Raising STEM career aspirations through the primary years

● Fran Long

Abstract

Within an already crowded curriculum, can primary teachers raise the STEM career aspirations of their pupils? A national shortage of engineers persists (Engineering UK, 2017) and a body of evidence highlights the need to inspire young people to consider future STEM careers by the age of 10 (Archer et al, 2013). This research study measured the impact on pupils of monthly contact with real scientists and engineers from a diverse range of careers, through a STEM assembly programme. STEM career aspirations, perceptions of the roles of engineers, and Engineering Habits of Mind (EHoM) exhibited by pupils were all measured through multiple research methodologies and were markedly higher in the trial group than in the control group. Science and engineering career aspirations overall in the trial were much greater than those reported nationally, especially amongst the girls. In this paper, we discover how this initiative could be replicated in your school.

Keywords: STEM, careers, engineering, science capital, research

Introduction

Limited prior research had specifically measured the usefulness of engineer visits in the primary years for enhancing STEM career aspirations. The author worked as a primary science specialist teacher in the South East of England, in a county rich in science and engineering heritage, research and industry, and saw an opportunity to utilise this, with the aim of enthusing the next generation of engineers.

Previously, a large-scale study, published in 2018, of 20,000 primary-aged children (ages 7-11), 13,070 of whom were from the UK, gauged pupil STEM career aspirations, reporting that boys were over four times more likely to want to become an engineer than girls (Chambers *et al*, 2018). It stated that *'Early intervention can be a very cost-effective targeted way of raising children's aspirations and broadening their horizons'* (Chambers *et al*, 2018, p.vi). There is a significant opportunity, as the ASPIRES report (2013) claims, that STEM career aspirations in primary-aged pupils act as an accurate indicator for future careers.

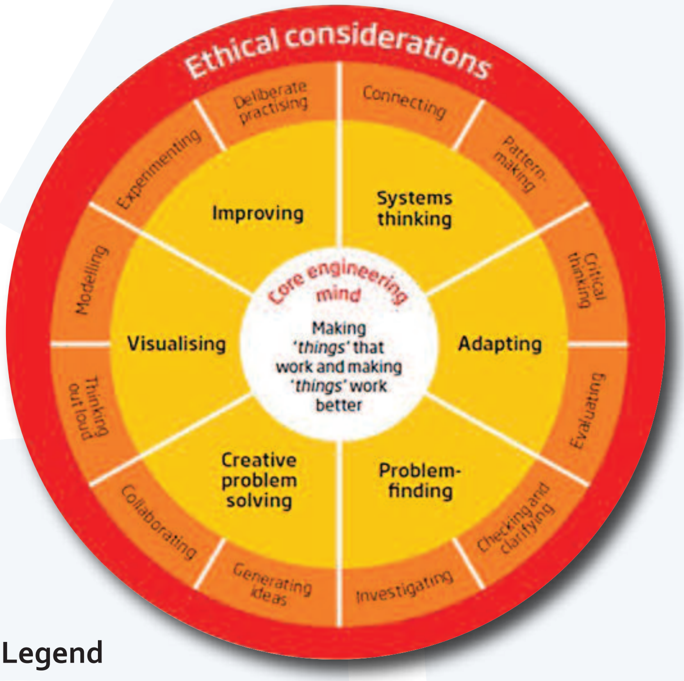
Engineering Habits of Mind (EHoM)

Lucas *et al* (2014) demonstrated distinct mindsets linked to engineering, showing that engineers are typically creative problem-finders and problem-solvers who are resilient and curious. A high proportion of engineers have a family/community member who is a scientist, engineer or practical type (for example, when the author interviewed 35 engineers in the workplace, this was true for 80%). Such links build 'science capital', with research confirming that families with medium to high science capital exert positive influence over pupils' STEM career aspirations (Archer *et al*, 2013). Providing opportunities for children to tinker and experiment with knowledgeable adults is key (Bianchi & Chippindall, 2018).

For pupils where there is a deficiency of engineering role models in families, can we compensate in school? *'Our current education system… does not sufficiently develop these habits of mind of young people to encourage them to pursue further study towards engineering careers'* (Atkinson, cited in Lucas *et al*, 2014). Can we, as teachers, be part of the solution?

Whether pupils pursue a STEM career in the future, or not, these habits of mind are beneficial to all walks of life and nurturing them in the younger years could be significant.

Figure 1. Engineering Habits of Mind (EHoM) (Hanson *et al*, 2018).



Legend
- Six Engineering habits of mind
- Twelve sub-habits

The curriculum

Whilst engineering is rarely visible in primary schools (Lucas *et al*, 2014), the National Curriculum (NC) design and technology (DT) content is highly supportive of developing EHoM as well as '*... develop[ing] a critical understanding of ...[the] impact [of DT] on daily life and the wider world'* (DfE, 2013, p.180). A report by the Institute of Mechanical Engineers (2016b) states that '*...pupils should be taught about engineering and the manufactured world alongside the natural world'* from the age of six. With non-core subjects frequently squeezed off the primary timetable, available time remains a challenge (Lucas *et al*, 2014; Leonardi *et al*, 2017; Macleod, 2017). However, the author believes that creative teachers can effectively use the current NC to provide ample opportunity to nurture EHoM, raise 'science capital' and open children's eyes to the numerous and varied career options that studying STEM subjects present beyond the traditionally recognised roles of doctor or scientist (Archer *et al*, 2013).

Methodology

Context and sample size

A monthly whole-school STEM Assembly series was designed and run for 16 months in an average-sized primary school in a market town in England. The impact on 59 upper Key Stage Two pupils (age 9-11) was evaluated as part of a Masters' level study with the organisation Primary Engineer and accredited by Strathclyde University.

The effect that this initiative had on attitudes and aspirations was monitored through multiple research methods (questionnaires, a focus group and pupil reflections), to canvass the opinion of all stakeholders (pupils, parents and staff). The study was designed to evaluate the impact of a STEM Assembly initiative that had already begun, so baseline pre-intervention data were not available. Therefore, a control group (26 Year 5/6, ages 10-11, pupils) from a local primary school of similar size and demographic, which did not run this programme, was used to make comparison. The gender split of the research groups was broadly even.

STEM Assembly practicalities

Recruitment of engaging engineers and scientists for the monthly STEM Assemblies came largely through the parent community, with additional speakers gained through Twitter and the STEM Ambassador network. Presenters were asked to foster curiosity amongst pupils by sharing about a day in their working lives, demonstrating how STEM subjects are used in the workplace, explaining what inspired their career choices, expressing their greatest job satisfaction, as well as the largest challenges faced.

An interactive talk of 20-30 minutes, with question time after (which the author led interview-style), was the model implemented. Contributors were asked to keep text on slides to a minimum, include photos and videos, bring kit to demonstrate work and give real world contexts. Curriculum-linked workshops for specific year groups followed, where applicable, with experts in these fields. For example, there was a session on aerodynamics and forces for Year 5/6 and an in-depth exploration of the skeletal system for Year 3/4 (ages 8-9) led by experts.

Range of role models

Contributors (male and female), from varied careers included a Formula 1 race engineer, who explained that there are 10,000 parts on an F1 car and 500 measurements that have to be taken, which requires patience, perseverance and resilience. Others included the Bloodhound Education team, an orthopaedic surgeon, design engineer, biomedical scientist, civil engineers, volcanologist, cardiologist, medical engineer, Olympic bicycle engineer and space engineer, who all enthused pupils by giving fascinating insight into their jobs.

Findings and discussion

Knowledge of STEM

98% of pupils at the trial school reported having heard the term STEM, compared to 19% in the control. On its own, knowledge of the acronym STEM may have a limited impact, but this finding does highlight the opportunity to raise awareness in primary schools.

Favourite subject at school

More pupils (49%) in the trial school listed science as a favourite compared to 4% (equating to 1 pupil) in the control school.

STEM career aspirations

Attitudes towards science as a future career were very low for pupils in the control group, at 3% of boys and 7% of girls. Scientific careers are considered by a significant number of pupils in the research school (28% of boys and 40% of girls).

The ASPIRES report (Archer *et al*, 2013) stated that 15% of young people (aged 10-14) aspire to become scientists. The trial school had a much larger proportion than the national average.

Whilst broadly similar numbers of boys would consider becoming engineers (48% versus 50%), 33% of girls in the research school were open to looking at a career as an engineer compared to none in the control school.

A comparison of the most popular potential careers (Table 1) reveals an interesting picture, with 'sportsperson' being the top choice locally and nationally (Chambers *et al*, 2018), but being matched with numbers of pupils in the study school who wanted to consider a career in engineering. Scientist takes third place in the research school compared to 7th nationally and 11th in the control school.

Figure 2. Favourite subject.

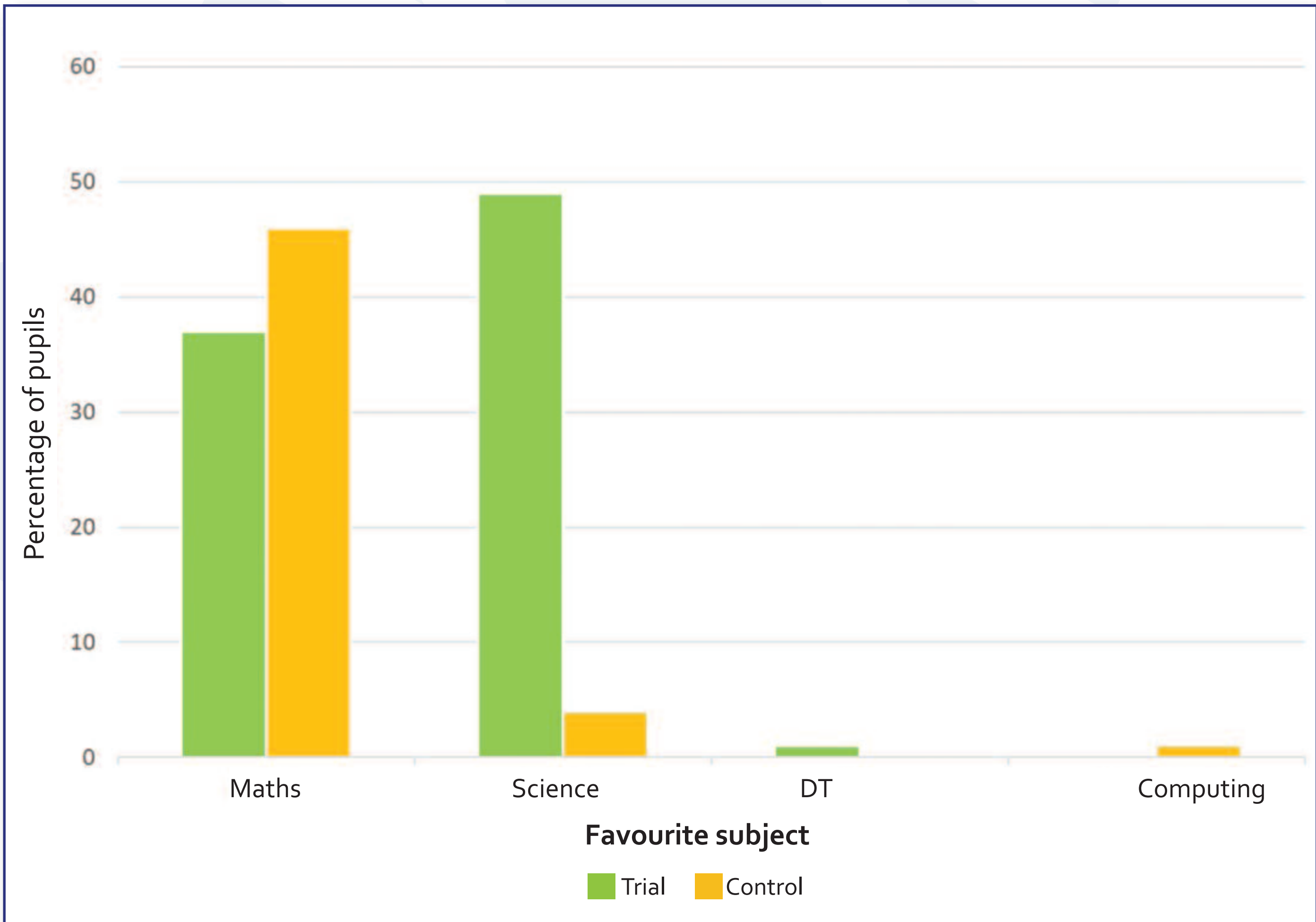


Table 1. Jobs that pupils aspire to do.

	Trial (n=59)		**Control** (n=26)		**Large scale study** (n=13,070)	
RANK	JOB CATEGORY	%	JOB CATEGORY	%	JOB CATEGORY	%
1.	Sportsperson / **Engineer**	41%	Sportsperson / Teacher / Artist / Dancer	31%	Sportsperson	21.3%
2.	-		-		Teacher	10.9%
3.	**Scientist** / Artist	34%	-		Vet	6.9%
4.	-		-		Social Media and gaming	5.7%
5.	Architect / actor/ police	29%	Architect	27%	Police / doctor	5.2%
6.	-		Author / chef / **engineer** / mathematician / vet	23%	-	
7.	-		-		**Scientist**	4.2%
8.	Author / film maker / mathematician / dancer	25%	-		Artist	3.9%
9	-		-		Musician	3.8%
10	-		-		Military	3.3%
11	-		**Scientist /** Police	19%	**Engineer**	2.5%

Figure 3. STEM career aspirations after intervention (trial) or no intervention (control). Pupils selected all jobs that they would consider.

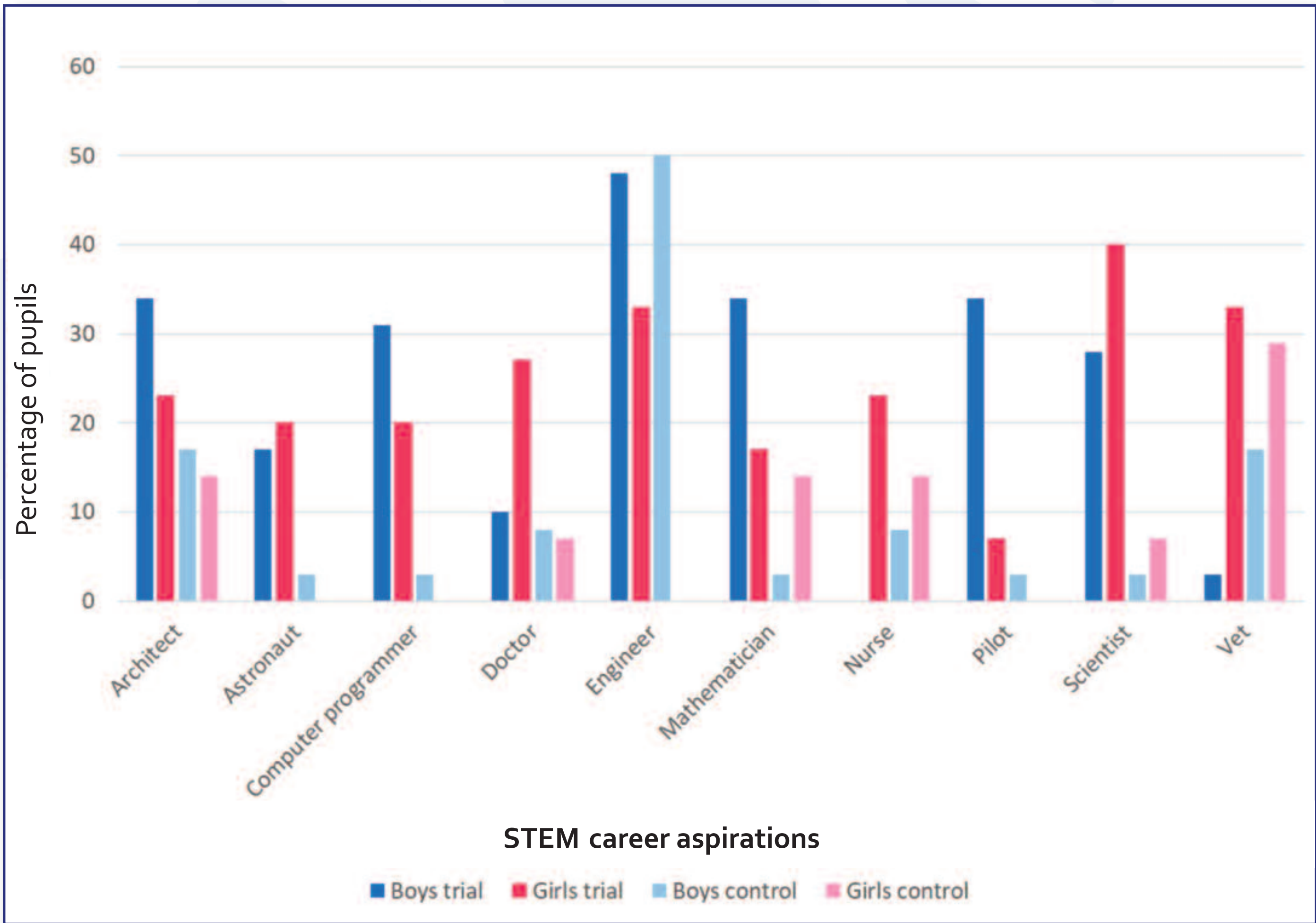
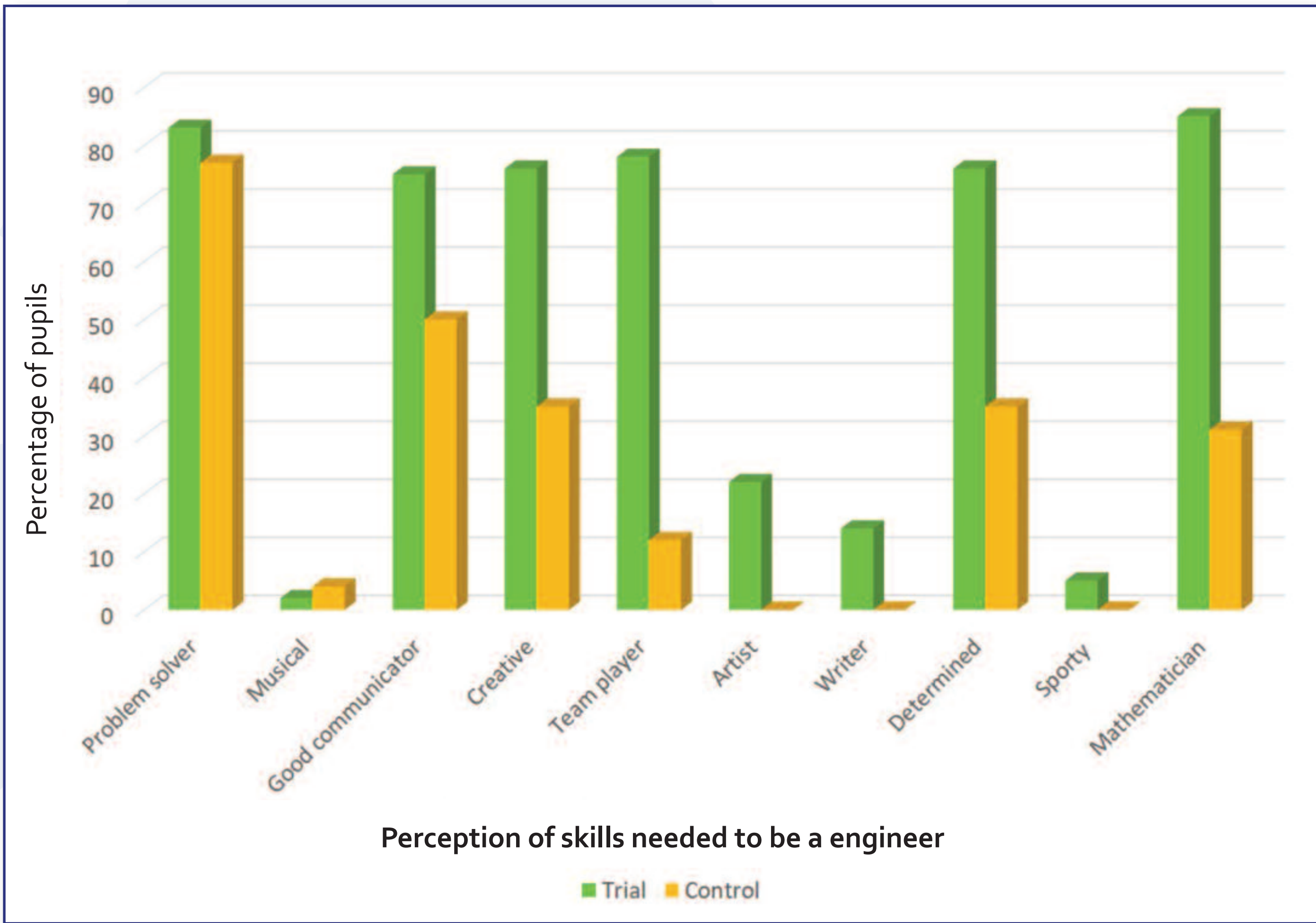


Figure 4. Perception of skills needed to be an engineer.



Perceptions of skills needed to be an engineer

Whilst problem-solving was widely acknowledged as important by both groups, the skills of good communication, creativity, team-playing and determination, which are all key to the role of an engineer, were undervalued by the control school. Only 31% of the control school indicated that maths skills were important for an engineer, compared to 85% in the study school.

What does an engineer do?

Only 57% of the girls in the control group attempted to define what an engineer did and, of those, 88% mentioned the word 'fix'. Whilst many girls in the research school also used the word 'fix', their comments were more detailed and often referred to the diversity of roles that an engineer might have.

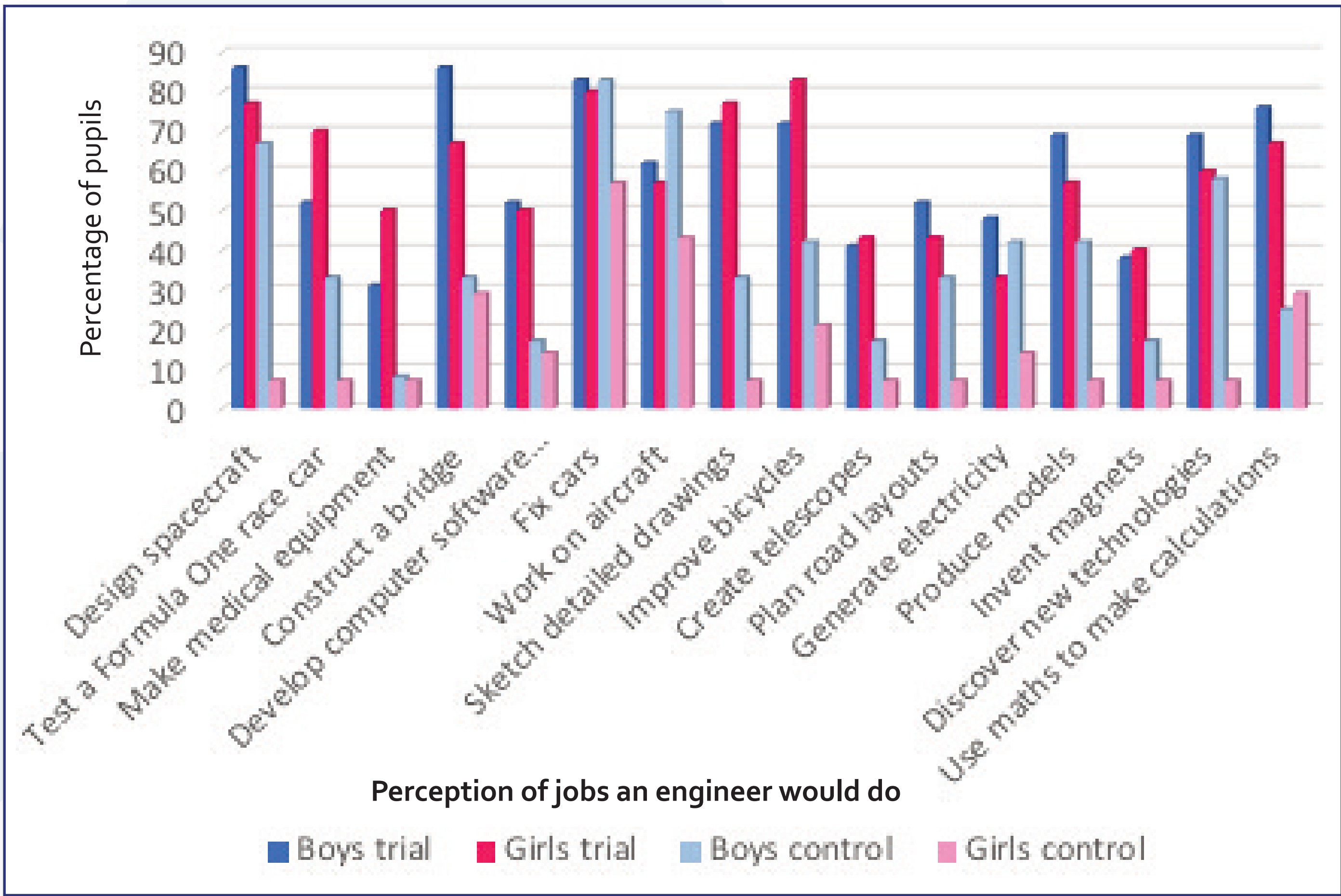
Understanding types of engineering

Greater numbers of pupils (boys and girls) in the research school had an awareness of the diversity of engineering roles. Multiple experiences of meeting different types of engineer were experiences highly valued by the research school pupils.

EHoM (self-reported)

The extent to which pupils in the trial school exhibited EHoM after 16 months of quality contact with scientists and engineers was observed first-hand, with a noticeable increase in creative problem-solving and resilience. In order to gain qualitative data, the EHoM self-report questionnaire, taken from the *Thinking Like an Engineer* (Lucas, 2014) research study, was used, as it had been tried and tested on a large scale. Boys scored similarly for both schools. Most notably, the trial school girls were more likely to enjoy making new things, to acknowledge that they come up with good ideas and use models to demonstrate them, to value group work and have a greater tendency to practise, even when problems are challenging, than their counterparts.

Figure 5. Perceptions of jobs that an engineer would do.



STEM Assembly feedback

100% of focus group pupils reported that it was the right decision to invite engineers to their school. *'The STEM assemblies are inspiring because it shows what you could do when you become older and how you can become that person.'* All expressed their preference to meet an engineer in person rather than see them on TV because '*...you get more about their personal lives by actually meeting them'* and '*... it's just for you'*. They felt more likely to consider a career as an engineer having met one in real life, because '*...they sort of like give you inspiration...tell you something like their life stories and...the challenges'*. Pupils recognised that skills required to be an engineer included '*...being patient because it's not going to work all the time'*.

Determination and perseverance were modelled consistently by visiting engineers. The researcher observed how pupils became more resilient when undertaking associated practical challenges in class linked to the use of the engineer design cycle (Figure 6).

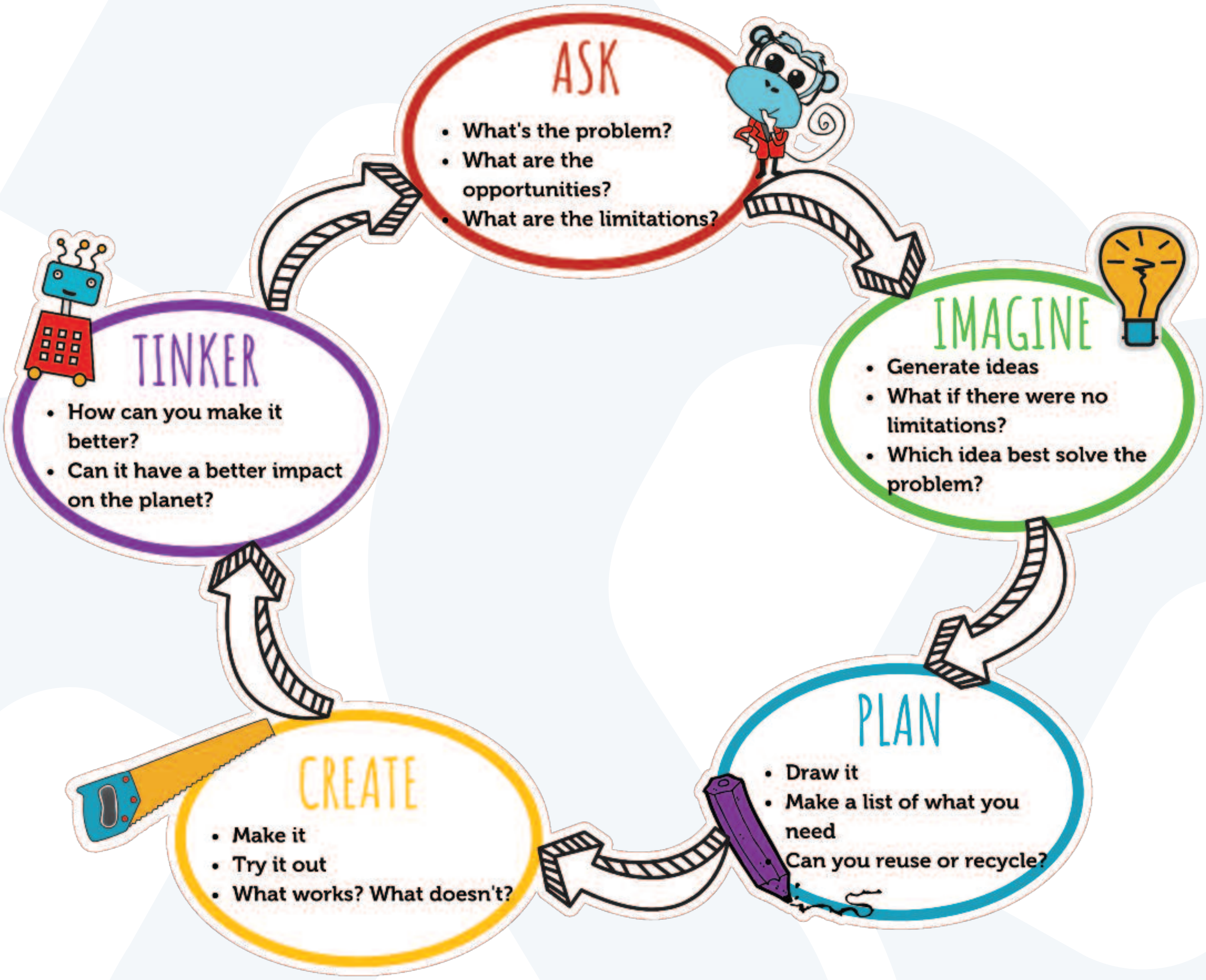
'It helped me to feel like it would be quicker and you actually knew what you were going to do next instead of making it up as you go...it makes it more likely to work.'

Summary of findings

The findings showed that, as a result of the initiative:

- engineering was the top career choice in the trial group along with sportsperson;
- trial girls were more likely to consider engineering and science as a career (compared to the control school and large-scale study);
- trial pupils had a far greater understanding of the role of the engineer and the skills needed;
- trial pupils demonstrated an appreciation for the diversity and scope of engineering careers;
- trial pupils got to experience how engineering related to their everyday lives with real world contexts; and
- science and engineering career aspirations in the trial group overall were much greater than those reported nationally (Chambers *et al*, 2018).

Figure 6. Engineer Design Cycle, The Curiosity Box (2019).



These findings raise the question of how to ensure that pupils regularly meet a range of engineering role models first-hand to see the importance of engineering to our society, view it as a credible, accessible career choice, learn how engineers think (what we now know as EHoM), and see its relevance as well as real world applications (Queen Elizabeth Prize for Engineering, 2017; Lucas *et al*, 2014). It is widely acknowledged by many authors that '*looking forward, engineering has the potential to tackle the global issues facing our planet*' (Engineering UK, 2017).

Impact on practice

This study has shown that, as part of a programme of enrichment activities, monthly STEM Assemblies can positively impact the career aspirations of pupils, most significantly amongst the girls.

As a model, this could be replicated in other schools. Issues to overcome would be gaining support from school leadership and teaching staff alike in order to maximise the impact. Logistics, such as the best time and frequency for the assemblies, would need careful consideration. It takes time and a good network to source high quality engineering presenters from a diverse range of engineering careers, which could be a challenge for some teachers (Lucas *et al*, 2014). Whilst engineers are willing experts, they need specific guidance about how to convey their knowledge to a younger audience. The author acted as a bridge between organisations, academic institutions and pupils to create content that was highly engaging, relevant and, where possible, linked to the curriculum.

With the new Ofsted framework (2019) stating that all pupils are to be given the '*knowledge and* *cultural capital they need to succeed in life'*, opening their eyes to the array of STEM jobs and real-world applications for what they are learning is key. STEM Assemblies and development of EHoM also build *'...knowledge and skills for future learning and employment'.*

Engineering can successfully be embedded in practical activities in the classroom, whether that be in science, DT, history or PSHCE lessons, for example, and through a range of National Curriculum topics such as forces (aerodynamics on a F1 car, making boats and studying floating and sinking, gliders or aeroplanes, bridge-building), space (rockets, space buggies) and climate change (electric vehicles, solar power, recycling). Highlighting to pupils how engineering is part of our everyday lives is vitally important as *'...looking forward, engineering has the potential to tackle the global issues facing our planet'* (Engineering UK, 2017).

Conclusion

In this particular school setting, under the organisation of an enthusiastic promoter of STEM, pupils did benefit from monthly contact with a dynamic range of engineers (and scientists). They were enlightened about the scope and range of engineering careers, made links between what they were learning in class and the real world, gained confidence in persevering with tasks to achieve a desired outcome, and were excited about science and engineering. Asking experts their questions first-hand made a real impression on pupils (as reported by the focus group).

The role and impact of primary educators in fostering and nurturing STEM career aspirations in young children is clearly demonstrated in this research, and is especially significant given that *'the sparks lit at this age could last a lifetime'* (Institute of Mechanical Engineers, 2016a, p.51).

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