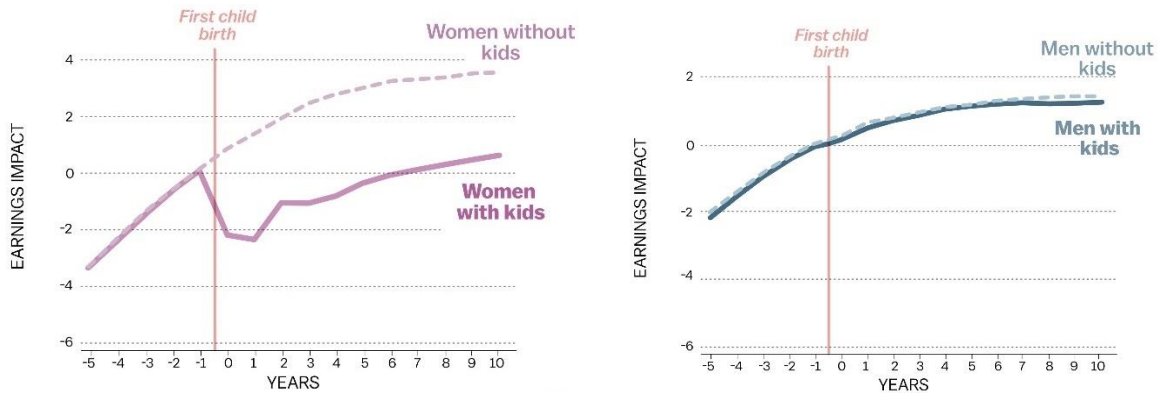
Global gender gap report

The most recent global gender gap report from The World Economic Forum measured indicators for economic participation and opportunity, education attainment, health and survival, and political empowerment[29]. It demonstrated a reversal on progress of all of these metrics in 2017. The WEF estimates, at the current rate of progress, it will now take 100 years to shut the gender gap, a dramatic rise from the 83 years predicted in 2016.

A recent report from the Institute of Fiscal Studies[30] concludes that the arrival of children and subsequent differences in career patterns have a key role to play in explaining the evolution of the gender wage gap across the life-cycle of a career in the UK. The analysis illustrates that there is a critical point in women's careers (late 20s to early 30s) when competing responsibilities come into play, usually the birth of a first child and/or onset of a caring role.

This is mirrored in a recent study in Denmark which demonstrates the impact of the arrival of children[31]. The arrival of the first child creates a gender gap in career earnings of around 20%, driven by roughly equal proportions by labour force participation, hours of work, and wage rates (figure 6). The arrival of additional children increases this impact progressively – however, not to the same degree as the arrival of the first child.

Figure 7: The cause of the Gender Pay Gap



Source: Children and Gender Inequality: Evidence from Denmark (Kleven et al, 2017)

The study also shows that the job characteristics of women change to ensure family convenience rather than financial reward. Women begin to fall behind men in terms of career progression, their probability of becoming a manager diminishes and they often look for alternative roles in organisations known to have flexible working conditions for parents (e.g. public sector).

In relation to the so-called 'motherhood penalty' Kleven considers why, for example, Danish women still take the vast majority of parental leave that could be used by either parent. Two, not necessarily mutually exclusive, possible explanations are presented: One is an environmental explanation, where social norms make it harder for mothers to stay in the workforce. Under this explanation, mothers may find that they aren't offered certain opportunities — a job that requires significant travel or long hours, for example — because of the perception that they are the primary caregiver to

[29] The Global Gender Gap Report. World Economic Forum. 2017

[30] https://www.ifs.org.uk/publications/8428

[31] Children and Gender Inequality: Evidence from Denmark, H. Kleven et al., National Bureau of Economic Research, MA, RESEARCH 2017

a child. Kleven also cites public opinion data that shows, that most Danish adults believe that women with young children should not hold full-time jobs. The other is a biological explanation: that women may have a stronger preference for spending more time in activities related to child care.

'"What our evidence shows is that a lot of gender inequality is associated with choices that suggest different preferences," Kleven says. "The holy grail is understanding whether those preferences are social norms, or something more intrinsic."'

Diversity Champions

The UK government supported network, Apprenticeship Diversity Champions Network (ADCN) was established in 2017 to address the various issues of diversity in apprenticeships. The good news is that this has set a target for increased BAME (black, Asian and minority ethnic communities) of 20% in apprenticeships. The bad news? It does not look at distribution across programmes and so does not consider gender diversity.

At a regional level the development of a Gender Diversity Charter Mark NI is to be welcomed – the Mark will recognise commitment to and progress on gender diversity. Those organisations which signed up when the Charter Mark was introduced in September 2017 have set out their commitment to advancing gender diversity by addressing areas of unequal gender representation at all levels, removing obstacles faced by women at key points of career development; and implementing structural and cultural changes.

The need to develop leadership competencies, in order to address the barriers to a more diverse and inclusive workplace is also highlighted in the RAE Diversity and Inclusion Toolkit, which includes creating inclusive cultures, building relationships with diverse teams and networks, and increasing understanding of how their unconscious biases influence the decisions they make.

Increasing understanding around this whole area – both in terms of the barriers, the benefits and how to address these is a priority across the whole workforce, but especially those disciplines where levels of engagement are particularly distorted.

NI Support landscape

Informal STEM learning initiatives

There are many highly commendable STEM initiatives, including those targeting girls, across the UK, and NI is no exception.

However, the sheer number and diversity of the many organisations and funders involved has created a cluttered and complex landscape.

In 2016, the Royal Academy of Engineers identified **over 600 organisations** across the UK involved in STEM activities[32]. Stakeholders acknowledge that this can be detrimental, both in terms of inefficiencies, and impact.

Issues include:

- the need to improve ease of access
- improved equity of access (schools in industry dense regions are often bombarded with offers of support, while schools in other regions are not catered for)
- lack of coordination
- lack of measurement
- evaluation
- visibility of impact

A much more joined-up approach to STEM support in NI is essential if we are to realize even a fraction of the impact we desire. Furthermore, we must ensure that access to support is equitable across the region - too many initiatives operate in distinct geographical areas.

The development of an overarching framework for both programme leaders and schools could potentially overcome some of these challenges. It is clear that if we are to achieve the impact we are seeking, NI needs a much more cohesive approach.

There is an appetite in the wider STEM community for strong leadership from government and a willingness to work with and support policy makers to improve the support landscape and its impact. This is driven in no small part by the undeniable fact that: **despite almost two decades of intense activity, and not to detract from any small gains recorded, overall there has been limited growth in the core STEM subjects for both boys and girls.**

[32] The UK STEM Education Landscape, Royal Academy of Engineering, 2016

Figure 8: A snapshot of some of theSTEM support currently available

Single point of government contact

As already mentioned, during the course of this study consultees also frequently cited overly complex government structures as an overarching barrier to progress, with many suggesting a single point of contact (perhaps based on the previous STEM business liaison role?) would go some way to addressing that challenge.

A Mechanism for Change

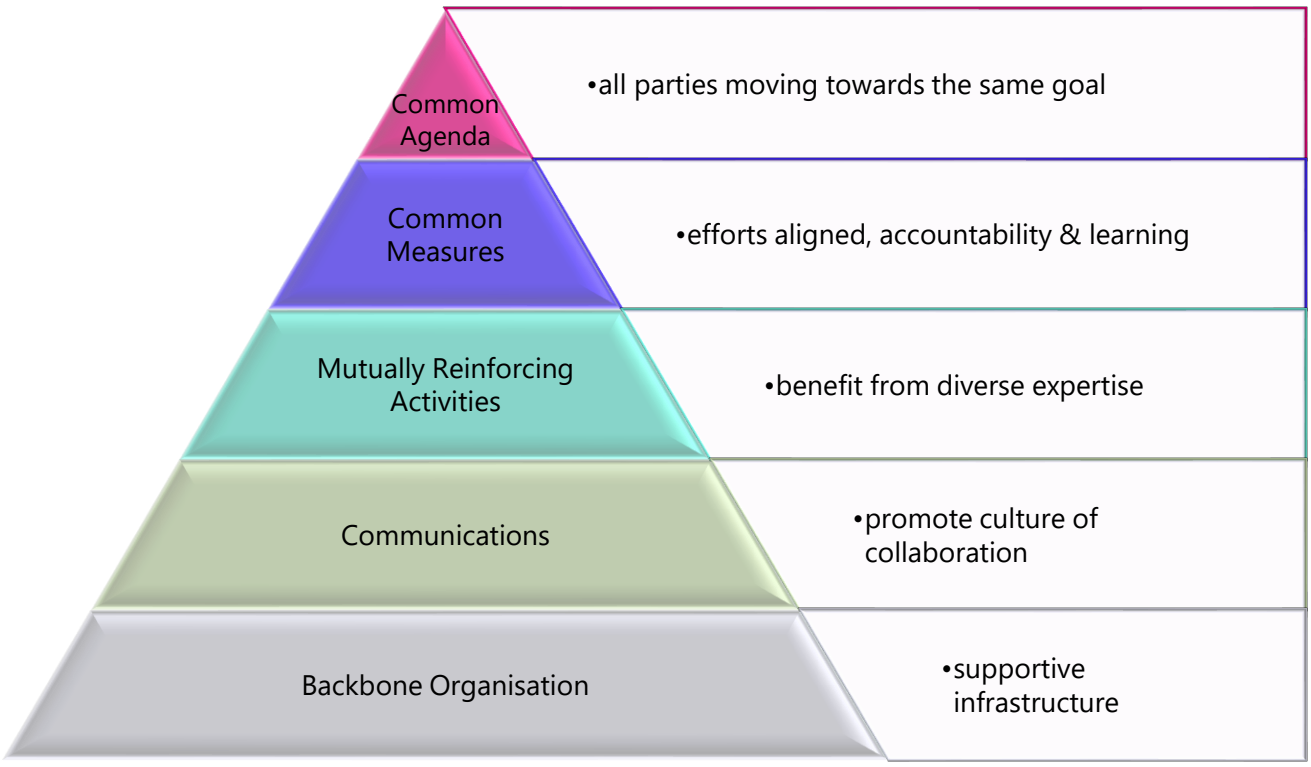
As the need to coordinate the many organisations working in isolation across the STEM arena in NI is widely recognised, so too must it be understood that, despite the complex support landscape, stakeholders across Northern Ireland are working towards a common goal and have a shared understanding of the issues.

But in the same way, no single intervention, no single policy, government department, organisation nor program can tackle or solve the issues around gender diversity in STEM alone. It will require multiple organisations and individuals from the various sectors to commit to a common agenda, shared measurement and alignment of efforts, not least in recognition of the fact thatthe challenges around STEM engagement play into wider societal issues.

Collective Impact

Collective Impact is a mechanism which would facilitate effective collaboration across all of these organisations and the wider community including, students, their families, philanthropists and wider society. Unlike collaboration or partnership, Collective Impact initiatives have support in the form of a backbone organisation with dedicated staff whose role it is to help participating organisations act in a cohesive way.[33]

Figure 9: The principles of Collective Impact



33 https://ssir.org/articles/entry/collective_impact

Time for action

The need for action is clear. Successive economic and industrial policy statements by government, have re-asserted that, if NI is to grow and prosper then the modern economy will need to be driven by innovation and reliant on STEM skills in high growth sectors and emerging technologies. The need to address the diversity issues within STEM sectors is also understood.

The primary concern emerging from MATRIX consultation during the development of this report has been the lack of government leadership across STEM in NI, resulting in a lack of vision and 'strategic stagnation'. The sum outworking of which has been limited impact on skills supply and continued shortfall of suitably qualified young people in the job market.

Recognising and understanding industry's concern is not enough, Government has a key role here in providing pro-active leadership and coordination. Northern Ireland's STEM agenda and subsequent, underpinning actions to address the diversity challenges must therefore be driven by government with support from industry, academia, education liaison bodies, and other 3rd party organisations, with impact measured and addressed in a dynamic, dedicated manner

The underlying risk of further stagnation in terms of STEM participation and progression within the region and the undermining of the small gains previously secured dictates a need for immediate action.

Recommendations

Leadership & Coordination

Encompassing government, industry and 3rd party representation, with authority to put in place:

- Transformative vision and commitment – challenge the status quo (based on the improvement of science capital to secure future economic and broader societal benefit)
- Address issues identified in relation to existing 'cluttered and complex' support landscape
- Coordination – to support collaboration and share best practice learning
- Key metrics
- Impact measurement

Visibility of STEM

The need to promote awareness of STEM careers is vital, in particular the promotion of:-

- STEM roles to children, parents, subject teachers and careers teachers – at all levels: primary, secondary and tertiary.
- All viable education and career pathways and visibility of earning potential.
- Development of resources to reflect future work opportunities – e.g:
    - Inspirational role models and celebration of women in STEM in NI campaign.
    - NI mentorship programmes (industry – schools; 3rd level students to secondary schools; secondary level pupils to primary schools).
    - Kitchen table skills barometer.
    - NI STEM businesses – case studies.

STEM Teaching

- Promotion of gender-neutral learning environments -teacher training to include STEM-specific focus on gender awareness and removal of stereotypes / unconscious bias training.
- STEM areas (e.g. engineering) embedded in initial teacher training and primary curriculum.
- Review need for STEM qualifications beyond GCSE for primary teacher training (explore incentives/use of quotas) and PGCE applicants.
- Time-tabled STEM-specific CPD for teachers, led by industry, with applied industry experience; and STEM-specific industry engagement for pupils.
- Review of metrics at policy level (realign grading towards employability measures). Provide an effective alternative to current league tables to incentivise / drive behaviour.
- Explore incentives to pursue courses in demand by industry (e.g. bursaries/fee reductions) – promoted alongside aspirational career pathways showcasing earning potential and real-world application of learning.

Workplace

- Inclusion and diversity education programme – articulate the return on investment.
- Promotion of benefits / celebration of pro-active employers.
- Re-setting the modern workplace – educate employers around needs of "millennials".
- STEM quality 'award' within the Gender Diversity Charter Mark NI (e.g. Athena Swann adapted /applied to business).

The Prize? NI 2030: STEM READY

- Government commitment to strike out on an ambitious and confident footing could establish Northern Ireland as an **exemplar STEM region.**
- By 2030, **33%** of young people moving into STEM careers are girls
- Every child leaving primary school knows what an engineer does
- Girls can see themselves in **any STEM role**
- Senior management teams in STEM are **fully inclusive** and representative of a diverse workforce

Next Steps

Establishment of a DfE led, cross-departmental working group to develop (by year-end) a STEM action plan fit to deliver NI STEM-ready by 2030.

This engineer will save more lives in one year than a GP will in their whole career.

Conclusion

Grasp the gender nettle

MATRIX isn't denying the need to attend to other important diversity challenges across the STEM workforce. Absolutely not - more can and should be done. However, as an economy facing ever increasing STEM skills and competitiveness challenges the biggest 'potential win' is indisputably engaging the untapped potential of half of the total workforce, NI's talented girls. By freeing up that future workforce we can begin to unlock a more competitive and more prosperous society, for the benefit of all.

Who knows? In tackling the issues preventing girls from pursuing STEM, it may become more accessible and attractive to more boys too – and all to the good. But what we must be clear about is that**, if we only promote STEM** as an exciting and attractive education or career prospect **without first tackling the gender issues** set out above; then, at this point in 2018, as with the decade before, we are accepting that we are **facing another 10 years of STEM supply stagnation – a further 10 years where the number of girls studying STEM between GCSE and A Levels drops by 65%**.

And in real terms what that means for society is another generation of girls unable to fulfil their potential, unable to explore "the world and wonder of engineering, as it touches every part of our lives - from spaceships to ice skates, the bubbles in chocolate bars to life saving cancer treatment."[34] **We are denying our young girls – some of the brightest and most creative talent at our disposal - the chance to make a positive difference to the future of the world around us.**

[34] Year of Engineering launch campaign, January 2018

WHAT WILL SUCCESS LOOK LIKE?

- That every child knows what an engineer actually is and actually does.
- That girls can see themselves in any role within STEM.
- That by 2030, the 'leaky pipeline' is plugged and 33% of young people moving into STEM careers are girls.
- That the senior management gender split in STEM organisations reflects a more diverse workplace.

These are challenging targets that require creativity, commitment & collective impact.

But with the level of enthusiasm and commitment already evident on the ground, there's every reason to believe that with leadership and a coherent, co-ordinated Women in STEM policy, government can help unlock the potential.

The whole area of STEM engagement is central to the core focus of MATRIX, so it is without hesitation that the Panel commits to working in partnership with government, industry and other stakeholders to pursue the recommendations contained within this report.

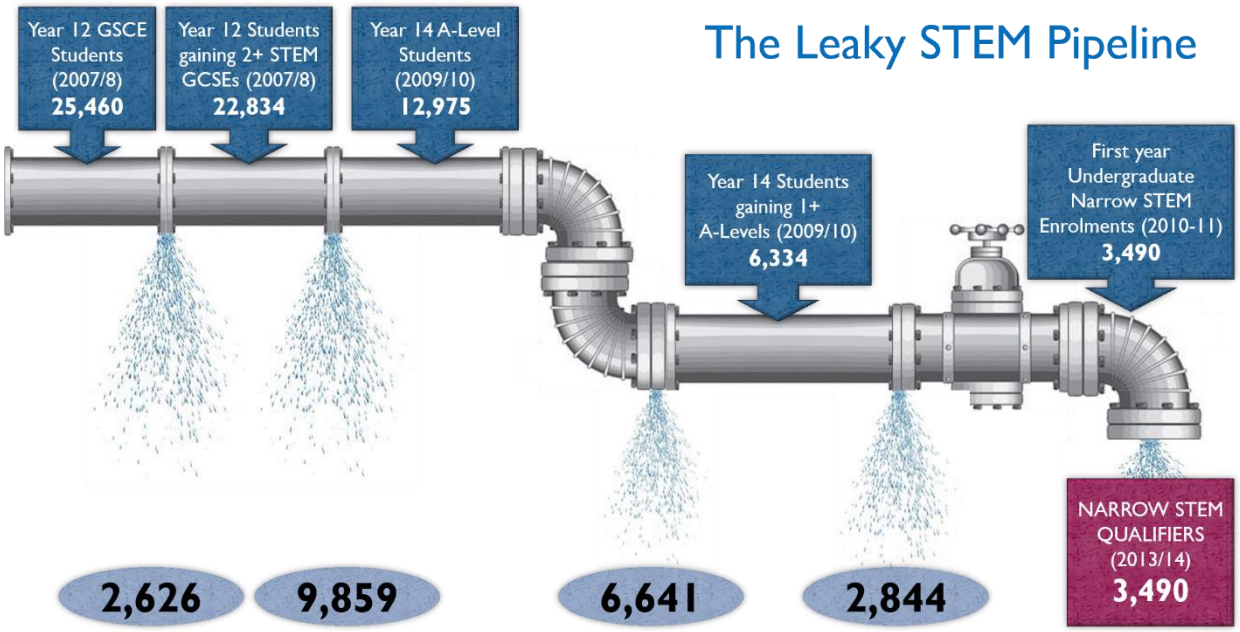
ANNEX

NI Skills Performance – Participation Levels

The Leaky STEM Education Pipeline

Like many other developed countries, Northern Ireland's young people become increasingly disengaged from STEM resulting in reduced enrolments in STEM subjects at various levels of the education pathway. The 'leaky STEM pipeline' is a well-known illustrative model used to demonstrate 'leaks', or retention difficulties in STEM education. We see evidence of this persistent leaky STEM pipeline from the early years of primary school and continuing throughout post-primary schools, further education colleges and universities. The natural consequence is a reducing flow, at all levels, of those who are qualified in STEM subjects into our workforce.

For girls in NI, the transition from GCSE to A-level STEM is particularly important in terms of not taking STEM subjects further. Girls continue to outperform boys across STEM subjects studied at GCSE and A-Level in NI and yet girls, in most of these areas, in terms of numbers remain underrepresented. Data suggests that enrolment across STEM disciplines at post-primary and further study is relatively static despite initiatives to encourage young people and girls in particular to pursue careers requiring these subjects. This issue of retention does not stop at education, it continues into the STEM workforce, where women remain stubbornly underrepresented to the same levels.

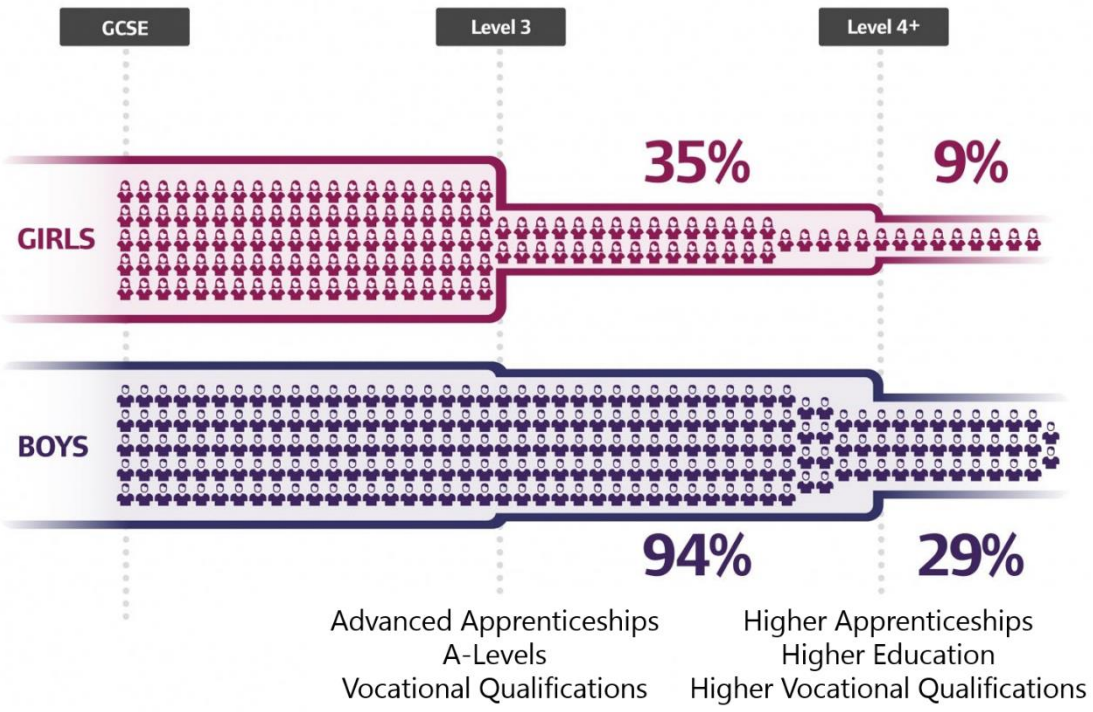


Source: NI Skills Barometer - DfE

86% decline across 4 years

The gender gap widens in secondary education when 'A' level/FE equivalent subject choices are made, with a clear gender pattern emerging in higher education. This pattern is not unique to NI; within the global female student population, only around 31% chose STEM-related fields of study (figure 8)[35].

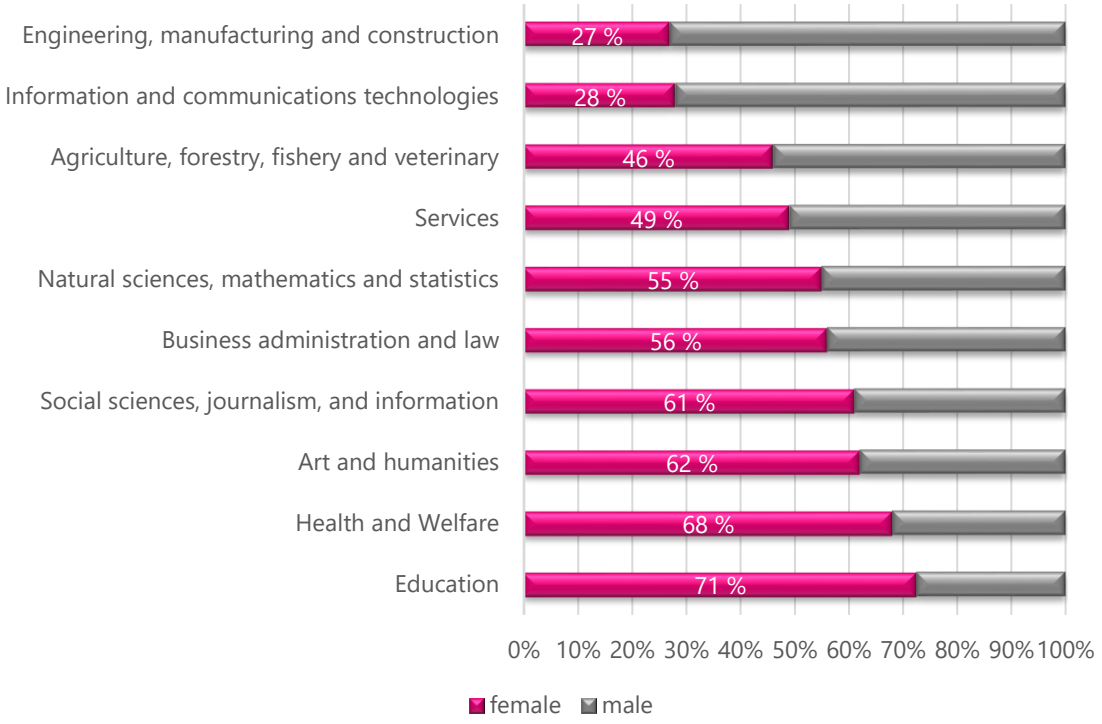
Figure 10: The leaky STEM pipeline by gender



Source: WISE

[35] Science and Technology Industry Scoreboard 2017, The Digital transformation OECD, 2017

Figure 11: Share of female and male students enrolled in higher education, by field of study, global average (%)



Source: UIS, UNESCO 2014-2016 uis.unesco.org

STEM enrolments NI

GCSE (data source: RM Education)

GCSE Design & Technology – Only 28.0% (compared to UK 39%, 2017) of 4,092 examination entries in NI are from girls and this proportion is static, yet more girls achieve A*-C grades in Design & Technology than boys (84.2% girls, 76.9% boys achieved grade A*-C in 2017).

GCSE ICT – Girls now represent 42.7% (compared to 41.5% in previous year and UK 39%, 2017) of total 7,544 entrants for GCSE ICT (84.2% of girls taking ICT achieved grade A*-C compared to 76.9% of boys).

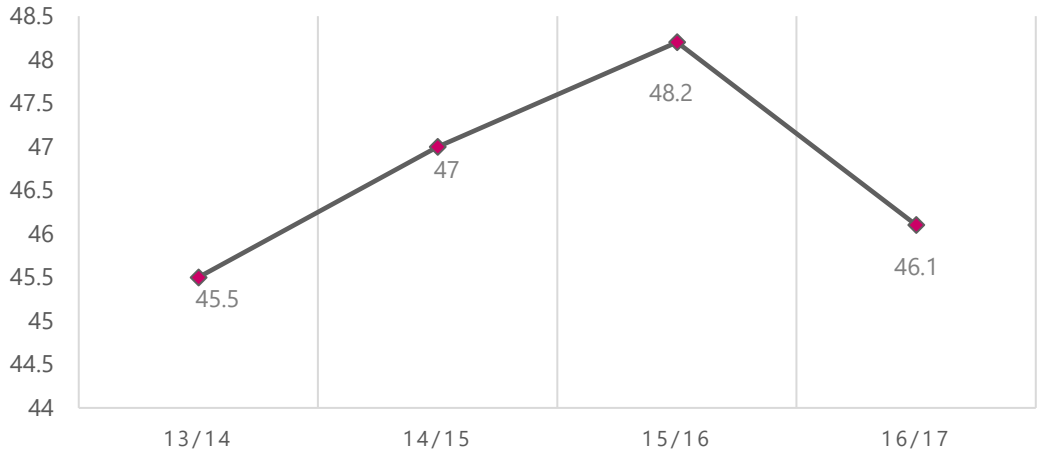
GCSE Physics – In 2017, girls represented 41.4% (UK 50%) of the 2,935 Physics examination entries in NI and this proportion is static. (98.7% of girls achieved grades A*-C compared to 95.6% of boys).

Others – 53.1% of GCSE Biology entries were from girls (UK 51%) and in GCSE Chemistry and Mathematics, girls and boys are equally represented (similar to UK). (94.4% of girls achieved grades A*-C compared to 92.9% of boys in Biology. 71.3% of girls achieved grades A*-C compared to 69.5% of boys in Mathematics).

A-Level (data source: RM Education)

In Northern Ireland, at 46.1%, girls represent a much greater proportion of core STEM examination entries at A-Level compared to the UK (average 36.7% in 16/17). The trend over the previous 3 years was promising however there was a drop in the proportion of girls enrolling in STEM A-levels in 16/17 (figure 10).

Figure 12: % STEM A-Level Examination Entries – NI Girls



Girls are still under-represented in the key subjects for students wishing to pursue further qualifications in technology and engineering.

A-Level Computer Studies – The popularity of this relatively new A-Level has been increasing steadily but examination entries overall are low at 324 in 2017 (243, 106, 167 in previous years). Girls represented just 19.4% of NI entrants in 2017 (UK 10%). (85.7% of girls achieved grade A*-C compared to 81.6% of boys entering).

A-Level Further Mathematics – Only 29.7% of the 195 entrants in 2017 were girls (UK 28%). (94.8% of girls achieved grades A*-C compared to 96.4% of boys).

A-Level Physics – Physics A-Level examination entries continue to fall for both boys and girls (2014 – 1,509, 2015 – 1,484, 2016 – 1,351, 2017 – 1,233). Only 29.0% of the entrants in 2017 were girls (UK 22%). (82.9% of girls achieved grades A*-C compared to 81.5% of boys).

A-Level Design & Technology - Of the 1,023 examination entries in NI only 28.4% are from girls (UK 38%). (79.4% achieved A*-C grades in Design & Technology compared to 74.0% of boys).

Other –Mathematics continues to be the most popular A-Level with 2,999 entries in 2017. Of these, 44.6% of entrants are girls (43.2% and 41.9% in previous years, UK 33%) (90.7% of girls achieved grades A*-C compared to 87.0% of boys in Mathematics). Biology is a close 2nd with 2,745 entrants of which 64.1% were girls (83.7% of girls achieved grades A*-C compared to 81.5% of boys).

Co-education versus all-girls post-primary environments

Girls studying in all-girls environments continue to do better on average than girls in co-education settings and this is also true for STEM subjects studied at A-level (figure x, Computer Studies/Computer Science and Information Technology are exceptions). However, girls studying in co-educational environments are more likely to choose STEM subjects (figure x). Exceptions to this were enrolments for Physics and Design and Technology A-Levels. Further investigation of the reasons for lower STEM enrolments in single sex environments is required but possible causes could include even deeper engendered stereotypes within single sex schools, peer influence, reduced provision of STEM resources (expertise and materials), timetabling, and focus on non-STEM subject areas. For example, there were no enrolments for Computer studies/Computer science at A-Level in all girls' schools in NI until the 2015/2016 academic year suggesting an absence of provision.

Figure 13: Proportion (%) of girls achieving A-C at A-Level in STEM subjects: co-education versus all-girls environments (average over 4 academic years).

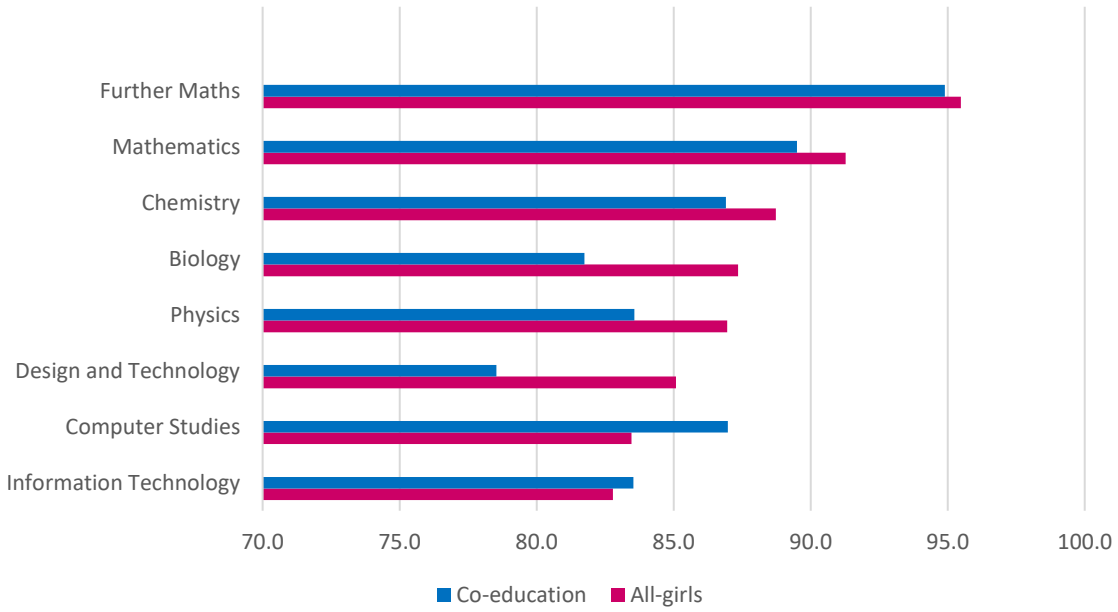
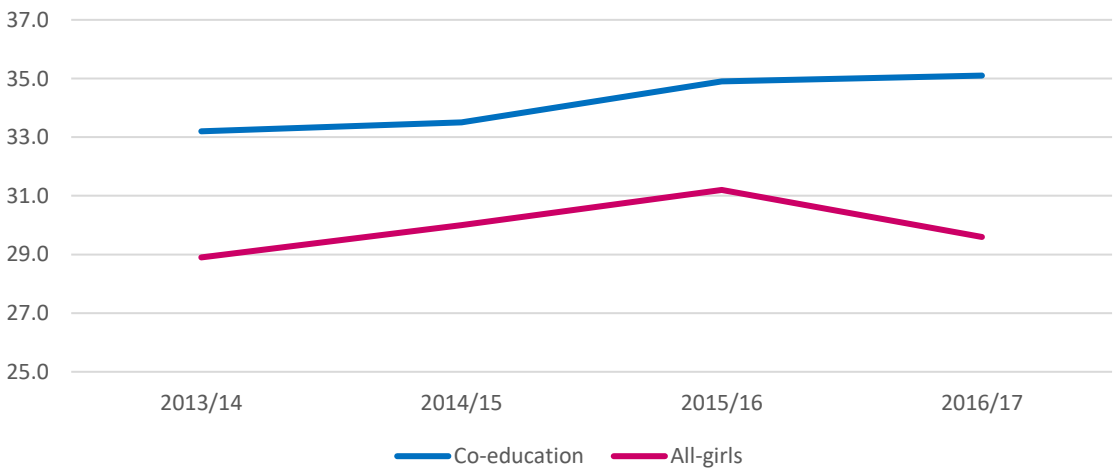


Figure 14: STEM enrolments at A-Level as a proportion (%) of all enrolments made by girls: Co-education versus all-girls environments.



Further Education (data source: ONS)

Enrolments to NI Further Education (FE) colleges show a similar gender pattern. Subjects with the highest proportions of females enrolled were:

[DN: Enrolment infographic - allied to medicine (83%), creative arts & design (80%) and social studies (74%)]

And the subject areas with the lowest proportions of females were:

[Enrolment infographic - engineering & technology (5%) and architecture, building & planning (3%)]

Apprenticeships – NI (data source: Department for the Economy, April 2017)

Males dominate enrolments on apprenticeships in NI and account for 65% of current participants. The gap between male and female is largest in the Level 2/3 Apprenticeship group, where males account for 86% of participants.

The uptake in IT user apprenticeships among females is around the overall average across all subjects (16.9%), however, females account for only 6% of Professional IT apprenticeships in NI. Females account for 8.2% of Engineering and Manufacturing Technologies apprenticeships and just 1.7% of Construction, Planning & the Built Environment apprenticeships.

Higher Level Education (data source: ONS)

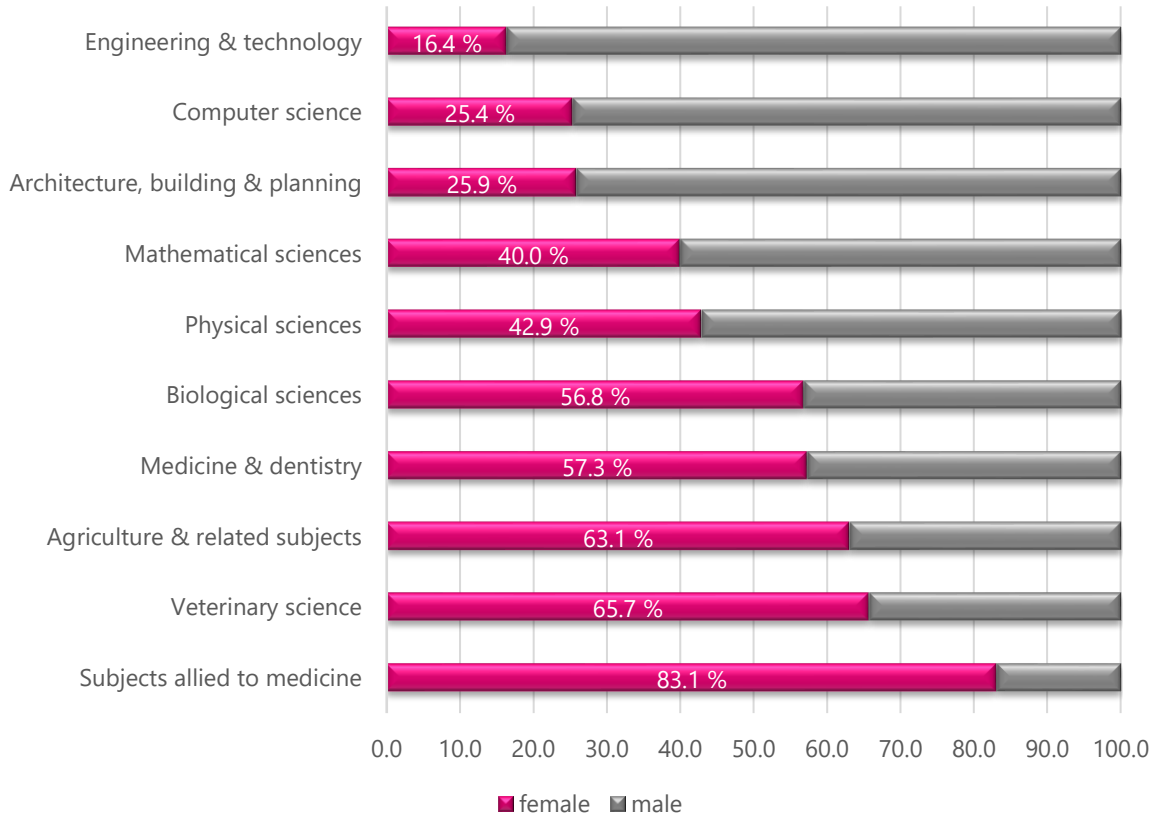
Undergraduate

The number of NI domiciled qualifiers from UK HEIs has remained stable in recent years (18,240 in 2016/17, 18,150 in 2013/14). In 2016/17, of the 18,240 NI domiciled students gaining qualifications, almost three-fifths (58.3%) were female. Females (79.7%) were more likely than males (73.3%) to achieve a first class or upper second class honours degree.

Of qualifications gained by NI domiciled students at UK HEIs, 47.8% were in a Broad STEM related subject. Within which a higher proportion were males (52.4%) than females (44.4%). Almost a quarter (23.5%) of qualifications gained by NI domiciled students at UK HEIs were in a Narrow STEM related subject, of which, again a higher proportion were males than females (35.6% compared to 14.8% of 1st degree qualifications gained).

Figure 13 illustrates the gender gaps in broad STEM subjects. Of the 1,185 graduates in Subjects allied to medicine, 83.1% of these were female. Conversely, in the male dominated narrow STEM qualifications of Engineering & technology, Computer science, and Architecture, building and planning, females are persistently underrepresented at 16.4%, 25.4% and 25.9% respectively.

Figure 15: Northern Ireland domiciled students gaining undergraduate qualifications at UK Higher Education Institutions by STEM qualifications gained and gender - 2016/17 (%)

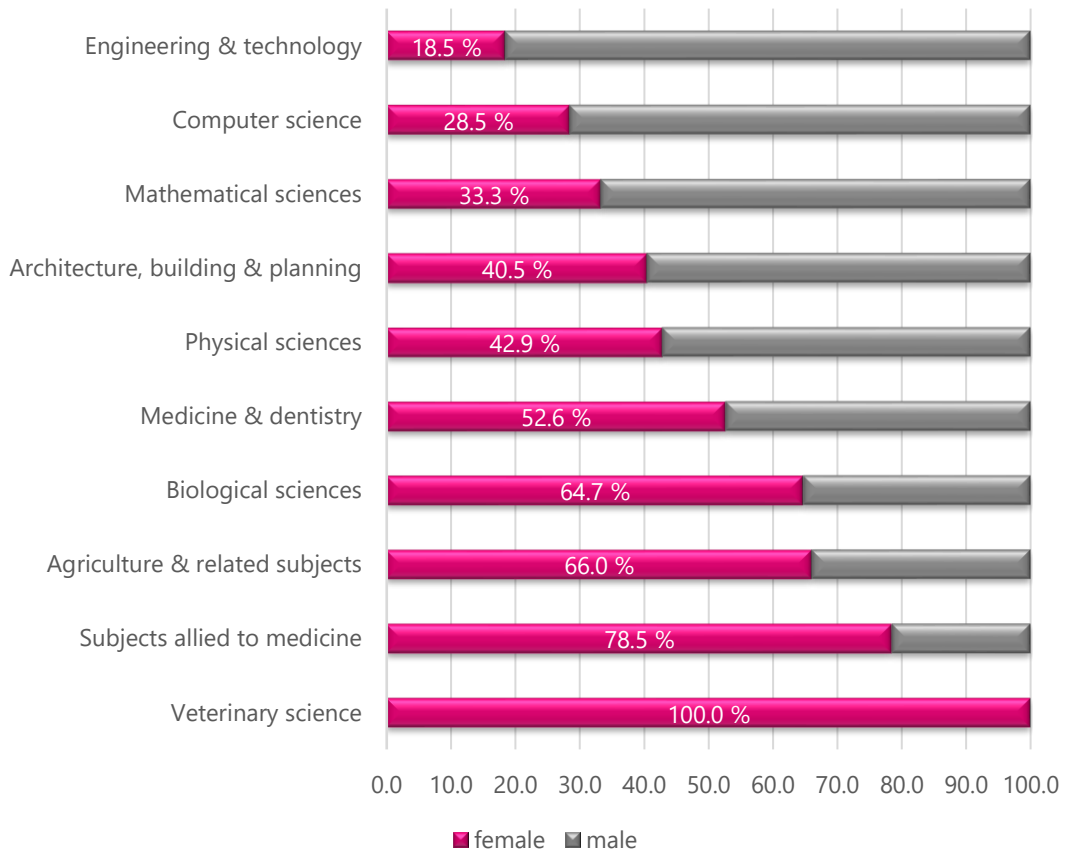


Postgraduate

Of the 4,665 NI domiciled students gaining postgraduate qualifications, 60.1% were female. 40.5% off all postgraduate qualifications were in STEM and a greater proportion of these were gained by females (54.7%).

The gender gaps in broad STEM subjects at postgraduate level, however despite these encouraging participation levels, present an all-too-familiar pattern. All five of Veterinary science postgraduate qualifiers were female. Of the 520 postgraduate qualifiers in Subjects allied to medicine, 78.5% of these were female. Conversely, in the male dominated narrow STEM qualifications of Engineering & technology, Computer science, and Mathematical science, females are again underrepresented at 18.5%, 28.5% and 33.3% respectively.

Figure 16: NI domiciled students gaining postgraduate qualifications at UK Higher Education Institutions by qualifications gained, subject area and gender - 2016/17



Key MATRIX Consultation Findings & Developed Themes

Young people increasingly disengaged from further study

Our young people, and girls in particular, become increasingly disengaged from STEM which manifests itself in reduced enrolments in STEM subjects at each level. Women significantly outnumber men participating in education however, despite outperforming their male counterparts at GCSE and A-Level, they are substantially underrepresented in the study disciplines of engineering (14%), computer science (16%), architecture, building and planning (35%), and mathematical sciences (39%) at tertiary levels.

Underrepresentation of women in Core STEM occupations

Women's participation in core STEM occupations is persistently low (23%, UK) in comparison to men's across OECD countries, a position which is compounded by challenges in terms of progression, opportunity and the gender pay gap.

Leadership

A recurring theme from stakeholder engagement was the lack of leadership and single point of contact across the NI STEM agenda from within government. In addition, the absence of an overarching STEM strategy is a concern to stakeholders.

The consensus is that there appears to be relatively well-resourced skills teams within DfE but with overly complex, difficult to navigate, structures. The obvious need to share STEM responsibilities with DE and third party organisations, and the cluttered landscape of interventions adds to this complexity. The loss of the STEM business Liaison officer from within DfE in particular was raised by many as having had a particularly negative impact across the NI STEM community.

The need for overarching leadership was therefore identified by many..

Education

A range of stakeholders expressed the concern that there are fundamental problems in the science curricula. Essentially, that the 'world around us' and post-primary curricula are not inquiry based and not therefore engaging students effectively in STEM experiences. The removal of science from assessment during transfer tests and the primary focus on literacy and numeracy (since 2007) is of particular concern.

The importance of ensuring STEM learning is practical and applied to real world scenarios while gaining knowledge of the wealth of STEM careers was highlighted. Research has found that girls in particular benefit from practical learning and gaining insight to different careers. This is especially important in the context of specific STEM roles which remain male dominated.

NI businesses have commented that the curricula do not reflect present, never mind future industry needs.

It is perceived that STEM is not always seen as a priority in primary and secondary education, with funding decisions dependent on Boards of Governors and Principals. This has led to inequality of provision across NI. Vital transferrable skills are gained through STEM learning – skills that will be to the benefit of all.

Other points raised include the need to:-

- shift focus from league tables (post-primary) to competencies and employability and;
- the requirement for more flexible approaches to time-tabling.

Recommendations to address these issues should include actions in particular for enhanced education links with industry and home, curriculum development with review of transitions (year 7-8 and year 12-13), assessment of provision, further development of STEM learning communities and STEM partnerships.

Continuous Professional Development

Stakeholders commented on particular challenges surrounding CPD which include lack of funding, staff resource to take time out to avail of development opportunities, a complex landscape and too much choice from various providers. Primary teachers in particular lack confidence in STEM teaching and there is an appetite for teacher professional development. The CPD role of the Education Authority is diminishing due to lack of funding from NI government. This is an area of particular concern.

Industry representatives are keen to get involved in CPD programmes but cite a lack of support when trying to access schools.

The need to focus on building teaching capacity in STEM with input from industry, and additional funding from government was therefore identified.

Retaining Girls in STEM Education

Stakeholders highlight the need to promote and provide relevant experiences of a diverse range of STEM careers more effectively. The need to establish enhanced links between industry, home and school is also identified. Parents and careers/subject teachers play a vital role in supporting young people to make the best choices for their future and to plan for their pathway through education and career. Therefore, offering greater support to parents and teachers is vital and initiatives such as industry open days and roadshows have an important role to play.

Another important consideration highlighted is the need to have truly inspirational role models, mentors and work placements in industry. If young people can see what others have achieved and how they can contribute to society, they can be inspired to continue with STEM education and ultimately pursue a STEM career.

Attracting and Retaining Female Talent in STEM Occupations

The importance of promoting a flexible and inclusive modern workplace was reflected by many stakeholders. The provision of affordable childcare and support to encourage men and women to take equal responsibility for work/life choices is central to achieving this objective. There are now a number of OECD countries taking this approach. In parallel with this concept, organisations must promote a meritocratic culture for all and equal access to development opportunities and progression.

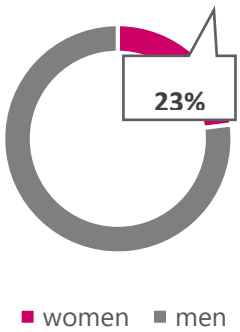
UK level data (ONS Labour Force Survey).

Women in core STEM occupations across the UK

(Labour Force Survey 2017, ONS)

Women make up 23% of employees in core STEM occupations in the UK. Core STEM includes science, engineering, information and communications technology and skilled trades.

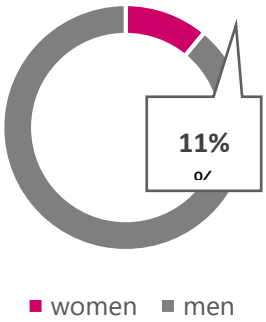
2017
864,278



Women in Engineering Professional Occupations

Male-dominated STEM fields of study such as engineering, manufacturing and construction have relatively high employment rates (85% across the OECD) but the greatest difference between the employment rates of men and women. In 2017 women represented just 11% of the UK's professional engineering workforce.

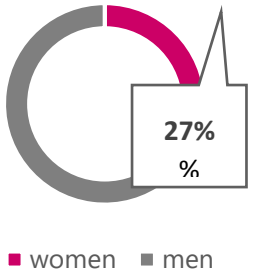
2017
48,449



Women in Science & Engineering Technician Occupations

Whilst we saw an increase of almost 22,000 women science and engineering technicians in the UK over a year since 2016, the number of men increased by 52,000 and the proportions remained stable.

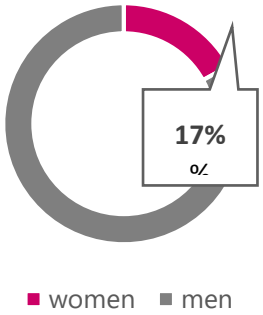
2017
97,064



Women in ICT Professional Occupations

The number of women and men working as ICT professionals across the UK dropped in 2017 by almost 11,000 and 15,000 respectively since 2016. The proportion of women in the workforce dropped by 1%. According to the Women in IT Scorecard (2016)[36], women represent 19% of the ICT Professional occupations in NI.

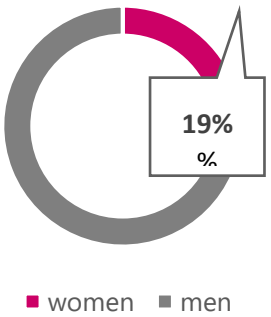
2017
172,411



Women in IT Technician Occupations

The number of women and men working in IT Technician positions across the UK increased in 2017 by more than 3,000 and 15,000 respectively since 2016. The proportion of women in the workforce remained stable.

2017
46,523

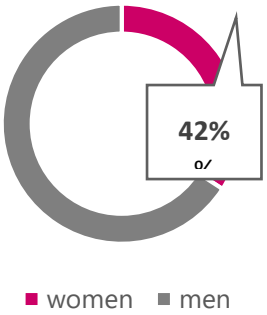


[36] Women in IT Scorecard. The Tech Partnership. 2016

Women in Science Professional Occupations

The number of women and men working in professional science positions in the UK dropped by 7,000 and 16,000 respectively over the year since 2016. Women make up 42% of the total. This category includes chemists, biochemists, biologists, physicists, geologists and meteorologists.

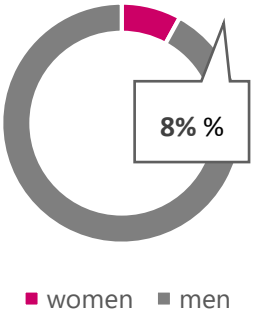
2017
57,371



Women in Skilled Trade Occupations

The number of women and men working in skilled trade occupations across the UK fell by 5,500 and 35,000 respectively over the year since 2016. Women represented 8% of the total workforce.

2017
266,244



Women in Science, Engineering & Technology Management Occupations in the UK

Across the UK, women represent only 15% of STEM management positions.

2017
97,630