What can a child's experiences tell us about engineering education activities?

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ABSTRACT

This paper presents the emergent findings from a current PhD study exploring children's experiences of 'active' engineering education. The study aims to develop a deeper understanding of the outcomes of participation in such activities for children in rural schools, and collects data from the first person perspective to enable this. The literature suggests that career aspirations may be formed by children as young as 8 years, however current debate largely overlooks the experiences of children at this age. The study presented takes a qualitative methodological stance and, adopting an approach based upon grounded theory, uses observations and semi-structured interview data to analyse participation in an engineering activity. The emergent findings suggest that many sources inform a child's knowledge of engineering, contributing to their view of engineering; it is a child's *a priori* perceptions of engineering and engineers which ultimately 'frames' how they experience organised engineering education activities. Simply, a child's view of their engineering suitability is influenced by a range of factors prior to formal engineering education being introduced. Formal engineering education activities have a role, but often these simply reinforce previously held beliefs. The implications of this finding are of great importance for the field.

Conference Key Areas: Engineering Education Research, Attractiveness of Engineering Education

Keywords: qualitative; primary school; group interviews; aspirations

INTRODUCTION

The lack of recruitment and retention of engineering students and issues faced by industry when recruiting STEM (Science, Technology, Engineering and Mathematics) skilled individuals is recognised globally[1]. Previous studies identify the ages of 8 – 11 as being fundamental in the development of career aspirations[2], with children already constructing ideas about what subjects are 'not for me'[3]. However, the area of engineering education at this age (UK Primary school) is rarely the focus within research. Government and media attention has resulted in engineering education initiatives being offered to UK schools (for example STEM Ambassadors[4] and the STEM Directories[5]) and there is support for STEM enrichment activities as a means to engage young people with STEM careers[6]. However, there has been minimal monitoring of these activities and the lack of 'impact' that current (and past) engineering education initiatives has had on the number of young people studying to become

engineers is now being highlighted by professional bodies[7, 8]. An understanding of how these activities are experienced by the children participating in them is currently missing in the literature and is crucial if we are to develop our understanding of the influence these activities have on the awareness and perception of engineering that children hold.

1 METHODOLOGY

The lack of exploration in this field influenced the choice of methodology with a grounded theory approach[9] being employed in this PhD study. This choice of methodology follows from the constructivist paradigm that this research is conducted under and allows the topic to be explored from the children's perspective. Whilst it has been argued that grounded theory aligns with a post-positivist viewpoint[10], Charmaz[11] has demonstrated a strong use of this approach when carried out from a constructivist stance. The value of exploring individual conceptual awareness of an experience rests on the process of data collection and analysis. The grounded theory approach allows concepts to emerge directly from the data and, through constant comparative analysis, be explored in more detail in subsequent data collection. Memoing is utilised to build a picture of the relationships between concepts (and their sub-concepts). These relationships are considered from the outset of data collection, continuing throughout the entire study to enable the construction of theory from the data. Whilst this approach gives researchers and practitioners the opportunity to understand what children at this age are experiencing in terms of engineering education, the limitations of this approach need to be recognised. The research contains inherent inequalities of power, the researcher-participant relationship is not an equal one, this is amplified when an adult conducts research with child participants[12, 13]. Interpretation of the data is necessarily carried out by the researcher, regardless of the clarification sought during data collection. These concerns are minimised through researcher awareness and reflexivity[9, 11] but can never be removed completely from a study of this nature. The individual experiences and perspective of the researcher adds both a strength and a limitation to the research and it is accounted for through being 'self-aware' throughout the research.

2 ETHICS

The university ethics committee granted ethical approval for this study, however ethical mindfulness is required throughout the study due to the age of the participants[12, 13]. The researcher drew on her experience of working with young people in schools and as a Brownie leader to understand the interaction between herself (as an adult and a researcher) and the children (as children and participants) and be aware of the safeguarding required, such as the requirement to hold a valid Disclosure and Barring Services (DBS) check. This knowledge and experience was also beneficial when gaining informed consent which was sought from the schools, the parents of the children and the children themselves. Information sheets and forms were created for each group and were tailored to provide the required information in an accessible format.

3 DATA COLLECTION

To date, data has been gathered from observations carried out in two schools, one a primary school and the other a middle school. The schools are both located in rural

areas of Staffordshire, UK. Each school facilitated a different engineering focused educational activity, one was delivered by the class teacher during Design and Technology lessons and one was provided by an external company in an off-timetable session. The observations were followed by group interviews with some of the children who took part, the data collected from the observations was used as context for the initial interviews. Semi-structured interviews were carried out and photo elicitation was used when necessary with photographs that had been taken by the researcher during the observations. The interviews were held in the school that the children attend, some interviews were carried out in the same room as the observed activity however the majority were carried out in either the computer room or the conference room of the school. In total 48 children participated in the first set of interviews.

A semi-structured interview guide was used, this was divided into five thematic areas: Aspirations, play/interest, awareness/perception of engineering, engineering role models, and hands-on engineering experience. This approach benefited the research as it allowed the interviewer to focus on the issues identified as important within the study whilst also giving the children the freedom to discuss their own thoughts. The children could raise matters which were not covered in the interview guide meaning that new concepts could be identified during the interviews. Grounded theory allows for this by using constant comparative analysis from the outset, once new concepts emerge the approach allows for these to be explored in subsequent interviews.

The data collection process was challenging, this was mainly due to the nature of the research participants. Identifying schools who engaged in engineering education activities was initially difficult and access to schools relied heavily on their being a known 'gatekeeper' who could be contacted directly. Secondly, encouraging schools to participate in the research process, which included administration of many consent forms, meant that multiple schools declined to participate. Once access was negotiated challenges were faced with observing and interacting with the children through interviews, these are akin to those described in existing literature[12, 13] and were not unexpected.

A second round of interviews is currently being carried out to explore the children's views and experiences months after taking part in the activity. A third round of interviews is scheduled to be conducted in the early part of the next academic year when the children have progressed to Year 7.

4 FINDINGS

Data from all participants has been combined for the purposes of this paper and the emergent findings from two of the interview concepts are presented here; awareness and perception, and aspirations. A third concept is also presented which emerged during the interviews, framing. The analysis is still being undertaken and so these should be viewed as a snap-shot during the analysis of the data.

4.1 Awareness and perception of engineering

The initial interview questions explored engineering from the child's point of view and what children think engineers do. However, the children's perception of engineering and what is means to be an engineer appeared throughout the interviews and was revisited by the children throughout their narratives. Only a minority of the children expressed a confident view of what engineering is and what engineers do, the majority of children expressed their thoughts as questions directed at the interviewer. The context in which the interviews were carried out may explain this, the implicit

expectations about the adult-child relationship and research setting, but it also suggests that the children are unsure of their own knowledge about engineering. Some children voiced that they had no knowledge about engineering and others input little of their own perception of engineering at the start and later mentioned their limited knowledge. However, most of the children held perceptions about engineering whilst simultaneously having little awareness of what 'being an engineer' involves. This mismatch of awareness and perception surfaced in the data multiple times and was also displayed as children having no ideas about engineering but offering their opinion about what an engineer does at work.

What does it mean to be an engineer?

When talking, children tend to refer to engineering in terms of physical artefacts (transport was mentioned frequently) or describe engineering in terms of the skills involved or the knowledge required by an engineer:

> *You would also know like how to build stuff and…erm you know how stuff works.*
>
> *I think engineering could be like, like finding something out maybe.*

Very few children referred to engineers and engineering in terms of the role they play in society:

> *They help the world move on to like high tech stuff.*
>
> *Is engineering like some kind of way of using something out of electricity and power to help you in your everyday job…?*

The influence of social and multimedia

The interviews explored how the children constructed their view of engineering and the importance of the concept of *knowledge acquisition* came to light through the children's narratives. Many of the children spoke about things that had led to their current thoughts, the role of media and gaming was a recurrent theme in the interviews:

> *…I've never experienced it but it looks fun, the stuff I watch on telly like Top Gear.*
>
> *I think it's the game that's put me into it, it's fascinating.*

Whilst reference was made by some children to television programmes and games that explicitly linked themselves with engineering through the title or description, often the programme or game being referred to did not have a specific engineering focus.

The importance of role models

In addition to the media, role models from the children's families were also mentioned by many children when thinking about what engineering is:

> *I don't really know anyone who does engineering or anything.*
>
> *I think, well my dad […] his first job was as an engineer but it wasn't for very long so I still don't know much about it.*

Interestingly, children view role models as a reason they know (or should know) about engineering and also their lack of engineering role models as a reason for not knowing about engineering. Some children also expressed that although they had access to engineering role models, these role models were not always utilised. This is illustrated in the interview excerpt below, as well as in other children's narratives (names are pseudonyms):

> *Interviewer: What does your Dad do?*
>
> *Pete: Erm, well he's designed, I think he's doing a helicopter and he's done like a ride, I think he is either doing or done the ride, and yeah.*
>
> *Interviewer: Does he tell you about his work?*
>
> *Pete: Erm no not really, I don't pay much attention.*

4.2 Aspirations: Engineering as a future career

The majority of children at this age hold career aspirations however only a minority of the children hold engineering focused career aspirations. A mixed response to engineering as a possible career was exhibited, the limited knowledge that the children have became evident and was recognised by some as hindering their ability to consider engineering as a career:

> *I don't know what certain jobs you could get for engineering so I'm not quite sure.*
>
> *I don't really know because I don't really know much about engineers so I dunno what it would be like to be one…*

For those children that considered themselves able and willing to be engineers, engineering was not their priority career:

> *I'd have it as a backup job.*
>
> *If like maybe when I get a bit older like after if I am an RAF pilot I might be an engineer for the RAF or something so I can fix the planes and stuff.*

The career aspirations that the children displayed varied with sports and animal care being dominant career aspirations. Many of the children who held strong career aspirations do not consider the possibility of becoming an engineer as they 'want to do something else'.

4.3 Framing

Career aspirations

The concept of *framing* emerging when the children talked about their views of engineering as a potential career as well as when they discussed the engineering activity they had participated in.

When talking about career aspirations, the children described themselves as either able to be an engineer or not. This differentiation was based on their perceived knowledge of engineering and their view of their own knowledge and abilities in relation to what they considered engineering to be:

…because I don't really know much about cars and stuff.

I like cars as well so maybe engineering might be like something that I want to do.

Contemporaneous views of engineering education activities

During the interviews the engineering content of the activity that the children participated in was explored as perceived by the children themselves. The resulting data displayed a split between those who thought they had done 'actual' engineering and those who thought they had not:

It's not like actually engineering, like a proper car or something like that.

…cos you had to figure out like where to put stuff…and where to like, how to make it work.

The perceptions that the children hold about engineering influenced how they framed the activity, as engineering or not engineering. In one interview Matt holds a firm belief that engineering is about cars, this had been informed through TV shows such as Top Gear. When discussing the activity that they had participated in, Matt was unsure about the engineering content of the activity until it was framed in the context of his existing perception of engineering, cars (names are pseudonyms):

Interviewer: The activity that you are doing, do you think that's engineering?

Matt: a little bit…

Bryn: yes, yeah.

Matt: …but I don't know why.

Jane: it's designing and making.

Becka: designing and making, yeah.

Matt: I mean you could design a new Lamborghini but…

Becka: yeah and you could like design a new engine.

5 ANALYSIS AND DISCUSSION

The main concepts that emerged from the data are those of *Framing*, *Perception* and *Knowledge Acquisition*. The children framed themselves as either capable of being an engineer or not, they also framed the activity as being engineering or not. This framing occurred largely from the perceptions that the children held about engineering which were formed based on knowledge acquired from a variety of sources. Figure 1 shows a conceptual model of the data, at this early stage of the analysis this should be regarded as a working model which will form the basis of future analysis.

At this stage in the study it is interesting to note the similarities between the emerging concepts and the literature where role models and media are cited as influencing a child's awareness and perception of engineering/engineers[14, 15]. As relationships between the emergent concepts are constructed it appears that children acquire their knowledge about engineering from a range of sources, with the influence of TV programmes, gaming and the internet not to be underestimated. The importance that

children place on role models as sources of information about the world is high, this fits with the findings of Archer et al. who identified the influence of social capital on an individual's ability to consider science as a potential career[16]. The current study finds that engineering specific social capital does inform a child's perceptions of engineering (which influences how they frame themselves as an engineer) however, access to role models does not mean active engagement with them; having access to social capital is not the same as utilising social capital. Whilst many of the children know family members who are or have been engineers, this does not correlate to obtaining knowledge of engineering or an aspiration to engineering. Although this may be the case, many of the children who displayed a lack of engineering social capital referred to this when talking about their inability to make informed career decisions regarding engineering. It is important to note that the child determines who they regard as an engineer. This, along with the link between social capital and engineering aspirations is an area that will be considered further in future analysis.

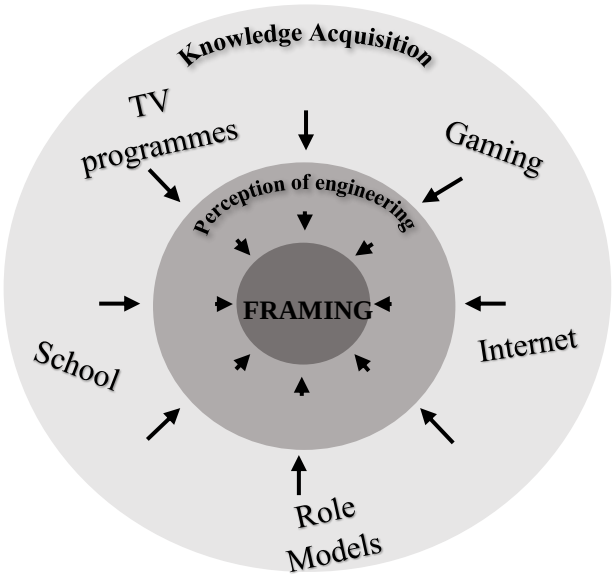

Figure 1: Emergent conceptual framework depicting children's experiences of engineering education activities within English schools.

An unexpected emergent finding is that of how the children 'frame' the activity. This study finds that rather than the engineering activity altering or informing the child's view of engineering, many children who participated in these activities either dismiss such activities as 'not engineering' or frame them within their existing world-view of engineering (which may or may not be accurate).

6 CONCLUSION

In conclusion, this paper presents the emergent findings from the first round of interviews conducted as part of a longitudinal study. Of interest is that it is the perceptions of engineering that children already hold at age 8-10 which are used to frame any subsequent engineering education activity. Whilst further analysis is required to examine the relationships between the concepts displayed within the data, the emergent finding of this paper is of great importance. It indicates that engineering activities are currently introduced at too late a stage to have the desired impacts on children's awareness and career aspirations; formal engineering education needs to

be introduced at an earlier stage to make the required difference. This research provides a previously unexplored perspective of current engineering education provision which challenges the perceived purpose, delivery strategy and evaluation of engineering education delivered to this age group.

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