GIRLS GET TECH: A SMART MODEL FOR ENGAGING FEMALES IN STEM

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Abstract

Investigation of Science Technology Engineering and Mathematics (STEM) student recruitment data for our own institution for certain subjects over the past six academic years has revealed a number of trends concerning gender balance. Whilst areas of study such as business, mathematics and chemistry have roughly a 50/50 % split of females and males, student populations in degree programmes for environmental sciences, geography and biological sciences have shifted towards a larger proportion of female students. Whilst there is also a larger proportion of females registering for degree programmes across medicine, dentistry, health and food sciences there is a long-term trend of low numbers of females registering for computing, physics and engineering. This year the female student component in our School of Computing was its lowest for six years.

In order to introduce physics, computing, electrical and electronic engineering to prospective students, smartphones, cloud computing and Application Program Interfaces (APIs) were used as a learning resource. In this way, the more creative side of digital technology learning was explored. A zero/very low-cost approach was taken using open source and free to use materials and students were encouraged to work in groups to reduce impact of participants not having the latest phones. Skills and competencies were developed through a quiz, design and virtual reality which in turn generated confidence to explore the more technological aspects of smartphones.

Exceptionally good feedback from participants and teachers resulted in over-subscription for these classes from schools and requests from teachers for our lesson plans. As a consequence, further learning materials are being developed covering optical recognition and augmented reality.

Girls seem to be more willing to engage in STEM-focused learning where they can use tools (smartphones) that they are already comfortable with in a problem-based learning type situation. Parallel learning of artistic/aesthetic design in combination with coding and cloud-based computing seems to provide a suitable model for contextualised learning, building skills and competencies to deal with more difficult problems as the level of work progresses. The availability of in-built functionality within smartphones also provides options for differentiation within groups allowing teachers to work with groups of different ability in the same classroom setting.

1 INTRODUCTION

The 2014 report ‘Women in Science, Technology, Engineering and Mathematics: The Talent Pipeline from Classroom to Boardroom’ [1] suggests that a different experience of Science, Technology, Engineering and Mathematics (STEM) learning is required in schools to generate the required step change in numbers of women moving into science and technology jobs. In the United Kingdom (UK), study of mathematics and science (incorporating chemistry, biology and physics) is compulsory up to age 16 and consequently there is broadly equal male and female representation. Across the UK at ‘A’ level (typically age 18) there are lower numbers of females being entered for STEM-related subjects (except Biology) [1]. At University level, the numbers of females represented across certain STEM subject areas drop even further, despite the gender balance of UK universities being skewed in terms of higher numbers of females on undergraduate programmes. In 2015 a University and Colleges Admissions Service (UCAS) report stated that UK women are 35% more likely to go to university than men, and that there are more women than men registered on two thirds of courses [2]. Analysis of our own university data partly confirms this picture with a gradual increase in the percentage of females taking undergraduate courses (62% across all undergraduate courses in 2016/17 academic year) but low numbers of females in Engineering (17%), Physics (23%) and particularly Computer Science (6%). Beyond university, initiatives have been put in place to address the low numbers of females in senior positions across STEM (and subsequently other) industries. The Athena Swan initiative, founded in 2005 is a good example which supports the career progression of women in STEM for the UK Higher Education sector [3].
Apart from the requirement to address trends in gender balance across post-16 subject learning, working practices have started to change reflecting the accessibility and take up of mobile devices and cloud-based computing. The Publicly Available Standard 3000 (PAS 3000) [4] is a UK government funded code of practice on smart working, which refers to the implementation of technology and flexible working patterns to improve work-life balance and maximize economic output. With these changes in mind, our learning sessions incorporate discussion on how technology can aid smart working. This paper seeks to share our experience as practitioners of outreach designed to encourage more females into sampling and following STEM-related qualifications and contributing to the future technological workforce (with hopefully a better work/life balance throughout their career).

2 METHODOLOGY

In order to further explore the integration of creativity and technology in our STEM teaching, we developed a series of lesson plans with components that can be strung together to form longer or shorter learning sessions under the title ‘Girls Get Tech’. Participating students were encouraged to bring their smartphones to the lesson and we had spares to loan out if any student did not have a phone or their battery died. Each component part had a mixture of teaching and learning styles including lecture, discussion, the use of props, interactive activity and the use of indoor and outdoor space. Each component also had strong contextualisation of learning – students taking part see the relevance of learning about something that they use every day. In order to access WiFi, we arranged for students to have a temporary log in and passwords for our on-campus system and in schools, use either the school WiFi network, or add an extra learning session around tethering, using our own mobile data connection. Students taking part in the exercise usually have a Google Account already set up, but if not we take them through the registration process. This enables the students to create and save files using cloud-based technology and gives access to a wide range of free to use software with inherent compatibility.

Our first session covers the background of smartphone development with reference to smartphone hardware and software. Use of props (old mobile devices, collected through an office amnesty) allows participants to examine the design and features of different mobile devices over around a 20 year period. Participants are asked to arrange the phones in date order. We finish off this first session with a fun quiz covering questions around mobile technologies and supporting infrastructure.

Our second section covers reflection, refraction and three dimensional (3D) projection using a Victorian stage technique commonly known as ‘Pepper’s Ghost’ [5]. The ‘Pepper’s Ghost’ technique uses a transparent screen and differential lighting to ‘project an image onto a stage in order to interact with real life actors. The smartphone version of ‘Pepper’s Ghost’ (Fig 1) uses a four-sided video image projected onto a transparent, upside down, truncated pyramid, creating the illusion of a ‘holographic’ video image inside the pyramid. The interactive learning part of the session involves a demonstration of the ‘Peppers Ghost’ illusion using a CD case and two tea lights and an explanation of how reflection, refraction and differential lighting cause the effect. This is followed by the students cutting and scoring an acetate sheet from a pre-designed template. The cut out is then folded and stuck together with clear tape to form the truncated pyramid. This is then placed in the centre of the smartphone screen (brightness turned up to maximum for best effect) and a video selected and played. Videos to suit the activity are readily available on YouTube and applications are available for both iPhone and Android for participants to create their own videos.

![Fig 1 Image created with the ‘Pepper’s Ghost’ effect.](image-url)
The third session in our series builds upon the first two, again combining smartphone technology and creativity in the discussion and exploration of Virtual Reality (VR) and 3D imaging. Students explore how Google capture images for their Google Street View™ mapping service, then further explore with their smartphones using the Photosphere or Surround Shot (or similar) function. At this point the students can go outside to take spherical images either across campus or the school premises. As the students return with their images they are asked to construct cardboard headsets and then to view their newly captured spherical images in 3D using Google Cardboard™ VR. The students then get a demonstration of how the Exchangeable Image Format (EXIF) section of metadata is used to give each image a temporal and spatial location and how this can be attached to a Google map or the Google Earth™ mapping service.

Logical extension of this type of activity can include digital mapping and embedding in web pages, construction of trails or pathways around a geographical area covering a certain theme, application development and use, coding and even smartphone design and software development. Virtual and augmented reality and 3D visualisation using mobile devices and appropriate headsets is already being used in a range of applications across science and technology [6] [7] and proving a popular choice with new students at university [8].

The series of activities has been tested across different groups (foster families, community groups, parents and school children aged between 12 and 17), and works well with all, but female groups tend to respond particularly well to this type of learning. We have now firmly embedded this area of activity in our outreach programme and used it to source external income for mapping and heritage projects. Future development will incorporate more 3D video, virtual and augmented reality work and possible exploration of how smartphones can be used as controllers for accessories like drones or in domestic situations (e.g. for programming heating). A further logical extension would be to explore the value offered by mobile technologies in new ways of working, complimentary to the PAS 3000 Smart Working Principles [4].

3 RESULTS

To date 377 young people and 200 adults have been exposed to this new learning experience at campus, community and school-based locations. Some degree of differentiation has been required for working in a community setting with foster families and adult learners, but overall the outline and content of the learning is similar to that reflected in the methodology section of this paper. The majority of the young people worked with have been female secondary school students attending our Girls Get Tech activity, for which bookings are typically four times over-subscribed.

Statistics for our Girls Get Tech sessions show that 97% of respondents rate this session as ‘Good’ or ‘Very good’ (a breakdown of 40% ‘Good’ and 57% ‘Very good’) in comparison with 89% our typical STEM learning sessions offered to a similar age group.

When asked if they would like to take part in future technology sessions with us, 100% of participants responded with ‘Definitely’ or ‘I think so’. 92% of respondents reported that they felt an increased interest in computer science and technology after taking part in the session (with a breakdown of 36% ‘Definitely’ and 64% ‘A little’). In response to this question, two students said they did not feel more interested in the subject matter, however, one commented that they already had an interest in it prior to taking part in the session. 97% of respondents said that they would be more likely to pursue computer science in further study if school lessons were taught in a similar way to our Girls Get Tech sessions.

Comments from participants include the following:

“This type of technology would encourage girls to just have fun and be themselves, they don't have to be cocky or know everything because they are discovering it for the first time.”

“I already know that tech, computing and science are great subjects and this workshop showed that well to others.”

“I believe that not making the event exclusively female would improve it. It would have been better if it had been open to all.”

When asked what the most useful aspect of the session was, responses include:

“Showing that girls can do these subjects”
“Finding out about important women in tech through history”
“Mixed education with practical activities to make a fun learning experience.”

Teacher feedback has also been collected following delivery of these sessions. 100% of teachers questioned felt that the event improved the students’ understanding of the subject and that students learnt something new by taking part. All respondents said that they personally found the session useful and would be able to take the information back to their school or college, and that they would recommend this session to others.

Commenting on the value of this session to pupils, responses include:
“Very interactive and brilliant in terms of expanding horizons”
“Very engaging workshops, great for increasing the girl’s confidence in computing”
“It was interesting to see mobile applications not used before”
“Very engaging and very valuable to promote science”

Our feedback comes from evaluation sheets used as part of our reporting as practitioners and not as researchers and we would welcome future collaboration in order to provide more effective evaluation in this area of STEM education.

4 CONCLUSIONS

In conclusion, our work with girls aged between 12 and 17 has shown that 97% of pupils found this activity to be good or very good compared with 89% for our broader STEM range of activities. This type of activity reinforces and contextualises some of the science curriculum already learned in school and our work with family and community groups suggest that this type of learning activity is popular and easily transferrable to different audiences regardless of gender or age.

Building the skills and confidence to work effectively with mobile technologies and retaining some degree of creativity for the participant, fits well with other initiatives to promote more women into the STEM pipeline and progress through Athena Swan [3] to hopefully have a future STEM (or other) career with a better work life balance in line with PAS 3000 [4].

This type of activity can also be combined with other areas of learning e.g. science curriculum – physics and light, electromagnetic spectrum, frequency, wavelength and amplitude, geography and mapping, electronics and VR, drone technology. There is also scope to investigate how mobile technology and smartphone applications are created and used in communication, business and entrepreneurship, data security, personal security and ethics.

In terms of resources, the programme is virtually zero cost, therefore can be easily integrated into programmes of study. Participants use their own mobile device and there is a small cost for Google Cardboard and WiFi or tethered data sharing.

It should be recognised that this paper is written from a practitioner perspective and the methodology reported is undergoing continual development in line with advances in virtual reality and smartphone technology. We are keen to expand our range of activities and audiences and will actively seek collaboration and sponsorship to develop this programme.

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REFERENCES


[8] CS@Illinois, “Virtual Reality Course Brings Students to the Forefront of Technology.”