Gender equality and representation within and beyond the University of the Highlands and Islands

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Aiming for Awesome: improving perceptions of engineering amongst girls through a digital, STEAM based intervention

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Abstract

The University of the Highlands and Islands STEM team has worked in partnership with the Royal Air Force in order to develop a series of workshops, encouraging students to explore engineering, and in particular aerospace. These workshops have been developed with a focus on encouraging more girls to become interested in engineering, and to see the sector as a possible career path for them to pursue, with the engineering sector currently experiencing a major deficit of women in engineering roles.

These workshops have been designed to combat the perceived barriers that research has shown may be deterring girls from pursuing engineering. This chapter will outline some of these barriers before exploring how the workshops have been designed through incorporating a STEAM (Science, Technology, Engineering, Art and Mathematics) based approach, bringing in the arts into various activities, and so demonstrating the creativity within the engineering sector.

Keywords: Girls, engineering, STEAM, stereotypes, creativity

Background

The University of the Highlands and Islands STEM (Science, Technology, Engineering and Mathematics) Team works to engage with communities and schools around the Highlands and Islands region, building scientific capital, and working to develop a skilled STEM workforce aligned with business needs and economic growth in the

local area. We work to address issues surrounding equity opportunity; gender, and rural isolation, with a particular focus with regards to equity of opportunity in the Highlands and Islands area. Projects run by the STEM Team are subject to funding, with a variety of partners, both academic and external, contributing to the team's work in order to develop a range of interventions, from developing school workshops, to running the Inverness Science Festival, and delivering teacher training sessions. It is through one such partnership with the Royal Air Force (RAF) that the STEM team has had the opportunity to develop a series of workshops entitled 'Aiming for Awesome', focusing on raising awareness and interest in careers in the engineering sector, and aerospace in particular. Due to the emergence of COVID-19 in 2020, the workshops were developed with a hybrid delivery model in mind, with physical activities run using equipment delivered in kits to schools. The theory behind each activity was delivered through online videos and worksheets developed by the STEM Team. This allowed the team to have a presence in school (not possible due to COVID-19 guidelines), and also to easily reach rural

areas with relatively low cost, extending the reach of the STEM Team's presence around the Highlands and Islands.

The 'Aiming for Awesome' workshops were based upon a kit that the RAF had initially delivered to the STEM Team. The kit contained various pieces of equipment required for activities associated with a workbook, created by the RAF, with a target audience of second level primary school students (Primary 5 to Primary 7). The STEM Team was requested by the RAF to rethink these activities, in order to better engage the school students, with a focus upon female students, Black and minority ethnic students, and students within rural areas.

Four separate workshops were developed, with practical activities for the students to undertake, whilst a STEM Team member talked through how to run them, and the underlying science, via pre-recorded video hosted on a dedicated webpage on the University of the Highlands and Islands website. Each workshop explored a different area of engineering, all linked to aerospace, with the first

investigating aircraft design, the forces acting upon aircraft, and the issue of ‘wingtip-vortices’. The second workshop explored communications technology, asking the student to explore the Electromagnetic Spectrum and its associated uses, from satellites, to unmanned vehicles, and RADAR systems. Following on from this was a third workshop investigating cyber security, and the development of codes through the ages, as well as the importance of random numbers and prime numbers in the digital age. The fourth workshop differed in that it focused on summarising the previous three workshops through allowing students to design, build, and fly their own bottle rockets, before analysing the rocket’s acceleration using data collected from an onboard Micro:bit.

A condition of the project, stipulated by the RAF, was that the STEM Team tailor the workshops to encourage more girls to see engineering as a viable career option, thus addressing the current gender disparity within the engineering sector, that has seen only 12% of women in the engineering sector, whilst making up 47% of the UK’s

overall workforce (EngineeringUK 2018). This chapter will proceed to discuss the reasoning behind this immense disparity, and the efforts that this workshop has taken in order to combat this crisis.

A leak in the pipeline

A leaky pipeline is a metaphor that is often employed when describing the loss of women throughout the academic journey toward a career in engineering, beginning in secondary school, where students begin to make choices regarding their preferred careers. It has been found that in Europe, girls first become interested in STEM at around age 11, with the average age in the UK found to be at age 11.3 (Microsoft 2017). This age corresponds with the second level of the primary school curriculum, encompassing students from P5-7, hence the Aiming for Awesome school workshops were all tailored to incorporate links from the science, numeracy and literacy areas of the Scottish 'Curriculum for Excellence' at this level, to reach these students at the most optimal age. This interest in STEM has been found to only continue until age 15-16 however,

before a sharp drop off was found, thus a window of only 4-5 years is available in which to nurture these interests in STEM amongst girls (Microsoft 2017). This leak in the pipeline is described as ‘progressive’ and ‘persistent’ by Cronin and Roger (1999), with three stages identified within this paper where women are increasingly underrepresented. The first stage, *access*, encompasses STEM at a secondary school level, followed by *participation*, where women pursue STEM at undergraduate or postgraduate level, and finally *progression*, where women are a part of STEM at a professional level. There are a number of issues regarding losing women through the ‘leaky pipeline’, eloquently put forth by Blickenstaff (2005). The issue of equity arises first, employing a moral argument whereby every person should have the opportunity to study and work in a field that they choose, regardless of gender. Secondly, as long as there is an underrepresentation of women in STEM, we are losing talented, intelligent women to other subjects in which to study and work. This poses a massive problem in that these women may have contributions that could greatly impact

the field of STEM if given a chance, thus in failing to recruit such individuals, we may be missing out on significant advances that could lead to the betterment of society. Finally, scientific and technical endeavours require fresh insights, and diversity of perspective in order to search for knowledge and answers to today's questions. Only through maximising diversity can we harvest such a wide range of viewpoints, which are shaped through the experiences of the individual. According to the EngineeringUK report 'Gender Disparity in Engineering' (2018), by bridging the gap in work between men and women in engineering, the UK could increase GDP forecasts by £150 billion by 2025, demonstrating the importance of combatting this disparity between men and women in this sector.

So why is there a leak in the pipeline with regards to women pursuing STEM, and in particular engineering? There are several perceived barriers for girls when considering pursuing engineering, including a lack of knowledge regarding careers within the sector, with 48% of girls in every age group responding that they knew almost nothing,

or very little, when asked how much they knew about what engineers did (EngineeringUK, 2018). It was also found that girls often had less of an understanding of the variety of careers available to them in engineering compared to the boys that were surveyed, whilst a disconnect between the girls' values, and what the girls perceive the values of those in engineering were, also proved to be a contributing factor, with girls more likely than boys to state that making a difference, being valued, and having the opportunity to be creative were all attributes that were important to them when deciding upon a career, whilst being less likely to see the engineering sector as a route to achieving these goals.

Stereotypes have also been found to have a profound impact upon the gender disparity in engineering, with numerous studies investigating this aspect, one such study highlighting that 'children have reduced interest in future academic courses and occupations that are incompatible with their academic self-concept (Denissen et al., 2007). Stereotypes prevalent within society surrounding gender and engineering have been known to influence students'

self-concept (Bem 1981). One such influence is the portrayal of those within STEM in the media, with Long et al. (2010) finding that television programmes consistently depicted those in STEM as an ‘unmarried Caucasian man who did not have children, held a high-status science position, and was likely to be portrayed as being intelligent’, with this stereotype perpetuating the idea that this type of career is primarily for men. Additionally, these stereotypes can be perpetuated by parents, who have been found to have a significant impact upon the decision making of the child when considering the pursuit of STEM (Bleeker and Jacobs 2004), and by teachers (Saucerman and Vasquez 2014). EngineeringUK (2018) investigated the stereotypes surrounding engineering, finding that higher proportions of girls to boys considered engineering to be ‘too complicated or difficult’, ‘a career for men’, ‘dirty, greasy or messy’, or ‘boring’, with these differences in attitude between boys and girls visible amongst the youngest of the survey’s respondents (age 7-11).

A STEAM based approach

STEAM refers to the educational approach that uses Science, Technology, Engineering, Art and Mathematics as access points, guiding students' exploration, discussion and critical thinking (Wajngurt and Sloan 2019). In this context, the arts include the visual arts (including drawing, painting, sculpture, filmmaking, architecture, photography ceramics), literature (poetry, drama, prose fiction) and the performing arts (theatre, dance and music) (Braund and Reiss 2019). There is significant evidence for the benefits of this interdisciplinary approach, most notably as reported by Root Bernstein et al. (2008) in which it was found that Nobel laureates (awardees of one of the most prestigious awards available in STEM) were significantly more likely to engage in arts and crafts than others in the study, with these scientists citing their hobbies as 'stimuli for their science'.

Not only does STEAM allow for the students to increase creativity when exploring various concepts in STEM, but there are several associated advantages with this

technique that benefit the students, including enhancing the chance of retention and recall of information through the creation of additional neural pathways (Land 2013), making the activity relatable and fun, and providing a means for those who identify with the creative arts to bridge the gap and to explore STEM (Segarra et al. 2018). In incorporating the arts into STEM, the level of creativity and personalisation with regards towards an activity or task increases, creating a more engaging approach to STEM education (Boy, 2013), one more inclusive, capturing the attention of those that previously showed no interest in pursuing STEM (Wajngurt and Sloan 2019).

The aforementioned study by EngineeringUK (2018), in which girls were found to have stated that “having the opportunity to be creative” was an important factor for them when considering future careers. This idea that engineering does not allow individuals the opportunity to be creative was the first to be considered when designing the Aiming for Awesome workshops. In order to combat this idea, art was incorporated into various activities, in a bid to allow the

students to utilise their own creativity, and to expand upon the task at hand, reducing the influence of the workshop presenter, and allowing the students to take ownership of the activity. The activities included in the workshops in which the STEAM educational approach was applied included investigating forces through the design of aircraft constructed from paper, in which students were encouraged to follow the iterative design process; investigating prime numbers through designing posters; creating an airbrush while investigating the Bernoulli Principle (1738); and designing a rocket through employing the knowledge gained within the first three workshops, to name but a few.

Stereotypes

Engineering, along with computer science, have often been stereotyped as “male-oriented fields that involve social isolation, an intense focus on machinery, and inborn brilliance” (Cheryan, Master and Meltzoff, 2015). The issue regarding stereotyping can be best described through the term ‘stereotype threat’, in which individuals who relate to

certain negative stereotypes can feel that they be at risk of conforming to such stereotypes, and as such this can influence their performance in this area (Spencer, Steele and Quinn 1999). It has been found however, that in altering these stereotypes, by broadening the diversity of the individuals seen to work in engineering, and by giving a greater view of what the work in this sector looks like, and the environments in which the work is done, that girls' sense of belonging can be significantly increased, along with their interest in the field (Cheryan et al. 2015). As such, the Aiming for Awesome workshops were designed to combat the negative stereotypes associated with engineering, with each workshop beginning with a short interview with a woman in engineering, discussing their work, their passions and their interests within the field, broadening the students' perceptions of what an engineer looks like, as well as the various career paths that they can follow. The wide variety of career paths that the students could pursue were further highlighted throughout the workshops, with each workshop focusing upon a specific area within engineering (mechanical engineering, cyber security, and

communications). This again links back to the survey run by EngineeringUK (2018), in which it was found that girls had less of an insight into the wide variety of career pathways available to them in engineering than the boys who were surveyed. Furthermore, at the end of each workshop, a follow-on activity was introduced, in which the students were encouraged to go and explore a woman in the engineering sector who has made a large contribution to her particular field, with the aerospace design workshop featuring Elsie Gregory MacGill, also known as Queen of the Hurricanes, who was the first woman to earn a degree in aeronautical engineering, and a prominent feminist in 20th century Canada (Sissons 2009). Following on from this, the second workshop, titled communications, in which the electromagnetic spectrum was explored, encouraged the students to research Dr. Wanda Diaz Merced, a leader in the field of the sonification of astrophysical data, and campaigner for equal access to astronomy (Royal Society 2021), with her loss of sight giving her personal experience of the barriers that students and professionals with disabilities may encounter in the field. The third workshop,

investigating cyber security in engineering, featured the story of Margaret Beedie, one of the team that had worked as part of the secret code breaking effort at Bletchley park during the Second World War. Beedie was focused upon in this workshop not only because of her important work at Bletchley Park, but also due to her links with the Scottish Highlands and Islands, having been born on Harris, and living for the majority of her life in Aberdeen (Scotsman 2014). Finally, the last of the four Aiming for Awesome workshops, in which the students are asked to design and build a rocket using the knowledge they had gained from the previous workshops, featured three influential figures of the 1969 NASA Space Project, Mary Jackson, Katherine Johnson and Dorothy Vaughn, whose work aided in putting a man on the moon on the 20th of July 1969.

The introduction of role models, such as the women that have been featured throughout the Aiming for Awesome workshops, has been proven to have a significant effect when combatting negative perceptions around women in engineering (Kekelis and Joyce, 2014). A study by

Microsoft (2017) found that the influence of role models was in fact the greatest factor in driving girls' interest in STEM, with the second being practical hands-on experience, which again, the workshops provide, through the highly practical nature of each activity. Following on from this, teacher mentors, visible real-life applications, and confidence in equality were also found to have an impact. Additionally, through highlighting these women, who have all made massive contributions to their respective fields, the Aiming for Awesome workshops also highlighted that individuals in engineering can make a difference, and are valued for their work, with these being attributes that girls interviewed in the EngineeringUK report were found to have given salience (EngineeringUK, 2018).Assessing the effectiveness

At the time of writing this chapter, the workshops were still in development, with the hosting website currently in construction, and so it was yet too early to tell as to whether these workshops will be readily adopted by schools, with a second lockdown in the Highlands and Islands area impacting upon the students' education and putting further

pressures upon schools to make up for time lost in class. In order to assess the impact of the Aiming for Awesome workshop series on students in a shorter timescale, each set of workshops sent to schools will be accompanied by a set of questions for teachers, asking questions related to the engagement by pupils with each workshop, with a focus upon the degree to which girls and boys enjoyed the workshops, and the degree with which each gender interacted with the workshops. Again, due to constraints, this will require qualitative analysis, as no STEM Team members will be present to record this data, instead relying on teachers' responses. Due to the lack of presence of a STEM team member at the school, the quality of evaluation will be impeded, with evaluation questions minimised in order to ensure a response is given, with team members understanding that teacher time is valuable, and that too large an evaluation may be seen as 'off-putting', thus reducing the chance of any response being received. A competition accompanying each workshop has therefore been devised, with students being asked to draw and design a new type of aircraft, whilst thinking about the

concept of biomimicry as they do so, thus again allowing students to use creativity, and also linking to the curriculum once more, by encouraging students to think about the characteristics of living organisms, and how their characteristics allow them to adapt to their environments, whilst at the same time allowing the STEM Team to qualitatively assess whether the students were utilising the concepts they had learned through the workshops.

A note on intersectionality

Although this work focused primarily upon the issues in engineering surrounding gender, it cannot be ignored that within the realm of gender, lies a wide variety of further overlapping identities, including age, ethnicity, nationality, and sexuality. The overlapping of these identities can be looked at using the concept of intersectionality, a term credited to Kimberlè Crenshaw (1991). Although this project focused upon gender as the primary characteristic in which the intervention was designed to support, the STEM Team could not ignore the fact that within the area

of gender lies a wide variety of further marginalised characteristics, with the complexity of an individual's experiences with discrimination increasing with the number of markers of identity and difference (Ortiz and Garcia, 2013). The STEM Team, therefore, when designing the Aiming for Awesome workshops, worked to ensure the greatest possible representation, with the role models that the students were tasked with investigating displaying a variety of these characteristics that the students could relate to themselves, through the inclusion of women with disabilities, Black women, and a researcher from Puerto Rico. Whilst all role models were women, we ensured that the role models we selected were representing the widest possible group of characteristics amongst women, and as such, hope that these role models are representative of the widest group of our potential audience.

Conclusion

The University of the Highlands and Islands STEM Team were requested by the Royal Air Force to adapt a series of activities into curriculum-linked workshops for second level

primary students. These workshops were developed with the aims of highlighting careers within the engineering sector, whilst also focussing on targeting groups that are currently underrepresented within the sector, namely women, Black and ethnic minorities, and those within rural communities. In this chapter, the development of the workshops was discussed, primarily looking into how to tailor the workshops to be inclusive of girls, with women in the engineering sector found to be woefully underrepresented (EngineeringUK, 2018). As such, the workshops focussed upon creativity, incorporating the arts into the intervention, with this being a proven method of increasing engagement in STEM with girls (Boy, 2013; Segarra et al., 2018; Wajngurt and Sloan, 2019). Additionally, the workshops span a wide range of areas within the engineering sector, highlighting the variety of careers available in engineering, with a lack of understanding as to what engineering actually is being found to be a further barrier as to the pursuit of a career in this sector amongst girls (EngineeringUK, 2018). Finally, the introduction of a wide variety of role models, all women,

showcased that women can be successful in this field, whilst also highlighting various accomplishments made by women in the field, and highlighting the women themselves, all of which have been found to be effective methods of engaging with girls with respect to engineering, and STEM in general (EngineeringUK, 2018).

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Author bio

Blair Watson began his role of STEM Programme Coordinator in September of 2020. Blair studied Marine Science with the University of the Highlands and Islands, prior to progressing on to study a master's degree at the University of the West of England in Science Communication. He then headed up to Northern Scotland to begin his first professional role, developing and delivering school workshops as a representative of a marine charity, before beginning his position at the University of the Highlands and Islands.

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