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Primary pathways: elementary pupils' aspiration to be engineers and STEM subject interest

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ABSTRACT
Across Europe, there is concern about the number and diversity of pupils taking study routes leading to Engineering. There is growing evidence that these career choices begin to form at elementary school age (Moote et al., 2020). Science, maths and design and technology are seen as subject choices necessary for pupils' progression into science, technology, engineering and mathematics (STEM) related occupations. Achievement in these subjects, identity, gender attitudes to the subjects, parents and informal activities may have an impact on these career choices. This mixed methods research draws on participants in the Children as Engineers project to investigate aspirations to a career in engineering and the links between these aspirations and attitudes to STEM subjects. It explores findings that suggest that there is little relationship between aspirations and positive attitudes to individual curriculum subjects. Pupils' out-of-school activities and the links to aspirations in engineering are also researched and discussed. The article discusses the pupils' rationales for these choices and the implications for intervention and informal engineering experiences that rely on a science and maths context for elementary school activities and for fostering interest in engineering.

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Informal education; elementary; attitudes; STEM; career aspirations

Introduction

Engineering is a major contributor to the economy (Perkins, 2013). The European Commission also reports that engineering skills are in short supply in the European Union (2019). Engineering occupations, in this article, refer to a full range of STEM-related careers but as Ing and Nylund suggest, not social science related occupations (2013). It is forecasted a shortfall of between 37,000 and 5900 engineers in the UK in the coming years and that those already recruited do not represent the population in terms of diversity. Although there is not a global shortage of engineers, in a post BREXIT UK there is pressure to train a workforce able to take on engineering-related careers (EngineeringUK, 2018). Perkins (2013), in his Royal Academy of Engineering Report, discusses the importance of pathways or pipelines to supply a future workforce with the right qualifications and attitudes to be able to choose an engineering career. These pathways may consist of pupils retaining interest and participation in STEM subjects to school-leaving age to keep the options of engineering-related further education qualifications or apprenticeships in engineering-related careers. Perkins (2013) suggests these attitudes and interests begin at elementary/primary level.

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Theoretical framework

The ways pupils make decisions about career aspirations is a complex process. A number of factors have been identified as significant to those decisions about STEM careers. Archer et al. (2015) identify gender, culture, socio-economic status, self-efficacy in science and attitudes to science as being factors that may influence the uptake of science in secondary school. Their underlying theoretical framework draws on the work of Pierre Bourdieu. Bourdieu's social theory suggested that we gain science capital from our background family; values and beliefs and study of sciences as well as people who know in scientific careers (Bourdieu, 2004). DeWitt and Archer (2015) argue that the possession of different amounts of science capital influence a pupil's likelihood of choosing science-based qualifications and then careers.

Bourdieu's social practice theory model can be considered in its three constituent parts; habitus, capital and field (Maton, 2008). It is the relationship between these three aspects that makes the model useful and relevant to explaining the process of pupils' development in relation to sciences and subsequently engineering.

Bourdieu's habitus describes the social structures that shape a person's present and future practices (Maton, 2008). Bourdieu sees habitus as a dynamic property of individuals, groups or institutions, which act on a person to produce their views, values, tendencies and beliefs, in this case on STEM and engineering.

The field is a 'social space' where interactions, transactions and events occur (Bourdieu, 2004). Thomson et al. (2014) compare Bourdieu's field to that of a football field, bounded by size and physical conditions that affect all players but unequally because of what each player brings to the game; the different skills, attributes and experiences that the players bring to the field are described as 'capital' by Bourdieu.

Bourdieu also coins the term 'science capital' (2004). As part of his theory of habitus, he suggests that the elevated status of science in society can inevitably create economic, cultural and symbolic inequalities among individuals. Bourdieu (2004) describes how science capital can be built up and transferred into other sorts of capital within society through qualifications, interest and participation in science by family and friends, and through participating in science in the wider world. Although, in his original writings, he was referring to the situated science societies of industry and research, the theory has some resonance for the pupil gaining science capital through their habitus, ultimately giving them a differing amount of science capital to access the choice of careers in science and engineering.

Moote et al. (2020) report the association between science capital, attitudes and aspiration to careers in engineering suggesting that the Bordieau's model of science capital can be viewed as 'STEM capital'. Our research, therefore, draws on the Bourdieusian theories of the processes in which pupils gain science capital in their schooling and out of school experiences to structure our methods and analyse our findings; to explore the inequality in which pupils get access to types of influences and experiences that may likely to help them identify with a future engineering related career.

Literature review

There is research evidence that proposes pupils form ideas about science and engineering careers as early as elementary school (Finlayson & Roach, 2007; Moote et al., 2020; Zubair & Nasir, 2011). It is likely that their habitus, gained through family activity and influence has already had a significant effect. Chambers et al. (2018), in an international study of pupils' career aspirations aged 7–11, found that their career aspirations were already influenced strongly by gender but also the socio-economic areas the pupils come from and who they know. Four times as many boys as girls identified engineering as a potential career choice and twice as many boys than girls identified scientist. However, 2.5 more girls than boys identified being a doctor as a career and 4 times as many a vet.

Pupils from deprived socio-economic areas appeared to demonstrate lower career aspirations than their peers in this study. The ROSE study also reported similar findings (Sjøberg & Schreiner, 2005). Alternately, Sheldrake and Mujtaba (2019:2020) found that, at aged 11, girls were more likely to express aspirations to science careers than boys but that the boys were more likely to aspire to science/engineering careers than medicine/health careers than the girls. These career aspirations appear to be persistent; the ASPIRES project found aspirations toward science careers changed little between year 6 (10–11) and year 9 (13–14) (Archer et al., 2010).

Projects to encourage pupils' ambitions towards careers in engineering often use science subjects and data that explore aspirations towards science subjects, like the Science Capital Teaching Approach (Godec et al., 2017). However, this can focus on developing science knowledge at the detriment of the design and make processes of technology (Güdel et al., 2018). Ing and Nylund-Gibson (2013) researched pupils' attitudes to science and maths and their long-term career aspirations. They found girls and underrepresented minority ethnic groups of pupils, were most likely to express positive attitudes towards science and maths but that they were the groups least likely to be employed in STEM careers. These attitudes appear to decline over time, towards STEM subjects, especially in girls, starting at senior school, aged 11 (Archer et al., 2015; Holmes et al., 2018; Jarvis & Pell, 2005; Kiwana et al.,2011; Murphy et al., 2005).

The extent to which pupils can imagine themselves as having a future career in a discipline or subject appears to have a significant effect on aspirations. This is dependent on the image that the pupil has of the career. Some pupils may see the sciences and engineering as less about people and more about things, which could appeal to some more than others (Miller et al., 2006). Pupils' self- concept about their abilities in maths and sciences also seems to impact the possibility of them aspiring to engineering careers (Moote et al., 2020); the ideas about being a STEM person or non-STEM person occurring from age 10 (Macdonald, 2016; Salas-Morera et al., 2021).

Although essential for the route to STEM careers, achievement within STEM subjects appears to have minimal impact on career choices. The TIMMS survey (Mullis et al., 2016) found little difference in achievement in science between boys and girls at the elementary level. This difference in attitudes and achievement may be explained by the Eurydice research that indicated that on average, girls had lower levels of belief in their scientific abilities than boys, in all European countries including the UK, even though both boys and girls had similar levels of interest in science. There was no overall difference in boys' and girls' inclination to use science in future studies or jobs (Eurydice, 2011). Eurydice suggests that this difference in perceived self-efficacy, pupils' beliefs about their capabilities to produce effects, may arise from pupils' culture or home environment. There also appears little difference in achievement in STEM subjects between the sexes at 16 in the UK (Smith, 2011; Woolcock, 2019). Moote et al. (2020) found no significant differences in 11-year-old girls' and boys' self-concept in their ability in science and Vinni-Laakso et al. (2019) found no differences in pupils' self-concepts aged 8. Yet, in a technology curriculum context, girls involved in projects consistently described themselves as being 'not technical' (Sultan et al., 2020).

Making subject choices

Gender can be a significant factor in who chooses STEM careers, especially engineering. Girls are less positive than boys about science subjects at 11 in the UK (DeWitt et al., 2014). This divide widens at GCSE (at 16) and subsequently, only 27% of STEM 'A' level entries (at 18) in 2017 in the UK were from girls (DfE, 2019). 10% of the Engineering workforce in the UK are female and 16% of engineering graduates (EngineeringUK, 2018).

Parents appear to have a major influence on careers aspirations and subject decisions pupils make through their own interests, attitudes and activities related to science and engineering. The ASPIRES 2 project researched the relationship between pupils' perception of adults' interest in science and whether it has an impact on aspirations in science careers (Archer et al., 2020). They found perceived parental interest, as suggested by Bourdieu (2004), was a factor that appeared to follow pupils with scientific career aspirations. Dabney et al., (2016) suggest a correlation between parents' educational level, the amount of informal science activity and subsequent interest in the pupil: Ardies et al. (2015)'s research suggesting the educational level of the father having a greater impact on career choices than that of the mother. However, polling for Tomorrow's Engineers, an organisation that promotes engineering careers, indicated a 9% gap between parents who would like an engineering career for boys and those who would like one for their girls (Perkins, 2013). Tenenbaum and Leaper (2003) suggest that parents perceive that science is harder for their female pupils than for their male pupils. Parents were also found, in this research, to believe that daughters had less interest in science than sons. Yet, the Engineering UK survey from 2013 to 2017 also suggests that only 31% of parents actually know what engineers do, so the pupils may not be receiving broad STEM careers advice (EngineeringUK., 2018). ASPIRES 2 have suggested from their research that girls, working-class pupils and pupils from minority ethnic backgrounds received less high-quality careers advice than other pupils (Archer et al., 2020), which could result in an even poorer understanding of the nature of engineering careers.

Pupils' attitudes towards science have been seen as key indicators to their future aspirations. In studying pupils' aspiration to scientific careers, the research of DeWitt et al. (2013) suggests that UK year 6 (10–11yrs) pupils' attitudes towards science, overall were generally positive, but this translated into 29% aspiring to a job that included science with only 17% considering a job as a scientist; the girls' aspirations towards STEM careers being lower than the boys.

Informal STEM activities

Engineering-based activities carried out in elementary schools and middle schools can have an impact on fostering more positive attitudes towards a career in engineering (Harnett et al., 2014; Stringer et al., 2020). This was suggested after units of work, where pupils were involved in a contextualised practical design tasks as part of the Engineering is Elementary (EiE) or Engineer EU materials. The pupils showed a greater knowledge of engineering and more positive attitudes to considering a career in engineering (Cunningham & Lachapelle, 2010; Harnett et al., 2014). However, research on a year-long engineering education project in an elementary school indicated that pupils built their understanding of engineering but the project had no impact on aspirations (Parker et al., 2020).

Out-of-school activities have also been identified as a possible factor that can foster positive attitudes towards STEM careers (Bell et al., 2009). Visits and activities such as STEM clubs, visits to science centres or construction kits at home have all been identified as possible activities that could have an impact on aspirations (DeWitt & Archer, 2017; Jarvis & Pell, 2005). Out of school activities may or may not involve parents but at elementary/ primary ages family are more likely to be a part of the activities.

The importance of science, maths and design and technology to an engineering-related career appears to be undeniably important. When these subjects are dropped by pupils it narrows the range of career choices available to them. However, does this mean that all intervention projects with the aim of raising interest in engineering need to use science, maths and design and technology (D&T) as vehicles for delivery of the experience? A focus on activities out of school may have a greater impact on career aspirations. This research aims to explore the attitudes to school STEM subjects and the correlation, or not, of these attitudes with career aspirations in engineering as well as the impact of out-of-school activities.

Material and methods

This research surveyed pupils aged 9–11 in elementary schools from deprived socio-economic areas of Bristol city in the UK over two years. The research was carried out as a part of the 'Children as

	Do you like........?	A lot	A bit	Not sure	Not much	Not at all
a	Doing maths?					

Figure 1. Sample Likert Scale from Children's questionnaire.

Engineers' Project (Fogg-Rogers et al., 2015), now run for 7 years, where third-year undergraduate engineers work with second-year initial teacher education (ITE) students to carry out engineering challenges using the EU Engineer materials (Engineer) in schools. The engineering challenges consist of problems relevant to pupils, such as building a floating platform for your phone to use when swimming, and used an engineering design process of a number of steps to support the pupils' understanding of the science and to develop, test and evaluate their designs. The engineering students and ITE students, in groups of two or three, plan and teach the engineering challenges, across 10 engineering fields, with pupils in their classrooms. The ITE students gain scientific understanding from the engineering students and, in return, the engineering students learn skills of public engagement.

As the pupils were between 9 and 11, great care was taken in gaining ethical consent from them as well as protecting their privacy and well-being. Information sheets were issued to all pupils, parents and teachers and a permission form was issued. The project and the use of the pupils' data were explained to the pupils verbally before the project and interviews. We offered to have consent forms translated for anyone whose English proficiency impeded understanding of the content. The project methods and remit were agreed upon by the university ethics committee.

The pupils were allowed to withdraw their data by asking their teacher at any time. The University General Data Protection Regulation (GDPR) procedures were attached to the consent forms to inform participants about the limits of use of the data.

The first year of this research used a sample of 334 pupils and the second year used a sample of 257 pupils. In the first year, the pupils completed a five-point Likert-type scale questionnaire on their attitudes to maths, science and D&T and whether they would consider a career in engineering and reasons for their choices. A Likert scale used facial expressions with words from like a lot to not at all, see Figure 1. Pupils were asked to circle the face that best described their feelings. We were aware than the faces could not represent the complexity of human emotion about school subjects or careers but indicate a scale of emotion. The scale had the advantage of being understood by pupils with all levels of literacy (Bai et al., 2019; Massey, 2021).

Use Lego or other building blocks?
Watch science programmes or science Youtubes? (like Blue planet, Operation Ouch, Spring watch, Fred)
Cook?
Look after animals?
Read books about animals or cars or motorbikes or human bodies?
Making things?
Helping parents fix things?
Going to clubs or museums?
Talking to parents/ grandparents about science/ technology topic?
Growing things?

Figure 2. Choices of out of school activities in pupils' questionnaire adapted from Tracey and Caulum (2015).

If qualitative data were required, such as asking for reasons for liking or disliking the idea of being an engineer, answers were elicited through a box for qualitative comments. The questionnaire was completed in the classroom with teacher or teaching assistant (TA) support for those who could not access the language. The questionnaires were administered before the intervention activities. Some of the older pupils may have been part of a previous year's project and not all pupils completed this questionnaire.

In the second year, the questionnaire was changed to also ask what the pupils liked to do outside school from a choice of activities adapted from Tracey and Caulum (2015), choosing activities relevant to engineering activity. Again, the questionnaire used a five-point Likert scale using faces. The choice of out-of-school activities is listed in Figure 2.

The quantitative data were analysed using both Pearson's and Spearman's correlation using SPSS v.10. The data were then analysed by gender as from the literature this was identified as a key variable in aspirations to engineering-related careers.

For the second year, the qualitative data of the Likert scale were analysed using Spearman's and Pearson's correlation using SPSS correlating the outside interests with the aspiration of a career in engineering. The transcribed questions from the group interviews were analysed using thematic analysis.

Parent and pupil group

A group of eight pupils, aged 10–11, had parent volunteers who attended sessions in school and also attended an out-of-school visit to 'We the Curious' an active science learning centre with the researcher. Two groups of five pupils were interviewed in focus groups by one of the researchers who had worked with the pupils in the classroom, including five pupils whose parents had attended the project, using semi-structured questions based on the themes in the questionnaire, to ask them further about their thoughts about the project, what they did outside school and what they discussed with their parents. The interviews took place in school but were defined by the number of pupils who were attending school that day willing to participate. Parents who had also taken part in the school activities were also to be interviewed but unfortunately this coincided with the COVID lockdown, so had to be cancelled.

For the questionnaire data, the pupil's qualitative responses of why they might want or might not want to be an engineer later in life were sorted into categories using thematic analysis as described by Braun and Clarke (2006). The emergent themes were identified through writing down all the pupils' responses and sorting them into themes. Some pupils did not offer any reasons for their choices.

The themes identified for wanting or not wanting to be an engineer can be seen in Tables 4 and 5.

Limitations of the study

The participants in the study may have taken part in previous years' projects which may influence their answers. The pupils who answered the questionnaires knew they were about to do an engineering project when they completed the questionnaire which may have altered their views although we tried to carry out the questionnaires before the pupils had formed relationships with the ITE and engineering students reducing the temptation to please the project team.

Results

The result of the question on whether the pupils aspire to be engineers is reported initially. The data on possible correlations between liking school subjects and an aspiration to an engineering career follows. This data are further analysed by gender. The reasons behind the pupils' aspirations or non-

Table 1. Pupils' declared ambitions to a career in engineering (Year 1).

	Correlation-Pearson's	Correlation-Spearman's	*P*-value-Pearson's	*P*-value-Spearman's
Maths and aspiration to engineering career	0.086	0.126	0.115	0.021
Science and aspiration to engineering career	0.098	0.132	0.073	0.015
Design and Technology and aspiration to engineering career	0.241	0.2	0	0

aspirations are then explored identifying the reasons for not aspiring to be an engineer and the reasons why pupils wanted to take that course.

The data from year 2 of the project is then presented identifying relevant engineering activities that the pupils may participate in out of school correlated with their aspirations towards an engineering career. Lastly, samples of the qualitative data from the focus groups are reported (Tables 1 and 2).

In the questionnaire, 59% of pupils stated that they would consider or wanted to be an engineer. 35.8% stated that they would not want to, 17.5% stated that they would. Girls were more positive about considering a career in engineering than boys with 68.6% considering or aspiring to an engineering career compared to 51.4% of boys. The majority of the pupils had been part of the Engineer project in previous years where we had activities that explored what engineering is and what engineers do.

In reviewing the data from the questionnaire on the attitudes to science, maths and design and technology and wanting to be an engineer, it was noted that there was no correlation between the pupils' positive or negative attitudes to science, maths and D&T and their aspiration to become an engineer (Pearson and Spearman's correlation >0.2). When the data were separated into girls and boys we found that there was no correlation between the girls' and boys' attitudes to science and maths subjects and their aspirations to become engineers. There was, however, a very weak correlation (Pearson's 0.317 *p*-value 0, Spearman's 0.267, *p*-value 0) between boys liking of D&T and their aspiration to become engineers. Pupils who had negative attitudes to STEM subjects in school appeared no less likely to aspire to a career in engineering than those who had positive attitudes. Table 3.

Although not all of the pupils completed the question, Eighty-four (40%) of pupils stated that they had already decided on a different career. These consisted of a range of careers such as Youtuber, footballer, singer, teacher and hairdresser. Thirty-four pupils expressed that they did not know yet what career they were considering.

There were some negative reasons cited by the pupils for not aspiring to an engineering career. Twenty-seven (13%) of pupils expressed that it was too hard or that they were not clever enough. Nine (4%) expressed some sort of trepidation at the nature of the career fearing they might break things or damage themselves, eight (4%) stated it was dirty and 24 (12%) stated that they did not like engineering.

Positive views for choosing engineering were that 28 of the pupils liked science, the reason for their choice. This seems to counter the main qualitative data that there was no correlation between liking science and aspiration to an engineering career.

One of the largest responses was that the pupil liked making or fixing items with 56 (40%) pupils expressing this view. Thirty-two (23%) pupils stated that they liked it or that it was fun.

Table 2. Correlation of scores of liking subjects with aspiration to a career in Engineering (n334, year 1).

Ambition to be Engineer	Percentage of whole (n334)	Girls percent (n143)	Boys percent (n189)
No	35.8	27.3	42.3
Maybe	41.3	49.0	35.5
Yes	17.5	19.6	15.9
No answer	5.4	4.2	6.3

Table 3. Correlation of scores of liking subjects with aspiration to a career in Engineering according to gender (n334, Year 1).

	Correlation-Pearson's	Correlation-Spearman's	*P*-value-Pearson's	*P*-value-Spearman's
Girls				
Attitude to maths and aspiration to engineering career	0.071	0.091	0.4	0.280
Attitude to science and aspiration to engineering career	0.022	0.018	0.791	0.830
Attitude to design and technology and aspiration to engineering career	0.106	0.114	0.206	0.176
Boys				
Attitude to maths and aspiration to engineering career	0.105	0.148	0.149	0.043
Attitude to science and aspiration to engineering career	0.138	0.183	0.059	0.012
Attitude to Design and Technology and aspiration to engineering career	0.317	0.267	0	0

The altruistic reason stated by the pupils about engineering, such as helping others (6%) and the world (6%) were identified less frequently as reasons for wanting to be an engineer.

When the pupils were asked about their out-of-school activities in Year two of the project. The activities that had the strongest correlation to aspirations to being an engineer were watching science programmes or science Youtube videos, as well as fixing items with parents and talking to parents and grandparents about science and technology topics (Table 6).

There were weaker correlations between using Lego, reading books with a science or technical theme, making things, going to clubs and museums and growing things to aspirations to being an engineer. There was no apparent correlation between cooking and looking after animals, and an aspiration to engineering careers. During the focus group, all 10 pupils identified that I.T./computing was a major out of school interest, identifying the use of i-pad, phones and computer games. Four pupils talked about building, including Minecraft, and making things.

When asking all the pupils whether they had talked to their parents about the activities in school, three pupils responded 'a little bit'. Two talked about how parents attending the school activities was for them, one describing their mother

> Because she's embarrassing and when you're building something she like, like I was building something for the team and then she comes over and knocks it over.

One pupil reported a positive experience of having a parent in the classroom

> If I screwed up, he helped me and stuff.

Table 4. Reasons for not considering engineering as a career, if stated (Year 1).

Stated Reason	Number	Percentage of responses
Engineering is too hard	27	13
I am not clever enough	17	8
It is boring	5	2
I don't know	32	16
I might break something or hurt myself	9	4
I have already decided something else	84	40
I don't like engineering	24	12
It is dirty	8	4
Total	206	99

Table 5. Reasons for considering engineering, if stated (Year 1).

Stated Reason	Number	Percentage (rounded up to nearest whole percentage)
I want to help others	9	6
I want to do it because I am good at science	28	20
I like making and fixing things	56	40
I like it or it is fun	32	23
I have parents who work in engineering	5	4
I want to help the world/environment	9	6
Total	139	99

Table 6. Out of school activities correlation to an aspiration to an engineering career (n257, Year Two).

Out of School Activity	Correlation-Pearson's	Correlation-Spearman's	*P*-value-Pearson's	*P*-value-Spearman's
Use Lego or other building blocks?	0.138	0.166	0.05*	0.05*
Watch science programmes or science Youtubes? (like Blue planet, Operation Ouch, Spring watch, Fred)	0.193	0.194	0.01**	0.01**
Cook?	0.030	0.067		
Look after animals?	0.030	0.067		
Read books about animals or cars or motorbikes or human bodies	0.136	0.233	0.05*	0.01**
Making things	0.130	0.171	0.05*	0.05*
Helping parents fix things	0.186	0.244	0.01**	0.01**
Going to clubs or museums	0.154	0.192	0.05*	0.01**
Talking to parents/grandparents about science/ technology topic	0.193	0.208	0.01**	0.01**
Growing things?	0.179	0.179	0.05*	0.05*

In discussing out of school activities with relevance to science and engineering interests, one pupil reported that they did not talk to their parents about their out of school activities, 5 reported they did not talk to their parents about their online activities including playing games or on Snap chat. One girl stated of her science-based activities

> Yeah, I get a bowl and then I put water, then I put salt, pepper and then I put raisins and other stuff in it and mix it and I put marmite, Nutella, and I mix it and I go and show my mum because I know that if I showed her, if I asked her if I could do it she'll say no because I just know she'll say no, because she does it all the time.

Although these are small samples of opinions, there appeared to be a reluctance to talk to parents about out-of-school activities.

None of the pupils or parents interviewed had been to the science centre before, even if it was a few miles from where they lived. The pupils reported that they enjoyed the museum trip, they said their parents did too.

> Miss, she (mum) enjoyed it because it was a family day out basically.

Of the pupils who had taken part in the science centre visit, three reported incidents in the centre with their parents which indicates interaction during the visit between the pupils and parents.

Discussion

This research aimed to explore the relationship between pupils' liking of STEM subjects and aspirations towards careers in Engineering as well as exploring reasons for their choices. In the second year, the out-of-school activities which might foster positive attitudes to being an engineer were explored.

The majority of pupils who completed the questionnaire were willing to consider engineering as a career. This is probably affected by the knowledge that we had come to do an engineering project with the class. However, knowing this, 35.8% were not prepared to say that they might consider engineering as a career, demonstrating similar trends to previous research (Chambers et al., 2018; EngineeringUK, 2018; Jarvis & Pell, 2005; Sheldrake & Mujtaba, 2019:2020). Some of the pupils might be the same 25% who had already decided they had their sights set on a different choice of careers, see Table 4, and some responses may be those who have negative views of engineering. Girls were much more positive about the possibility of an engineering career, which supports the findings of Ing and Nylund-Gibson (2013). The lack of positivity in the boys and positivity in the girls may indicate a mismatch in career aspiration and a developing personal identity in both the boys and girls or it may indicate that girls make decisions about careers later than boys; which then appear resistant to change (Finlayson & Roach, 2007; Moote et al., 2020; Zubair & Nasir, 2011).

The lack of a strong correlation between the pupils' liking of science maths and design and technology appear to be counter to the research in secondary/high school that indicates that positive attitudes to science and maths as one indicator, along with other factors (DeWitt & Archer, 2015), of considering engineering careers (Aschbacher et al., 2014). It may be that younger pupils have unformed ideas about the nature of engineering as a career or have had less time to gain science capital. As only 1% of the first-year participants stated they had a parent in engineering field, this could be likely. Knowledge can be gained through family contacts and experiences as stated in the social theories of Bourdieu (2004). Previous data suggested that the majority of pupils believed that engineers were people who fixed things or built bridges, rather than a range of problem-solving and design careers, from electrical engineering to agricultural engineering (Harnett et al., 2014). Pupils need a clear understanding of the breadth and range of engineering that exists and more ideas about the process and perhaps the environments that they work within. This may counter the fears about the role being 'dirty or dangerous'; which is not always the case.

Other factors could be the pupils' lack of understanding of the relationship between maths and science and how they contribute to engineering; pupils who were less positive about science, maths and technology still identified an aspiration to a career in engineering. However, many informal and intervention activities use science and maths, such as the Engineer EU project, as a way into elementary/primary schools. Even the UK STEM Learning website categorises engineering-based resources for schools by the science topic it covers in the Science National Curriculum (Stem Learning, 2022). Perhaps, not linking engineering projects into curriculum subjects where pupils have readily formed self-concepts, could be more successful.

Alternately, maybe teachers need to explain the links between science, maths and engineering more fully, if pupils already have an interest in engineering-related careers. Projects such as the EU Engineer (Harnett et al., 2014) and Engineering is Elementary (Cunningham & Lachapelle, 2010) and often teaching in design and technology have distinct stages of the design cycle process where science is the main focus and where design and evaluation is the process. The differences between areas of skills and knowledge in engineering and science may need further definition and delineation in primary/elementary schools (Rohaan et al., 2010). This could support pupils' understanding of the relationships between the two disciplines and its importance in career pathways. If pupils are not gaining this information from their home setting it is important that they understand the range of careers from information at school. However, teachers also may need this understanding themselves to support the pupils' knowledge and choices.

There are other motivating factors that are driving pupils' thoughts about what they like to do and the image of their trajectories in life. One factor might be that the pupils who make and fix items out of school understand a process more akin to the engineering process and may be gaining enjoyment from that process. This is supported by the data which suggest a weak link between liking design and technology (D&T) and aspirations to engineering-related careers. In England, a result of pressures on curriculum achievement in maths and English means subjects such as D&T, art and even science get little coverage in the school curriculum (Duncombe et al., 2018; Spielman, 2018). Less than 5% of teachers come to primary teaching with science or technical qualifications (Ofsted, 2013). This lack of background knowledge could also contribute to a limited understanding of the nature of science, engineering and their relationship to other subjects. The teachers' low knowledge base and skills in subjects relevant to engineering based careers may result in an inability to develop pupils' interests, skills and possibly achievement (Flores, 2015).

The pupils' interests in out-of-school activities and their correlation to aspirations in engineering has interesting implications for future interventions. Fixing things with parents, talking to parents and grandparents about science and technology topics and possibly watching science-based television, all include interacting with family; all are likely to increase the positive habitus of the family towards STEM subjects, influencing values and beliefs (Maton, 2008). The results resonate with the work of DeWitt and Archer (2015) and Archer et al. (2020) who identified the important role of the adult in the formation of attitudes and aspirations. It is these types of activities that could contribute to the accumulation of the habitus aspect of Bourdieu's science capital. Pupils who talk to their parents about science and technology may have greater science capital and this could raise their interest. This has implication for further outreach work, suggesting activities where the pupils and parents can have shared experiences to discuss. These activities could be homework such as watching science-based popular TV programmes together, solving an engineering problem, school trips with parents, discussion cards or an interview to start conversations, as part of a task. These activities could go some way to improving the science capital of the pupils and inform the parents further.

Intervention programmes that have a focus on giving pupils more practical experience of construction, making, designing and exploring ready-made objects could have a greater impact on interest in engineering than relying in pupil's interest in science and maths where the links may not be obvious. This may also support the fun element that seems to be a factor in some pupil's choice (Bevan et al., 2015). In schools, planning can be valued over the exploratory part of design, especially in STEM subjects, despite STEM professionals using problem-solving and exploration frequently in their work.

Conclusion

This paper set out to explore the attitudes to school STEM subjects and the correlation, or not, of these attitudes with career aspirations in engineering. It also aimed to explore some of the out-of-school activities which may foster these positive attitudes. The data found that there was no correlation between liking science and maths and aspiration to an engineering-related career. The weak link in boys between design and technology and career aspiration may be symptomatic of the lack of priority of D&T in English schools at present. The pupils' reasons behind wanting and not wanting to go into engineering careers were supportive of previous research. The correlations between certain out-of-school activities, specifically watching science-themed TV programmes or YouTubes, fixing things and discussing science and technology involving parents, demonstrate the importance of the home environment and shared parental activity. If pupils are unlikely to get informal exploratory experiences in school, it is likely to be those, whose families provide informal science and engineering experiences, who develop interests in STEM careers; gaining science and engineering capital. If families and schools do not provide these kinds of experiences, where do pupils get experiences which might give them a better idea about the process of being an engineer and the career of engineering, not bound up with preconceptions about school science and maths?

Pupils' experiences of discussion and fixing with parents appears to be an important factor in fostering children's interests. Intervention projects may need to focus more on involving parents in homework, after-school activities and discussion. If pupils are forming their ideas before the end of elementary/primary school then we need to be offering them a wider range of experiences in this phase of schooling to extend their knowledge of engineering processes to offer a true choice of vocations, no matter their background or gender.

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