DESIGN AND TECHNOLOGY AND STEM: TEACHERS' PERCEPTIONS OF GENDER.

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II. Abstract

Gender equality issues in Science, Technology, Engineering and Maths (STEM) have been played out on an international stage for the last five decades. The stark differences in numbers of girls and boys in STEM subjects in secondary schools filters through to university and the workplace. This has been a cause of concern in all STEM industries but especially engineering. These gender differences are also manifest in Design and Technology (D&T) classrooms in Britain. Not only does the subject sit awkwardly within STEM but it has a complicated history that tie gendered social roles to material specialisms. Recent GCSE reforms have led to a single title D&T qualification which provides an opportunity to tackle gender inequalities.

Research into gender inequalities in STEM is both substantial and broad, ranging from neuroscience and psychology to sociology and education. Only a small fraction of this published work includes gender inequalities in D&T. This study attempts to address one small aspect of that gap. Adopting a pro-feminist, critical realist stance, drawing on social reproduction theories as well as socio-psychological models of motivation, this research project is interested in teachers' understandings of the critical choices that pupils make at Year 9 about their GCSEs and potential career paths.

The study revolves around in-depth interviews with D&T teachers from a variety of settings, using Implicit Association Tests, lesson video and focus groups as stimuli. Thematic analysis is used to generate themes from the transcripts.

The principal findings highlight the need for: (i) clarity about the value of interdisciplinary, value led, context rich, iterative project-based D&T project work *as* STEM, (ii) clarification about professional boundaries when providing guidance and positive action initiatives, (iii) D&T teachers to unpick stereotypes in their behaviour management and relationship building practices, (iv) engaging parents and older pupils in efforts to tackle inequalities, (v) separation of the various functions of practical work in D&T and (vi) redefining the disciplinary boundaries of the D&T curriculum in an equitable manner.

III. Glossary

A-level	Advanced Level
APU	Goldsmiths College University of London Assessment of Performance Unit (1975 – 1989)
BTEC	Business and Technology Education Council – provider of level 3 vocational qualifications
CDT	Craft, Design and Technology
CPD	Continuing Professional Development
D&T / DT	Design and Technology / Design Technology
DCSF	Department for Children, Schools and Families (2007-2010)
DfE	Department for Education (2010 -)
DfES	Department for Education and Skills (2001 – 2007)
DIT	Developmental Intergroup Theory
EBacc	English Baccalaureate
EPQ	Extended Project Qualification
EVT	Expectancy Value Theory
FSM	Free School Meals
GCSE	General Certificate in Education
GDPR	General Data Protection Regulation
GIST	Girls in Science and Technology
HMT	Her Majesty's Treasury
HoD	Head of Department
HPQ	Higher Project Qualification
IAT	Implicit Association Test
IPA	Interpretive Phenomenological Analysis
IRIS	Video technology system for collaborative teacher development
ITT	Initial Teacher Training
JCQ	Joint Council for Qualifications
KS3	Key Stage 3 (Years 7-9, ages 11-14)
KS4	Key Stage 4 (Years 10-11, ages 14-16) GCSEs
KS5	Key Stage 5 (Years 12-13, ages 16-18) A levels
NQT	Newly Qualified Teacher
RAEng	Royal Association of Engineering
RCA	Royal College of Art
RCT	Randomised controlled trial
STEAM	Science Technology Engineering Art and Maths
STEM	Science Technology Engineering and Maths
VSI	Video Stimulated Interview

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Chapter 1 Introduction

This chapter sets the scene for the research by introducing the context in which the subject of Design and Technology has developed; focusing on its recent history and key aspects of the relationship with the Science Technology Engineering and Maths agenda. The chapter includes a discussion on the formation of the research questions and how they could lead to significant findings. My background and personal reasons for conducting the research are discussed before providing signposting for the remaining chapters.

Design and Technology (D&T) is a relative newcomer to the United Kingdom curriculum with its precursor, Craft Design and Technology (CDT) first taught in the 1980s. CDT was, in turn, based on post war technical education projects with the Royal College of Art's Design in General Education report, the School Councils' Project Technology group working out of Loughborough University and the Design and Craft Education Project based at Keele University. The conclusion from these experiments in the 1960s were that "technology is a process which can be observed fully only from the inside; it is an activity, not a readily definable area of knowledge" (Schools Council 1970, in Kimbell 1997 p4).

The lead of the Keele research team, Prof John Eggleston established and formalised a design process that would become integral in all later forms of the subject. This significant emphasis of the design and making process included drafts of methods to assess pupils' capability (Kimbell 1997). These features appeared in its first embodiment as Design and Technology in the 1988 National Curriculum framework and have played an important part in its turbulent history in the following decades.

The emphasis on the project as a process, and the application of knowledge also forms a key part of cross curricular Science, Technology, Engineering and Maths (STEM) projects. Yet D&T has been remarkably invisible in the STEM literature. This invisibility may also be due to the plummeting numbers of pupils taking D&T at GCSE[1], only a fifth of the school population are currently studying the subject at GCSE compared to the numbers at the turn of the century; the numerous social, political and economic factors leading to this are explored later.

[1] D&T GCSE entries have dropped from 436,963 to 90,805 in the last 18 years (Ofqual 2019, JCQ 2001, Spielman 2019)

D&T has always had strong links with vocational training and industry. Unfortunately, this includes gender role divisions which are associated with the different material strands of the subject: food technology, electronics, textiles, systems and control, graphic design and resistant materials. Drilling down into the falling GCSE statistics reveals some startling gendered differences. In 2001 47% of the D&T GCSE entries were girls but, after Food Preparation and Nutrition became a discrete GCSE in 2018, girls represented only 32% of the total D&T entries (JCQ 2018). Combining the overall fall in D&T numbers with this reduction in the proportion of girls we see a net reduction from over 200,000 girls in 2001 to under 42,000 girls in 2018 following GCSE D&T. Those remaining 42,000 girls represent less than 7% of the total number of students taking GCSEs[2] and yet there have been no reports, studies or initiatives to tackle this directly.

In direct comparison to the lack of publicity about the proportion of girls in D&T there are numerous studies and reports over a similar period that bemoan the low numbers of girls and women represented in STEM studies at GCSE, A-level and undergraduate level (Seymour 2002, Herman & Carr 2009, Hill, Corbett & St Rose 2010, STEM 2010, UNESCO 2017). The Royal Association of Engineers (RAEng) consistently report concerns about the low numbers of women in the profession; citing that only 9% of the engineering workforce are female (EngineeringUK 2017). Much of the research about the causes of these discrepancies and inequities explores socio-cultural factors of stereotypes, bias and implicit associations (Brotman & Moore 2008, Stoet & Geary 2018, Halpern et al. 2007, Spelke 2005). I am interested in how teachers perceive these three fields; D&T, STEM and gender overlap.

1.1 Research questions

My aim is to explore the role of D&T as a secondary school subject in the UK's low representation of girls and women in STEM fields. Although gender inequalities in STEM are an international phenomenon that have been widely investigated, there has been much less work on D&T. As a relatively new addition to the secondary school curriculum the subject has been in a state of flux over the last five decades.

The intersection between these three fields can be described in a simple Venn diagram and the research questions attempt to hone in on the intersection between all three by exploring, in

[2] Based on total GCSE entries in 2018 of 5,457,326 (JCQ, 2018) and mean number of GCSEs taken by students as 8.6 (Carroll & Gill 2017)

sequence, the intersection between D&T and gender, gender and STEM and then STEM, D&T and gender.

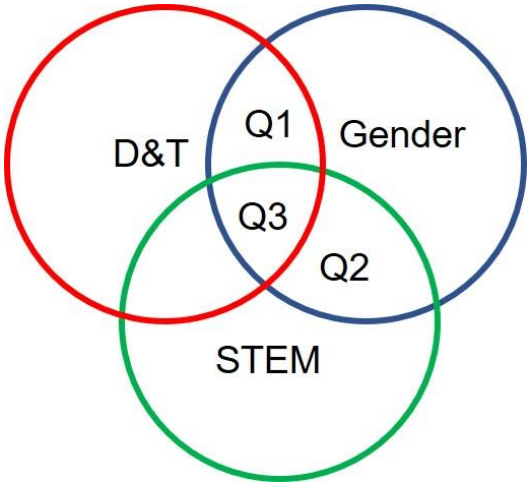

Figure 1-1 Intersecting fields and research questions

Numerous research questions were considered, modified and adapted in order to focus the research. Factors that were of importance in developing the questions included the need to keep the number of questions to a minimum to avoid the research overextending and ensuring that the questions were clear. Most crucially though was a desire to focus the questions on teachers' perceptions; this was thought to be a rich source, clearly focused on the profession and pragmatic. I have developed the following research questions to help focus the project:

RQ1. How do D&T teachers perceive how gender stereotypes play out in the subject?

RQ2. How do D&T teachers perceive how boys and girls make choices about GCSE subjects?

RQ3. How do D&T teachers perceive how the subject fits into the wider gender-in-STEM debate?

1.2 Significance of the research

I hope that exploration of these questions will contribute to the ever-growing literature on the low representation of girls and women in STEM fields. As the subject of D&T continues to be redefined and repositioned, it is an appropriate time to explore its role within society in general and STEM in particular.

The subject of D&T started with Archer's (1978) taxonomy of design in the late 70's; over four decades later the discipline remains an unfinished project (Hardy 2017, Bell et al. 2017). Hopefully this research will add a small block to the building process.

As this is part of a professional doctorate I hope to apply the skills, knowledge and attributes developed in the early part of the course to identify possible routes forward for teachers to help in some small way to tackle a problem that has confounded the engineering and teaching professions over the last quarter of a century.

1.3 Positionality

As a D&T teacher of twenty-five years I find myself in front of fewer and fewer girls in GCSE and A level sets. As an engineer by training, I am painfully aware of the low numbers of women in the engineering profession and want to explore the symbiosis between these two phenomena.

It is important that I outline my own position and agenda, so that the reader can interpret the work and judge the credibility of the research findings (Cresswell & Miller 2000). There is little guidance on what information is appropriate and I recognise that presenting a detailed personal history could be regarded as self-indulgent (Sikes & Goodson 2003).

Doing work in the field of gender inequality as a male is clearly problematic; many would dispute the claim of a man to be feminist. Numerous blogs appeared as part of the Me-Too movement which denounce the possibility of a male feminist because men have no lived experience, understanding of or solidarity with women (Dempsey 2019, Alimi 2017, Fabello & Khan 2016). The term pro-feminist is more apt and is associated with the concept of a being an ally. Kahn and Ferguson (2010) caution that men doing feminist research can use it as a vehicle to demonstrate dominance or to bolster their own egos. I intend to use four prompts that Jonathan Crowe (2013) suggests to counter these charges; I am not where they are, this is not about me, I can make a difference and I am here to learn.

I am not where they are. I have experienced indirectly the subjugation of girls and women through several roles I have held. As a father I have listened to how my own son and daughter have been treated differently in maths and computing lessons. As a husband I have been made aware of various forms of harassment as my wife trained as an engineer and has risen to senior management roles in a male dominated school sector. As a housemaster I have had eight years with direct pastoral care of over 150 teenage girl boarders. As a manager I have appraised and supported the professional development of considerably more women than men. In each case my eyes have been opened to a range of inequitable experiences. I have undoubtedly caused my own share of problems along the way, it would be naïve to believe that I could tread lightly in so many different situations, especially in twenty-five years of teaching D&T. Although I am not where they are, I have become more aware of the differences in the treatment of boys and girls, men and women.

This is not about me. Sustainable design and technologies are based on developing solutions to real world problems in an altruistic manner. My own undergraduate studies were in engineering design and appropriate technology, the application of engineering to provide sustainable energy and practical solutions in developing countries. I believe that D&T has a hugely important part to play in working towards social justice;

> "*The power of technology to transform societies is unparalleled. It has the potential to produce great universal benefits or to reinforce inequalities and cause harm to people and the environment*" (IBO 2014 p11).

Technology has the power to change lives for the better and I hope that, through the study of the D&T, pupils will understand and appreciate this concept. If some pupils go on to be engineers and designers that make a positive difference, even better. STEM subjects have for too long been stifled by the dominance of male thinking. Francoise d'Eaubonne presented ecofeminism, a powerful argument for the role of women in developing ecologically sound solutions, over forty years ago (Roth-Johnson 2013). Aiming for a better balance of men and women working in the field should lead to a more balanced outlook on problems. These activities have the power to do much good in the world and should not be the preserve of men.

I can make a difference. This project is a response to the growing awareness of inequalities in design, engineering and technology and is an attempt to explore the situation in schools, add to the current understanding and identify some possible routes forward. I hope that I can add something positive, however small a contribution to the field. I appreciate that the principle of providing a voice for girls is inherently problematic for a male researcher and so I will focus my attention on the teachers of those girls.

I am here to learn. I have inevitably reinforced stereotypes in my role as a teacher, leader, housemaster, father and husband. In these roles I will have aggravated any inequalities, either by trying too hard or in unthinking moments. This project is partly a journey of self-discovery and an attempt to reduce any future damage. I expect to learn as much about my own bias and attitudes as those of others. Although I employ many of the skills and attributes of a design engineer in my work in D&T, teaching has required me to develop a new set of skills and learn new knowledge. Understanding people, rather than inanimate objects, necessitated a shift in my readings and observations to focus on a very different kind of messy real-world problem, the classroom. After four years of teaching I embarked on a master's degree to try and unpick what was going on in my classroom and in the minds of my pupils; exploring the techniques novice designers use in the creative process. This current research project looks beyond my own classroom to other schools, beyond my own students to other teachers and yet continues my learning journey into previously hidden 'thinking in action' processes (Schön 1995).

Hopefully this shows how my own background and experiences have shaped my desire to understand how D&T is linked to gender inequalities in STEM and engineering.

1.4 Signposting

Chapter 2 is the literature review where I follow the research questions in turn; I start by exploring the limited literature on D&T focusing on gendered aspects of its history over the last century. The much richer gender in STEM literature body covers perspectives from sociology, biology neuroscience and psychology, concluding with socio-psychological factors. The final section of the literature review describes the relationship between STEM and D&T concentrating on gendered political, cultural and economic factors.

Chapter 3 covers the methodology of the research. I start with a discussion of the conceptual framework and outline the spectrum of different paradigms from which I have identified my preferred epistemological and ontological starting point. This leads on to the methodological basis on which I attempt to answer my research questions before detailing the methods employed, ethical considerations, sample selection process and strategies adopted to maintain rigour. I also describe the way evidence is produced from these methods and finish the chapter with a detailed description of the analysis process.

Chapter 4 captures the findings of the fieldwork conducted and discusses these in relation to the existing literature.

Chapter 5 summarises the main findings and draws a series of conclusions which, in turn, lead to recommendations. I provide a discussion of the limitations of the research and identify possible future research directions.

Chapter 2 Literature Review

The three research questions determine the next steps, identifying the current state of the art in each of the intersections between the fields of gender, STEM and D&T. I start by working through the short history and limited literature on D&T exploring how key moments have had implications for different gender. The much richer body of literature on gender in STEM includes four quite different perspectives. The first is based on appropriations of Pierre Bourdieu's social reproduction theories including Margaret Archer's feminist theories and Louise Archer's science capital. The second approach briefly covers debates the effects of biology and neuroscience on gender in STEM education. The third is an overview of psychological approaches before examining, in depth, the socio-psychological factors of stereotypes, bias, implicit associations concluding with Jacquelynne Eccles' Expectancy Value Theory. The final section of the literature review attempts to tie together the histories of STEM and D&T with descriptions of the interacting gendered political, cultural and economic forces.

2.1 Design and Technology and Gender

The following exploration of Design and Technology loosely follows a chronological pattern; highlighting key moments over the last century where the subject has pitched forward in its evolution. At each point, the unique features of the subject are offered and examined from a pro feminist perspective. The exploration revolves around the highly contested purpose of the subject competing instrumental and liberal views jostle at every turn. This struggle underpins the difficulties consolidating the formation of a distinct discipline of Design with the interdisciplinary nature of problem solving and the various material specialisms.

The subject is a relative newcomer to formalised education in Britain; its roots can be traced back to needlework in elementary schools early in the 19th Century (Sutton 1967). And yet when the 1882 Samuelson Commission recommendation that handicraft be introduced into schools as an answer to Britain's economic decline (Penfold 1988) the focus was on crafts rather than predominantly 'girls' subjects of home economics, food and textiles. Over a century later, some elements of this economic link are retained in the National Curriculum purpose statement for D&T:

> *"Pupils learn how to take risks, becoming resourceful, innovative,* ***enterprising*** *and capable citizens… High-quality design and technology education makes an essential contribution to the creativity, culture,* ***wealth*** *and well-being of the nation".* (DfE 2013, emphasis added).

One implicit message in both the Samuelson Commission and the DfE's statement is that practical education is included in schools partly to provide a workforce, the instrumental purpose of the subject. According to the social norms of the time, Samuelson expected girls to take up unskilled employment or responsibility for households whilst boys undertook pre-vocational practical activities (Harding 1997). As a result, the practical handicraft subjects of woodwork, metalwork and technical drawing were offered to boys, and needlework, cooking and home economics provided to girls. These separate subjects became part of the curriculum and the division between the sexes has not changed much since. Before exploring these imbalances there is a need to discuss the alternative and competing liberal purpose of the subject. D&T and other subjects can all be view as areas of contention between these two purposes of education;

> "*Education policy finds itself at the centre of a major political struggle between those who see it only for its instrumental outcomes, and those who see its potential for human emancipation*". (Taylor et al.1997 p.vii).

Numerous individuals, groups and initiatives from higher education have spearheaded the development of the subject as a vehicle for general education that provides a foundation for a liberal and democratic society. In the 1960s with the School Council's Project Technology, Royal College of Art's Design in General Education programme and Eggleston's Keele Project provided a radically alternative view to project work, skills teaching and creative problem solving (Kimbell & Stables 2007). These signature pedagogies remain at the heart of D&T in its current form five decades on (Stables 2008).

Bruce Archer, Ken Baynes and Phil Roberts led the RCA's influential Design in General Education programme. This started with a commission from the Secretary of State to diagnose how secondary level design, craft and other practical activities related to other areas of the curriculum. The resulting argument positioned Design alongside Science and the Humanities, each with a distinct language and skillset. Baynes and Roberts argue that "design ability, like language ability, is something that everyone possesses at least to some degree" (1982). Defining design capacity as a universal attribute of all humans implies an equality of opportunity for all people, whatever their age, gender or ethnicity. This bold philosophy can be seen most succinctly in Archer's 'The Three Rs' (1979) where he clarifies modelling as the medium of Design and provides a comprehensive taxonomy for the discipline of Design. This framework includes descriptors of that define Design as a discipline; Design is useful, productive, intentional, integrative, inventive and expedient (Archer 1991). These characteristics have been assimilated into the subject of D&T and can be seen most clearly within the subject's approach to projects, practical work and problems.

Stables reinforces the liberal purpose of the subject to offers pupil, “designerly wellbeing - the satisfaction, pride, confidence and competence of being able to engage designerly thinking and action with criticality and capability” (Stables 2014 p9). D&T is much more than training pupils to be engineers or architects. Stables argues that design capability, “the motivation and ability to bring future possibilities into reality through an intentional process of thought and action, designing and making” (2014 p10) is an inherent human characteristic that should be nurtured.

A liberal and general education aims to provide a foundation for design capability but also technical literacy for all in society, whatever their gender. Norton (2007) argues that solutions to raising technical literacy are explicitly emancipatory; the development of systematic reasoning skills and technical knowledge in the general population can only raise standards and quality of life. Examples relate to how technological products or systems are presented to the public; especially in marketing (Archer, MacLeod & Moote 2020). Hybrid cars, drones for deliveries or 5G mobile networks all require significant understanding of technical issues before being able to take part in an informed debate and make sensible decisions (Barlex & Steeg 2016). One only has to watch an Apple mobile phone or hair product advert to see how technological and scientific terms are manipulated to sell products.

> “*One of the greatest social problems of our time is where the gullibility among the population at large mean that they accept, without question, any old codswallop that someone cares to tell them*”. (Qualter et al. 1990).

Project-based learning has similarities with the problem-based learning methods employed in engineering and medical undergraduate programmes (Williams, Iglesias & Barak 2008). The differences are subtle although both are student centred, based in authentic real-world situations and require independent inquiry. Problem-based learning tends to be structured and limited in scope where project-based learning tends to be messier and interdisciplinary (Mettas & Constantinou 2007). Conceptual knowledge alone is inadequate and procedural knowledge and creativity are required to apply scientific principles to solve problems (McCormick 1997). Clearly, offering primary children complex open-ended real-world problems would be exciting; up to the point when limited conceptual and procedural knowledge prevented success (Hill 1998). The impact of open ended, wicked or loosely defined problems on the success of boys and girls was investigated as part of the Goldsmith University Assessment Performance Unit (APU) studies in D&T. Their conclusions were that 15-year-old girls generally do better than boys in more reflective areas of work such as identifying underlying issues of a problem, empathising with users and evaluating products (Kimbell, Stables & Green 1996).

There needs to be a phased development of this design capability and the D&T curriculum provides scaffolding and frameworks to build knowledge and skills through a series of increasingly challenging and open-ended problems (Kimbell & Stables 2007). Limitations and constraints are manipulated through primary and secondary school so that in their final A-level project, students are expected to tackle a client's real problem and produce a working prototype as a solution that is commercially viable.

Another aspect of project-based learning is the importance of values in real world contexts. Stables (2017) describes the powerful engagement of pupils with 'big design' challenges that have direct socio-cultural relevance to the pupils. D&T can provide a significant contribution as a vehicle for understanding environmental, ethical and cultural values in a global society (Stables & Keirl 2015). Some examples of how values permeate D&T include:

> Ergonomic principles that determine flow of people in crowded spaces can be used to designing effective fire escape routes **or** for determining the optimum location of goods in a store for maximum sales.
>
> Colour theory can be used to signify safety issues **or** employed to influence consumers subconsciously at point of sale displays.
>
> Obsolescence can be the natural evolution of technological progress **or** the manipulation of products to accelerate redundancy, boost sales and so maximise profit.

In each of these examples the D&T teacher has freedom to present these design principles within altruistic or profiteering frameworks. There are only a few voices that warn of the dangers of D&T following Western consumer culture excesses (Baynes 2010). Pupils can learn about ergonomics, colour theory and obsolescence in D&T but also understand how values can empower them as consumers. The subject's 'importance' statement in the 1999 National Curriculum Orders, clarifies this claim of empowerment through the subject,

> "*Design and Technology prepares pupils to participate in tomorrow's rapidly changing technologies. Through design and technology, all pupils can become discriminating and informed users of products and become innovators*." (QCA 1999 p15).

The important role of the teacher in presenting these concepts and skills in a gender sensitive manner is highlighted in much of the D&T and STEM literature in Britain (Archer, MacLeod & Moote 2020, Withey 2003) and internationally from Finland (Niiranen & Hilmola 2016) to Australia (Rogers 1998). Just as a D&T teacher has choices about delivery, the pupils also have choices

about contexts when tackling their non-examined assessment projects. Providing choices of context has benefits for all pupils, girls and boys, to make meaning of their work (Withey 2003). A study shows that 14-year-old boys and girls have variations in their interests but when tackling 'big design' challenges these differences are minor (Stables 2014). However, if the contexts focus on people the girls tend to outperform boys and the opposite occurs when the contexts are technical or industrial (Kimbell, Stables & Green 1996).

Part of problem-based learning is the role of failure in iterative design (Cross 2001, Song 2018). Iterative design is explicitly outlined in the subject's importance statement, repeated in textbooks and even used as the title of one of the non-examined assessments - OCR's Iterative Design Challenge. Failure is managed quite differently by different pupils; studies on anxiety levels and motivation in maths and science show distinct gender differences which may well be applicable to girls in D&T (Moeller et al. 2015).

Project-based learning is also interdisciplinary. Interdisciplinary work between sciences, maths and technology is recognised as producing "educationally significant cognitive outcomes" for learners throughout the 5-18 age range because of the effectiveness of learning in context (Norton 2007). Van Langen and Dekkers (2005) in their comparative international study of STEM participation suggest that offering broad based interdisciplinary studies, rather than early specialisation, encourages greater participation of girls.

The potential of the subject to provide both a vocational and a liberal education is both promising but also challenging. Most problematically in the subject's history are the efforts to corral together the sub-disciplines of electronics, systems and control, graphic design, product design, resistant materials, food and textiles. These were all D&T specification titles in GCSE and A-level offerings between 1995 and 2017 and are a reflection, in part, of the unfinished project of D&T as a school discipline (Hardy 2017, Bell et al. 2017). Other disciplines have refined their knowledge and skills base in the curriculum whilst D&T has been struggling to arrive at a consensus on approach, skills and knowledge content; it has "weak, poorly defined external disciplinary boundaries" (Bell et al. 2017). This is partly a difficulty posed by the rapidly changing technologies underpinning D&T but also a result of the very different backgrounds of D&T teachers, the dual purpose as a vocational and academic subject and the lack of a single common philosophy (Bell 2015). If D&T teachers are articulating conflicting messages based on alternative understandings of the subject, then pupils and parents will find it difficult to make a judgement on its value.

Most significantly for this research project, is the representation of boys and girls in each of these sub-disciplines. Figure 5-1 shows the stark differences in the gender balance between the specialisations[3] (DfE 2010).

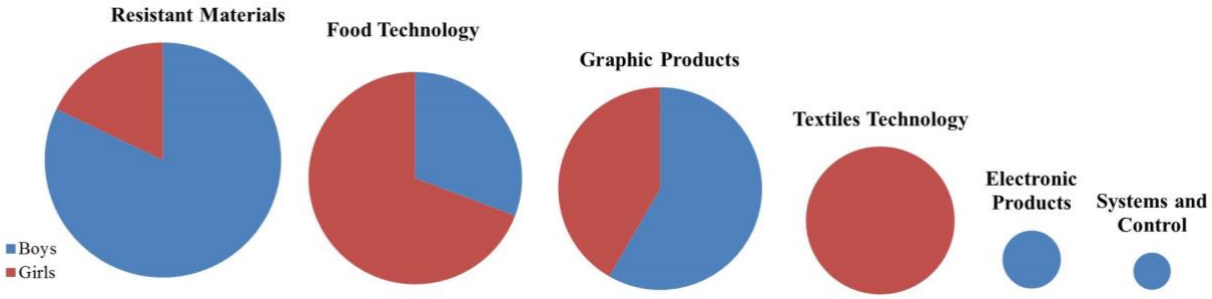

Figure 2-1 Strands of Design and Technology by gender (DfE 2010).

The overall size of each pie chart represents the relative proportion of pupils entering that exam in 2010 with 14% of all GCSE pupils taking Resistant Materials and less than 2% taking Systems and Control. Less than 50% of pupils took a GCSE in D&T of any kind. Within each pie chart the proportions of boys and girls taking the subject is shown with virtually no boys taking Textiles Technology and no girls taking Electronic Products. Only Graphic Products has a relatively even proportion of boys and girls. The titles may have changed but the gender imbalance has not altered much in 120 years.

Over 20 years ago Jan Harding (1997) identified the National Curriculum as an opportunity to tackle the strongly gender differentiated structure of technology. Harding's focus at that time was on the provision of gender inclusive opportunities; this included training for D&T teachers to manage both their bias and boys' behaviour. The latest GCSE reforms provide yet another opportunity and yet little has moved forward. Most disturbingly is that these gender imbalances could now be hidden; the reformed single title GCSE provides optional questions based on textiles, electronics, graphics and resistant materials but the proportion of boys and girls attempting each optional question will not be part of exam board published figures. The visibility of these inequalities deserves greater attention; these cannot be swept under the carpet.

Before exploring equal opportunity issues within D&T there is a need to define the concepts of equity and equality. Striving for gender equality could be presented as equality of opportunity,

[3] Electronic Products and Systems and Control are very similar in nature but offered by different exam boards with different titles.

equality for all or equality on average. If the educational goal is to meet targets for equality on average, then it should, "guarantee that average students from different socio-economic, ethnic or gender groups will stay in the educational system to some defined level" (Espinoza 2007 p352). However, Secada (1989) suggests that rather than striving for equality between boys and girls we should work towards fair treatment, or equitable inequalities, that reflect the needs and strengths of the different groups. To compensate for society's inequalities boys and girls may need to be treated unequally and provided with unequal resources (Tyker 1977). *Equal* treatment assumes the fundamental or natural equality of all persons whereas *equitable* treatment is associated with a fair and just provision that considers individual circumstances (Corson 2001). Greater equity may mean less equality of opportunity. Equity, unlike equality, involves both a quantitative assessment and a subjective judgement which makes it much more difficult to apply.

Initiatives in place to help tackle inequities in higher education include the Athena SWAN Charter, established in 2005 to recognise commitments to advancing the careers of women in STEM. Most universities have voluntarily signed up to the charter with varying levels of commitment and success recognised by graded awards. In schools, the only national guidance comes from the Equality Act (2010). This includes a clause on positive action which "allows schools to target measures that are designed to alleviate disadvantages experienced by, or to meet the particular needs of, pupils with particular protected characteristics" (DfE 2014 p6). These protected characteristics include gender and the Act includes examples of how single gender classes are permitted in certain circumstances.

Positive action is not the same as positive discrimination and the DfE guidance uses D&T in two of the examples in describing unlawful discrimination in the delivery of the curriculum if;

> *"…girls are not allowed to do design technology or boys are discouraged from doing food technology".* (DfE 2014 p14).

> *" … a school (were) to require girls to learn needlework while giving boys the choice between needlework and woodwork classes*". (DfE 2014 p20).

Although these examples clearly represent unequal and unfair treatment of girls and boys in D&T they also reveal a shockingly outdated understanding of the subject. Single gender teaching is highly controversial (Spielhofer et al. 2002, Robinson & Smithers 1999) with much of the research from twenty years ago focusing on boys' academic achievement (Younger, Warrington & Williams 1999, Gray & Wilson 2006). An example of equitable, rather than equal, teaching is in the provision of considerably more 'wait time', the time allowed for pupils to

respond to questions, for girls (Mansfield 1996). Mansfield's conclusion was that this additional wait time for girls contributed to greater gains in academic achievement; his study was driven by a desire to identify causes of boys' underachievement rather than exclusion of girls.

Although there are no national initiatives targeted at gender equality in D&T there is guidance from over three decades ago. Evaluation of the Girls in Science and Technology (GIST) project in Manchester discussed the obstacle of teachers' biologically deterministic views (Whyte 1986). At the same time, from within the ranks of D&T teachers, Cattan (1988), Down (1986) and Withey (2003) all highlight the need to tackle the dominance of boys in CDT lessons. They also suggest the following:

Provide short single gender interventions to develop spatial skills and tinkering approaches.
Offer gender-neutral contexts or individual choice for projects.
Maintain equal access to practical equipment in coeducational settings.
Work with parents as the primary socialisers.
Draw on older girls studying CDT and women technologists as role models.

Two of these suggestions relate to the practical element of the subject; the subject is based on the study, design and manufacture of physical products, the man-made world. The root of the word technology is linked to the Greek techné, often translated as craftsmanship. Most pupils, teachers and parents readily recognise this feature of D&T as it is taught today in Britain. The iterative problem-solving process moves backwards and forwards between practical modelling and imaginative or critical thinking; an iterative interplay of mind and hand (Stables & Kimbell 2007). The Royal Academy of Engineering also recognise purposeful practical problem solving as one of their key engineering habits of mind and describe it as 'tinkering' (RAEng 2017).

The Goldsmith APU findings confirm that there is variation in performance between boys and girls when tackling tinkering, practical work or active modelling (Kimbell, Stables & Green 1996). Their studies show how these effects are compounded by the structure of the task; tightly defined and dominantly active pieces of work will enormously favour boys, loosely defined and dominantly reflective activities will enormously favour girls. In addition, the lower the prior attainment then these effects are exaggerated. These reported differences in the way boys and girls approach practical tinkering are often associated with early childhood socialisation (Salminen-Karlsson 2007, Baker et al. 2007, Virtanen, Räikkönen & Ikonen 2014).

Rogers (1998) identifies how early tinkering experiences in primary D&T sessions could help to mediate gender-role stereotypical approaches practical work. D&T teacher perceptions of girls' low confidence with practical work is rather nuanced; Withey (2003) proposes that girls spend

more time on designing as means to avoid conflict in the workshop with dominant boys and not because of a lack of confidence with machinery.

The contemporary interpretation of this difference between theoretical and practical knowledge is often associated with concepts of class (Dorter 1973). The combination of practical and vocational elements has remained with the subject throughout its history including the effect of the 1944 Butler Education Act to isolate practical subjects to secondary modern schools (Ball 1993, Atkinson, Gregg & McConnell 2006). Hansen (2008) uses technology teacher's journals to describe how values and beliefs about the learning process in D&T are not recognised as important by school leaders and policy makers. This practical way of knowing has less cultural value than academic knowledge in education and Western society (Bell et al. 2017). In direct contrast to D&T, Physics has maintained its value and status amongst A-level subjects with notoriously harsh standards. Unfortunately, this feeds a stereotype that Physics is suitable for clever boys and effortless genius (Archer, MacLeod & Moote 2020, Ryan 2012). Computer Science also holds a similar status associated with masculine geeks (Mendick, Allen & Harvey 2016).

The relative value of the subjects is often described in their position as core or optional subjects. In 2004, D&T became an optional subject at GCSE but numbers remained high and it was still was the most popular optional subject (Green & Steers 2006). During the next six years the number of students following non-academic qualifications with a GCSE equivalence dramatically rose between 2004 and 2010 (Jin, Muriel & Sibieta 2010) as schools adjusted their offerings, partly under pressure of performance tables, and partly to provide vocational routes for their pupils. During this period the percentage of pupils achieving five or more A*to C grades rose from 57% to 75% but most of this improvement was in the collection of 'equivalent' GCSE courses. This was particularly pronounced for young people in lower socio-economic backgrounds (Sutton Trust 2011) and viewed dimly by the Conservative government.

> "*For a decade now, we have steered hundreds of thousands of young people towards courses and qualifications which are called vocational even though employers don't rate them and which have been judged to be equivalent in league table to one – or sometimes more – GCSE, even though no-one really imagines they were in any way equivalent*". (Gove 2012).

To counter these changes in KS4 qualifications and to reassert the importance of core subjects the English Baccalaureate (EBacc) was introduced. The principle of the EBacc is to encourage pupils to enter a well-balanced set of GCSEs as a solid foundation for future studies or work and prioritizes subjects with a 'powerful knowledge' base (Young 2013). The EBacc has a part

to play in developing a talent pool for STEM careers and develop a STEM literate population but has effectively removed D&T from the mix. This emphasis on strong disciplinary coherence (Bernstein 1996) immediately rules out D&T's interdisciplinary approach (Hardy 2017). The poorly defined disciplinary boundaries of the subject relate not just to the material specialisms but the importance of retaining an interdisciplinary approach.

> *"…by design and technology over the last 30 years arises from its awkward insistence on being neither a specialist art nor a specialist science. It is deliberately and actively interdisciplinary. The design sub-label leans towards the arts, and the technology towards the sciences. But neither will do as a natural home. It is a restive, itinerant, non-discipline*." (Kimbell & Perry 2001 p19)

Although not compulsory, the EBacc, announced in 2010 and first implemented in 2013, is used as another piece of information in the achievement and attainment tables (Long 2016). Although the DfE explicitly state that action will not be taken by Ofsted in response to EBacc performance measures, many schools have responded positively to the reform and adapted their guidance and options choices accordingly (Fellows 2017). The effect on the take up of creative subjects Music, Drama and Art has been widely reported with 93% of arts teachers agreeing that the EBacc had reduced opportunities for students to select arts subjects (NSEAD 2016). The response, the 'Bacc to the Future' petition, was supported by schools, creative industries and HE establishments to include a sixth pillar of creative subjects into the EBacc to help "create a generation of fully rounded individuals" (Adams 2013). It is important to note that D&T "is not defined as an 'arts' subject by the DfE… partly because it incorporates disciplines like electronics and resistant materials" (Fellows 2017 p8). As such, D&T is omitted from calculations of the change in numbers taking GCSE creative subjects.

The Progress 8 Measures introduced in 2014 reinforced this emphasis on core subjects and one of the effects was that D&T remains in a large pool of optional, mainly creative, subjects from which students have a limited choice. Partly because of these reforms and the loss of GCSE Food and Nutrition, the numbers of pupils following D&T GCSE fell from 270,401 to 156,280 between 2010 and 2017, a staggering 42% drop (Ofqual 2017).

This history identifies numerous ways in which gender features within the subject of D&T. There are moments in its history where the instrumental role of the subject features more heavily than the emancipatory, liberal and democratic function, and vice versa. This examination of the subject also identifies the development of the signature pedagogies of D&T as they have implications for gender differences. Signature pedagogies are the "types of teaching that organise the fundamental ways in which future practitioners are educated for their new

professions" (Shulman 2005 p52). D&T's signature pedagogies include practical elements and interdisciplinary, context-rich, value-laden, iterative project-based learning. These can have different effects on boys and girls; the interdisciplinary, value-rich, loosely defined problems favour girls whilst failure in an iterative approach and the practical aspects favour boys. The practical element of D&T is often associated with life skills and vocational training; which have low cultural capital. Girls also tend to have lower confidence in practical tinkering.

D&T's sub-disciplines have been tightly linked to societal norms and gender stereotypes; the new integrated GCSE has the potential to transcend material specialisms and build a more unified approach to design as a discipline. It could also end the discriminatory practices of gendered specialisms with positive action initiatives, but it could also hide gendered divisions within performance measures. Alongside the fallout of these poorly defined material boundaries pupil numbers in GCSE D&T, and girls especially, have reduced significantly after the introduction of the EBacc, the separation of Food and Nutrition and the exclusion of creative subjects from performance measures.

The cultural value of D&T has been deeply damaged in the last two decades and how teachers perceive this value is communicated and developed needs investigating.

Within this description of D&T there are other points of interest that may also influence the perceptions of teachers when considering gender; these include the prior attainment of students, the importance of parents and the function of role models. From this short but turbulent history, a series of issues have been identified how teachers might perceive gender to play out in the subject. Understanding these perceptions is crucial; they will have a profound bearing on how teachers deliver D&T to their pupils and in turn, determine the next phase in its evolution.

2.2 STEM choices and gender

The second research question targets teachers' perception of the factors influencing the choice of students at GCSE level. This expands the scope of the literature review beyond D&T to the wider Science, Technology, Engineering and Maths (STEM) arena. There is an enormous body of literature from the last four decades covering STEM and gender; and I make use of international studies ranging from primary to higher education. The scope of STEM gender research is often limited to specific fields of engineering, physics, computing or maths even though many useful insights have the potential to translate across these boundaries. Much of the STEM gender research also spans international boundaries and so a broad search is employed throughout this chapter, with references to the limitations of disciplinary boundaries and cultural background where necessary. The scope of the literature review is moderated in

part by a focus on engineering rather than science. The proportion of women studying life sciences at undergraduate level is very different to those following computer science degrees (Alegria & Branch 2015, Eccles 2005). These variations are mirrored in British secondary schools; of all the pupils taking Biology and Computer Science at A-level in 2016 the proportion of girls were 41% and 9% respectively (JCQ 2016).

The literature arises from three quite distinct fields; scientific studies of a biological and neurological nature, social theory and psychological approaches. I explore each of these in turn and identify useful theories that tackle gender inequalities in education; these include feminist appropriations of Pierre Bourdieu's theories, Margaret Archer's critical realist developments, Louise Archer's model of science capital and Jacquelynne Eccles' Expectancy-Value Theory. These all draw out questions relating to freedom of choice, domination, transformations and structures.

There is much to be learnt from these theories and studies that affects all teachers, STEM teachers and D&T teachers. Investigating these will help to understand the foundation of teachers' perceptions and, in turn, help us to suggest future directions for D&T and STEM.

2.2.1 A biological perspective

We tend to divide the world and construct borderlines of discrimination between male and female, masculine and feminine, boys and girls (Haraway 1991). Sex and gender are terms that are frequently interchanged although sex usually refers to biological characteristics and gender to roles and identities that arise from social influences. The term gender is usually linked to the "traits, behaviours and expectations that cultures train boys and girls to practice and hold" (Howes 2002 p25). Here gender is based on social influences and the social roles imposed on people based on their sex. Feminist writing argues strongly against biological determinism, Simone de Beauvoir claims that one is not born, but rather becomes, a woman (1972). More recently, gender has evolved to refer to social identity; the fluid, changing spectrum where agency is prevalent, and change expected. The term offers scope to include lesbian, gay, bisexual, transgender and queer communities and people.

These alternative uses of gender; to describe both aspects of social roles and aspects of personal identify, place different meanings on the agency of players and their relationship to society. This variation has led to a significant and long running debate about the use of the terms sex and gender in feminist writing. One dominant force in this body of knowledge is Judith Butler where her argument breaks down the link between the terms sex and gender completely,

> "*If gender consists of the social meanings that sex assumes, then sex does not accrue social meanings as additive properties, but rather is replaced by the social meanings it takes on; sex is relinquished in the course of that assumption, and gender emerges, not as a term in a continued relationship of opposition to sex, but as the term which absorbs and displaces sex*". (Butler 1993 p6).

Continued discussion of Butler's work, and her radical linguistic constructivism, is not one that I feel would fit with the direction of this study. However, I will follow her lead and continue to use the term gender to describe the biological binaries as well as the roles and identities that are socially constructed. This section is not intended to contribute to debate about the effects of nature and nurture on behaviour but to present possible biological and neurological reasons why STEM and D&T teachers may ascribe differences in behaviours of boys and girls.

Sex differences and similarities have regularly been of interest to educators. Gonadal hormones, androgens and oestrogens, provide the major biological influences, along with genetics, on sex differentiations. These hormones are released to effect physical changes at prenatal and pubescent stages (Hines 2004) but there are no significant differences in levels of testosterone, oestradiol, or progesterone between boys and girls for the ten years between these phases. During puberty, hormone levels change dramatically but relatively little research has been conducted on cognitive development during this phase (Blakemore & Frith 2005). Post pubescent adolescents are then exposed to varying levels of testosterone, oestrogen and progesterone; testosterone is released, triggered by pulses of luteinising hormone in a daily cycle for boys and oestrogen levels fluctuate throughout the menstrual cycle for women.

Many studies have investigated the effects of these hormones on cognitive skills such as spatial abilities, numerical processing and verbal fluency, all important features of D&T and STEM. For example, spatial navigation is improved with increased levels of testosterone, in both men and women, but the differences are small. In addition, the cause of the phenomenon is less likely to be due to evolutionary adaptation and more likely to be due to socialisation (Clint et al. 2012). Eliot (2013) describes how the results of many studies on hormonal effects on cognitive function show weak links, are often disputed and rarely replicated. The studies tend to focus on cases with abnormal hormonal levels and are based on limited numbers of participants, normally adults. The consensus is that ability to extrapolate beyond these cases to general behaviours of boys or girls is limited. However, teachers are presented with biological differences daily and their beliefs about hormonal effects may well come in to play.

There are other studies that investigate the immediate and reversible activational effects of these gonadal hormones on adult behaviour such as risk taking, aggression and competitiveness;

these may also have an impact in the classroom. Again, Eliot alerts us to the relative significance of these effects and describes how our beliefs about hormones also affect behaviour, perhaps more powerfully than the hormones themselves. Differences in behaviours that are measurable in laboratory conditions become insignificant when the normal environment of a busy classroom is factored in. If the effect of different hormones on behaviours is overplayed by teachers, students and parents they can form the basis of stereotypes that then affect the decisions and choices of each of these players. These stereotypes can have more effect than any hormonal differences.

In a similar way, there are findings of differences between the sexes from neurological studies which are often reported rather simplistically in the popular press:

> *"The amygdala tends to be larger in males which may make males more aggressive".* (Gurian 2001 p20).

> *"A more active frontal lobe, which facilitates speech, thought and emotion allows for improved verbal communication in girls".* (Gurian 2001 p20).

> *"Boys use the right side of brain to work on abstract problems; girls use both sides".* (Sax 2005 p87).

> *"The areas of the brain involved in language and fine-motor skills (such as handwriting) mature about six years earlier in girls, the areas involved in math and geometry mature about four years earlier in boys". (*Sax 2005 p93).

Cognitive neuroscience has enormous potential for informing educational practice but neuroscience studies in language, emotion, memory, attention and cognitive control can be limited by the constructivist model within which they operate. The field is relatively new and the facilities to study boys and girls directly in a complex classroom environment are not yet available. Excitement about the potential for neuroscience to map Visual, Auditory and Kinaesthetic leaning styles (Lisle 2006) is an example of the misapplication of science to education. Eliot (2011, 2013) demonstrates how sex differences in the brain are distorted in public discourses; Sax (2005), Pinker (2008) and Gurian's (2001) popular books misreport, wildly extrapolate, exaggerate or cherry pick neuroscience results from contradictory studies. In addition, a lack of correlation, a negative result, is often not deemed worthy of reporting. These studies support the notion that differences between the brains of men and women are often insignificant, the differences between individuals is much larger. Eliot's recommendation is that

all neuroscience studies report negative results, even if in a single sentence, to mitigate any misreporting.

Correlation between observed behaviours and fMRI results in neuroscience studies are reported on but rarely are the causes of the differences confidently identified. Just because sex differences are evident in the physical brain this does not mean that behaviours are related or even are fixed. Neural structures and functions can change through experience and practice (Eliot 2013) yet not enough studies explore the relationship between socialisation and brain sexual differentiation.

Many neuroscience studies are carried out with men and women although it is known that brains have a neural plasticity; they change and develop according to the social, physical and sensory environment (Greenough, Black & Wallace 1987). Boys and girls will therefore develop differently depending on their environment and treatment. A relevant example is the claim that women's thicker corpus callosums could impair women's ability to perform some specialised visual-spatial skills like reading maps or diagrams (Gorman 1992). Anne Fausto-Sterling (2000) highlights the following warnings that need to be considered when making inferences from correlations:

> *"Correlation does not necessarily prove causation; in fact, a reverse causality is also likely. Differences in corpus callosums are not found in infants; this may suggest that physical brain differences actually develop as responses to differential treatment…. Given that visual-spatial skills (like map reading) can be improved by practice, even if women and men's corpus callosums differ, this does not make the resulting behavioural differences immutable".* (Fausto-Sterling 2000 p156).

Goswami (2004), Blakemore and Frith (2005), Howard-Jones (2007) and Geake (2008) are all key proponents and advocates of neuro-cognitive research and its application to education. They remain firmly within the post-positivist paradigm and refuse to endorse any application until it has been empirically tested and proven beyond reasonable doubt. Many popular accounts of brain functioning are based on scientific research but extrapolations to inform classroom practice go well beyond the laboratory data. The critiques of these popular applications include Geake's 'neuromythology' (2008), Fine's 'neurosexism' (2010) and Sax is even described as a 'pseudoscientist' (Halpern et al. 2007).

These popular myths; females wired for emotional awareness, writing ability and language, boys wired for competitiveness, self-esteem, maths and spatial skills, are clearly differentiated gender differences but are not definitively linked to sex differences in brain structure. By linking

behaviours to myths about hard wired brains, the public and educators reinforce gender stereotypes. This gender essentialism (Skewes, Fine & Haslam 2018) oversimplifies the nuanced scientific studies into sex differences and their hormonal, neural and evolutionary basis. Fine echoes Geake's recommendation to neuroscientists to be cautious about providing clear, undisputed, directions in which to treat boys and girls. As Spelke concludes in her comprehensive review of research on sex differences in intrinsic aptitude in maths and science;

> "*Studies of cognitive development, and of its biological basis, do not explain the preponderance of men on academic faculties of mathematics and science. We must look to studies of our society for insights into this phenomenon*". (Spelke 2005 p24).

Lawrence Summers (Summers 2005) included in his speech at Harvard University on gender equality in STEM the inflammatory remark that, "research in behavioural genetics is showing that things people previously attributed to socialisation weren't due to socialisation after all". This prompted a response in the form of a special issue of Psychological Science in the Public Interest. The consensus in the USA at the time was that there are no single or simple answers to the complex questions about sex differences in science and mathematics and a bio-psychosocial or psycho-biosocial model is needed to describe the reciprocal interplay between biology and environment (Halpern et al. 2007). Human brain development is altered by life experiences; the brain remains plastic, changing in response to learning and environmental events.

It is difficult to separate sex from social and cultural influences. Brotman and Moore's (2007) meta-analysis of STEM and gender literature identifies how research has shifted from a deficit model of girls' failings to a focus on equitable access to curriculum and pedagogy. They also identify a theoretical shift towards more critical feminist studies that focus on identity with sociocultural factors. This chapter follows the same path and I next look to social theories models for explanations of teachers' perceptions of gender whilst acknowledging that neuromyths may well form part of teachers' understanding of their pupils.

2.2.2 A social reproduction perspective

Social reproduction theorists refer to the mechanisms by which schooling reinforces the dominant structures of power within society, but their approaches include those that are largely deterministic models and others that focus on agency (MacLeod 2009). Critical theorists such as Bourdieu and Passeron (1977), John Dewey (1916) Willis (1977), Bowles and Gintis (1976), Apple (1978) and Archer (1995, 1996, 2000) vary in their scope of analysis and methodology

but all attempt to trace links between economic structures, schooling and cultural activity (Collins 2009). They suggest that a function of education is to reproduce the social relations and class structure, the transmission of rituals, routines and knowledge, along with all the inherent inequalities.

An example from the STEM field to demonstrate how this might play out is a study on the effects of gender bias of teachers in Israel (Lavy & Sand 2015). Their comparison between boys and girls results in non-blind classroom tests in Year 7 with blind national exam assessments at GCSE level were used to identify the level of gender bias in grading by teachers. Teachers' favouritism in Year 7, the over-marking of boys' maths tests, resulted in significant positive effects including a much higher rate of successful completion of advanced maths courses than girls. There are countless other examples of how teachers can reinforce and reproduce gender inequalities in STEM.

Teachers may only be part of the reason why the numbers of girls and women in engineering has remained consistently low; Miriam David concludes her review on studies in gender inequalities with this rather despairing comment;

> "*As feminist and social researchers, we have learnt over the last 30 years that, despite strong research evidence, social and gender inequalities remain stubbornly resistant to policy change*". (David 2008 p270).

Even if an individual from a lower socio-economic background, ethnic or gender minority group breaks out of the norms, rather than challenging the system, this can strengthen the structures by contributing to the appearance of meritocracy (Sullivan 2002).

Carr and Hartnett (1996) argue that the study of education is an analysis of how society both reproduces itself and changes over time. The potential of education to transform is an appealing aspect of these theories. Sociological shifts may well affect education, but education can also modify society;

> *"Although education always has a tendency to reproduce the social life or society, it also simultaneously serves to transform existing patterns of social life so as to promote alternative views of the good life and the good society. Thus, there is, at any one time, always an unavoidable tension in education between social reproduction and social transformation reflecting the internal tension between social stability and social change."* (Carr & Harnett 1996 p37).

It is within this tension between forces of reproduction and change that Bourdieu's conceptual framework of social reproduction, despite numerous stumbling blocks, has been identified. His work is based primarily on class rather than gender, his early writings tended to structural determinism rather than agency, his definitions include "occasionally incompatible meanings" (Lamont & Lareau 1988) and there is an evolution of his concepts over his academic career (Arnot 2002, Mickelson 2003). This next section will address the strengths and weaknesses of Bourdieu's cultural capital and habitus with gender in D&T education in mind. The aim will be to 'appropriate' (Moi 1991) any useful aspect of his theories.

Capital

Cultural capital is shown to be embodied in practices, objectified in books and paintings and institutionalised in academic qualifications (Bourdieu 1973). Others present cultural capital as, "institutionalised, widely shared, high status cultural signals (attitudes, preferences, formal knowledge, behaviours, goods and credentials) used for social and cultural exclusion" (Lamont & Lareau 1988 p154). In all the many definitions, power is exercised through the exclusion of access to cultural capital as well as economic capital. This exclusion involves the legitimising of cultural norms and practices rather than overtly influencing decisions or political agendas and this, "exclusion of these resources becomes one of the most pervasive forms of power" (Lamont & Lareau 1988 p159).

An example of how women can be excluded from STEM can be found at the very foundations of science. As a founder of the Royal Society, Robert Boyle's work in the seventeenth century included papers on the reporting and communication of controlled scientific experiments. This production of knowledge revolved around the important role of witnesses, or 'social philosophers' (Shapin 1984).

> *"If [witnesses] reported experiments they were to do so in a matter-of-fact way…. they needed to show that they were not constrained or dependent on others in any way. That they were free agents, unbeholden to anyone. Only gentlemen could fulfil this social requirement. Only gentlemen were not beholden to anyone else. Women, even upper class, were likely to be dependent on men – fathers, husbands, brothers. Their testimony was accordingly unreliable*" (Law 2004 p120).

Discussions about these gendered roles suggest that Boyle's writings reflected the cultural norms of the day, a patriarchal model of the scientist, rather than a deliberate attempt to exclude women (Macdonald 1995). However, once the "source of any bias has been shown, then it

should be easier to see that there is no reason to continue in such a manner" (Sargent 2004 p866).

There are numerous studies that explore the mechanisms by which cultural capital in terms of gender and STEM is distributed, accessed or controlled. One feature of these studies is a longitudinal approach to study the transfer of capital between generations and over time. Many stress how parental involvement varies according to the family's class and gender of the child (David 1997, Allard 2005, Archer, MacLeod & Moote 2020).

The persistent nature of gender inequity (David 2008) has been of interest to the Institute of Physics (Murphy & Whitelegg 2006). A-level Physics is subject that acts as a crucial academic qualification for many STEM careers but has struggled to recruit girls over the last four decades (IOP 2012). Louise Archer is an important figure in this field with numerous contributions, including the ASPIRES research programme which has suggestions for STEM teaching practice (Archer et al. 2013). Louise Archer explicitly identifies with a Bourdieusian approach in her recent work and has expanded on cultural capital to include four components that relate to STEM education (Archer, MacLeod & Moote 2020):

Science literacy - what you know.
Networks - who you know.
Behaviours - what you do outside school.
Attitudes – how you think.

I intend to apply these elements of Louise Archer's science capital model to design, technology and engineering. The relevant D&T attitudes, behaviours, networks and curriculum are explored in depth in the next chapter.

Habitus

Another feature of Bourdieu theory that has been appropriated for the purposes of this study is habitus, "a strategy-generating principle enabling agents to cope with unforeseen and ever-changing situations" (Bourdieu & Passeron 1977 p72). The analogy that I have found particularly useful is that of habitus as a cloak; the 'garment' can be changed according to the environment, the weather or modified to suit the wearer's mood or fashion. The analogy of the cloak is found in feminist writing too. Nicholson describes how our sexed bodies are like coat racks and "provide the site upon which gender [is] constructed" (1994 p81).

The notion of habitus is discrete from concepts of identity (McLeod 2005); it is a tool to help one function more effectively in that environment or field. "Habitus is a system of dispositions

adjusted to the game" (Bourdieu 1984 p34). Bourdieu presents habitus as an active, self-generative set of dispositions rather than as a passive store of information. The habitus of various players will never be identical as everyone's history, class, ethnicity and gender combine differently.

Habitus is highly dependent on the concept of field: "the competitive system of social relations functioning to its own specific logic or rules" (Moi 1991 p1021). Bourdieu and Wacquant use the metaphor of card games to expand on the concept of field (1992). Just as the rules, regularities, stakes and relative value of cards changes according to the specific games, so the value of capital (economic, social, cultural and symbolic) varies across different fields.

Habitus can be useful in describing how girls and boys navigate their way through D&T and STEM. Studies show how active coping strategies to counter gendered STEM bias rely on knowing the rules of the game (Robnett 2016). Others describe the gendered patterns of behaviour that contribute to choices and decisions of girls in STEM (Niiranen & Hilmola 2016) or way women engineers deal with their 'technicist' identities (Faulkner 2007).

Transformations

There are limitations of Bourdieu's concepts; he suggests that; "dispositions are both shaped by past events and structures, and shape current practices and structures" (Bourdieu 1984 p170). He is suggesting that individuals have a part to play in the transformation of structures; gender inequality in STEM for example. Many feminist writers refute this; Butler (1999) argues that habitus is so imprinted by the field that there is no reciprocating effect on the field. McLeod argues that "habitus is useful for explaining patterns of continuity but not processes of change" (2005 p20). Arnot's (2002) critique suggests that habitus is both difficult to pin down and that the "theory implies that planned action for change can have little impact against social determinism". Clegg argues that there will always be "tension between poststructuralism's denial of agency and feminism's constant need to recoup it" (2006 p318).

Rather than dismissing habitus altogether; others suggest that by focusing on the detail in mundane actions there is opportunity for individual agency. Moi's micro-theory (1991) shows how decisions in everyday practices such as marking an assignment or gossip can lead to positive changes. Other's work on habitus (Allard 2005, Mills 2008, MacLeod 2009) identifies how multiple fields, and therefore the numerous forms of habitus, are essential in developing full understanding of cultural, social and economic capital. Their micro-level analysis includes actively seeking out positive interactions between people, rather than just looking for patterns across groups.

To identify how transformations occur at a structural level we need to look at Margaret Archer's morphogenesis (1995). Her theories are based on critical realism and have value in feminist research (Clegg 2006). Archer posits that "personal emergent powers are exercised on and in the world – natural, practical and social – which is our triune environment" (Archer 2000 p318). These three domains follow the critical realist model:

> Structure: real and social domain of material goods and social roles.
> Culture: natural and empirical domain of ideas and beliefs.
> Agency: practical and actual domain of human action and interaction.

By dividing these concepts Archer shows how structural and cultural powers impose on agents but also how agents use their own personal powers to act. She moves away from social conditioning as determinism and presents modes of reflexivity, or 'internal conversations' (Archer 2003) to explain how individuals navigate their way through life. Baker (2019) uses these reflexive modes to describe the decision making and educational choices of students making the transition from further to higher education. Case's (2015) study of South African engineering students concludes that STEM educational settings need to enlarge the possibilities for exercising and developing pupil agency; morphogenesis of human agency centres on the coming together of personal and social identities (Archer 2000). In other words, pupils need opportunities to confront social conditioning. There also needs to be provision for agents, pupils and teachers, to collectively use resources to act creatively and transform social structures.

This discussion of equal opportunities and positive action has focused so far on the economic STEM pipeline analogy. I now move onto the second aim of the STEM programme to enhance the "STEM literacy in the population" (STEM 2006 p4). This is to provide a balanced argument where;

> "*Education policy finds itself at the centre of a major political struggle between those who see it only for its instrumental outcomes, and those who see its potential for human emancipation*". (Taylor et al. 1997 p.vii).

Archer suggests that policy makers would be better served by describing STEM education as a 'springboard' (Archer et al. 2013). The springboard emphasises the wider value of science and technology knowledge, skills and attitudes to modern life and careers beyond STEM.

In summary, Bourdieu's cultural capital, modified by Louise Archer, provides insights into how gender inequalities in society, STEM and D&T can be resistant to change through the restricted

access to cultural, scientific or technological capital. The concept of habitus provides a starting point for the study of individual agency if the focus remains on detailed and positive interactions. Possibilities for institutional structural transformation are found in Margaret Archer's morphogenesis. These theories relate directly to the perceptions of teachers on how structure, culture and agency work within their classrooms, schools and communities. The next section of the chapter delves into individual agency in more detail and from a socio-psychological angle.

2.2.3 A socio-psychological perspective

Educational psychology offers a rich collection of theoretical models for studying the ways pupils make educational choices. Motivation dominates the models and wraps up concepts of engagement, incentives, intrinsic and extrinsic factors as well as choice. John William Atkinson (1957) is recognised as establishing motivation as a distinct field in psychological research in the 1950s by combining needs, expectancies and values into one all-encompassing framework. He differentiated between expectancy of success beliefs - being able to do the task - from beliefs about the importance, value, and desire to do the task (Pintrich 2000).

However, the application of these theories is not straightforward as there are multiple models ranging from drive reduction theory (Hull 1943) based on biological needs to self-determination theory (Deci & Ryan 1985) based on psychological needs of competence and autonomy. There are numerous others including goal related theory (Locke & Latham 2002), attribution theory (Weiner 1972) and mindset theory (Dweck 2017) which all use differing underlying frameworks (Schunk, Pintrich & Meece 2008, Stipek 1998, Wentzel & Wigfield 2009).

Of the numerous other motivational concepts, Bandura's self-efficacy (1977) has been used extensively in a variety of settings including clinical management of phobias (Bandura 1983), depression (Davis & Yates 1982), social skills (Moe & Zeiss 1982) and athletic performance (Lee 1982). More recently self-efficacy beliefs have received attention in education (Pintrich 2000) and STEM education more specifically (Hughes & Roberts 2019). Efficacy beliefs determine the effort, persistence and resilience one applies to a task. Bandura's model is based on a triadic model of personal factors, behaviour and environment which all interact reciprocally (Pajares 1996).

One of the reasons self-efficacy differs from other expectancy constructs in that it focuses on specific tasks in specific contexts rather than general perceptions of competence. This is reflected in the types of questions used in self-reporting questionnaires; a self-efficacy assessment may include the rating of confidence to solve a specific maths problem. An

assessment in other expectancy constructs may relate to general ratings of confidence in maths. This task and domain specificity are strengths of self-efficacy, but it is difficult to predict academic outcomes based on self-efficacy results alone. Those filling in self-efficacy reports find it easier to relate to the specific tasks and domains and hence results tend to be internally consistent. The problem is that a large range of specific tasks is needed to provide any sort of predictive power in wider domains.

One problem with all expectancy and motivational constructs in general, is the large number of subtle variations in terminology. This relates to the constructs and the questions used to assess them. Compare, for example, perceived ability (Greene & Miller 1996) with subjective competence (Boekaerts 1991). The terms 'ability' and 'competence' are closely linked and yet different, as are 'perceived' and 'subjective'. In another example from Greene and Miller's assessment, one of the items for perceived ability is, "I can do well on this exam". However, a very different question, "how have you been doing in Maths this year?", is one of the items in Meece's assessment (Meece, Wigfield & Eccles 1990). Despite these different questions, both researchers use the term 'maths ability perceptions' in their definitions.

These two very different questions about performance are also a useful way to clarify the differences between expectancy-value theories and self-efficacy theories. It seems logical to assume the two are directly connected; a pupil who has a strong perception of their ability in D&T has high self-efficacy and can expect to achieve high scores and perform well in D&T. However, there are environmental factors beyond the control of the pupil that could affect the outcome of any assessment. There is also the possibility that high self-efficacy may not directly result in high performance if the student also believes that there are undesired effects of a high score. Other complications arise when outcome expectations play a role in creating self-efficacy perceptions and learned helplessness (Teasdale 1978). Here, cause and effect are flipped and suggest that the models are less useful as *predictors* of choice, performance and persistence but very useful ways to *explore* the interactions between pupil choice, performance and persistence.

When we then also factor in the value of a task or a subject, the issue becomes even more problematic. Atkinson (1957) argues that a pupil would place greater value on tasks that they believe are difficult and are least likely to accomplish whereas Bandura (1977) argues that because beliefs partly determine expectations, pupils generally value tasks they believe capable of accomplishing. It is no wonder then that the distinction is highly contested and context specific. Despite this theoretical distinction between ability beliefs and expectancy constructs they are empirically highly related (Pajares 1996).

Self-concept is another construct that is confused with self-efficacy and is used within the expectancy-value model. Self-concept tends to be more global or multidimensional whilst self-efficacy is task and context specific (Bong & Skaalvik 2003). Self-concept also includes judgements based on comparisons with the performance of others and includes. Self-concept of ability affects academic performance, persistence and choice so that students with positive self-perceptions of their ability approach tasks with confidence and high expectations for success (Eccles, Adler & Meece 1984 p27). This inclusion of confidence in this definition raises some interesting gender differences. Although most students are overconfident about their academic capabilities, high achieving girls tended to report lower self-concept (Pajares 1996).

At this point in the discussion of psychological concepts it needs to shift from the individual to groups. Teachers will have an imperfect understanding of each individual student's self-concept and self-efficacy they will be making decisions and judgements based on groups of pupils within a class. How teachers and pupils perceive social roles affect them is linked to how teachers understand groups of pupils and revolves around the importance of stereotypes.

Stereotypes

A dictionary definition is a useful starting point, stereotypes are, "a widely held but fixed and oversimplified image or idea of a particular type of person or thing" (Stereotypes 2019a). Over two decades ago the definition read as, "a person or thing that conforms to an unjustifiably fixed mental picture" (Stereotypes 1996). The difference in tone reflects how our understanding of stereotypes has changed. 'Unjustifiably' has changed to 'oversimplification'; recognising the importance of evidence and bias in the formation of a stereotype. There are three possible ways of looking at the phenomenon.

The first is the economic approach (Arrow 1973) which represent stereotypes as statistical discrimination; the rational formation of a belief about a person in terms of the aggregate distribution of traits in that person's group. This approach often fails to recognise the oversimplification of the stereotype and by trying to avoid judgement effectively provides an acceptance of the status quo.

The second is a sociological approach and views stereotypes as derogatory generalisations of a groups' traits often based on the stereotyper's prejudices (Steele 2010). This approach tends to ignore the evidence on which a stereotype is based, the positive attributes associated with some stereotypes and the tendency for stereotypes to change over time. The 'fixed' (Lippmann 1965) rationalisations of 'prejudice' (Lapiere & Farnsworth 1936) or exaggerations based on

'small kernels of truth' (Allport 1954) have much in common with a more detailed dictionary definition of a stereotype as;

> "...*something conforming to a fixed or general pattern especially: a standardized mental picture that is held in common by members of a group and that represents an oversimplified opinion, prejudiced attitude, or uncritical judgment*" (Stereotypes 2019b).

However, as data becomes more easily accessible, our understanding of stereotypes has changed. A third approach is the socio-psychological view that stereotypes are special cases of cognitive schemas which become intuitive generalisations that people use in everyday life to save on cognitive resources (Bordalo et al. 2016). Most teachers would recognise the need, in a busy and complex classroom environment, to conserve cognitive resources and in so doing, tend to make judgements quickly or even subconsciously. This heuristic approach to stereotyping suggests that we selectively focus on features that are the most distinctive and relevant to the task in hand.

Recent understandings recognise that, rather than being based on "small kernels of truth", a stereotype of a group is often based accurately on empirical evidence (Judd & Park 1993). There are studies that have set out to test the accuracy of stereotypes by comparing people's beliefs about a group to the criteria that establish those group characteristics. Lee Jussim and his team have reviewed over 50 studies of race, gender, political affiliation and national characteristics that make this comparison. They conclude that, rather than being based in cultural myths, the shared component of demographic stereotypes is often highly accurate with only a few inaccuracies (Jussim, Crawford & Rubinstein 2015). The shared component represents consensual stereotypes shared by members of a culture rather than personal stereotypes which are individuals' beliefs about groups. In using this measure, they are employing a 'wisdom of crowds' effect (Surowiecki 2004). It is worth highlighting that they found political and national character stereotypes, stereotypes other than demographic ones, to be less accurate. Jussim's team also recognise that just because individuals hold a stereotype that may be accurate, this may still have a role to play in prejudice and discrimination.

This socio-psychological approach identifies stereotypes as learnt associations arising from the normal working of the predictive brain in everyday life. Stereotypes are therefore seen as "culture in mind" rather than an unconscious cognitive bias in individuals (Hinton 2017). The EVT model clarifies that two groups of people mediate with the stereotypes held in the cultural milieu. These are the pupils making decisions about their GCSE options and future career paths, and the socialisers of those pupils, the teachers, tutors, career advisors and parents. Unsurprisingly,

having parents in STEM professions is seen to help children identify their self-concept more readily with STEM professions (Holmes et al. 2017, Eccles 2015). Parents are key transmitters of social and cultural expectations. Decisions for pupils and socialisers are made at two levels; in subconscious rapid, instinctive responses made in the heat of the moment, such as in a busy classroom environment and when conscious, careful thought is applied such as when planning a scheme of work or selecting GCSE options (Landy 2008).

A natural assumption would be that cultural stereotypes could be eliminated, or at least minimised, when making conscious decisions as more information is available. However, research shows that judgments based on higher levels of processing are more likely to last over time, to resist change in reaction to an alternative view and even resist change when reminded that certain biases might be at work (Wegner, Clark & Petty 2006).

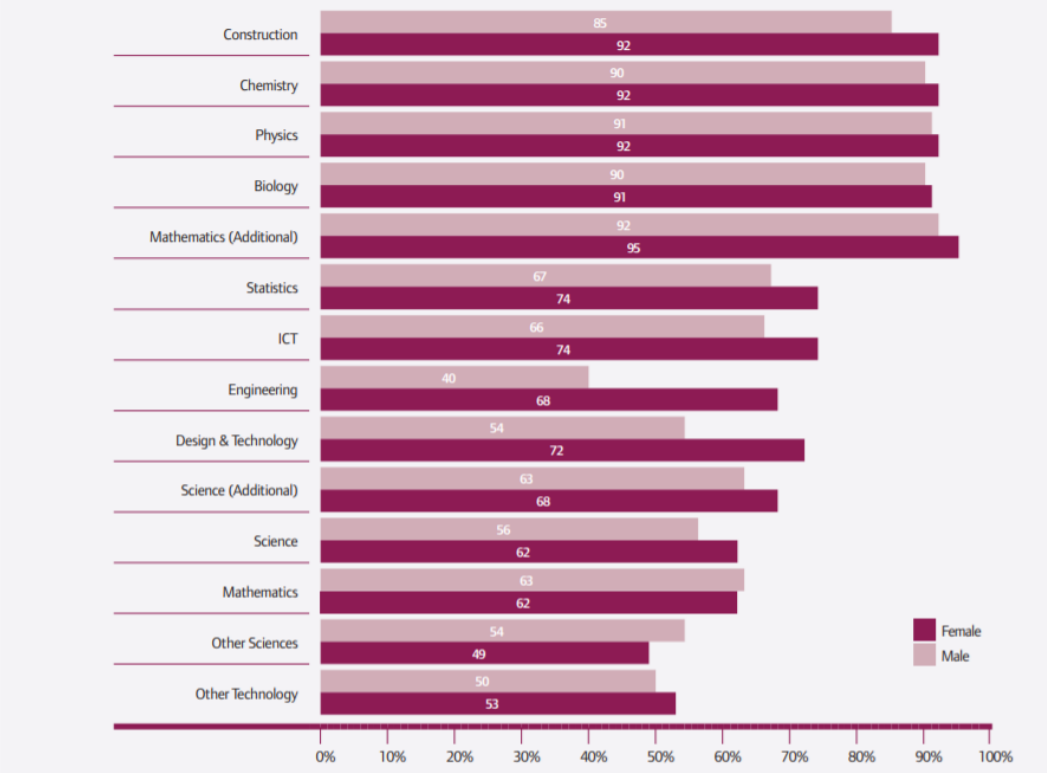

Figure 2-2 STEM GCSE A*-C grades in the UK (WISE 2014).

It is not necessarily the cultural stereotypes that are problematic when making decisions but the distortion, exaggeration and representation of difference that causes problems. We tend to think diametrically and seek out differences. Because of this, similarities are rarely reported and so stereotypes are reinforced (Campbell & Storo 1994). An example that has relevance to STEM is shown in Figure 6-1.

This shows that girls outperform boys in almost all STEM subjects, with 66% of girls achieving A*-C/9-4 grades compared to 62% of boys. Maths is the only subject, apart from the undefined 'other sciences', where boys outperform for girls. The difference is a relatively insignificant 0.5% increase in pass rates. If we probe a little further into these Maths differences we find the following differences, Figure 6-2.

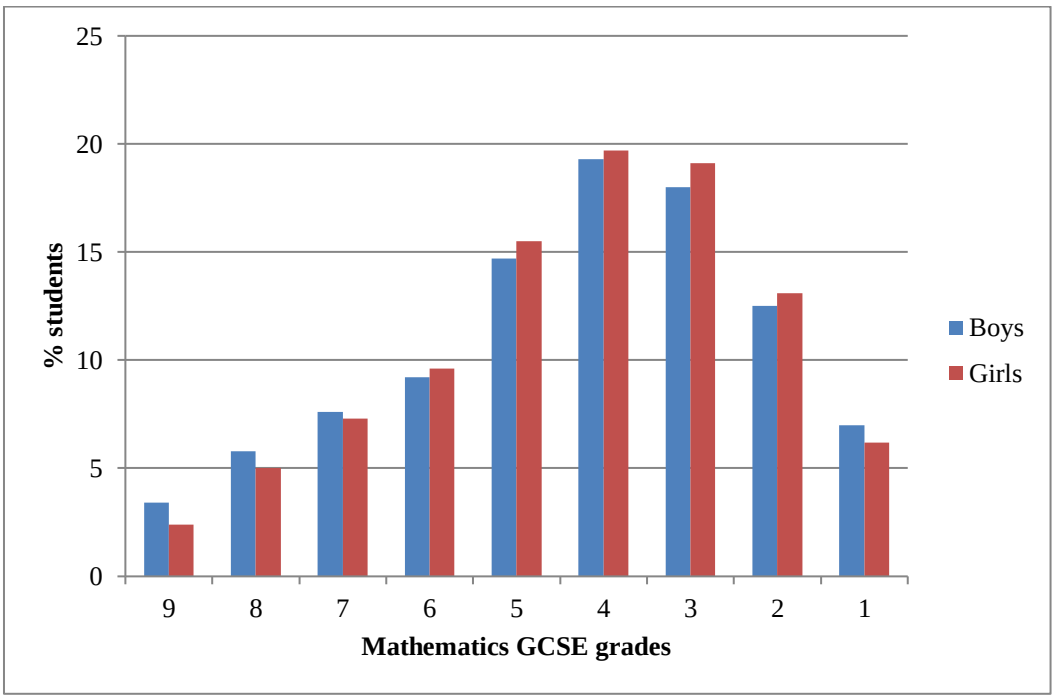

Figure 2-3 Mathematics GCSE results 2018 (JCQ 2018).

Boys have a slightly higher incidence at the extremes, the top grade of a 9 and lowest grade of a 1. Even here we only see a single percentage point difference between the sexes (3.4% boys with a grade 9 compared to 2.4% girls). Overall, the pattern of performance is very similar between boys and girls and yet these differences are widely reported without the accompanying data. By focusing on the difference, rather than the similarities, between boys and girls in Maths we feed the prevailing stereotype that male maths performance is high and female maths performance is poor (Eccles, Jacobs & Harold 1990). Predictions that students, teachers and parents then make based on this data can be exaggerated. Experimental evidence shows that all pupils underestimate girls' ability in simple maths tasks, even when controlling for past performance (Reuben et al. 2014). These affective memories influence both the pupils' subjective task value and their expectancy for success.

Many teachers will bring to the classroom their own understanding of differences between boys and girls. Differences between students in the classroom are always being made salient; that is part and parcel of a teacher's role, to make judgements about attainment, progress and plan

interventions accordingly. The differences teachers identify between boys and girls may be no greater than differences within sex groupings but become easier to categorise and label.

Stereotype threat

Reminders about stereotypes have been shown to affect performance in a task and, in doing so, reinforce the stereotype. Subtle reminders include having to indicate gender, race or class on a test form or being in a minority in an exam hall (Croizet & Claire 1998). Overt reminders include sitting a test that has been described as a diagnostic for ability between groups (Steele & Aronson, 1995) or exposing participants to articles claiming differences between groups before a test (Aronson et al. 1999). The subtle reminders for girls in STEM subjects could be the higher number of boys in their D&T set or their awareness that there are fewer women in engineering. Studies show that even subtle reminders of difference have a detrimental effect on girls' performance in Maths (Goetz et al. 2013) and this may well translate to other STEM subjects.

This phenomenon is sometimes termed social identity threat (Nosek et al. 2009) or stereotype threat (Steele 1997, Spencer, Steele & Quinn 1999) and various mechanisms have been suggested as to how it operates. Smith (2004) suggests that behaviours change, such as spending less time on questions, claiming to be tired or perceiving test to be unfair. Performance may also be affected if working memory is dominated by concerns or self-awareness (Schmader, Johns & Forbes 2008). None of the empirical testing of these constructs provides a complete answer although Smith proposes that negative behaviours and experiences may feed off each other to produce a poor performance.

Underpinning the phenomenon is a theory of motivation that is based on performance approach goals and performance avoidance goals (Ames 1992, Elliot & McGregor 2001, Elliot & Church 2002). A performance approach goal is defined as wanting to demonstrate competence - I want to do the best in the exam. A performance avoidance goal is defined as wanting to avoid demonstrating incompetence - I want to avoid failing the exam. Girls have shown to use both goal types in studies of Maths (Nguyen & Ryan 2008) and STEM career decisions (Diekman et al. 2010).

Counter-stereotypes

Stereotype threat is not always present; one study demonstrated that female engineering students did not display reduced maths performance under test conditions (Crisp, Bache & Maitner 2009). The researchers' suggestion was that this could be a result of strong association between self-concept and STEM. Counteracting stereotype threat by emphasising self-concept

in that specific domain can be supported using role models or salient counter-stereotypic exemplars (Croizet et al. 2001, Martens et al. 2006, Smeding 2012). However, it has been suggested that people need multiple and mutually reinforcing counter stereotypical examples across diverse contexts to change their personally held beliefs (Eagly & Wood 2012).

Counter-stereotypes do not always act in the interests of the minority. Bourdieu and Archer's theories of social reproduction and morphostasis suggest that high-status group members act to maintain the status quo. If a girl or woman develops a strong link between their own self-concept and STEM they are able to resist social stereotypes and become successful in this field. As these high-status group members benefit from the existing system, they are even more likely to perpetuate stereotypes and attitudes serving the status quo (Jost, Banaji & Nosek 2004).

Stereotype stratification

In a study on stereotypic beliefs on gender differences in the spatial domain (Vander Heyden et al. 2016), boys had strong explicit and implicit male stereotyped beliefs that they were superior to girls in the spatial domain. Girls agreed with the stereotype on explicit measures although less strongly than the boys. Most interestingly was that they showed gender neutral beliefs in the implicit measure. This suggests that they recognised the stereotype but did not personally endorse it. They may consider themselves to be a member of a subgroup which does not fall into the stereotype, a process called stereotype stratification (Steele 2003). This reinforces the need to use both implicit and explicit measures when studying stereotypes.

Self-fulfilling prophesy

Eccles has investigated the extent of any gender-differentiated perceptions parents hold of their children in Maths (Eccles 1986). Her team found that parents of Year 12 pupils hold gender differentiated views of their children's maths competence even though boys and girls do equally well at that age (Eccles et al. 1983, Eccles 1986). As a result, girls are less encouraged and motivated by parents to make non-traditional, counter-stereotypical educational choices in STEM (Schoon & Eccles 2014).

Even when there are no gender attainment differences, parents attribute performance to different causes leading to different conclusions about their daughters' or sons' 'talents'. Yee and Eccles (1988) found that parents of boys rated natural talent as a more important reason for success than did parents of girls. Parents of girls tended to associate success with effort, ease of task, teacher and parental help. It will be interesting to see if teachers make similar misjudgements.

A possible explanation for why parents make different judgements about the reasons for their own children's success based on gender is because they may be affected by gender-role stereotypes. They differentiate between general stereotypes (category-based beliefs) and individual judgements (target-based beliefs). Most people, when presented with information about an individual, neither ignore the information, nor do they suspend their stereotypes but make judgements and predictions based on a dynamic interplay between the two (Hilton & Fein 1989).

In summary, despite parents being provided with plenty of data concerning their children's performance, small but consistent biasing effects are evident that affects the judgement of their child's competence in line with socio-cultural stereotypes. In turn these parental gender-related beliefs influence their children's self-concepts of ability and interest in a domain (Eccles, Jacobs & Harold 1990, Jacobs 1991) and a subsequent train of events eventually leads to a dip in performance, ultimately creating the very differences the parents originally believed to exist (Tenenbaum & Leaper 2003, Tiedemann 2000).

This self-fulfilling prophesy, based on biased perceptions, may explain the very small differences in Maths GCSE outcomes presented earlier. Teachers have a very similar role to those of parents. The long-term effects of teachers' biased marking on pupils' achievements and in STEM fields has already been identified (Lavy & Sand 2015). Parents and teachers need to work together as the primary socialisers to tackle gender-role stereotypes (Lazarides & Ittel 2012, Schoon & Eccles 2014).

Stereotype development

Most of the discussion about stereotypes so far has been based on the transmission and effects; this section examines more closely the way they develop in pupils. Research on stereotypes with children are difficult because of the ethical issues involved (Bigler, Jones & Lobliner 1997). Most research is therefore based on artificial groupings, based on identifiers like coloured T shirts, before manipulating proportions, attributes and messages about the groups. Bigler and Liben (2007) have posited a developmental intergroup theory (DIT) as a model, shown in Figure 6-3, to help explain the root cause of stereotypes.

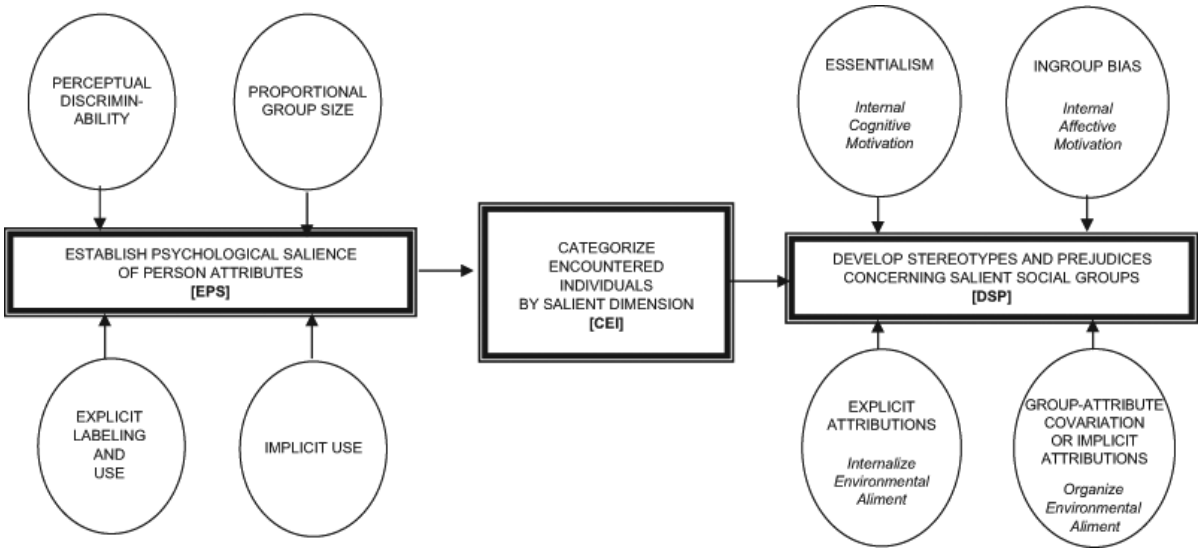

Figure 2-4 Developmental Intergroup Theory (Bigler & Liben 2007).

In the model, the ovals represent factors that influence the processes in the rectangles, the following section aims to clarify the model.

The model suggests that salience of attributes is required before categorising of individuals into groups occurs. These groups build to form the stereotypes and potential prejudices. Salient features in this project would be gender and are more pronounced when the proportions of girls are in a minority, making those groups potential targets of stereotyping. Frequent labelling or identification in the form of routines such as welcoming a class with “Good morning, boys and girls” or using gender for classroom seating plans is suggested as having an effect. These are further reinforced by implicit actions such as a father asking his child to, “ask that lady if we are in the correct line.” Bigler and Liben suggest that children construct their own hypothesis based on all these factors; building a picture about the importance of gender.

The next process in the model is based on the categorisation of stimuli to reduce cognitive complexity (Mervis & Rosch 1981); a feature that becomes particularly important in busy classrooms and relates to myth production. Here children go beyond what they have observed, their empirical evidence, and make judgements about other attributes that are based on essentialist understanding of the groups such as believing that African Americans have different blood types to European Americans (Gelman 2003). The mere act of categorising into groups produces intergroup prejudice (Tajfel & Turner 1979) and children view their in-group as superior, often fabricating attributes to reinforce this (Bigler, Jones & Lobliner 1997). Any further explicit remarks such as “girls are shy”, that link attributes to groups are powerful because they raise the salience of the category through labelling but also provide reinforcement of existing attributes or new attributes to build stronger view of the category. Any

non-verbal behaviour observed becomes another source of implicit information. These non-verbal behaviours are likely to be unconscious and this makes them more powerful in the formation of prejudice.

This model starts with the concept that stereotypes are accurate generalisations of group attributes (Jussim, Crawford & Rubinstein 2015) but describes how prejudices develop based on fabricated unobserved traits or behaviours and from the power of in-group bias. Studies suggest that stereotypes about gender and maths form as early as six years old (Baron et al. 2014) and stereotypes about spatial ability from as early as ten years old (Cvencek, Meltzoff & Greenwald 2011).

Although Bigler and Liben recognise that further work is required to provide empirical support of the model they do suggest that social policies can moderate stereotyping and prejudice formation in children. These policies relate to reducing the salience of gender through segregation, labelling and managing proportions, actions that schools and teachers have control over. Unfortunately, research shows that teachers' responses and strategies tend to reinforce pupils' gendered roles and behaviours (Younger, Warrington & Williams 1999, Eccles & Wigfield 2002). The next section provides a closer examination of teachers' implicit behaviours in the development of stereotypes.

Bias and implicit associations

An unconscious implicitly held belief can produce biased thinking which could lead to unequitable attitudes or prejudices. If these prejudices were then acted on, consciously or not, they would become a form of discrimination. Although it has been shown that stereotypes, if viewed from a socio-psychological perspective, often have a basis in fact, because of their simplification, their potential to affect performance and their self-fulfilling nature, most people are unwilling to share that they believe a stereotype. Asking teachers to identify with a statement such as, "girls are not as good as boys in D&T" is unlikely to reveal the full extent of their belief. Teachers may not be aware that they hold that belief, they may be aware of the viewpoint but do not endorse it or finally, they do not want to reveal that they hold that belief. Explicit, or self-reporting, measures are useful but may not reveal the whole picture.

There are many tools available to measure gender roles such as the Bem Sex Role Inventory, the Modern Sexism Scale, the Ambivalent Sexism Inventory or Tougas's Neosexism scale (Campbell, Schellenberg & Senn 1997). However, all of these inventories are self-reporting and fail to consider an individual's implicit attitudes and their desire to modify their responses to fit a socially acceptable form (Nosek et al. 2009). Greenwald introduced a series of psychometric

tests of implicit association (Greenwald, McGhee & Schwartz 1998) and has worked with Banaji and Nosek to adapt them for wider applications. One of these psychometric tests, the gender-STEM Implicit Association Test, is a behavioural measure based on the relative response times of participants to categorise words into male or female and science or liberal arts categories. By changing the pairing of these categories, differences can be established. Most people are able to categorise the words faster and more accurately when male and science use the same response key. This is taken to reflect stronger associations of science with male and interpreted as an implicit gendered STEM stereotype. The claim is that conscious, explicitly shared beliefs are bypassed as the test requires rapid actions.

Although the IAT is claimed to avoidsocial desirability bias, the tendency to hide socially undesirable beliefs (Rutland et al. 2005), it continues to receive much criticism (Fielder, Messner & Bluemke 2006, Kim 2003). The argument against its construct validity is that faster response times may indicate that the concepts (male and engineering) are similar in salience because of existing social norms (Rothermund & Wentura 2004, Arkes & Tetlock 2004). The test could therefore be measuring cultural knowledge rather than personally held implicit beliefs.

Cognitive dissonance between the externally espoused beliefs and implicit associations is of interest when considering teachers' beliefs about girls and boys in D&T and STEM. Although the IAT has failings, it could be a useful starting point for a discussion about the difference between unconscious bias, explicitly shared beliefs, general and individual stereotypes of gender issues in D&T and STEM.

Myths

The chapter began with a review of how biological, neurological and hormonal differences between boys and girls are appropriated by the public, teachers and schools. Dangers arise when research findings are used to justify gender differences and legitimise stereotypes. Teachers, short of time, are prey to sensationalist headlines, myths, oversimplified categorisations and stereotypes (Adey & Dillon 2012, Spaulding, Mostert & Beam 2010). Teachers use these because they seem to fit observations, they simplify decision making, they justify behaviour, they can be applied to practice, and it is easier to believe them rather than challenge them (Combs 1979).

We naturally seek explanations for the complex behaviours and results of our pupils and so generate models that link our (often unreliable) observations, and (poorly) remembered behaviours of our students to (over) simplifications of (potentially inaccurately) reported research findings. This is how teachers bring stereotypes to the classroom (DCSF 2009). I believe that

it is important to acknowledge the gendered myths and stereotypes that teachers may use to explain their pupils' behaviours. Understanding how these stereotypes develop, transmit and affect pupils is also part of this project.

Expectancy Value Theory

Within the STEM education field, the strongest proponent of the expectancy-value model is Jacquelynne Eccles. She has developed, with colleagues, the socio-psychological Expectancy-Value Model of Achievement Related Choices to explore pupils' choices in education (Eccles et al. 1983).

This theory was first derived from data in a maths study and draws heavily on Bourdieu's theories of cultural capital. Eccles expands on Atkinson's 'Value' component to include other motivational beliefs of anticipated interest and enjoyment as well as the anticipated psychological, economic and social costs of choices. Eccles also integrates the work of Brophy and Good (1974) on teacher expectancy effects. Brophy and Good's study focuses on the interactions between teachers and students and identifies evidence of teachers' different approaches to boys and girls. These three origins highlight the holistic nature of the model and make it eminently suitable for studying gender in D&T education, represented in Figure 4-1.

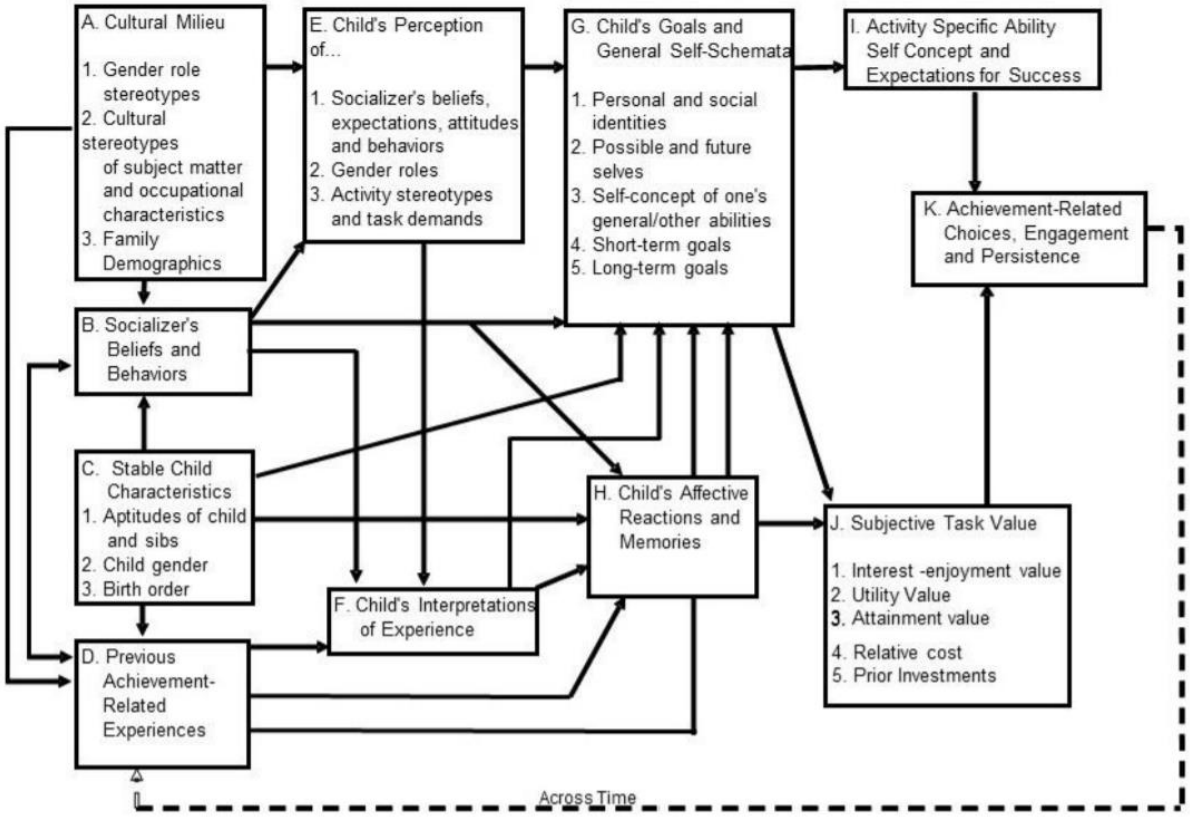

Figure 2-5 Model of achievement related choices (Eccles 2011).

Eccles assumes that expectancies and values directly influence choices but also performance, effort and persistence on a task (Eccles 2011). There are three features of the theory that improve on traditional expectancy-value models. The first is that attempts to use mathematical calculations are dropped to provide a model that explains rather than predicts motivations. The second aspect is that task value has been elaborated to include four components that describe how people judge the value of a task from a variety of perspectives (Chow & Salmela-Aro 2011).

> Attainment value is defined as individuals' perceived importance of performing well in a task, which closely relates to their perception of how relevant the task is to their identity.
>
> Intrinsic value refers to the expected enjoyment of engaging in a task.
>
> Utility value is the perceived usefulness of a task in facilitating the achievement of goals or in obtaining any immediate or long-term rewards.
>
> Perceived cost refers to what individuals are willing to give up for participating in a task, for example, their time and energy.

The third feature is that the relationship between expectancies and values to socio-cultural constructs and processes are emphasised in the numerous connections made across the

diagram to the cultural milieu. In doing so, the fluid and complex nature of the processes underlying choice is acknowledged.

The EVT model has been used frequently by researchers investigating gender issues in STEM over the last 30 years. It has been used over that whole time period (DeBacker & Nelson 1999, Lloyd et al. 2018) in many different countries from USA to Germany (Lykkegaard & Ulriksen 2016; Lazarides & Ittel 2012), at various educational settings from primary to postgraduate level and early career (Weinberg et al. 2007, Battle & Wigfield 2003, Roberson Hayes & Bigler 2012) and in the full breadth of STEM subjects from maths to computing (Ball et al. 2019, Lauermann, Chow & Eccles 2014).

Most recently the EVT has been useful in unpicking the gender-equity paradox, the phenomena whereby girls are less likely to follow STEM careers in wealthier countries with greater levels of gender equity (Stoet & Geary 2018). STEM careers have high utility value, graduates earn more, but the subjective task value decreases in countries where there are more opportunities for higher earnings and quality of life is affected by other factors than career. Other aspects of the EVT also come in to play; the relative prior attainment across various subjects of individuals; the intra-individual differences, vary by gender. Although girls may collectively outperform boys in STEM subjects, their self-concept includes judgments of their performance in STEM subjects against their performances in all other subjects. These include subjects that rely on reading and comprehension where, in general, girls perform even better, partly because of gendered socialisation. Boys, on the other hand, have an academic profile where their best performances tend to be in STEM subjects; even though they may well perform at a lower level than girls. This performance feeds the boys' self-concept and expectations for success, which in turn feeds into the decision to follow STEM subjects.

The breadth of applications confirms the EVT's relevance to educational choices in STEM. Some reasons often put forward by researchers for selecting the model include:

The model is comprehensive; comparisons with other models from psychological studies demonstrate that it includes all the facets of others in a similar form including self-efficacy, intrinsic and extrinsic motivations.

Eccles is explicitly a feminist psychologist and the model focuses on the reasons women themselves provide. She asks, "Why do women choose particular occupations?" rather than using focusing on deficits; "Why aren't women making the same choices as men?"

The questions ask participants to compare their expectations, interests and achievement levels with other students and other subject areas. This is often easier to manage than

judging interest in isolation and the use of comparisons leads to strong internal validity and reliability (Østerlie, Løhre & Haugan 2019).

There are also some practical reasons that may appeal to researchers:

Eccles' initial study investigated the choices of pupils to follow Mathematics as a subject (1983) and this may be why researchers in STEM and education keep returning to the model. References in similar studies link and multiply over the decades to produce a web of connections across STEM research.

The measures are based on a relatively simple 17 question self-reporting questionnaire using a Likert scale which is easy to deliver and quick to answer.

This model has been amended and refined by Eccles over many years and referred to as a model, framework and theory with a variety of different titles including Eccles' Expectancy-Value Theory (EEVT) and the Expectancy-Value Theory of Motivated Behavioural Choices (EV-MBC) (Eccles, 2011). I will use the abbreviation EVT throughout the rest of this project.

An example of how the EVT could be applied to this project relates to evidence about the high levels of pupils' enjoyment of D&T (Colley & Comber 2003, DfE 2010). An anecdotal report of how this enjoyment affects choices is reported by a D&T teacher;

> "*However, enjoyable and academic don't always go hand in hand. Often some of the best students choose not to take the subject because they perceive that because they enjoy it, the subject has less worth*". (Walland 2018 p31).

Walland is highlighting the complex relationship between choice (K), student aptitude (C1), interest-enjoyment value (J1) and utility value (J2). The utility, cost and enjoyment value of D&T are important features of this study. Teachers, as key socialisers, have an important role to play in transmitting, explaining, exemplifying and clarifying the value of D&T to boys and girls whilst also being immersed in the cultural milieu.

The top left corner of Eccles' EVT model represents the interplay between societal norms, socialisers and pupils. This section was isolated and developed further by Eccles when investigating parental influence (Eccles, Jacob & Harold 1990). I have adapted their model in further by replacing the parent as the socialiser with the teacher; this is shown in Figure 4-2.

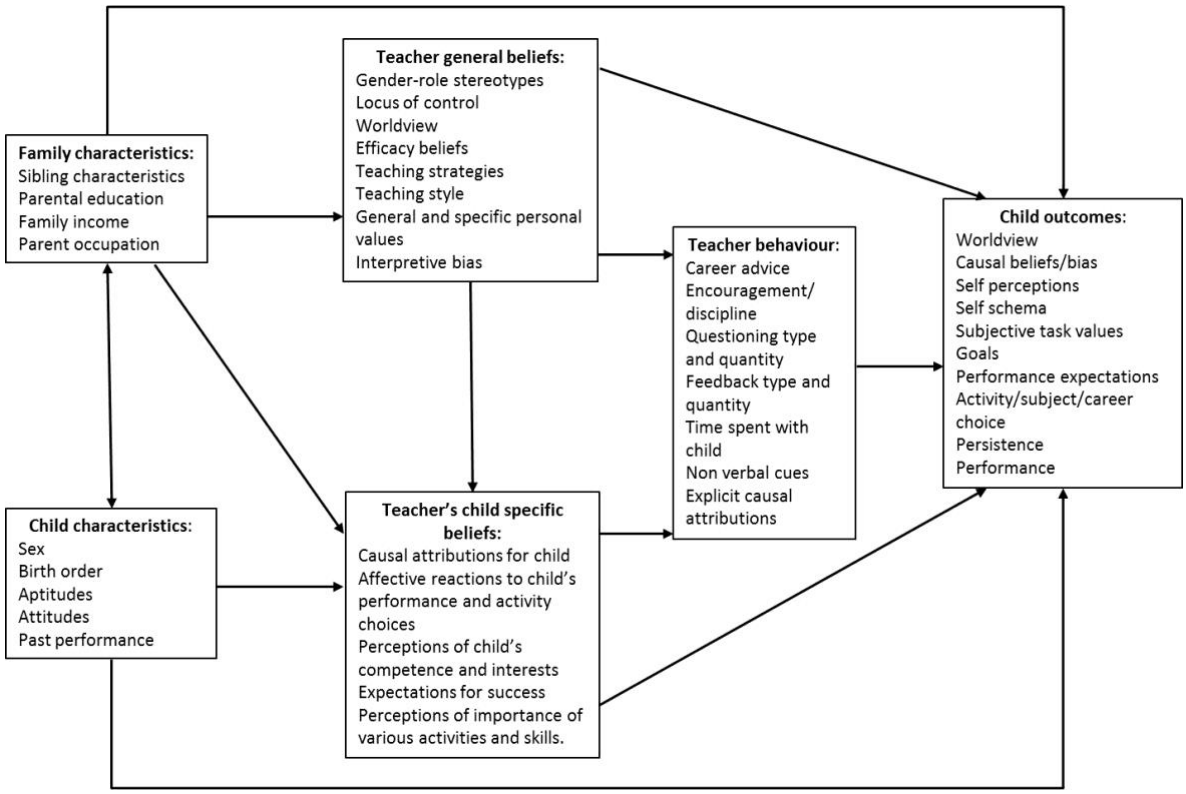

Figure 2-6 Expectancy Value Theory - Teacher as socialiser.

This development of Eccles' EVT model concentrates on teachers' general and pupil specific beliefs; these beliefs can influence teacher behaviour including the time taken with individuals, the tone and style of questions posed, the type of encouragement or feedback provided. Each of these actions can influence their pupils' outcomes and choices. These teacher perceptions are the focus of this research project and tie in with earlier descriptions of Margaret Archer's morphogenesis where three layers of reality all link together; structural social roles impact on cultural beliefs which in turn affect the agency, actions and decisions of pupils and teachers. The analogy of theory as a lens to view research is helpful; these approaches allow me to concentrate both on structures at a distance and close detail. This stereo vision should allow me to keep in focus individual meanings and larger social and institutional structures.

Teacher perceptions about their pupils are closely linked to stereotypes; these can have a direct impact on pupils' own beliefs, performance and choices through mechanisms of stereotype threat and self-fulfilling prophesies. Although stereotypes can be countered with role models, they are inherently resistant to change as implicit associations are hidden. Any future research needs to identify ways to expose these hidden beliefs, perceptions and implicit associations, especially those that may be linked to neuromyths that affect D&T; differential spatial awareness, numerical or verbal abilities.

The extent to which teachers are aware of their role in reproducing social role stereotypes will be a key part of the next steps in this research project. There is the distinct possibility that many D&T teachers will also be aware of their potential to transform society through the transmission of design and technology capital. When we modify Louise Archer's science capital model to fit D&T, we can see how teachers are directly involved in building technical knowledge and literacy which can be empowering. Teachers also have a role in preparing extra-curricular activities which help to build networks that are so important for success in any field. How teachers perceive these extra-curricular or enrichment activities to affect D&T capital is worth exploring further, especially those activities that are focused on addressing any gender imbalances through positive action initiatives. The final component of D&T capital is the development of domain specific thinking skills and attributes which relate to the signature pedagogies of D&T; the interdisciplinary, value led, context rich, project based iterative and practical approaches. The next steps need to unpick how teachers perceive how these pedagogies are gendered.

Teachers also have a crucial role to play in explaining the value of the subject, the other component of the EVT model. Self-efficacy is associated with confidence and belief of success, but pupils will not perform or persevere if the value of the tasks is not seen as worthwhile. D&T teachers have a role to play in clarifying the value, or worth, of the subject to their pupils. This is particularly challenging when considering the numerous challenges facing the subject in recent years.

2.3 Design and Technology, STEM choices and gender

This final section explores how issues of gender in STEM are tied to those within D&T. The relationship between these two fields is complex and the challenge is to condense the understandings from many different sources whilst retaining a focus on gender. Weaving together these strands is compounded by the two aspects of the literature which have already been discussed; there is remarkably little overlap in the research literature on STEM and D&T and gender issues dominate the research literature in STEM but is all but absent in the literature on D&T education (Down 1986, Cattan 1988, Harding 1997, Rogers 1998, Withey 2003, Atkinson 2005).

The common thread that binds the two fields is the conflict between the instrumental, vocational and economic driving forces on one hand and the liberal, democratic, empowerment ideals on the other. Schooling is motivated in part by the desire for a better society and in part to supply a skilled workforce (Taylor et al. 1997).

Economic forces stand firmly at the heart of the STEM agenda and the starting points are often described as a series of statistics:

> The number of jobs requiring STEM skills is expected to rise at twice the rate of other occupations over the coming years (UKCES 2016).
>
> There is a projected shortfall for 2024 of 265000 skilled engineers and technicians which could cost the UK economy £27 billion a year (Engineering UK2017).
>
> Women currently make up less than 10% of engineers (Engineering UK 2017).

The British government's response to these shortages is in the form of a STEM programme…

> "…*set up to examine the range of initiatives that currently support this agenda and to look for ways to enhance the effectiveness of Government funding in two areas: the flow of qualified people into the STEM workforce; and STEM literacy in the population*". (STEM 2006 p2).

The British response is not unique with American, Scandinavian and Australian studies describing similar programmes (Seymour 2002, van Langen & Dekkers 2005, Norton 2007, Hill, Corbett, & St Rose 2010). The British STEM programme was initiated jointly by the department for education (DfE) and industry (DTI, BERR, DIUS, BIS and most recently BEIS) and includes a ministerial steering group, a high-level strategy group and an advisory forum with a national director overseeing 231 different bodies (STEM 2017) including the Royal Academy of Engineering, the Qualifications and Curriculum Authority and professional teaching associations for each subject. Each body has its own guiding principles and agendas although all would undoubtedly support the aims to increase the numbers of the STEM workforce and STEM literacy.

A repeated theme in much of the literature produced by government agencies, industry and researchers alike is the STEM pipeline. This identifies pupils as a commodity to be moved as efficiently as possible through an educational route towards a successful STEM career. There are numerous initiatives to improve the flow:

- Increase the volume of the flow of entrants overall: by increasing the proportion of minority ethic and women participants at the entry points of science and technology GCSEs.

- Keeping the pipe opening wider: by relaxing entry requirements to engineering degrees and providing foundation courses for pupils, especially girls, who have not studied

Physics A-level (IOP 2014, 2018). This is particularly appropriate for the British educational system with its early specialisation.

- Blocking leaks in the pipe: by improving STEM teaching and learning (Archer et al. 2013) and support networks for STEM undergraduates (Seymour 2002) there should be fewer dropping out. The EBacc has a similar function by ensuring that the core subjects of Maths and Science are studied for longer by more pupils.

- Adding extra pipes: using STEM initiatives to complement the teaching and learning of the curriculum. These include the WISE "People Like Me" campaign (WISE 2017), the STEMNET (2010) ambassador network and a plethora of competitions for schools sponsored by multinational technology firms including Jaguar Land Rover (4x4 in schools), Lego (Robotics Leagues), BP (STEM Challenge), Autodesk (F1 in schools), Ford, Siemens, IET (GreenPower) and smaller local sponsors of Rotary Technology Tournaments. The government provides substantial funding to support these initiatives[4] although, despite decades of similar efforts, the numbers of girls entering STEM stubbornly refuses to change (Piper et al. 2016).

- Increasing the pressure in the pipe: by providing financial benefits to pupils and teachers. High achieving students can apply for Arkwright Scholarships with financial and networking benefits. The salaries of STEM graduates are regularly touted in career-based initiatives with pupils to encourage take up. There are bursaries available to trainee teachers in shortage areas of Maths, Physics and Chemistry although D&T trainees teachers get half the support of the other STEM subjects (DfE 2020).

There are numerous voices that highlight the potential of D&T to act as an 'integrating' tool in STEM (Barlex 2007a, 2007b, Norton 2007) where science seeks to understand phenomena, maths to accurately model it and technology to creatively harness it.

> "*According to the National Curriculum, D&T is about solving real world problems, drawing on Science, Maths and Computing whilst innovating through the evaluation of the past, almost identical to that of STEM*" (Walland 2018 p30).

[4] £990 million spent on, or committed to, key STEM-specific interventions between 2007 and autumn 2017. National Audit Office 2018.

In other research D&T is completely invisible. Petray (2019) suggests that the engineering profession need to develop critical and creative thinking, communication, collaboration and teamwork, information and technology skills, problem solving and innovation. These are all features of D&T and yet the subject is not mentioned once. Other policy recommendations include rethinking the STEM curriculum to provide an agreed definition, a shift to practice and a more integrated curriculum (Timms et al. 2018).

The first references to D&T found in British STEM policy texts demonstrate a misunderstanding of the subject, “it should be noted that engineering and technology are not typically considered as curriculum subjects in schools – though design and technology and ICT may count as such – but they are often college subjects” (DTI 2006 p10). This confusion about the subject could have its roots in the amorphous and complex state of D&T outlined earlier but it does beg the question of how far reaching these misconceptions extend within society, head teachers, parents, those in government and potentially even D&T teachers. An example from the government’s draft programmes of study for D&T included repairing clothes and fixing bicycles (Mitchell 2019).

Factors that may be affecting the policy writers include the cultural issues at stake, their age profile and the academic/vocational dichotomy in the educational structure. A woodwork, technical drawing or home economics lesson from 40 years ago would look very different to a D&T lesson today, and this assumes policy-makers had even had this form of practical experience. Comparing the phrases found in the Royal Academy of Engineering’s report on educating engineers and the opening line of a submission from the Design and Technology Association to parliament highlights the divergence of opinions; “maths and physics, the essential precursors of undergraduate engineering studies” (RAEng 2007 p.4) and, “design and technology is a National Curriculum subject which introduces students to skills and knowledge essential to engineering” (DATA 2008). Although these statements are not necessarily contradictory, they do suggest a difference of opinion on the importance of D&T and emphasise the difficult early relationship between the RAEng and DATA.

The misunderstanding between D&T providers and the engineering field continues; “Design and Technology is a popular subject with students, but they do not associate being an engineer with the designing and creating that they enjoy so much in the classroom” (Kumar & Buglass 2010). This reference is lifted directly from Engineering UK’s annual report which provides policy makers with an evidence base for STEM engagement. This failure of the D&T community to effectively link the subject to STEM and engineering has serious implications for pupils, parents, headteachers and policy makers (Green 2010).

The awkward early relationship between D&T community and the RAEng contrasts strongly with the professional development provided for Maths and Science teachers by the National Centre for Excellence in the Teaching of Mathematics and the National Science Learning Centre. These bodies aim to "improve teaching and learning through CPD for mathematics and science teachers" where the Royal Academy of Engineering has very different raison d'être and is expected to "lead the improvement of teaching and learning by engaging teachers with engineering and technology" (STEM 2008 p5). The open reference to 'teachers' does not necessarily exclude D&T teachers but does not identify them as the sole distributors of engineering education. There is also a difference in improving teaching and learning through CPD and improving it through engagement. The inference is that engagement does not have to be classroom based and, as a result, many STEM initiatives follow an extracurricular format. This reinforces the high cultural value of maths and the sciences as the 'gateway subjects' to STEM careers (Barlex 2007b) and downplays the potential of D&T.

Recently though, the RAE and DATA have started to collaborate much more effectively. The shared understanding of the role of tinkering has been an important part of this growing bond. Throughout this description of STEM and D&T the focus has almost exclusively been on the instrumental function of education and any suggestions of initiatives to improved gender equality or extend design capability or technical literacy for all is overshadowed by the shortage of engineers and other STEM professionals.

One of the more noteworthy initiatives in recent times to tackle equality in STEM has been the science capital teaching approach which is one outcome of years of research in the ASPIREs project. This is partly funded by the ESRC (IOP 2010a) to explore the reasons why only low numbers of girls and pupils of ethnic minorities have followed the subject over many decades. Numbers in Physics have been declining since the 1960s with only 20% of girls opting to take the subject at A-level in the UK in 2010 (IOP 2010b). Girls attending independent, single-sex schools, for example, are four times more likely to choose physics than their contemporaries in mixed, state-funded schools (IOP 2015). And yet independent single sex girls only schools have been in rapid decline over the last four decades[5].

[5] The number of single-sex independent schools in UK has roughly halved since 1990. In 2020, only 12% of independent schools are girls-only and 10% boys-only. Of maintained schools only 5% are girls-only and 3% boys-only. Of selective grammar schools 37% are girls-only and 34% boys-only. (DfE 2020)

Physics A-levels are ‘usually essential’ subjects for access to Russell Group university engineering courses (Russell Group 2019). D&T sits alongside Further Maths and Computing as subjects that ‘could also be useful’ in the latest Informed Choices website guidance (Russell Group 2019). The term ‘facilitating subject’ has been dropped by the Russell group despite its original meritocratic intention of providing clear guidance to students who may be disadvantaged by being at a school with limited levels of career advice. Sutton Trust research that finds bright, but disadvantaged, A-level students are only half as likely as their wealthier peers to be taking subjects considered useful for access to selective universities (Sutton Trust 2011, Montacute & Cullinane 2018).

The Women in Science and Engineering (WISE) organisation has featured throughout the decades as a leading force in support of gender equality in STEM. Their “People Like Me” campaign (WISE 2017) is the latest iteration of their efforts to increase the participation of girls in STEM. The programme starts with girls being introduced to STEM opportunities and careers in a single gender setting before completing attribute and personality tests which focus on adjectives rather than verbs. This is a format which girls have been found to prefer (MacDonald 2014) and relies on a stealthy approach. This is then followed by a speed dating experience with several female STEM professionals. Other aspects of the ‘People Like Me’ initiative include raising awareness of unconscious bias, highlighting gender inequalities and including parents in the process. The evaluation of this initiative (Herman, Kendall-Nicholas & Sadler 2018) identified that the meetings with role models were the most memorable aspect for the girls.

In Australia there is a similar recognition of the failure of decades of extracurricular initiatives to increase the number of girls in engineering. “No amount of family-friendly policies or inclusive outreach programmes (as vital as they are) will overcome the gendered sorting that begins before school”. (Petray et al. 2019 p24). They propose that labelling activities as STEM deters those that do not normally associate with STEM, including girls and ethnic minorities. This echoes MacDonald’s stealthy approach.

Although the STEM agenda is concerned with recruiting girls and women for economic reasons, there are elements that match the desire to increase equal opportunities and diversify engineering. There is the potential for D&T’s signature pedagogies; the interdisciplinary, value-led, context-rich project-based approach has the potential to both integrate STEM subjects and attract girls. The alignment between D&T pedagogies and extracurricular STEM initiatives is extremely close and yet the relationship between DATA, RAEng and the STEM programme has only recently been constructive. The common ground on which this relationship is being built is that of tinkering which has significant implications for girls in D&T and engineering.

2.4 Conclusion

To conclude this chapter, I draw together the findings from the literature review of D&T and gender, the various perspectives on gender in STEM from biological, social and socio-psychological angles as well as the features of the relationship between D&T and STEM.

The first research question focuses on teachers' perceptions of gender within D&T; the literature suggests that there are several ways in which gender plays out; these are listed below:

- There is evidence the subject's signature pedagogies can affect boys and girls differently. The interdisciplinary, value-rich, loosely defined problems can favour girls. The practical and iterative approaches, especially with regards to failure, can favour boys.
- The material specialisms have been tightly linked to societal norms and gender stereotypes; the new integrated GCSE has the potential to transcend these, but it could also hide gendered divisions within performance measures.
- The purpose of the subject; whether it be for instrumental and vocational purposes or for a liberal, democratic and general education, is understood differently by teachers.
- The value of the subject is affected by its association with the immature discipline of Design; this also linked to misunderstandings of policy makers as evidenced in the EBacc.
- Positive action initiatives can tackle gender inequality through unequal equities.
- Other factors are associated with the pupils themselves; their prior attainment, their parents and the function of role models.

Understanding how each of these factors is perceived by the teachers is crucial; these perceptions will have a profound bearing on how teachers deliver D&T to their pupils. This in turn will have an effect at an individual level of choice and a larger structural scale that relates to the subject's future.

When looking at the second research question; the perceptions of teachers regarding choice, the literature review broadened to include biological, sociological and socio-psychological models of the associations between gender and STEM. Louise Archer's interpretation of Bourdieu's capital is extended to include D&T. Jacquelyn Eccles's Expectancy Value model has much to offer as a model that describes how teacher perceptions and beliefs affect their pupils. Many of the issues relating to purely D&T are reinforced and expanded upon:

- Teacher perceptions about their pupils are closely linked to stereotypes; these can have a direct impact on pupils' own beliefs, performance and choices through mechanisms of stereotype threat, counter-stereotypes and self-fulfilling prophesies. The teachers' implicit associations are hidden, and care will be needed to reveal them.
- Stereotypes may be linked to neuromyths that affect D&T such as differential spatial awareness, numerical or verbal abilities.
- Teacher beliefs influence classroom decisions such as the time taken with individuals, the tone and style of questions posed, or the type of encouragement or feedback provided. Each of these actions can influence pupils' immediate outcomes and future choices.
- Teachers have the potential to reproduce social role stereotypes and also transforming society through the transmission of design and technology capital in the form of technical knowledge and literacy, extra-curricular activities to build networks domain specific thinking skills and attributes which relate to the signature pedagogies of D&T.
- Teachers also have a crucial role to play in explaining the value of the subject. Self-efficacy is associated with confidence and belief of success, but pupils will not perform or persevere if the value of tasks is not recognised as worthwhile.
- Although the STEM agenda is concerned with recruiting girls and women for economic reasons, there are elements that match the desire to increase equal opportunities and diversify engineering.

There are also some other factors that arise from the investigation into the relationship between STEM and D&T:

- Although the relationship between the STEM agenda and D&T has not been historically strong, there are indicators that offer promise.
- D&T's signature pedagogies; the interdisciplinary, value-led, context-rich project-based and practical approach has the potential to both integrate STEM subjects and attract girls.

The next step in the project is to identify suitable methods to explore how teachers perceive each of these factors; the next chapter covers a theoretical foundation from which a methodology is adapted, and methods are chosen.

Chapter 3 Methodology and Methods

Having reviewed the literature on cultural, sociological and biological aspects of gender in STEM and D&T, I have been drawn to the role of teachers in pupils' choice making. Bourdieu's cultural capital, Archer's science capital and Eccles' Expectancy Value Theory emphasise the importance of the role of socialisers on pupils' self-concept, and in turn pupils' choices about subjects and careers. I have chosen to focus on the teachers, partly in recognition of the challenges faced in accessing parents but also because a key function of a professional doctorate programme is to improve professional practice. Working with teachers seems to be the most direct route to practical solutions.

This chapter begins with a broad examination of theoretical approaches and paradigms within educational research before identifying critical realism as the most suitable foundation to explore teachers' perceptions about the role of D&T in the low representation of girls and women in engineering and STEM fields. This first section is not intended to be a précis of a textbook on educational research but a review of the pertinent opportunities and problems of various worldviews.

There are two aims of this review; the first is to identify the criteria by which I will judge the work of others in the literature review and evaluate my own work. The second purpose of the chapter is to provide the reader with clarity about my worldview that will invariably determine the direction of the study, affect the choice of tools used in the fieldwork and guide the techniques used for analysing the data (Robson 2002).

Various methodologies are identified in the second section of this chapter that align with the critical realist framework.

3.1 Worldview

There are many debates in educational research, and social sciences in general, about paradigms and paradigm wars. Paradigms are significant in the value of educational research practice and the field is clearly lively, dynamic and evolving. A worldview is represented by a paradigm, a set of basic beliefs, or metaphysics, that deals with first principles (Guba & Lincoln 1994). These can be represented in several ways and are labelled slightly differently depending on the author, era and field. However, in all the models there is general agreement on the fundamental questions on which research is founded. These are ontological, epistemological and methodological questions:

The ontological question asks what is the nature of reality and therefore what is there that can be known about it?

The epistemological question asks what is the nature of the relationship between the researcher and what can be known? Clearly this is inextricably linked with the ontological question.

In turn, the methodological question asks how the researcher can go about finding out knowledge, whatever the form of that knowledge is? Methodology is different to the methods, or tools, the researcher uses in the field.

The simplest representation is often based on the dichotomous distinction between qualitative and quantitative methods (Guba 1990) as shown in Table 2-1.

	Fundamental questions	**Positivist beliefs**	**Constructivist beliefs**
Ontology	What is there that can be known?	Realism	Relativism
Epistemology	What is relationship of the knower to the known?	Objectivist	Subjectivist
Methodology	What are the ways of finding out knowledge?	Interventionist Quantitative	Hermenuetic Qualitative

Table 3-1 Qualitative and Quantitative Paradigms (Adapted from Guba 1990).

Within a few years this model of research approaches had been expanded upon in Guba and Lincoln's text book of qualitative research methods (1994) to include two more paradigms shown in Table 2-2. The practicalities of these approaches relate to the way researchers within each paradigm deal with voice, measures of quality, ethics, values and purpose. Guba and Lincoln recognise that positivism and post-positivism are so closely aligned that many of the practical differences are minor. Positivism is also seen as naïve, even by the scientific disciplines from which it springs, and so in the interests of time and clarity I will limit my descriptions to the post-positivist work currently managed within educational research.

Item	Positivism	Post-positivism	Critical Theory	Constructivism
Ontology	Naïve realism; apprehendable reality	Critical realism; imperfectly apprehendable reality	Historical realism; virtual reality shaped by values; crystallised over time	Relativism; local and specific constructed realities
Epistemology	Dualist/ objectivist; findings true	Modified dualist/ objectivist; findings probably true	Transactional/ subjectivist; value mediated findings	Transactional/ subjectivist; findings created
Methodology	Experimental verification of hypotheses, chiefly quantitative methods	Modified experimental; falsification of hypotheses, may include qualitative methods.	Dialogical/ dialectical	Hermeneutical/ dialectical
Purpose	Explain, predict and control	Explain, predict and control	Critique and transform	Understand and reconstruct

Table 3-2 Basic beliefs of alternative paradigms (Adapted from Guba & Lincoln 1994).

There are widely different approaches to research evident in the educational research field and covered throughout the literature review. I will now describe the post-positivist, constructivist and finally critical realist positions in educational research settings using examples of methodologies.

I use specific examples to situate educational research with the three world views. The post-positivist worldview is exemplified by an experimental methodology, the randomised control trial where research focuses on a search of a truth based on the belief that "there exists a reality out there driven by immutable natural laws" (Guba 1990 p19). The constructivist perspective is exemplified by heuristic phenomenology, a methodology based on the belief that "reality is in the heads of persons, and that the thinking subject has no alternative but to construct what he or she knows on the basis of his or her own experience" (von Glasersfeld 1996 p1). The critical realist position is exemplified by the Interpretive Phenomelogical Analysis methodology (Smith 1996). For each methodology the description is followed by critiques discussions about quality.

Post-positivism - Randomised Control Trials

Randomised control trials (RCT) rely heavily on statistics to identify a universal 'truth' or evaluate interventions. They have been appropriated from clinical trials in the medical research field and become popular in education over the last decade (Connolly, Keenan & Urbanska 2018). The main role of RCTs in an educational research setting is to generate hypotheses, arrange an initiative in schools and conduct observations to test the effectiveness of that initiative; this use of hypothetico-deductive logic is linked to scientific claims.

Michael Gove, as Secretary of State for Education, introduced Ben Goldacre, a medical researcher and journalist, to a Teach First meeting to underpin the unique contribution RCTs could have to informing policy and practice in education (Goldacre 2013, Menter 2013). Gove backed this approach with £125 million of DfE research funding for the Sutton Trust and the Education Endowment Fund (EEF). The resulting EEF Toolkit prioritises effect sizes derived from systematic reviews of research and quantitative syntheses of data such as meta-analyses of experimental studies. It focuses on the cost of the initiative, the progress made by pupils in terms of months and the strength of the supporting evidence (Higgins et al. 2016). Interestingly it explicitly excludes research studies if there is no quantifiable evidence base on which to derive effect sizes. The findings have been used extensively in schools across the country to guide their spending and teaching priorities when allocating Pupil Premium funds, estimated at £675 million of school spending in 2013-14[6].

Connolly's (2018) systematic review of RCTs identified that three quarters of the 1017 unique RCTs conducted between 1980 and 2016 were conducted in the last decade. The RCT uses a deceptively simple logic: RCTs measure the progress of randomly selected students participating in an educational intervention against that of a control group of equivalent students who, usually, continue as normal. Recent educational research is awash with examples of research that claims to provide robust evidence of 'what works' in schools. The Chartered College of Teaching, the new arbiter of teacher professional standards, emphasises the importance of a research engaged profession. RCTs feature widely in Impact, the Chartered College of Teaching journal and the methodology has become a byword for the 'gold standard' in evidenced based professional teaching practice.

Critiques

> "*Randomised controlled trials belong to a discredited view of science as positivism."* (Cohen, Manion & Morrison 2000 p314).

This disparaging remark is found in a seminal educational research methodology textbook and is based on criticisms of RCTs that the studies ignore context, generate simplistic laws of cause and effect and contribute little to theory. There are significant problems with post-positivist

[6] In 2013-14, the total Pupil Premium spending was £1.875 billion. If 36% of senior leaders said they used the toolkit to guide spending in March 2013, it has influenced the allocation of about £675 million of school spending for 2013-14 (36% of £1.875 bn) (REF 2014).

research in educational settings. Attempts to isolate variables using an experimental method are difficult in the complex, messy situations that are our schools and classrooms.

The principle of hypo-deductive logic means that empirical generalisations are rarely explained (Scriven 1970) which, for many teachers, is like waving a red flag to a bull. Our profession is based on understanding; knowing what, why and how. To offer a generalisation that an intervention or action will have a particular result without explaining why or how, is problematic for educators. The very basis of our profession is called into question if simple cause and effect can be used to explain teaching practice. The implications are politically significant if teachers are trained to mechanically teach using highly scripted pedagogies.

Inferential statistical tests cannot be taken at face value and an understanding of statistics is required. Not only are the results of statistical significance tests dependant on sample size, but also data distribution patterns; non-parametric tests are needed for data that is not normally distributed and interpretation of P values depends on whether hypothesis or significance being tested (Blume & Piepert 2003). Not all teachers, by the very nature of the diversity of school subjects, are competent enough statisticians to be able to judge the appropriateness of the statistical tests adopted.

Connelly's review identifies that some (37.7%) of the RCTs he studied in his review included a process evaluation component that examined the views of participants, how the intervention was implemented in different contexts and how it affected subgroups. A majority of the RCTs (77.9%) also reported their findings sensitively with a discussion of their limitations in terms of generalisability to the wider population. In addition, many (60.5%) of the RCTs included reflections on the implications of their findings for theory. These sensitivities, contributions to theory and considerations of contexts show that RCTs need not be dismissed out of hand.

Quality

The quality of any post-positivist study is judged primarily on conventional benchmarks of rigour (Guba & Lincoln 1994). These focus on the quantifiable nature of the inquiry with measures of validity, generalisability and reliability. In simple terms, post-positivist research is deemed good if its results can be shown to correlate with the independent variable (internal validity), can be generalised or transferred to other populations or situations (external validity), different researchers can record the same data in the same way and arrive at the same conclusions (replicability and reliability) and the researcher is neutral (objectivity) (Scotland 2012).

These terms are widely reported, and this is not the place to discuss the subtleties or distinctions between the terms. It is, however, worth identifying how these criteria are employed in the meta-analysis and systematic reviews that are often used in educational research to justify policy change. The Sutton Trust Toolkit (EEF 2018) categorise the security of their evidence based on a series of criteria. The 'extensive security' category, the highest level, includes measures to judge validity and reliability of meta-analysis, shown in Table 2-3.

Quantity and type of study	At least 5 meta-analysis which meet the following criteria • They have explicit inclusion and search criteria, risk of bias discussed, and tests for heterogeneity reported, • They explore which features of the intervention or approach might explain variation in impact (moderator analysis). • The majority of included studies should be from school or other usual settings (i.e. studies with ecological validity with lessons taught by usual staff, with typical conditions for non-school settings, rather than laboratory studies). • At least 3 of these meta-analyses have been carried out within the last 3 years.
Outcomes	Nearly all of the underlying studies in at least five of the meta-analyses use education attainment outcomes including standardised tests, cognitive tests and curriculum tests (e.g. schools assessments or national tests or examinations.
Causal inference	Those meta-analyses have strong causal inference: most included studies having appropriate designs, such as randomised controlled trials, well-matched experimental designs, regression discontinuity designs and natural experiments with appropriate analysis.
Consistency requirements	Results are broadly consistent across the meta-analyses (i.e. the spread of the pooled effects is relatively narrow, such as less than 0.5 standard deviations, or the variation is consistent with the differing inclusion criteria and largely explained by the moderator analyses).
Effect Size requirements	Effect size must be a mean, median or weighted mean, rather than indicative.

Table 3-3 Security of evidence criteria (Education Endowment Foundation 2018).

The emphasis on experimental approaches as the appropriate way to study education stands out as presumptuous. Amongst the quantitative methods and measures it is noticeable that several additional criteria are included that go some way to address the charges against post-positivist research. There is recognition that reliability is threatened by observer bias and variations in context. Connelly's suggestion is that a more consistent approach to RCTs is required; not a high enough proportion of RCTs currently include sensitive reporting, explicitly seek to test and develop theory or use rigorous process evaluations. The implications are that RCTs are not the 'gold standard' of educational research unless they include these practices. On the other hand, RCTs and post-positivist approaches can provide an invaluable contribution to educational practice and policy.

It is tempting to work within the dominant paradigm, using quantitative techniques that fit well with my own engineering training. There are clearly techniques and methods that can be employed to provide a more valid piece of research, but they are borrowed from other paradigms and are watered down in the process. My decision to eliminate this post-positivist

methodology is based on practical as well as theoretical principles. The scale of post-positivist research projects becomes a factor in its validity and as a novice researcher with limited resources and no funding I want to openly acknowledge that I have shied away from this challenge. Most significantly though, I feel that a study of inequality requires a commitment to questioning, rather than replicating, the dominant mode of research.

Constructivism- Heuristic Phenomenology

At the other end of the spectrum lies a methodology that has a philosophical basis. Heuristic phenomenology combines the study of experience (phenomenology) with the interpretation of meaning (heuristics) (Henriksson & Frieson 2012). Hermenuetic phenomenology uses inductive logic to derive findings from reports of lived experiences. This involves an openness to meaning, possible experiences, revision and reinterpretation; it does not seek to "understand the object, but its meaning" (Levinas 1987 p110). Although phenomenology originated from Edmund Husserl's philosophical framing of the study of 'essences', the method has developed to include approaches from very different worldviews; it is a flexible method that has been adopted and morphed under a number of different banners. Fundamentally, by linking phenomenology with heuristics, Heidegger (1962) describes being compelled to ask questions about ourselves, about the nature of the situation and about who we should be and become in it.

This emphasis on meaning and lived experience has a powerful attraction to researchers in a variety of disciplines from psychology, nursing, social work and education but it differs from other constructivist approaches in its additional and significant emphasis on literary forms, discourse and words;

> "*Unlike other phenomenological and qualitative approaches, hermeneutic phenomenology is particularly open to literary and poetic qualities of language and encourages aesthetically sensitized writing both a process and product of research*". (Henriksson & Frieson 2012 p1).

Heuristic inquiry explicitly acknowledges the involvement of the researcher, to the extent that lived experience of the researcher becomes the focus of the research (Moustakas 1990). Moustakas goes further to explain that in heuristic inquiry the researcher is not only personally involved in creating a story but experiences growing self-awareness, self-knowledge and self-discovery.

Critiques

There are numerous critiques of this approach that centre on arguments against all postmodern, poststructuralist and deconstructivist approaches; that 'anything goes', generalisability is never claimed and academic writing resorts to 'navel gazing' through over-reflexivity;

> "…*where language is seen as an unstable system of referents, thus making it impossible to adequately capture meanings of social actions or texts leading to messy, critical, reflexive, intertextual representations*". (Finlay 2012 p17).

While over-reflexivity can seem to present a narcissistic presentation of facts, an absence of reflexivity fails to consider how the researcher's assumptions and beliefs influences their research (Wright & Ehnert 2010). An unreflective researcher presents the act of research and its findings as neutral and objective. Cunliffe argues that "research is as much about the world of the researcher (our experience, culture, language and writing conventions) as it is about the world we are studying" (2003 p994).

The fundamental nature of constructivist research is that meaning is subjective and individual; individuals include the participants, researcher and reader. Attempts to improve the validity of the work involves comparing understanding between these various players and is invariably doomed (Rolfe 2006).

Knowledge produced by constructivist research is always tentative and highly contextualised; policy makers and teachers are reluctant to engage with the work for different reasons. Policy makers expect and seek robust evidence to justify spending in a variety of contexts and therefore unlikely to fund interpretive research that is fragmented (Berliner 2002). Teachers struggle with the difficulties in applying constructivist research findings to their own practice. Constructivist research is about producing rich or thick descriptions of lived experiences. The researcher can claim to understand partial knowledge of the context of the research site but cannot know the reader's context. It is not the responsibility of the researcher to generalise but for the reader to interpret the findings on their own terms and for their own purposes (Czarniawska 2003). But teachers need time to draw out the similarities and differences between constructivist research findings and their own context in order to understand and improve their own practice.

Participants in constructivist research are vulnerable to the researcher's interpretations, especially when the focus of the research can be intimate, private and personal. The interpretive researcher produces theorised accounts that represent their participants'

sociological understandings (Danby & Farrell 2004). Ethical questions about voice are therefore a priority for researchers working in this paradigm.

Quality

It is clear from the critiques above that the conventional benchmarks of quality as applied to post-positivist research such as validity, reliability and generalisability do not fit the constructivist research paradigm. Suggestions for evaluations include tests of authenticity, usefulness, criticality, plausibility, credibility and verisimilitude (Wright & Ehnert 2010). Others have used different terms; Lincoln and Guba (1985) describe credibility but also transferability, confirmability and dependability. These seem to mirror the post-positivist criteria of quality; creditability matches internal validity, dependability is similar to reliability or stability of the data (Rolfe 2006), confirmability relates to accuracy or objectivity and transferability is similar to generalisability. The reader has a large part to play in this and makes a subjective judgement about the quality of the work.

Although there is very little consensus on the terms to use to define the quality, goodness or rigour of constructivist and interpretive research then at least the strategies recommended are similar (Cohen, Mannion & Morrison 2007, Houghton et al. 2013, Lincoln & Guba 1985, Cresswell & Miller 2000). It is Cresswell and Miller's framework which I adapt below. They describe judging quality through the lens of the researcher, participants and external characters (reviewers and readers) but as I use the analogy of a lens elsewhere in the project for a different purpose I have dropped that term.

Researcher

Triangulation – the use of multiple approaches to study the same phenomena allows the comparison of data to explore the extent that they verify the findings. This process also helps build a fuller picture of the phenomena. Triangulation approaches include using multiple participants, alternative theories, different methods or using different investigators (Denzin 1978).

Disconfirming evidence – searching through the data for findings that do not fit into the developing themes, or even contradict the narrative is a difficult process (Miles & Huberman 1994). Reality, for constructivists, is multiple and complex and so this search supports the account's credibility.

Reflexivity – as the researcher is part of the research instrument (Rodgers & Cowles 1993), a diary allows the rationale for decisions, inductive leaps and personal

challenges to be made transparent (Rolfe 2006). This diary will help in the development of the final thesis. Reflexivity, a focus on the researcher's own position, interests, purpose and values demonstrate how the theoretical perspective affects the direction, design and analysis of the fieldwork.

Participants

Member checking - participants are asked to read their own transcripts to ensure that they have been accurately recorded (Stake 2006, Koch 1994). Using participants to check the interpretations of that data will inevitably lead to some disagreement and sensitive handling of this in a constructivist paradigm is required. Multi-voice reconstructions are expected (Guba & Lincoln 1994) and focus groups during the analysis phase would allow themes to be checked to see if they make sense or the account is realistic. Comments at this stage can be included in the final narrative.

Prolonged engagement and persistent observations –sufficient time in the field allows the researcher to gain a fuller picture of the phenomena being investigated. This should be extended to the point when the lack of new emerging data identifies that a saturation point has been reached.

Collaboration – participants are involved in the study as co-researchers by helping to form research questions, assist with data collection, analysing and even writing. This is clearly only possible when the time, maturity and willingness of the participants allows.

Others

Audit trail – explicitly outlining the decisions made throughout the research, from design and fieldwork to analysis, allows the reader to discern how the findings have been drawn, even if they do not share the same interpretation (Koch 1994).

Thick, rich description – a full and detailed description of the context of the research allows the reader to make informed decisions about the transferability of the findings to their specific context. This should include examples of the raw data from interviews or observation, accounts of the individuals and the research methods to contextualise the findings and increase the credibility of the narrative.

Peer debriefing – an external colleague or expert can be used to check whether they agree with coding labels and the logic used in analysis rather than the interpretations themselves.

In summary, heuristic phenomenology, like much research that falls under the broad church of constructivism, has plenty to offer educational practice and policy as long as the limitations of the worldview are recognised. Many of these nine procedures to ensure rigour can, and should, be used in conjunction although whether all of them are appropriate in every constructivist, interpretive research project is debatable. Most of these procedures are just as applicable to any quantifiable methods and therefore could also be used in the third paradigm described below, critical realism.

I effectively eliminated heuristic phenomenology for two reasons. The first reason was that the "aesthetically sensitized writing" does not sit comfortably with my own personal background, experience and skillset as a design engineer. The second was that the heuristic phenomenological emphasis on avoiding labels and laws of theory (Hendrickson & Friesen 2012) can undermine the very phenomenon under investigation. It is this reasoning that leads teachers and policy makers to judge findings from such a methodology as holding less weight than post-positivist, quantifiable methods.

Critical realism – Interpretive Phenomenological Analysis

So far, I have presented two very different methodologies that are prevalent in educational research to highlight their affordances and shortcomings. In doing so, I have described strategies used to ensure a rigorous approach. These suggestions often include a complementary approach, a mediating method, which seems to draw the methodologies towards a more central ground. It is this central ground I now want to explore as this is where I see educational research as potentially having the most success at changing professional practice and policy.

If post-positivism has an ontological basis for reality as "imperfectly apprehendable", constructivism as "locally constructed" then critical theory assumes reality is "shaped by values" (Guba & Lincoln 1994). Critical realism has origins in the work of Roy Bhaskar (1975) who questioned the dominant positivist and constructivist paradigms in sociology.

> "*People do not create society. For it always pre-exists them and is a necessary activity for their activity. Rather, society must be seen as an ensemble of structures, practices and conventions which individuals reproduce and transform, but which would not exist unless they did so*" (Bhaskar 1989 p36).

His work has been extended by others and in particular links to the work of critical theorists in the Frankfurt School, including Jurgen Habermas (1972). Critical realists believe that as

knowledge is shaped by social, political, cultural, economic, ethnic and gender values it crystallises, or becomes reified (Lukács 1967). In other words, the structures become, for all practical purposes, objectively real. Critical realists believe that reality is stratified into three layers or domains:

> Empirical: the level of experiences, perceptions and observations.
> Actual: the level at which events occur.
> Real: where generative mechanisms or structures lie.

The generative mechanisms in the real domain are not usually directly observable and many may not even be aware of them. A key aspect of critical realism is its focus on identifying causal mechanisms (Danermark et al. 2002). Causality is identified through the stratified ontology and, researchers can go beyond *empirical* observations to determine the mechanisms in the *real* domain that result in *actual* events. Critical realism relies on the logic of retroduction working backwards from empirical regularity to attempt to identify a suspected explanatory mechanism (Whelan 2019). The links between the domains is not one way and, as well as helping to provide possible mechanisms that generate structures; they also help to understand how agency can be enacted.

Critical realists recognise that cultural, social, political and economic factors influence the employment opportunities, educational level, life expectancy and pay gaps between people of different race and ethnicity, class, sex and gender. At the same time critical theorists of the Frankfurt School have an emphasis on change and want an "argued justification for concrete, emancipatory practice" (Moi 1991). The transactional nature of the inquiry requires a dialogue between the researcher and the participants,

> "… to *uncover and excavate those forms of historical and subjugated knowledges that point to experiences of suffering, conflict and collective struggle… to link the notion of historical understanding to elements of critique and hope*" (Giroux 1998 p213).

Power is also explicitly referenced in other critical realist projects such as Frierian Participatory, Feminist, Neo-Marxist and action research. Critical realists accept that as reality is alterable by human action it seeks to address issues of social justice and marginalization (Crotty 1998). As my research interests relate to the inequalities evident in the STEM professions and D&T in schools, the critical realist paradigm, and feminist approaches in particular, align well.

Of particular interest is the Interpretive Phenomenological Analysis (IPA) as a methodology which seeks an insider perspective of lived experience, acknowledges differing values and

embraces the view that understanding requires interpretation (Smith 1996). It is a framework for analysing qualitative data that has similarities with Grounded Theory and the Constant Comparative method but has been developed within the educational field. This methodology will be explored in much more detail in Chapter 9.

Critiques

Critical research has an agenda of change and is not often supported by existing agencies; funding for such research is likely to be difficult to justify (Berliner 2002). In educational research in the UK the dominant paradigm of post-positivism remains the firm favourite of policy makers at school, regional and national level. Habermas argues that these explanations of social phenomena form part of the dominant positivist narratives and play a role in ensuring the continuation of the status quo (Whelan 2019).

The change that is hoped for is difficult to implement and is fraught with problems. Highlighting inequalities to participants is difficult to do as they are likely to have varying levels of understanding of the generative mechanisms. Their reactions to the newly identified mechanisms will be unknown and potentially harmful if change is not possible or immediately evident. Judgment about what transformation is needed could be argued as the right of the participants and not the researcher (Lincoln & Guba 1985).

Just as power differentials are exposed by the critical realist's work, so power differences apply to the relationship between researcher and participants. Sensitivity to the issues of collaboration, consent, coerciveness and autonomy is important for such work but particularly difficult to manage in schools if pupils are the participants. As an insider researcher (Chavez 2008, Mercer 2007) these issues are compounded even further. The advantages of intimately understanding the field and context include ease of access, avoiding culture shock, more natural interactions, being able to ask inciteful questions and eventually to project a more authentic representation of the issues at stake (Greene 2014). However, the intimacy brings with it dangers of bias, even at the early stages of identifying the research questions. Assumptions can be made too easily and occasionally, shared knowledge between researcher and participants will need to be made explicit (Chavez 2008). During analysis the difficulties of maintaining a distance and being critical can compromise the study's validity.

Quality

The quality of any critical realist research can be judged on its account of the social, political, cultural, economic, ethnic and gendered values in the studied situation. It should also be judged

on the extent to which the research erodes misapprehensions and ignorance and the extent to which it provides a stimulus to transform the existing structure. Guba & Lincoln (1989) resolve the issues of quality criteria by proposing four forms of authenticity:

> Ontological authenticity: enlarges personal constructions.
> Educative authenticity: leads to the improved understanding of constructions of others.
> Catalytic authenticity: stimulates to action.
> Tactical authenticity: empowers action.

The latter two forms of authenticity are ways to judge the emancipatory purpose of critical realism, the first two forms of authenticity relate closely to constructivism. Both social constructivism and critical realism assume a created, subjective and personal understanding of the world so both employ interpretive forms of investigation. They both aim to probe beneath the surface of common-sense descriptions and to offer alternative understandings; although critical realists explicitly aim to foster change if this is seen as appropriate. The methodologies adopted by critical realists are therefore flexible but tend to rely on qualitative methods. All the procedures outlined in the constructivist section that promote the quality of the research can therefore be applied to critical research. Those that stand out as particularly apt for critical research are reflexivity, collaboration, an audit trail and a thick, rich description.

Conclusion

The critical realists' explicit agenda for change sits well with a professional doctorate in educational research that aims not just to improve understanding but to develop possibilities for improving professional practice. I hope that this chapter has identified my reasoning for the approach without dismissing out of hand post-positivist and constructivist paradigms.

Although I present the critical realist worldview as most closely aligned with my own and will use this as a basis for further work, I should clarify that this has not been an easy chapter to write. I question the assertion that the researcher's worldview or paradigm is "not merely a perspective that changes with time but one that is rooted in the belief system of the researcher" (Denzin & Lincoln 2013). I have already described the tensions and contradictions inherent in my own training as an engineer, work as a teacher of D&T and now a researcher in the social sciences. There have been challenges along the way, not just in learning a completely new body of knowledge in a different discipline, but challenges in the assimilation of the very different worldviews. I believe that worldviews can change in individuals; if not dramatically, then at least shift along a spectrum. This is a struggle that I have been engaged in over the

last few years during this study and I toyed with a range of different methodologies without fully comprehending their different ontological and epistemological foundations.

I plan to clarify in the next section how this critical realist worldview underpins the choices of methods and analysis through a discussion of methodologies.

3.2 Methodology

This section builds on the critical realist paradigm to identify a methodology and in turn, methods, to explore three research questions. Wellington describes methodology as "the activity or business of choosing, reflecting upon, evaluating and justifying the methods you use" (1996 p16). The following discussion on forms of interpretive inquiry should provide the reasons why individual and focus group interviews were selected along with lesson video (VSI) and psychometric implicit association tests (IAT). This research design aims to stimulate a deeper dialogue with the participants to develop a richer description of their perceptions. For each of the methods I describe the practicalities of the fieldwork including pilot studies, interview schedules and recording tools. I also assess the validity and credibility of the methods and describe how the participants were recruited. This leads on to the thematic analysis framework as the final section of the chapter.

Critical realist methodologies

The middle ground of critical realism described in earlier chapters sits comfortably with my own understanding of the purpose of educational research. Katrin Niglas (2004) has usefully described a continuum of ontological and epistemological belief systems, rather than competing paradigms. In doing so she has shown how methodologies can work within various worldviews. The blurred boundaries in the centre of Niglas' representation shown in figure 7-1 mirrors my own growing understanding of the complexity of educational research. Methodologies are appropriated by various research projects and specific aspects of the methods emphasised or omitted according to the research teams' underlying ontological and epistemological beliefs.

Critical approaches cover a broad range of methodologies, embracing qualitative phenomenological methodologies such as ethnography, case studies, grounded theory and discourse analysis as well as quantitative methods and collaborative research. As critical realism sits in the middle ground it can also employ qualitative and quantitative methods in a mixed methods approach (Johnson & Onwuegbuzie 2004, Cresswell & Miller 2000).

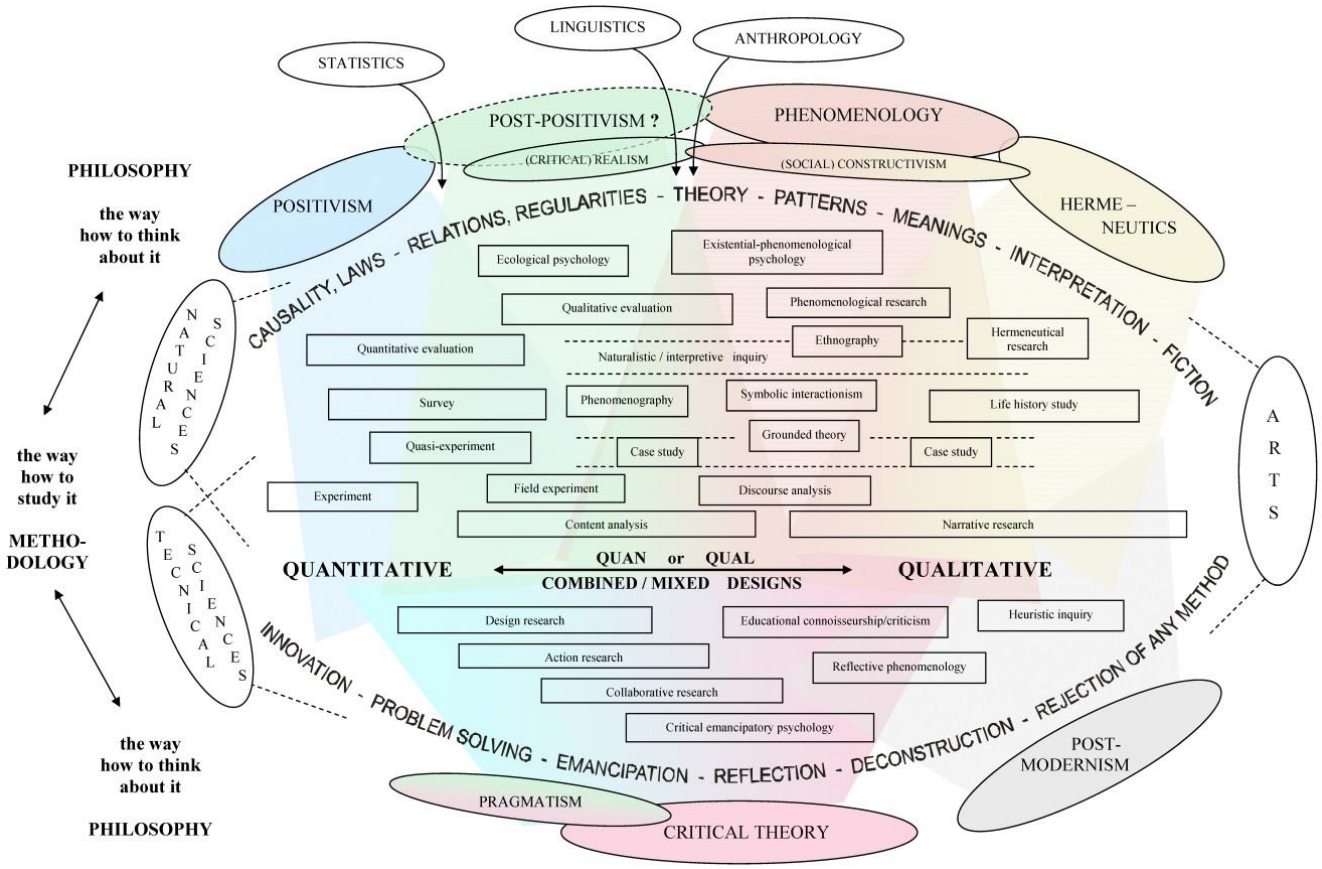

Figure 3-1 Relationship between Philosophy and methodology in social science and educational research (Niglas 2004).

What now follows is a discussion of how my critical realist worldview leads me from my research questions to research methods.

Research Questions

The research questions focus on the choices pupils make, and the understandings teachers have about those choices. Most pupils make their first choices about career routes effectively when they choose their GCSE subjects in Year 9. I want to develop a better understanding of D&T teachers' perceptions of pupils' choices, their own teaching and external factors. The three research questions are:

1. How do D&T teachers perceive how gender stereotypes play out in the subject?

2. How do D&T teachers perceive how boys and girls make choices about GCSE subjects?

3. How do D&T teachers perceive how the subject fits into the wider gender-in-STEM debate?

Investigating perceptions is inevitably a qualitative exercise and best managed through interviews or journals (Cohen, Mannion and Morrison 2007). I dismissed journal writing as I felt this would be a significant undertaking that many teachers may not be willing to engage with; especially without any incentive. Interviews also have their limitations when the topic is so personal, loaded and potentially hidden from consciousness. The challenge for this study then is to find ways to openly discuss these private and implicitly held beliefs.

I use three tools as part of the interview process; a psychometric implicit association test, reflections on a video of a lesson and focus groups. Before discussing each of these in turn I outline how the validity of the research can be tested.

Validity

This section assesses the validity in critical realist research with specific reference to generalisability and triangulation. Claims of validity in this project will be based on the quality of the interpretations drawn from observations and interviews. In qualitative studies the power of specific examples is crucial to telling a story, but these stories are, by definition, interpretations (Denzin & Lincoln 1994). To make judgements about these interpretations of the participants and the researcher we need to refer to each of the domains in the critical realist ontology. In attempting to develop a model of a mechanism or overriding structure in the real domain we use concepts from the all three domains, but specific objective claims will be made about observations in the actual domain. Subjective claims are made of interpretations in the empirical domain. Normative, or intersubjective, claims are made of the mutually constructed truths from participant perceptions and researcher in the real domain. These normative claims are based on social consensual norms and values, which are generally what people 'ought' or 'should' do (Carspecken 2003). Interpretations derived from claims in all three domains are entangled together (Long 2017) and validity of the any claims made can only do so by recognising this complexity.

Concerns revolve around the insider researcher approach being adopted. Although most participants will be from other schools; as D&T teachers we will tend to over-emphasise the importance of the subject in a form of ethnocentrism (Greene 2014). Personal bias that needs to be paid attention to throughout the project is my engineering background and instrumental role of the subject in preparing fresh engineers.

Triangulation

Validity is often associated with triangulation (Cresswell & Miller 2000), the means by which findings are compared from different angles to check for consistency or discrepancies. Denzin and Lincoln (1994) suggest four forms of triangulation that can complement each other and strengthen the validity of any research. I have added some detail below of how I could usefully combine these different forms in this project.

Data triangulation – coding of video footage, IAT test results, interview transcripts
Investigator triangulation – participants as co-researchers.
Theory triangulation – Bourdieu's cultural capital and Eccles' expectancy-value theory.
Method – Interviews, IAT results, video stimulated interviews and focus groups.

Although I have planned to use the three different interview methods as the central part of the study to generate textual data there are opportunities for quantitative analysis of data. Wellington (2000) suggests that detailed qualitative studies can lead to subsequent quantitative research. In the VSI, if the participants identified an interesting feature worthy of further investigation, it is possible to code and quantify data from the video footage. Video is especially powerful in allowing multiple viewings of activities to record frequencies, delays, intensities, durations, densities and sequence of actions (Summerfield 1983).

> *"The investigation of educational phenomena frequently requires a combination of approaches; the rich detailed meaning centred accounts produced by qualitative methods must be supplemented by information on frequency, duration and intensity provided by quantitative methods and vice versa*". (Foster 1996 p14).

The IAT also produces quantitative outputs and the single gender groupings initiative, discussed later (Appendix 1g), will generate quantifiable measures that will be discussed in the focus group. Although I intend to present the quantifiable data from the single gender initiative, IAT and video coding, these will add to the richness of the account of the cases rather than form part of any separate data analysis.

The development, criticisms and validity of the Gender - STEM Implicit Association Test (Nosek et al. 2009) have briefly been covered in the previous chapter. The discussion highlighted the limitations of the IAT tool in exploring individual perceptions; it is much more effective at reflecting cultural knowledge. Initial plans included using the IAT in an experimental action research approach with a pre-test/post-test arrangement to assess the effects of a gender equity intervention (Erden et al. 2009). However, without obtaining a large sample, the IAT results

would have no real validity. Additionally, the Harvard team have commercialised the IAT operation and payment is required to access detailed scores. The online version of the IAT has recently been updated to provide a general level of strength of implicit association rather than a detailed breakdown of data including response times. The primary problem though was not financial or practical but theoretical, although action research models fit the critical realist paradigm, the exploration of deeper understanding did not seem achievable using an experimental method.

Generalisability

As findings from this study are unlikely to be generalisable or replicated due to the small numbers involved, then the value of the study has to be judged differently. Bassey (2001) uses the term relatability, Lincoln and Guba (1985) transferability; by providing a range of examples there is greater chance that readers can relate to the similarities and in doing so, potentially glean something useful from the reading for their own practice. To ensure credibility an attempt will be made to describe the incidents, participants and contexts in enough detail for the reader to make connections and comparisons with their own situation.

To ensure that many readers can make these connections I have attempted to provide a broad sample of teachers, representing a range of teaching experience and both male and female teachers. In addition, I have sought to target a wide range of school contexts. Gender balance is a critical factor and although some schools may be labelled as co-educational, they may not have an equal mix of boys and girls. Three single-gender arrangements were identified; a girls-only school, a diamond formation where KS3 girls and boys are separated and finally a school that used single gender setting for a few STEM subjects in Year 9 only.

The recommended sample size thematic analysis ranges from three to ten participants (Braun & Clarke 2013) due to the intensity and length of the interviews. I originally aimed for eight interviews but, as the project developed, used six interviews using IAT as a stimulus, two further focus group interviews and two video stimulated interviews.

Identifying suitable schools and D&T teachers to volunteer to take part was not found to be particularly easy. The topic of gender seemed to be viewed more of a personal than professional concern and a wariness or reluctance to engage with the topic at an institutional level was seen when approaching gatekeepers in schools. The use of video is also quite intimidating for teachers and the gatekeepers were also wary about data protection issues; I received lots of questions about consent and these will be dealt with in the ethics sections of each method.

The sample selection was based on existing contacts where a level of trust had already been built up. Very few of the participants were enlisted through cold calling process and this approach was only adopted to ensure that a breadth of school types was included. The senior leaders responsible for professional development were approached next as the gatekeepers. The list of participants, a summary of their school type and the research elements that they participated in is shown in Table 7-1.

Teacher				**School**				**Method**		
Code	**Subject**	**Sex**	**Exp**	**Girls**	**Funding**	**GCSE Grade 5**[5]	**FSM**	**IAT**	**Focus**	**VSI**
Mike	D&T	M	20*	50%	Maintained	38%	15.1%	x		
Ruth	D&T	F	1	50%	Maintained [1]	61%	12.5%	x		
Bree	D&T	F	2	42%	Independent	97%[4]	0%	x		
Greg	D&T	M	10	46% [2]	Independent	92%[4]	0%	x		
Pete	D&T	M	15*	100%	Academy	89%[4]	5.9%	x		
Jake	D&T	M	1	37%	Independent [3]	81%[4]	0%	x	x	x
Thom	Art	M	25						x	
Doug	Computing	M	5						x	
Cole	Computing	M	1						x	
Kate	D&T	F	5*	52%	Maintained	45%	12.6%		x	
Lynn	D&T	F	1						x	

Table 3-4 List of participants and schools.

*** - Head of Department.**

1 - No post 16 offering.

2 - Diamond formation.

3 - Faith school.

4 - Selective entry.

5 - Percentage of pupils gaining Grade 5 or above in English and Maths (England average 43%)

Social class and ethnicity compound gender inequalities independently and together (Gillborn & Mirza 2000). The manner and extent that these intersecting factors play out is complex and findings suggest that the gender gap is present within each ethnic group regardless of social class background (Gillborn 2015, Unterhalter 2007, 2012). Ideally, this study would include a range of schools in maintained and independent schools, selective and non-selective, those with high proportions of pupils with Free School Meals and schools with different proportions of pupil ethnic backgrounds. The range of school types eventually selected was not as broad as I would

have hoped, there are a disproportionate amount of independent schools, and this limits the size of my audience.

The focus group participants were not deliberately chosen by gender but in both cases one teacher was unable to make the meeting and the groups became single gender. I imagine that a gender mix may have provided a different dynamic, but I can only speculate. The second focus group also became a meeting of only two which will have inevitably affected the dynamics of the conversation; there were less opportunities for "synergy, snowballing, stimulation and spontaneity" (Catterall & Maclaren 1997). The power dynamics of that pairing, a head of department and her newly qualified teacher (NQT) unfortunately inhibited the contributions from the younger participant[7].

3.3 Methods

Having explored the validity, reliability and generalisability of various critical research methodologies, the next section of this chapter homes in on three specific methods based on interviews. For each one I describe the practicalities and the ethical concerns.

Interviews with Implicit Association Tests

The most suitable form for the interview was deemed to be a semi-structured approach, to encourage a conversation (Bernstein 1996) whilst also maintaining a purposeful focus. The option of an unstructured interview was tempting as it would allow uniquely individualised accounts and viewpoints of the situation (Lincoln & Guba 1985). However, I felt that the unpredictability of this format and the potential difficulties in analysing the dialogue (Wellington 2000) were challenges I was not prepared to tackle as a novice researcher. For the semi-structured interview, I planned a series of fixed questions and a number of probes to explore the responses, but I was also prepared to follow interesting strands of the conversation to their conclusion. This emphasis on a conversation highlights the critical realist approach that respects the participants as equals in an exploratory journey (Kvale 1996). In most cases this was genuinely the case; all participants were colleagues, mostly in D&T, and some had similar teaching experience and responsibilities to me. During interviews with teachers that had less

[7] Kate (head of department) made 189 refences, Lynn (NQT) made 79 in the Focus group 2 interview. Appendix 2n: Participant coding.

experience I found that there was a need to consciously hold back from a coaching or mentoring role.

The Gender-STEM Implicit Association Tests are included mid-way through the interview to generate a deeper response from the participants. This psychometric test is conducted online and provides a measure based on the relative response times of participants to categorise words into male or female and science or liberal arts categories. By changing the pairing of these categories, differences can be established. Most people can categorise the words faster and more accurately when male and science use the same response key. This is taken to reflect stronger associations of science with male and interpreted as an implicit gendered STEM stereotype. The claim is that conscious, explicitly shared beliefs are bypassed as the test requires rapid actions.

Practicalities

The interviews were all conducted in the participants' own schools, often in their classrooms and D&T workshops. The familiar surroundings helped to put the participants at ease and hopefully helped mediate any power differentials. These settings did generate a few problems; there were occasional interruptions from other staff members who needed to access equipment from the rooms and a fire alarm sounded in one instance. The workshops were large rooms and care had to be taken to ensure that the sound quality of the recordings was adequate.

The equipment used for recording included a Philips Voice Tracer laid on a nearby table or bench as the primary recording device. As a back-up recording I also had an iPad positioned on a short tripod to record non-verbal cues with an iPod Touch connected as a microphone, both linked to the IRIS servers. In this way, the length of recording was not limited by the available storage space on the iPad. An additional benefit of the iPad/iPod combination was that it provided an opportunity to share and discuss the ease, security and practicalities of the video system with the participants. The aim was to follow up some of the interviews with the Video Stimulated Interviews and a preview of the IRIS system was part of that process. However, the IRIS system requires a stable Wi-Fi connection which was not possible to arrange easily in all the schools. This limited the number of schools that I could then return to conduct the VSI and removed the back-up function. In these situations, I used the voice memo app on the iPod touch as the back-up recording.

A pilot interview was conducted in my own school with a colleague who understood the subject matter and the research agenda, the recordings from this interview are not used in the final

report. The pilot provided an opportunity to test the equipment fully, identify the length of time required, the time required for the IAT, the most appropriate sequencing of the questions and provided tweaks to the wording of those questions. Unforeseen benefits of this pilot were the development of a bank of probe questions and reminders about the dangers of leading questions. Wellington (2000) highlights the difference between prompt questions that lead the interviewee and probing which seek clarification and detail rather than guiding the interviewee. This led to the final interview schedule (Appendix 1a) which includes an administrative checklist, the preamble with ethical assurances, the questions and follow up probe questions. The pilot also identified the need for a notepad to record the responses to one of the questions so that the interviewer and participant could refer to the list in subsequent questions. The original plan was to allow the participants to take control of this list but after the first two interviews it was recognised that it became a distraction and I took control of the list making.

The Gender-STEM IAT is readily available online and simple to administer. The process takes between five and ten minutes but the timing of the IAT within an interview is critical. Offering the IAT before the interview would effectively prime the participant to focus on gender issues and stereotypes. This could make the interviewing a much more streamlined and focused process, but it could also make the participants more defensive in the discussions. There is also the possibility that participants could modify their responses to present a more socially acceptable gender-neutral approach. Nosek (2009) identifies that it is useful to explore both implicit and explicit associations, so I made the decision to place the IAT in the middle of the interview as a 'break-set' moment (Putnam & Borko 2000) and use the results to initiate deeper discussions about stereotypes, implicit associations and bias.

The need to slot the IAT midway in the interview provided a useful break. The initial questions took between forty and fifty minutes with the IAT taking the participants around six to ten minutes to complete. The final section varied between ten and thirty-five minutes as the IAT generated very different responses from the participants; some effectively shut down and others became quite animated. Those that did not engage with the IAT results may well have interpreted the results as a challenge or seen the turn in the discussion from abstract to personal as out of bounds. There is clearly a limit of intimacy for some participants that even an insider researcher is unlikely to be able to breach in an interview.

Ethical considerations

The principles of confidentiality and anonymity from the ICO guidelines (2014) were applied. The only form of identifiable personal information is in personal emails to the participants and on the

consent forms. All other identifiers such as names, ages, schools and locations were anonymised as soon as practically possible, at the transcription stage. Names were replaced by a neutral alternative so that, for example, Bristol University became City University. A pair of initials was allocated to each participant that had no relevance to identifiable personal information. However, to make the reading of the findings flow better, a four-letter name was randomly selected. The gender of the participants is deemed important to the project although age was never recorded or asked for.

The consent form (Appendix 1f) that accompanied the information sheet (Appendix 1e) included assurances that confidentiality was to be maintained , participation was voluntary and they were able to withdraw at any time without anything been said or reasons required. Clarification of the anonymisation process was also outlined in the consent form and to ensure that all of these issues were fully understood the consent forms were signed by participant and only when I had repeated the details in the initial interview briefing did I then countersign the form.

Video stimulated interviews

Just as the IAT could be used a primary data production tool, video observation was considered early in the study as a primary data generation method. Observations could be invaluable in exploring possible differences in the way that teachers deal with boys and girls in D&T. However, this becomes research *on teachers* and not *with teachers*. I am more interested in exploring how participants make sense of the interactions in their lessons. To allow participants to become their own observers I used video to stimulate a discussion based on motivations, perceptions and previously hidden thought processes. This leads to a two-stage interpretation process where “the participants are trying to make sense of their world [and] the researcher is trying to make sense of the participants trying to make sense of their world” (Smith & Osborn 2008 p53).

The literature referring to video in educational research falls into three camps; video as a professional development training tool, video as an ethnographic research tool and the much less common video stimulated interview (VSI) (Lyle 2003). I will return to the multiple affordances of video in the concluding chapter.

A good example of the VSI is evident in Tartwijk’s study of multicultural differences (2008). Immediately after each recorded lesson, the teacher and researcher review the video footage as part of an interview. The researcher stops the footage at natural transitions or seemingly significant events, but the teacher is also at liberty to pause the tape to describe their own actions, behaviour or emotions.

The advantages of using the video rather than memory are numerous. Video is particularly well placed to capture the non-verbal gestures, facial expressions and body language that are such powerful tools in conveying emotional messages in classrooms (Salminen-Karlsson 2007, Tartwijk et al. 2008). Memories are fallible, and teachers will inevitably miss reactions thoughts and ideas that were being processed during the lesson. In this way it allows an insight into the in-the-moment experiences of professional interactions, Schön's reflection-in-action (1995). Recommendations are that video stimulated interviews are conducted within 48 hours of the original lesson to aid this process (Kettley, Ketley & Bates 2015, Larson et al. 2008, Tartwijk et al. 2008, Kagan 1984, Nguyen et al. 2013).

The VSI provides the opportunity for teachers to reflect on their thoughts and articulate their experiences more fully (Larsen, Flesaker & Stege 2008, Muir 2010). The interview therefore needs to include wait time for the participants to remember, reflect and then articulate their thoughts. This articulation may require assistance in the form of dialogue and Charmaz (2006) suggests that interview conversations become shared attempts to make implicit experiences explicit. As such, the participants and interviewer in a VSI are partners in meaning making; they are co-investigators (Larsen, Flesaker & Stege 2008). This does not mean that agreement must be made in the interview itself and the collaborative analysis of a lesson "preserv[es] multiple realities, the different and even contradictory views of what is happening" (Stake 1995 p12).

The VSI process requires the teacher to adopt an observer role (Kagan 1984, Rennie 1992). There is therefore a separation between the participant's current thoughts and their remembered experiences of the lesson. In the pilot there was the tendency for the participant to relive the lesson and describe details and features that are already evident. My role became one of refocusing the attention on the decision-making process rather than the content of the lesson (Nguyen et al 2013, Larsen, Flesaker & Stege 2008). Other features of the questioning involve using the careful use of tense to help focus on the thinking-in-action or to provide a more reflexive response. Examples of this could be the difference between, "what were you thinking then?" as opposed to "how do you think that affects the pupils?" As with all interviews there is the possibility that participants may well censor their responses to provide a more favourable image of themselves (Nguyen et al. 2013, Smith & Osborn 2008).

In summary, any questions need to reference a specific video moment, focus on the process rather than content and choose between the past and the future tense. The full VSI schedule is shown in Appendix 1c. The VSI is not an easy process to manage; I will now discuss the practical, technical and ethical limitations of the process which meant that the VSI became a much smaller part of the project than originally intended.

Practicalities

Video can generate a huge volume of information. Warnings abound of the challenges in managing such large quantities of data appear frequently in educational research methodology guides; “because we can accommodate ever-increasing quantities of data, we have to be careful not to get buried under avalanches of our own making” (Wolcott 1990 p35). A handful of lessons would provide enough data to keep any researcher busy for weeks. The pilot identified that care was needed on defining a practical limit on the number of lessons used. Experiences matched those from the IPR field where a fifty-minute counselling session can lead to a two to three hour IPR interview (Larsen, Flesaker & Stege 2008) which in turn could lead to eight or even up to twenty-four hours of transcription. To make this project manageable the initial interviews were used to selectively target, in a purposeful sampling process, one or two teachers to take part in a video stimulated interview.

Embarrassment often comes from the direct comparison of a participant’s self-concept with video footage and I found it necessary to provide some ‘giggle-time’ (Tartwijk et al. 2008) for teachers to discuss their voice, dress, and mannerisms.

Decisions about the equipment to be used were largely based on the issues of reactivity. This principle refers to participants change in behaviour in response to the observation such as excitement in pupils and stress on the teacher (Foster 1996). Methods that can reduce reactivity include educating the participants about the process, familiarising them with the equipment, providing time to adapt to the process and aiming for minimal intrusion (Renne, Dowrick & Weseck 1983).

To minimise intrusion, fixed cameras were selected over video camera operators. For professional development purposes where the video footage is often shown to other teachers (ILEA 1969) camera operators can ensure high quality images but this is distracting and, probably more importantly, add an additional layer of interpretation. I wanted the participants to choose the focus of the discussion and not be limited by where the camera was pointed.

Experience from the pilot trials suggests that fixed cameras were not a significant distractor and teachers and pupils tended to settle into their normal roles quickly. However, there are limitations of using fixed cameras that “can’t glance, they can only stare” (Macbeth 1999). Camera angle, field of view, framing and lens choice all have a dramatic impact on the aesthetics of any footage. Film and television editors use a host of techniques to maximise these effects; such as a low camera angle to generates a sense of domination or a wide view to places the viewer outside the action. These aspects of video need to be recognised as “too

often researchers have fallen back on the implicit assumption that the camera sees what the human eye sees" (Summerfield 1983 p5). Camera position, height and angle may need to be acknowledged in the analysis. Systems that included multiple cameras were identified to capture as much of the lessons as possible.

Studies repeatedly discuss the effects of poor sound recording in video; especially in large rooms with lots of people. Directional microphones, hidden microphones and halter microphones on teachers are all suggested (Dowrick 1983, Pirie 1996, Bliss & Reynolds 2004) and were experimented with in the pilot trials. Two systems for video recording were compared in these trials, the Reflections and IRIS systems. The Reflections system is based on a laptop with three webcams connected using long cables and a wireless microphone which is designed to be worn by the teacher. The sound recording of this system is only effective for picking up the teacher's voice but the software does allow for instant access for review.

The IRIS system uses two iPads as cameras and two additional iPods as microphones, one for the class and the other for the teacher. These are paired using Bluetooth and, using Wi-Fi, send recordings to a cloud-based server. The IRIS software is online and so can be accessed from any device with internet access. The recordings can be adjusted on screen to switch between either video feed, or show both together with any of the four sound channels from each of the devices. During trials this was found to be especially useful if one of the devices was recording poor quality sound. The wide angle of the camera lenses on the iPads is effective at including all the classrooms although details such as facial expressions are less easy to see. Ensuring access to robust Wi-Fi connection in different schools effectively eliminated several participants from the opportunity of taking part in a VSI. The final aspect of the IRIS system which is worth noting is that the combined uploading of the video takes a few minutes and so it is important to keep the devices connected to Wi-Fi after the lesson finished. Despite all these issues the IRIS system was selected as the most appropriate to use in the VSI context.

Ethical considerations

At the time of identifying the participants, schools were preparing for the introduction of the new GDPR regulations (ICO 2019). The heightened awareness of confidentiality and data protection generated certain amount confusion. It became clear that permission to use video in the classrooms was going to be problematic for a number of schools. Video inevitably shows pupil and teacher faces and, as such, is deemed to contain identifying data. A solution was found with one school using the guidance provided by IRIS (2019). If the purpose of employing, storing and sharing personal data, in the form of video and audio recordings, is deemed to provide part of

the professional development for teachers that enables them to engage with self-evaluation, reflection and receive feedback from colleagues then this falls under the remit of the lawful basis as the school's 'public task' to function effectively (ICO 2019). The statutory requirements outlined in the teacher standards (DfE 2010) include professional development for teachers and so the use of video feedback can be argued as a requirement of running a school.

Informed consent from all the relevant pupils and their parents was unnecessary as the school already had a standard consent arrangement in place for all pupils. A list of those that had opted out of the use of photographs and video for public purposes was available but there were no pupils in the classes chosen in this category. However, it was still felt that pupil and parents should be made aware of the process and provide reassurances that the video was only to be used for professional development purposes; as reflection of the teacher participants and for this teacher/researcher project.

There are several features of the IRIS system that help with confidentiality and anonymity in their privacy-by-design service. The most important security feature is that all recordings are held on a secure server meeting a range of international security standards including ISO 27001 (IRIS 2019). This ensures that only users approved by the school can access the data and only when it has been specifically shared with them for an educational purpose through a password protected portal. The software also has a cartoon feature to obscure faces of participants if video or screenshots are used beyond the original team.

Just as with the IAT results, the potential challenge that video footage can provide for participants needs to be borne in mind. Teachers will remember aspects of a lesson quite differently to the students, the observers and presenting these potentially contradictory interpretations of a lesson to teachers is problematic. It is effectively challenging the participants to reflect quite deeply on their actions and perceptions which can engender powerful dialogue and discussion but could also generate a defensive approach or worse, spark upset and anger. Mitigating against these latter responses requires the researcher to emphasise their potential to the participants beforehand, being alert to emotional responses during the interview and allowing participants to decline or withdraw at any stage. As an insider researcher, there is the potential to be more comfortable and intimate with participants which could exacerbate these harmful outcomes.

Focus groups

Focus groups are heavily used by the marketing industry and, as such, have had a reputation in social sciences as being rather vulgar (Berg 1995). There is certainly a need to question their purpose carefully (Kruger & Casey 2000). Before the interviews were scheduled to take

place, an opportunity arose within one of the participating schools. A carousel for the subjects of Art, Drama, Computer Science, Music and D&T was being proposed by the senior leadership team to manage teacher timetables, workload and pupil numbers. Volunteering to lead the working group allowed me to present an opportunity to the other heads of departments that finally opted to take part in the carousel; Art and Computing joined D&T. The initiative was based on my readings of single gender approaches to STEM. I already had a diamond formation and single gender school in the project and asked the curriculum leaders whether they would be happy to accommodate single gender grouping in the carousel.

The discussion that followed revolved around the potential ethical concerns of pupils, parents and teachers. They had chosen a coeducational school and the purpose of single gender groupings had to be presented very carefully. The argument that swayed the curriculum leaders was that this was to be a limited intervention to explore the stereotypically gendered subject choices made by the pupils. This matched an item in the school development plan and the initiative was approved by the Senior Leadership Team. This purpose of the setting by gender was explicitly offered to pupils, parents and teachers at various stages throughout the year. For the pupils it became a discussion point at the start of every rotation in the carousel. Parents were openly invited to discuss the issues at Parents' Day and had similar opportunities at each of the grading and reporting points. All the participating teachers involved were consulted throughout the year and took part in a focus group evaluation of the intervention at the end of the year.

Although action research fits comfortably within the critical realist worldview it has been overtaken by post-positivist and postmodern approaches in education since Carr and Kemmis wrote Becoming Critical (1986). The principles of teacher as researcher are underpinned by Lawrence Stenhouse's 'extended professional' (1975) and Schön's 'reflective practitioner' (1987). Ironically, action research seems to have played a part in the deprofessionalisation of teaching once separated from its critical function. Action research is often portrayed as an over simplistic method involving a cycle of action and reflection (Baumfield, Hall & Wall 2012). This 'technically rational' model tends towards post-positivist experimental approaches without the critical questioning of values and practices. Carr and Kemmis remind action researchers to hold firm to the original meaning "of enabling educational practitioners to expose the tensions and contradictions between their emancipatory educational values and prevailing educational policies and practices" (2005 p9).

To avoid any confusion in this thesis I use the single gender setting initiative not as an action research project but to draw together reflective practitioners in a focus group. The minutes of

the focus group includes results of the initiative (Appendix 1g) but are not discussed further. The focus group provided a comfortable atmosphere of disclosure in which participants shared ideas, experiences and attitudes about the topic whilst influencing and being influenced by others (Kreuger & Casey 2000). It is this two-way process that appeals to the critical realist; the participants will hopefully gain something from the experience. By collaborating with others and being valued as experts (Byron 1995) there is a distinct possibility, although not a certainty, of empowering the participants.

Jurgen Habermas is widely recognised as one of the founding philosophers in critical theory (Long 2017) and his work on intersubjectivity is of relevance to focus groups. He suggests that the process of reaching a shared understanding amongst participants in a dialogue relies on moving implicit understandings to explicit articulations (Carspecken 2003). Within a critical realist paradigm, the dichotomy of objective and subjective realities is inadequate (Biesta 2010) and it is the intersubjective understanding that emphasises the importance of mutual communication and constructed meaning.

The focus group inevitably provides a different dynamic to the standard interview. The interactions between participants include "synergy, snowballing, stimulation and spontaneity" (Catterall & Maclaren 1997) to generate a broader view of the phenomenon. Some participants, especially with the controversial topic of gender stereotypes, articulated their thoughts and shared beliefs very differently in a public forum than in a private interview (Michell 1998). Although the focus group is primarily employed as a means to evaluate the initiative of setting by gender I asked similar questions to those used in the interview; the shared construction of meaning in the focus groups enriched the results from the individual interviews (Katz 2001).

Practicalities

The only practical differences in between the arrangements for the IAT and focus group interviews are in the schedule (Appendix 1d). The difficulties with focus groups relate mostly to the role of the researcher (Katz 2001) and the need to be aware of power differentials in the group whilst respecting the input of all participants. The dynamics of the focus group require the chair of the meeting to act both as an interviewer asking questions and as a moderator facilitating a discussion. Managing dominant characters and the flow of the discussion is expected to be a challenge (Kreuger 1993) and so the schedule includes warm up questions (Breen 2006), fewer questions than the interview, clear ground rules about the conversation dynamics and fewer planned probes.

In summary, this section has positioned the methods chosen within a critical realist and interpretive framework. The ethical and practical considerations have been developed along with details of the sample selection. The final section of the chapter expands on the thematic analysis process.

3.4 Analysis

This section provides details of the transcription and coding processes involved in the study. I start with a description of the thematic analysis approach adopted and how this strategy fits with previous chapters on worldview and methodology. The bulk of the chapter is a chronology of the steps involved in the coding including the tools used in the analysis and plans for presenting the findings. This is not a presentation of the findings but part of the audit trail so that the reader can make judgements about the validity of the findings.

Identifying a suitable strategy from the myriad of alternative approaches to analysing qualitative data is not a simple task. Three approaches that were considered; Glaser's constant comparative method, Lincoln and Guba's thematic analysis and Smith's Interpretive Phenomenological Analysis method are summarised here before expanding on Braun and Clark's thematic analysis. These approaches have much in common, but some are described purely as tools whilst others as a complete methodology.

Interpretive Phenomenological Analysis seemed to fit closely within a realist orientation (Smith & Osborn 2008) as it values both the participants interpretations of their experiences and the researcher's interpretations in a double hermeneutic (Jeong & Othman 2016). However, the sequencing of coding seems excessively rigid and prescriptive.

The constant comparative method stems from grounded theory, a naturalistic, interpretive methodology that builds theory (Glaser 1965, Glaser & Strauss 1967). Glaser's suggestion is that hypotheses are generated through the redesigning and reintegrating of codes in repeated reviews of the material. His sequence attempts to add rigour to this bottom up coding process. This method does allow researchers to work at several different levels of generality and is very flexible but relies heavily on the interpretations made by the researcher and presents difficulties in the relationship with prior research.

Lincoln and Guba (1985) elaborate on the constant comparative method with numerous refinements and additional steps. Both Grove and Fram (2013) separately conclude that there are elements of Lincoln and Guba's adjustments to the constant comparative method that "stray too far into more traditional deductive logic which is not generally supportive of a

naturalistic paradigm" (Grove 1988 p279). Although Lincoln and Guba's method is not a truly top-down coding sequence for deductive analysis of a testable hypothesis, it has been appropriated by many researchers in this way.

It is Braun and Clarke's work on thematic analysis that seems to provide the most useful route to exploring the evidence in-depth and to bring together viewpoints from different stakeholders. Their descriptions of thematic analysis as a tool within a range of orientations seems to provide the most flexible and pragmatic approach. Braun and Clarke's (2013) seven stages of the thematic analysis are as follows:

1. Transcription.
2. Reading and familiarisation.
3. Coding.
4. Searching for themes.
5. Reviewing themes.
6. Defining and naming themes.
7. Writing.

In all stages they recommend that researchers are open about the ways they construct the themes from data and provide three pointers for theme development.

Prevalence of themes

The question about what counts as a theme does not have a hard and fast answer. There may be several instances of a theme across all the interviews, but more instances do not necessarily mean that the theme itself is more important. I reported on the frequency of codes across and within interviews so that the reader can identify the basis on which I make judgements about the importance of the themes.

Semantic vs latent themes

The next decision to make in the analysis of the transcripts depends on the level at which a theme is identified. I describe later how I conducted word and text searches to help identify themes, this an example of analysis at a semantic level where the codes are explicit in the participants' talk. However, I develop the analysis later to make interpretations about the codes and explore possible meanings beneath the surface descriptions. Often these interpretations were initiated by running matrices of codes against other elements of the study including the participant demographics, school type and even links with other codes. Here I was looking for patterns, similarities and discrepancies to generate secondary, or latent, themes.

Inductive vs theoretical themes

I have already described the different approaches in the form of inductive bottom-up or theoretical top-down approaches to thematic analysis. Although I primarily adopt the inductive approach I am aware that within my literature review I will have taken on board a range of different theories about the topic and am unable to forget or unread that background research. Midway through the inductive coding process I do attempt a theoretical analysis as a form of comparison.

The remainder of this chapter describes these stages as I applied them.

Stage 1 - Transcription

As the primary source of information, the transcripts of the interviews play a crucial part in the quality of the research. Understanding that the process of transcription as a form of interpretation is important and as Braun and Clarke identify, “a transcript is two steps removed from the actual interview experience” (2013 p162). An audio recording will never capture all the interview experience and the conversion of spoken word to written form is a point at which information can be modified or lost.

To manage this interpretation process as systematically as possible I used two tools; video and notation guides. The video backup was originally intended to complement the audio recordings throughout the transcription so that nonverbal gestures could be included. However, I only referred to the video in the first two interviews as the time taken to synchronise the voice and video recordings was excessive. I included my own comments in later interviews to highlight any nonverbal gestures so that these could be recorded in the transcription process. I also found that there were clues in the recordings such as the scraping of a chair or tapping of a desk that helped with the recall of the interview and were used to rebuild the interview experience for the transcription. When transcribing the VSI, I matched the relevant frames of the video to the interview transcript in a third column (Larsen, Flesaker & Stege 2008).

The second tool was a notation guide, shown in Table 8-1, used to maintain a consistent and rigorous approach when recording the conversations. The aim was to record a verbatim transcript of the interview to provide as full a picture of the process as possible.

Features	Notation	Explanation of Use
Participant identity	4 letter pseudonyms	A randomly selected four letter name for each participant. Example – Pete. I retained my own initials.
Non-verbal incidents	( )	Use of brackets to state or explain non-verbal utterances. Examples – (laughs), (sighs), (points at list).
Pupils' names	None	People's names replaced with a short randomly selected name of the same gender to help both with the flow and to ensure consistency if that person was referred to again later.
Place names	*Italics*	Place names replaced with Town, City to represent the size of the place. Example - this will be my 11th year teaching at *Town A* School
Pausing	(…) (..)	Pauses in speech not identified as the end of a sentence are shown as (..) or (…) depending on the length of the pause.
Abbreviations	As spoken	Will transcribe as spoken. Example - DT, D&T or Design and Technology.
Punctuation	. ? !	A full stop, question mark or exclamation mark is added when the speech indicates a sentence completion and according to the tone of the speaker.
Unclear	Highlighted	Words that cannot be identified from the recordings are included as a best guess, highlighted and participants were invited to correct them.
Word Emphasis	**Bold**	Words that are emphasised in the speech are made bold. Example – That's when they take their GCSE **option** choices.
Spoken	" "	Wherever the speaker delivers a phrase as though they, or another person would, this is indicated with quotation marks. Example – I sat her down and said, "look, this is what you will do".
Interruptions	[xx – xxxxx]	Where anyone interjects a comment as part of the natural conversation this will be added within the main speaker's text to avoid breaking up the flow of the transcription excessively by using a new line. Example – First year of teaching as well [BJ – I know] which was the first time I've ever taught A level.

Table 3-5 Transcription key.

Stage 2 – Familiarisation

Additional hand-written comments in a journal were used as an attempt to separate any judgements, thoughts or interpretations of the interviews from the typed transcription process. As my interviews were spread over a few months I started working through the stages before

all the coding had been completed. This meant that I cycled through stages four, five and six iteratively rather than treating them as discrete or linear phases. Familiarity with the transcripts developed considerably in this process.

Stage 3 - Coding

Initial coding was started manually using a highlighter and printed copies of the transcripts of the first two interviews with Mike and Pete. Codes were attached to significant sections of text and these codes were added to as I read through the interview. I then grouped codes alongside others into categories, or themes, that were based on the research questions. For example, the category of 'teacher's perception of choice factors' included twelve codes; parental influence, school structures, career aspirations, siblings and extracurricular activities are just some. Braun and Clarke describe how a theme "captures something important about the data in relation to the research question and represents some level of patterned response or meaning within the data set" (2006 p 82).

I found that there were numerous aspects of the verbatim transcript that did not relate to the discussion, especially at the start of conversation. These sections would later be coded as fact-finding elements. After the first interview transcription with Mike it was felt that the first batch of codes did not fully capture the respective points and they were renamed with three letter abbreviations and colour coded according to their categories. This renaming process matches Braun and Clarke's (2013) suggestion that labels for the codes should be meaningful without reference to the transcripts.

Coding Pete's interview raised an additional number of codes that often added more detail to the first set, for example; extra-curricular activities included trips, competitions, talks and work experience.

It was at also this stage where I started to recognise how participants often viewed similar aspects of choice in radically different ways. For example, Mike viewed parental influence passively whereas Pete saw parents as partners in the choice process. Mike dismissed real world factory floor experiences as a negative, Pete saw them as positive experiences for pupils. This was probably a reflection of their differing backgrounds, Mike was a graphic designer, Pete an engineer. A difficulty arose in presenting the findings so that each of the individual participants' voices can be heard whilst also discussing collective messages.

Stage 4 – Identifying themes

The twenty-one codes within four categories were based on selective coding rather than complete coding. Although there seemed to be very little overlap between the categories the process felt clumsy, the coding simplistic and few insights were evident at these first few passes of coding. The themes, or categories, were identified as:

Teacher factors:	teacher background, gender, subject skills, reflection.
External factors:	parents, peers, siblings, home environment, school structures, society, testing process.
Stereotypes:	organisation and presentation, practical confidence, achievement, real world production, styles, behaviour.
Enjoyment:	project content, subject breadth, clubs, trips, competition, teamwork.

The next stage of the analysis involved uploading the interviews conducted so far to NVivo 12 software. I recognised that the coding was an iterative process and numerous passes would be required. At this point I had the transcripts of Bree, Emma and Doug to add to Mike and Pete's interviews.

The first step with Nvivo was to auto-code each interview by speaker name to form a series of cases. These cases allow me to conduct detailed analysis on the responses of each participant even though many were transcribed together in the same file or across numerous files. It also allowed me to eliminate my own comments from any searches or queries. I then classified each case according to their gender, experience, subject specialism as well as their school size, funding and selective nature; these individual and school demographics allow for more detailed analysis.

My first exploration of transcripts in Nvivo was a word frequency count; this was a word search for the most frequently mentioned words of five or more letters was presented as a word cloud. This allowed me to step back from previous coding stages and focus on the most common words, shown in Figure 8-1. It was tempting to work through a series of stop words to refine the word cloud but this is highly subjective and I decided not to do this. For example, the work 'think' would be an obvious word to block; most participants when asked about a topic would start their statements with, "I think…".

Figure 3-2 Word cloud: example.

Reducing qualitative data to quantitative data seems like a rather positivist approach but I found myself returning to frequency of word counts regularly in the analysis. As Braun and Clarke (2013) point out, the most prevalent theme or code or even word does not necessarily mean that this needs to become the focus of the final report; there may be infrequent features that are potentially the most unusual, revealing and interesting.

Stage 5 – Reviewing Themes

This stage is built on producing maps of the provisional themes and subthemes, and identifying relationships between them. I attempted both theoretical and inductive approaches, as differentiated by Braun and Clarke (2013), to identify differences in the emergent themes.

Top Down

The next pass of coding used themes identified in the literature review such as Bourdieu's habitus, Archer's science capital and Eccles' EVT. This top down, or theoretical approach, generated very different categories to the initial themes:

Structural factors:	career and vocations, school structure, society, curriculum format.
Networks:	parental influence, peers, siblings, teacher background, teacher relationship, teacher gender.
Subject features:	teamwork, projects, skills, clubs, trips, competition, real world links.
Behaviours:	pupil behaviour, practical confidence, achievement, organisation, presentation.

Choice is multifaceted and is affected by a wide range of factors in a complex dynamic that becomes more evident when the codes and categories are laid out in a map, Figure 8-2.

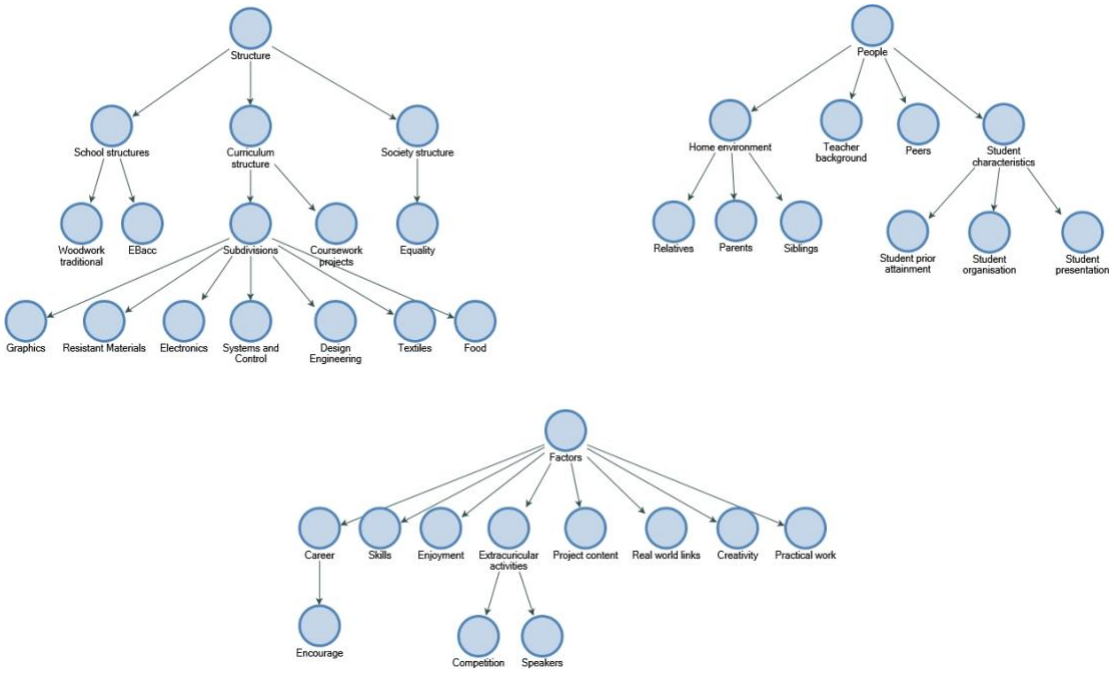

Figure 3-3 Top-down thematic map.

Bottom up

At this stage I had completed all the interviews, including the two focus groups and video stimulated interviews. I started afresh with Bree's interview, coding from the ground up. A third of the way of coding through her interview I then used the codes that had arisen so far to search through all the other cases using a text search. This allowed me to judge the spread across the various cases using the summary chart; an example of a text search for 'engineering' is shown in Table 8-2:

Name	References	Coverage
Focus Group 1	3	1.48%
Focus Group 2	6	2.88%
Interview Bree	9	4.83%
Interview Greg	8	16.39%
Interview Mike	1	1.34%
Interview Jake	21	8.70%
Interview Pete	31	30.87%
Interview Ruth	3	1.53%
Video Interview 2	2	1.76%

Table 3-6 Text search results by interview: engineering example.

I found it useful to make a judgement about the value of the context by producing a word tree of the text search. The example in Figure 8-3 for ‘equality’ shows the context in which the word is found in each sentence. I also found it useful at this stage to broaden the review by scanning through the segments of the interviews to ensure that the sentence or paragraph in which the word was found was relevant to the code. Occasionally the meaning of word was different and a new code was added.

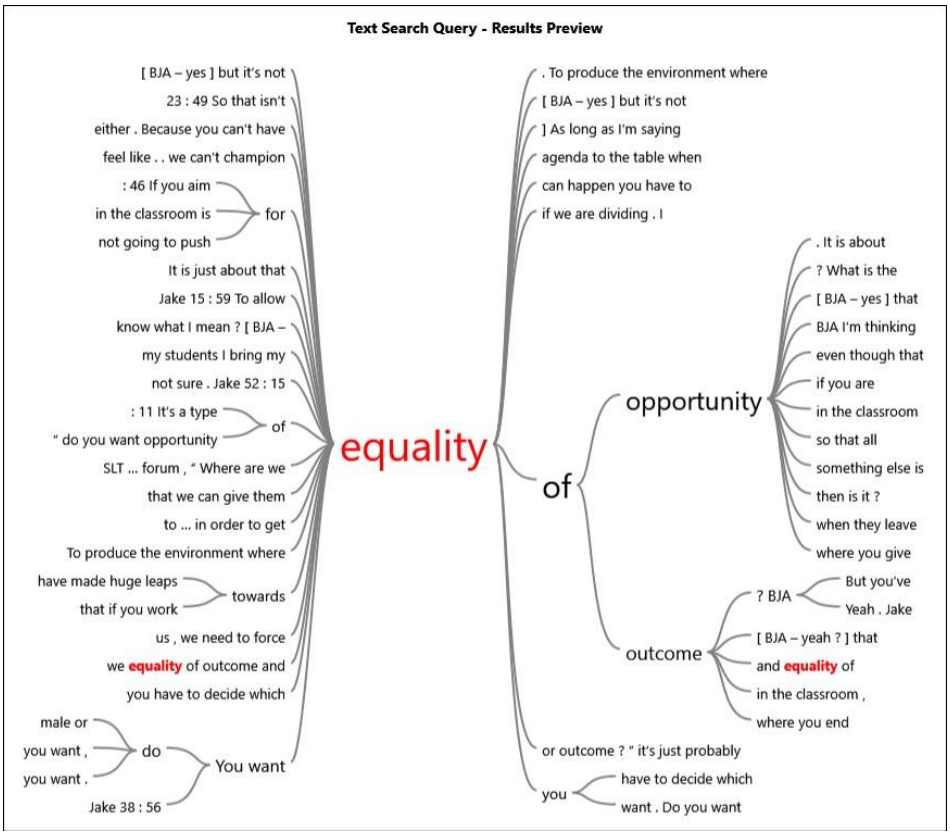

Figure 3-4 Word tree connections: equality example.

The most promising text searches were then added to the coding. Occasionally the text search resulted in a series of unconnected phrases or comments and was discounted from the coding. At this pass of one complete interview the codes totalled and were them grouped together to form themes in yet a third pattern shown in Figure 8-4. Although there are similarities of the codes to the top down or theoretical approach shown in Figure 8-1, these inductively developed themes follow a different shape.

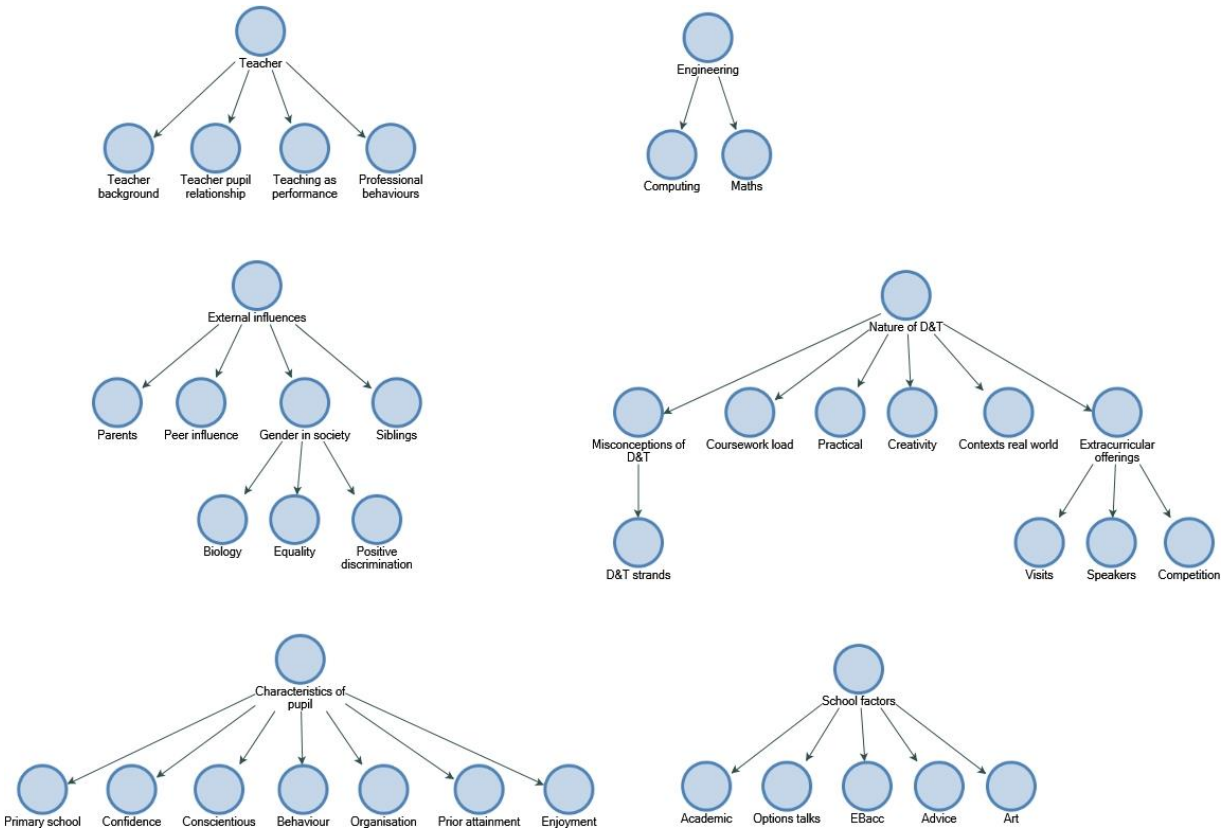

Figure 3-5 Bottom-up thematic map.

More transcripts, those of Greg and Ruth, were coded and decisions had to made whether the participants were always talking about the same thing. For example Bree mentions bright or academic students whereas Greg focuses on talent. These are both related to ability and attainment but not in the same way; I decided to separate these codes out. Bree mentions conscientious pupils, Greg discusses neat, organised pupils and again, these are similar but not necessarily the same. In this case I combined these into the pupil 'conscientious approach' code.

Even as I coded the last individual interview transcript for Jake I was still generating a few additional codes. I felt it necessary to conduct further text searches across all participants, including the earlier transcripts, for items such as STEM and career.

At this point I had completed the coding of all the files and had reached saturation with no new codes being generated. The video stimulated interviews with Jake were challenging to code as there were numerous tangential discussions such as technician training in Crumble or whether iPads should be used in all lessons. Jake could not help but focus on the behaviour of students that he had missed in the original lesson. There were interesting discussions about

the support provided with the boys and the practical skills of girls that feature in the findings later.

Stage 6 – Defining themes

After this pass it was felt that the categories or themes could be tidied up. Some of the codes were taken out of a theme and placed on their own, other were relabelled. I still had two codes at this stage which had transcript extracts coded against them and yet were also category or theme headings; 'Gender in society' and 'Engineering'. I was struggling to see how the parent and child codes could be separated out into themes. Two codes were merged into another; 'teacher advice' and 'teaching as performance' were subsumed into professional behaviours. In some cases, where a code had only been mentioned by one participant, that code was isolated from the categories; an example of this was 'sports analogy'. I also isolated 'fact finding' responses although knowing how many students were in each class for example was clearly going to be useful when presenting the findings.

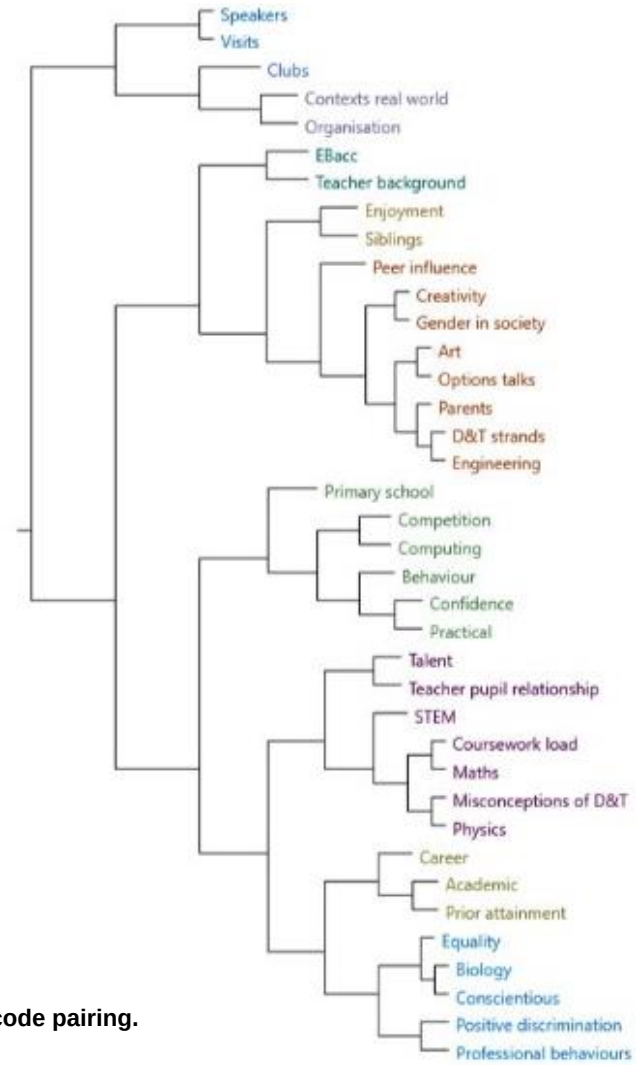

Figure 3-6 Dendogram: code pairing.

I felt that an alternative view of the themes would be useful at this stage to identify other patterns, categories and themes. I ran a cluster analysis by coding similarity to produce a dendogram that allowed me to see how codes were paired. There were similarities with a circular project map of the codes which I had rearranged to show the parent/child nodes (or themes and subthemes).

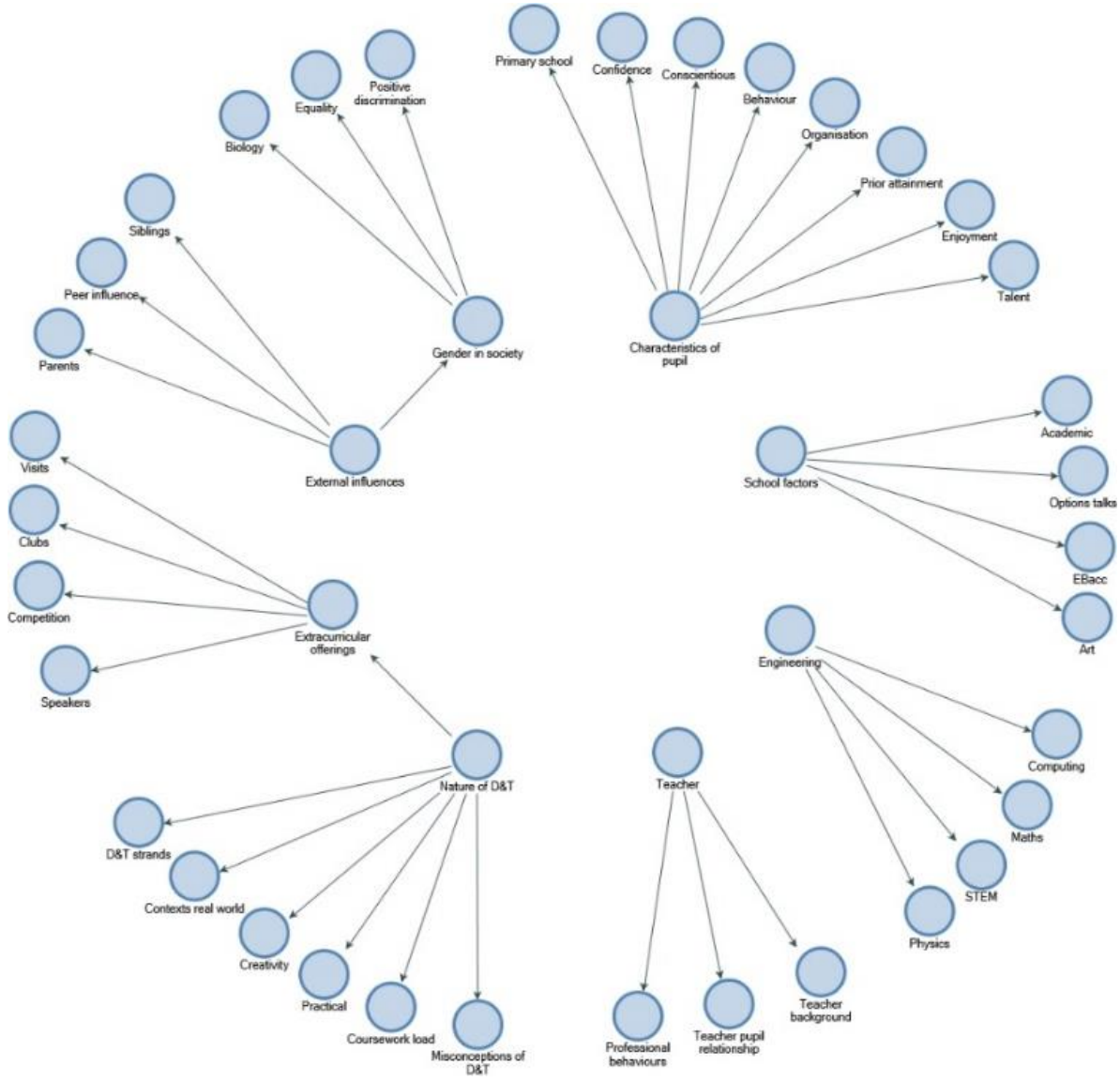

Figure 3-7 Project map: circular.

It was becoming evident that the emerging themes were often linked closely to codes within other themes. At this stage I ran a matrix to identify close matches between codes and realised that this matrix tool would be useful in the most heavily associated codes but also the more unusual links between codes across different categories. I refer to these matrices in the findings chapter and they are included in full in Appendix 2.

Stage 7 - Writing

The findings chapter that follows primarily uses extracts from the interview transcripts although occasionally I refer to data from the IAT results and the setting pilot. The extracts are used to build the narrative primarily as illustrative examples (Braun & Clarke 2006). Illustrative extracts complement the rich and detailed description in the form of a narrative but, if they were to be removed, the story would still be able to be understood, if less authentically and with less richness. Occasionally the participant's explanations and comments are so clearly stated that additional explanations are not needed. These analytic extracts form an integral part of the findings and cannot be removed.

In quoting my participants I treat all extracts as personal communications which are not publicly accessible so use in-text citations rather than references. The format will be as follows (pseudonym, timestamp). As the transcripts are verbatim records they include interruptions, pauses and filler words. To assist the reading of these quotations I have used Kvale's guidelines to drop filler words and "translate their oral style into a written form in harmony with their habitual modes of expression" (2007 p133). I have applied this as lightly as possible to retain the integrity of the original interview and the assumed intentions of the participants. I have not included context for each response as Kvale suggests this would interrupt the narrative.

This section has offered a detailed description of the analysis process so that the reader can judge how my sculpture of the participants' narratives has been built. The thematic analysis process was built on the critical realist framework identified at the start of the chapter as the most fitting for exploring perceptions of inequities. A wide variety of methods fit within the this framework and the methodology section of the chapter describes the issues surrounding the choices relating to validity, generalisability and reliability. Three adaptions of the interview method, the use of the IAT, video and focus groups, are designed to draw out the deeper and multiple perceptions of teachers. This chapter has described the practicalities and ethical of those methods. The next chapter goes on to present the findings and discuss how they relate to the earlier literature.

Chapter 4 Findings and Discussion

Six overarching themes were constructed from the coding of the interview transcripts; the nature of D&T, external influences, the characteristics of the pupils, teacher effects, STEM and school factors. However, there were further themes generated from the weighting of codes, relationships between codes and links to demographic data. This chapter is organised by loosely matching the resulting twelve themes to the three research questions as shown in table 4-1. The relative weighting, in terms of the number of participant responses relating to each theme, is represented in a hierarchy chart (Appendix 2a) but this does not affect the order in which these findings are presented. The boundaries between the themes are not as distinct as the table suggests; many of the participant responses can be linked back to the first research question. An alternative way to categorise the themes is by stakeholder; this is shown in the table 4-1 and will help when aligning the findings with recommendations for the various groups.

Research question	Theme	Groups
How do D&T teachers perceive how gender stereotypes play out in the subject?	1. Teacher background 2. Teacher gender 3. Classroom relationships 4. Teacher models of society	Teacher
How do D&T teachers perceive how boys and girls make choices about GCSE subjects?	5. Professional boundaries 6. Family guidance 7. School restrictions	External (local)
	8. Attainment and failure 9. Conscientious girls 10. Practical confidence	Pupil
How do D&T teachers perceive how the subject fits into the gender-in-STEM debate?	11. Contexts and specialisms 12. Lost in STEM	Social

Table 4-1 Research questions and themes

The reader should recognise that this forms part of a sculpture that I have built and, as Braun and Clarke (2013) suggest, the sculpture would look very different if created by another even if using the same interview transcripts.

Throughout the chapter, I refer back to existing literature to examine how the participants' perceptions match or conflict with current understandings; in particular I refer to Eccle's Expectancy Value Theory and the concept of technological capital. I also strive to distinguish

between the various layers of understanding using the critical realist approach highlighting, where possible, the *real* underlying mechanisms, *actual* events and most frequently, the teachers' perceived or observed *empirical* understandings. There are numerous findings identified that all need to be prefaced with the caveat that this is a small-scale study. The sample can never be truly representative of the whole population of D&T teachers in the UK.

Although the transcripts are not recorded in this thesis, Appendix 2 contains a series of matrix charts that describe the number of codes across all transcripts for each participant, the relationships between codes, participant and school demographics as well as coding cross references. Throughout the narrative I have included sections of these matrices or added footnotes to expand on terms such as most frequently, rarely or significantly. This is part of the transparency of the analysis.

Theme 1 – Teacher background

I start by reporting on teacher background as a way of acquainting the reader with the participants. References to their backgrounds consisted primarily of details about specialisms, training and experience. Many of the differences in the teachers' responses in the interviews can be traced back to their further and higher educational experiences as well as any work outside education. This training of the participants can be divided clearly into two camps; the 'engineers' and the 'artists'.

Three participants spoke about the links to engineering frequently[8] in their interviews. The dominance of engineering in Pete's interview is a result of discussions based around his own experiences as an engineer, his vocational training in engineering, his teaching of Engineering as a strand of D&T and the STEM specialism granted to the school in which he was working. Greg regularly mentions engineering in the context of his role outside school as a STEM ambassador for the RAEng rather than his training as a product designer. Although Jake followed an engineering degree after Maths, Biology and Physics A-levels, he had proportionately fewer references to engineering overall due to his focus in the second and third interviews on the lesson observations.

Ruth, Mike, Greg, Bree and Lynn all completed Art A-levels before their Art or Design related

[8] Engineering references in interview; Pete 21%, Greg 9.4%, Jake 4.5%. Appendix 2d.

degree courses. Both engineers and artists referred to the various D&T strands regularly[9] when describing their own backgrounds; often based on their own school experiences of the subject and how it led to their current position. The extract of the matrix that cross references the number of comments from the participants that include both elements of their background and other codes is shown in table 4-1; the higher the number of cross references, the darker the shade.

Pupils								STEM									External influences								Nature of DT								School factors			
Behaviour	Competitiveness	Confidence	Conscientious approach	Enjoyment	Organisation	Prior attainment	Talent	Engineering	Computing	Extracurricular offerings	Clubs	Competition	Speakers	Visits	Maths	Physics	STEM	Gender in society	Biological differences	Faith	Inequality Equality	Positive discrimination	Parental influence	Peer influence	Siblings and older pupil inf	Contexts real world	Creativity	D&T strands	Misconceptions	Practical	Primary school experience	Project factors	Value for future studies an	Academic	Art	EBacc	Options and limitations
0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	6	4	0	0	0	0	1	0	0	0	4	0	1	11	1	1	0	0	1	0	7	0	0

Table 4-2 Matrix of teacher background vs other codes (Appendix 2m).

The individual journeys into teaching D&T were all very different; Lynn, Mike and Pete's descriptions of their trajectories are offered as examples;

> "*I did Graphic Products at GCSE and Art and Product Design at A level before my Art Foundation course. I'd got accepted to do Textiles and then changed my mind to do Design, Crafts, Decorative Arts at another university and loved it. I went in thinking I would be doing be textiles and ended up doing a lot of laser cutting, ceramics, metal work, metal sculpture, enameling*". (Lynn FG2 4:21).

> "*Throughout school into A level … it was more of a fine art avenue I wished to take. I then did an art foundation course to decide what area of art to go in, and then studied an HND in graphic design. I then started thinking about the teaching side because I realised then that graphics was part of Design and Technology*". (Mike 6:12).

> "*I got made redundant. I had the choice of either finishing my engineering degree or transfer onto the teacher training certificate, the BSc in Design and Technology at City University. So they were doing this taster day and... I really enjoyed it, thoroughly enjoyed it. I never looked back*." (Pete 1:10).

[9] There were 11 cross references between Teacher Background and D&T strands. Appendix 2m.

Finding 1 *- D&T can attract teachers from the quite disparate disciplines of art and engineering, both highly stereotyped gendered fields.*

The wide variation of backgrounds within this small sample ties in with warnings about the lack of cohesion in the subject (Hardy 2017, Bell et al. 2017). Engineers and artists are trained in quite different, often opposing, disciplinary approaches. The engineering habits of mind (RAEng 2014) are different to creative approaches of the visual arts and have links to quite gendered stereotypes.

These different teacher backgrounds are likely to be relevant to boys and girls in the classroom if the teachers present the subject from within their own trained field rather than as a distinct discipline. The difficulties in defining the discipline of D&T have already been identified by Kimbell and Perry (2001) as they describe D&T as an iterant non-discipline, falling into neither the camp of the artist or engineer. Those charged with delivering the subject, whether engineer or artist, could do more to celebrate the interchange between these two approaches and mindsets. This feature of the D&T is also a strength in that it offers an opportunity for an interdisciplinary approach and negate any gendered stereotypes associated with the relevant fields.

The literature review focused on the potential misconceptions that policy makers may have about the subject. These findings suggest that at the very core of the subject, teachers delivering the lessons have different disciplinary foundations. This suggests that there is a great responsibility for initial teacher training programmes to support all D&T teachers, whatever their background, to embracing different approaches. ITT and early career programmes could possibly do more to emphasise the unique contribution of the subject and the way in which it can transcend traditional disciplines and gendered stereotypes. The subject association, DATA, also has a crucial role to play in continuing to reinforce and communicate this interdisciplinary principle to practicing teachers, examination boards and government agencies as well as ITT providers.

Theme 2 – Teacher gender

The variation in backgrounds of teachers is of most interest to this study when it relates to gender. The female participants made unprompted references to the gender imbalance on their undergraduate and postgraduate teacher training courses. Yet none of the male participants made any reference to the proportions of men and women during their education; even though the engineers would have inevitably been trained alongside very few women. This reinforces how a majority group is unlikely to view differences as problematic whereas the minority would attend to the differences. The interviews explored whether stereotype threat, the suppression of

performance in minority groups when reminded about the imbalance (Steele & Aronson 1995), could be a factor for the pupils in their classes. Jake's comment below seems to support this statement:

> "*I found that having sets of mostly boys with a couple of girls doesn't drive the girls to better things; it completely puts them off."* (Jake FG1 41:34).

Just as the female participants were able to recall the proportions of women in their own STEM experiences, it is likely that the girls in D&T classes would be similarly aware of imbalances in the proportions of girls in the school and teaching sets. The proportions in each of the schools and D&T sets are shown in Table 4-1.

Participant	Proportion of girls in school	Proportion of girls in Year 9 D&T classes	Proportion of girls in D&T GCSE classes
Pete	100%	100%	100%
Kate/Lynn	52%	52%	43%
Mike	50%	50%	6%
Ruth	50%	50%	36%
Greg	46%	100%	17%
Bree	42%	42%	21%
Jake	37%	100%	14%

Table 4-3 Proportion of girls in participating schools, Year 9 and GCSE D&T sets.

In three of the schools, Year 9 girls take D&T in single sex classes, either because they are in a single sex school (Pete), a diamond formation arrangement (Greg) or single sex STEM classes (Jake). Neither the diamond formation or single sex STEM classes seem to be having an impact on the number of girls taking up D&T at GCSE. If anything, the impact of these initiatives seems to having a detrimental effect on the take up at GCSE as evidenced by the numbers above. Greg's school has used the diamond formation for over five years and yet from the 46% female pupil body only 17% of their GCSE D&T sets are girls. In Jake's school the single sex STEM teaching had been running for only two years and the take up of girls at GCSE D&T, from a 37% female pupil body, had not changed much from 14%.

These two cases suggest that single sex D&T classes within coeducational settings could exacerbate, rather than counter, stereotypes. However, this sample is too small to draw conclusions on the effectiveness of single sex interventions and the focus must return to how teachers perceive gender plays out. Greg and Jake both acknowledged how many girls dropped D&T in their schools and discussed stereotypes at length. In Mike's school the difference in

proportions of girls in the school and in D&T GCSE sets are even more dramatic and yet he struggles to explain the drop from 50% to 6%; "I have no answer for it" (11:35). Mike's indifference in the early stages of the interview suggest that he had accepted the small number of girls in D&T as matching social norms.

The data suggests that Jake's earlier comment about stereotype threat must relate to girls in his GCSE sets and not the younger years. None of the Year 9 girls in any of the schools will have experienced stereotype threat due to an imbalance in numbers directly in their own D&T lessons and so we need to look at alternative mechanisms for these choices. Pupils' awareness of these imbalances could develop through indirect observations, through teacher comments or discussions with older pupils GCSE and A-level classes. One possibility of how stereotypes could affect girls' choices is offered by Greg:

> "*If a girl is living with a stereotype that Design Technology is for boys.. and she doesn't do too well.. it doesn't really matter because it fits within the stereotype… So, she's not ever expected to achieve because she was never expected to from the beginning. So if she does well, great.. but if she doesn't, no one's going to bat an eyelid about it. With a boy however, they might think, "well, I'll just do it anyway because I enjoy doing the subject."* (Greg 41:27).

He describes "living with a stereotype" which implies a pervasive concept that extends beyond the classroom. His interpretation of the mechanism by which stereotypes affect choices relates to the attainment value of the subject; the gender imbalance provides girls with a justification for poor performance and an acceptance of failure which can be internalised into their self-concept and, in turn, influence their future educational choices. This mechanism involving self-concept is supported by the literature (Chow & Salmela-Aro 2011). The difference in response between Mike, Jake and Greg to inequality in D&T numbers at GCSE level in their schools is interesting; Mike seems to have accepted societal norms without question, Jake is aware of an effect and Greg is able to identify a likely sequence of steps that girls may take in response to those same norms.

The small sample suggests that the direct stereotype threat effect for younger girls in D&T can be ignored. It does suggest that there may be potential harmful effects of single sex interventions in coeducational settings; this was not explored in depth in the literature and may need further investigation. In terms of teacher perceptions there are two related findings that have value:

In each of the interviews, teacher gender was raised by the participants as a possible factor in influencing the choices of pupils. The literature describes how teacher gender can affect pupils' choices through role model effects (Sansone 2017), the reinforcement of stereotype threats (Watson et al. 2014), teacher-pupil relationships (Paredes 2014) and through more subtle biases that affect behaviour (Elstad & Turmo 2009). Mike sums up one argument for teacher gender having an impact on the enjoyment of the pupils in their classes;

> "*I think it has to be questioned whether as a male teacher, subconsciously you make decisions about what is interesting and exciting purely because you are male, and you have a particular area of interest. I think it's very difficult to put yourself into another person's shoes, let alone another person's gender, and look at it from another point of view*". (Mike 9:16).

This inability to fully understand another's perspective was evident in each of the male teachers' accounts of their surprise at least one girl selecting GCSE D&T. Whether male D&T teachers are genuinely less able to recognise whether girls are interested in the subject should be questioned. It may be that all teachers, male and female, will miss recognising a pupil's interest within their normal teaching practices and so be surprised when a particular boy or girls opts for the subjects at GCSE. It may be that only male teachers were willing to admit to this oversight. The interview may have led the male teachers to consider girls' choices more carefully than they had done before. It may be that more girls than boys are less likely to express their interest openly in classes. Whatever the mechanism at play, this potential blind spot suggests that training initiatives could be helpful to support D&T teachers, and men especially, to identify pupil interest in the subject.

Thom, Pete and Kate all questioned the impact a male or female teacher could have on the pupils' perceptions of the subject. Each presented their thinking as a hunch or a question rather than with a secure sense of an effect. Their uncertainty is understandable; as they are unlikely to have seen more than a handful of different D&T teachers and so were not confident in making any claims.

> "*Can I ask… however much the teacher is aware and is trying to push the subject and be fair and balanced and open minded and professionally proper, how much is the fact that you are taught by a man to do D&T… just that primal instinctive thing… or a woman to do Art, how much*? (Thom FG1 51:51).

In a focus group this topic generated a brief discussion where Kate, the head of department, seemed to correct Lynn, an early career teacher, on the impact of teacher gender. Bree,

another younger teacher, supported Lynn's belief that the gender of the teacher can reinforce stereotypes. Much of the research on the effect of female role models in STEM links closely to concepts of self-identity for girls (Smeding 2012, Eagly & Wood 2012). The argument for role models follows Bree's thinking:

> "*I mean, how can we expect women to feel as comfortable in a subject when they don't have female role models within the school?*" (Bree 44:40).

The problem with role models is the accessibility to the individual's own self-identity (Eccles 2007). Few teachers can act as effective role models because of the difficulties for adolescent girls to identify with them (MacDonald 2014).

Finding 2 *– in this study the female D&T teachers understand stereotype effects very differently from their male counterparts and the levels of understanding for male teachers is highly variable.*

This finding suggest that much more could be done to support novice, early career and experienced D&T teachers, particularly men, in developing their understanding of the effects of stereotypes. This variation of perceptions about the effects of stereotypes and teachers as role models is supported by the research; Sansone (2017) confirms that, at first glance, the gender of the teacher affects student interest and self-efficacy. This aligns with the impressions of the younger and less experienced teachers. However, once teacher behaviours and attitudes are considered, teacher gender becomes irrelevant. How teachers treat boys and girls in the classroom matter more than the teacher's own gender and this is the focus of the next theme.

Theme 3 – Classroom relationships

Classroom relationships are closely linked to the concept of enjoyment. Enjoyment, or intrinsic interest, is one of the five subjective task values within the EVT model and Eccles suggests that this has the most influence on the choices of pupils (Eccles et al. 1983)[10]. All of the participants, bar Bree, also ranked enjoyment of the subject as the most important factor in pupils choosing a GCSE as shown in table 4-3 below.

[10] Subjective task value: 1. Interest value, 2. Utility value, 3. Attainment value, 4. Relative cost, 5. Prior investments (Eccles et al. 1983).

Ranking	Jake	Greg	Ruth	Pete	Bree	Mike
1	Enjoyment	Passion / enjoyment	Practical enjoyment	Enthusiastic staff	Quality of teaching	Enjoyment
2	Academic pressures (tutors)	Talent / aptitude	Break from academic work	Project engagement	Coursework loading (Art + D&T)	Career paths
3	Parents	Career requirement	Open evening, careers talks	Competitions, trips	Practical confidence	Parents
4	Relationship with teachers	Family, parents	Siblings and friends	Siblings	Academic pressures	Peers
5	Older students	EBacc, Progress 8	Parents own experiences	Parents	Parents	Final allocations

Table 4-4 Ranking of factors influencing choices of pupils (Appendix 2c).

All the participants confidently[11] linked pupils' enjoyment of the subject to the relationship with their teacher; from all the interview extracts, Jake puts it most succinctly;

> "*I think part of this enjoyment is the relationship they build with teacher*." (Jake 17:22).

When we drill down into the perceived differences between the way boys and girls develop relationships with teachers, there are significant differences in the way the women and men teachers describe enjoyment and classrooms relationships.

> "*I think for boys, because I'm a male teacher, I think this relationship with the teacher is massive and I think that was bigger for boys than it is for girls*." (Jake IAT 24:20).

What he seems to be describing is that boys find it easier to identify with a male teacher and that these positive relationships have more of an impact on the choices made by boys. He confirms this by then proposing that the boys tend to base decisions on their relationship with the teacher whereas girls tend to base their decisions on a wider range of factors. According to Jake, enjoyment is less pertinent for girls in their decision making than other factors. This is supported by comments from Greg that suggest that girls are more aware of the utility value

[11] 5 directly linked references between enjoyment and teacher-pupil relationship. Appendix 2h.

of D&T than boys (41:27). This fits with research that suggests that teacher relationships for girls tend to decline in quality throughout secondary school (Eccles et al. 1993, Lazarides & Ittel 2012).

Greg and Jake's thinking does, however, seem to conflict with aspects of the women's reports of their own experiences. When describing their backgrounds, all of the participants' spoke of their motivations to enter the profession. Kate's own enjoyment of her Textiles GCSE was a factor in choosing to follow a degree in teaching D&T and Bree described the positive effect of all her D&T teachers:

> "*And I loved my teacher. That's another reason I did it. I had a teacher called Mr. Woods and he was amazing. And he was so interesting, and he built boats, and he told me about the boats he built, and I thought he was awesome*". (Bree 31:43).

None of the male participants in this study spoke of their own relationships with their schoolteachers at all. This discrepancy between the perceptions of male and female teachers about positive relationships suggests that some training could have an impact. On one hand, the male teachers suggest that relationships are less important for most girls' decision-making and this is supported by some prior research. On the other, the female teachers highlight the potentially powerful role of positive relationships to support girls' decision making and continued engagement in the field, especially within STEM. The key finding is that positive relationships are more important than teacher gender in the decision-making process for pupils (Sansone 2017, Paredes 2014, Elstad & Turmo 2009).

When describing their motivations to teach, Pete refers to redundancy from an engineering firm, Jake describes other vocations and Greg describes a failed industrial design job application. This difference is supported by Wall's (2012) Australian study exploring STEM teacher's motivations for entering the profession. Women tended to report on positive prior teaching and learning experiences as well as intrinsic career value and the desire to work with children. Men in Wall's study also reported choosing STEM teaching as a contingency career significantly more frequently. The implications of these differing motivations become relevant when considering Wall's findings that there is a significant correlation between teaching as fallback career or motivations of personal utility and reports of more negative interpersonal interactions with students.

Negative interpersonal interactions are associated strongly with the way teachers manage a class and teachers can fall into the trap of adjusting their responses for the boys in a class (Younger & Warrington 2005). Not only is a class dominated by boys likely to raise stereotype

threat issues for the girls, but the teacher may use tactics of control and coercion for the boys that alienate the girls (Harding 1997, Withey 2003). Ruth describes the negative affect on GCSE girls of a group of poorly behaved boys that "waste my time and theirs".

> "*The girls are not responding too well to being in a group of boys that moan and complain a lot… They just get put on the back burner because I have to deal with the attention seekers*". (Ruth 35:47).

This supports Younger and Warrington's findings that boys dominate classroom interactions but not those that support learning (2005). Managing these attention seeking boys requires a range of strategies and Greg describes one approach that he has developed with some of the 'lads' in his classroom.

> "*I guess, as a teacher… you are dealing with a bunch of boys that act like a mob, and therefore you become the chief wolf of the pack. You don't become their friend; you make it quite clear that from the start that you are the chief wolf and you'll bite them … and [over] time they want to work for you. Now that mentality is great if you want to get a result out of 15, slightly disenfranchised, rowdy, rugby lads but, as one or two girls in the corner it doesn't work very well at all. So, we are kind of, maybe, instrumental in their decision-making and... we might have ourselves to blame in that respect*". (Greg 18:51).

As well as Greg's 'chief wolf' analogy, Thom makes the following assessment of the impact of positive and negative relationships on girls' choices;

> *"If you are pretty and nice and lovely first off. And clean and easy. They don't want somebody who's going to be… ugh. And if I jump down your throat because you've forgotten your ruler; I think that counts massively with them on their choice*" (Thom FG1 43:14).

Finding 3 *– Participants suggest that the intrinsic value and enjoyment plays an important role in pupils' decision making but that many girls are negatively affected by dominant boys and teachers' controlling behaviour management strategies.*

This study provides further insights into behaviour management and negative interpersonal interactions with Jake's recorded lessons. The significant[12] proportion of Jake's interview allocated to behavior management is likely a result of the reflections he made whilst watching his own teaching of these lessons in the video stimulated interview. Before the recording Jake's perceptions, supported by comments from Thom and Greg, were that boys and girls prefer different behaviour management approaches:

> "*I think the girls are looking more for who is friendly and the boys are looking more for who is strong*". (Jake IAT 24:38).

When comparing the girls-only and boys-only lessons the focus of the paired video observations and discussion turned to behaviour and the management of that behaviour. Jake managed the behaviour of boys and girls quite differently; in the opening minutes of his lesson with a girls-only group he uses tone and phrasing that could be viewed as humorous but also patronising or even sarcastic:

> *00:43 Ye-es, your iPad. (quietly to one girl). Ahhh. (when she moves to fetch the iPad).*
> *00:57 Ladies, hurry up please.*
> *1:02 Abbie, stop having a conversation and come back over here please. (loud)*
> *1:08 Buttons done up on the jackets, they don't work well if you leave them undone. The idea is that they cover your clothes; magic.* (Jake VSI1).

With the boys-only group set there was much more direct instruction:

> *00:06 Quick quiz on your iPad as soon as you get in. Just leave that alone.*
> *01:26 Gents, you should be working on a quick quiz. Shh. Nick, sit down (loud).*
> *01:35 You should be doing a quick quiz right now. Nobody should be doing else. You shouldn't be reading your emails.* (Jake VSI2).

In Jake's recorded lesson with the girls-only group, the pupils entered the classroom noisily but responded immediately to Jake's instructions and were all engaged with the test within two minutes of the lesson starting. In comparison, the boys took almost twice as long to settle, and Jake had to repeatedly tell the group to be quiet (ten times in the first four minutes) and he

[12] 8.1% of the references in Jake's interview related to behaviour. Appendix 2d.

responded at length to three interruptions. Despite this conspicuous difference in behaviour at the start of the lessons between the boys and girls, Jake makes a judgement based on the first few seconds only:

> "*There's no difference [in behaviour] there. But the boys are more likely to come in and just be in a world of their own, quietly. The girls are more likely to come in noisily*". (Jake VSI1 07:33).

The difference between his assessment and the video evidence demonstrates how the VSI approach can provide a useful tool for coaching in a model of professional development (Kennewell et al. 2009). The coaching model is based on recognising and discussing differences between perceptions, observations and concepts. Jake's reflections support findings that teacher's perceptions of behaviour are not always reliable (Hook & Rosenshine 1979) even when confronted with evidence. This study was not designed to coach the participants and so to minimise conflict this contradiction was not challenged in the interview. One possible reason for Jake's response may be that he was attempting to draw attention away from his classroom management strategies for fear of looking less effective. This may have been an unfortunate effect of an unbalanced power relationship between interviewer and interviewee (Chavez 2008).

Reports from the female teachers about behaviour management also tend to focus on the boys:

> *"Power is interesting. Because a lot of young boys that I teach do not like being told off by a female member of staff and they will react very differently if they are being told off by a male member of staff*". (Bree 6:28).

This matches research that shows boys have a higher tendency to be stressed when challenged by female teachers due to a clash of perceived gender stereotype roles (Elstad and Turmo 2009). In summary, the participants perceive that the behaviour of some pupils, primarily boys, and the management of that behaviour, primarily negative strategies, affects the intrinsic value and enjoyment of others, especially girls, to such an extent that it influences their choices. This suggests that behaviour management strategies could become a more important part of supporting equitable choices than the literature suggests. These negative behaviour management strategies are associated most strongly with male teachers that report on their teaching as a fall back career. Behaviour management strategies for women teachers are equally pertinent as they can clash with pupils' perceptions of gendered social roles. Jake's example suggests that video feedback and coaching have an important part to play in developing behaviour management strategies of teachers as perceptions are resistant to change.

These findings would also suggest that single sex D&T initiatives have the potential to support gender equity and yet the evidence from the previous theme shows that conditions for such initiatives are precarious. Perceptions of teachers to such positive action initiatives are discussed in a later theme.

Behaviour management is only one aspect of a positive teacher-pupil relationship. The relationship also depends on whether teachers listen to pupil ideas, whether they make their subject interesting and whether they think that every student can be successful (Sansone 2017). The latter point is closely associated with the beliefs of D&T teachers about the stereotypical gender roles and is explored in the next theme, teacher's models of society.

Theme 4 – Teachers' models of society

Sansone's (2017) work on teacher gender includes findings that suggest that teachers' prejudices and discriminatory behaviour harm both male and female pupils by affecting their confidence and enjoyment in STEM subjects. Jake, Greg and Pete all suggest how societal stereotypes of engineers as "middle aged men with dirty lab coats shuffling around laboratories" (Greg 18:51) and "people messing about with cars" (Pete 37:30) can be detrimental to the development of a strong self-concept as an engineer for girls. Girls show more interest and higher self-efficacy when their teachers believe that all students can be successful in the field.

In order to explore the beliefs of teachers about the potential of their pupils to succeed in STEM fields the participants were asked to take the Gender-STEM Implicit Association Test (IAT) and discuss the results. Although the purpose of the IAT was primarily to stimulate discussion, the results for each of the participants are shown below with comparisons to the general population (Greenwald, Nosek & Banaji 2003).

IAT level of automatic association of male with STEM and female with liberal arts.	Participant[13]	Percentage of all participants with each score internationally
Strong	Jake, Mike	26%
Moderate	Ruth	28%
Slight	Pete, Greg	18%
Little / None		18%
Slight negative association		6%

Table 4-5 Participant IAT results vs general population.

There were two quite different participant responses to being informed of the their IAT results. Greg and Jake saw the test results as a reflection of existing societal norms rather than a measure of their personal opinion. They both pinpoint the concerns about the external validity of the test (Arkes & Tetlock 2004, Rothermund & Wentura 2004, Hinton 2017, Surowiecki 2004) and Jake describes this well;

> "*Part of this is that the majority of engineers **are** men so you are associating engineering with men… so mathematically that would make logical sense. It doesn't make it the right thing to do*." (Jake IAT 3:50).

On the other hand, Mike and Ruth interpreted their results as a personal failing. They both seemed disappointed by their score and were very quiet after the results were shared before eventually discussing their feelings:

> "*I'd like to think that I didn't associate men with engineering. I'd like to think that I didn't give that perception to my students*." (Ruth 00:25).

> "*I thought I'd have a more open mind to these things, but clearly my automatic, instant response proves differently*." (Mike 00:52).

Although the results were interpreted quite differently by the participants, the IAT did provide a break in the interview for all participants and provided the desired cognitive dissonance that then prompted an in-depth discussion of stereotypes, inequalities and bias (Brophy 2004).

[13] Bree did not record an IAT score as her response times and key hits fell outside the parameters of the test. Her explanation of this is explored in the LGBT section.

Three interesting features of the participants' responses were identified when exploring stereotypes that related to faith, biology and LGBTQ+ issues. Although faith and LGBTQ+ issues were not prominent in the literature review, biological sex differences were identified as a potential source of edumyths and stereotyping. This gender essentialism is viewed as outdated (Spelke 2005, Skewes, Fine & Halsam 2018); attempts to understand and tackle gender equality in STEM requires more nuanced bio-psychosocial understandings (Halpern et al. 2007).

The aim of exploring perceptions of teachers is to generate understandings of gender equity in D&T and the foundational beliefs that give rise to those understandings. Jake's responses to questions on similarities and differences of pupils, were often very confidently delivered. In exploring this, he divulged the importance of his faith in providing the framework for his beliefs on gender and sex. The following quotes are offered in a sequence that represent a logical argument rather than the chronological order of the interview.

> "*I mean biblically, I've always had… part of my faith has been that men and women are different. Equal, but different, and different in a way that complement each other*." (Jake IAT1 27:07).

> "*So inherently boys and girls are completely different so therefore will be able to do these subjects differently. Should we not just be happy with the number of boys and girls that do the subject?*" (Jake IAT1 51:39).

> "*There is no benefit for society, or humanity, by having more women in engineering and more men in medicine*." (Jake IAT1 39:31)

> "*Just because I know what the outcome is going to be doesn't mean I don't give them a fair opportunity to do what they want to do. Whether they end up doing it or not is irrelevant to me*". (Jake, IAT1 25:30)

Jake's logic can be traced back to his fundamental beliefs about the differences between men and women. He justifies his approach to teaching in terms of providing equality of opportunity but openly accepts an indifference to any inequality of outcome.

Greg also uses the phrase, "let them do what they want to do" (3:20) and there are other similarities between Jake's and Greg's responses; both present opinions that align with gender essentialism (Skew, Fine and Haslam 2018). Jake's absolute certainty about different traits of boys and girls is reinforced by his explanations of biological differences. Bearing in mind that

he studied Biology at A-level before embarking on his engineering degree; the following comment is not surprising.

> "*I just ignore gender because it's frustrating and annoying… any difference is down to sex and at that point it is irrelevant because it is not a cultural construct. It's a biological likelihood.*" (Jake IAT 6:02).

Greg presents his beliefs indirectly as a series of questions; two examples are shown below:

> "*People should be allowed to make decisions but also there is a certain nature/nurture thing going on. Is it natural for boys to want to like electronics and taking things apart? Is it natural for girls to like being creative and doing things like that? Maybe*." (Greg 37:31).

> "*Can we as teachers influence this… or are we trying to meddle with nature in that respect*?" (Greg 4:53).

Greg and Jake's comments mirror the infamous Lawrence Summers' speech (2005) at Harvard denying the effects of socialisation on the differences between the performance of men and women in maths and sciences. There was a public backlash to that speech, but this study suggests that teachers can hold similar beliefs privately without question. In his use of questions, I sensed that Greg was being rather guarded about his responses and disguising potentially socially undesirable beliefs (Rutland et al. 2005). His wariness is explicitly outlined here:

> "*We get into a situation where everybody's just so scared to say anything for fear of offending anybody that nobody does anything, it's getting ridiculous*." (Greg 27:37).

Jake extends his discussion on equality of opportunity and outcome by referring to reports of recent research on the gender-equality paradox (Stoet & Geary 2018). This research explored the phenomena where countries with high levels of gender equity have some of the largest gender gaps in secondary STEM education. Jake's interpretation of the paradox is outlined below:

> "*You have to decide which equality you want. Do you want equality of outcome where you end up with 50% of engineers male or do you want equality of opportunity where you give everyone the choice as to whether they want… which*

involves removing the societal pressure and then you just watch and see what happens? What happens must therefore be biological." (Jake IAT 15:59).

This interpretation simplifies the complex interactions between cultural norms, societal pressures and biological differences. Jake's phrase, "removing societal pressure" relates to high levels of gender equity in this country but he discounts the effect of wealth on reducing the utility value of STEM subjects. Stoet and Geary (2018) discuss at length the additional effect of intra-individual differences on the subjective task value of STEM subjects. Although girls may collectively outperform boys in STEM subjects, their self-concept includes judgments of their performance in STEM subjects against their performances in all other subjects. This includes subjects that rely on reading and comprehension where, in general, girls perform even better, partly because of earlier gendered socialisation. Boys, on the other hand, have an academic profile where their best performances tend to be in STEM subjects similarly affected by socialisation; even though they may well perform at a lower level than girls. This performance feeds the boys' self-concept and expectations for success, which in turn feeds into the decision to follow STEM subjects. Jake has latched onto the headline of the study as it reinforces and confirms his belief that differences between the behaviours and choices of boys and girls are biological whilst ignoring the socialisation effects on the subjective task value, intra-individual differences and utility value of STEM.

Just as Jake's faith will inform his practice, so too does this gender essentialism. There is evidence from observations of his lessons that he challenges boys and girls differently (see Theme 3, Classroom Relationships). Although he presents his approach to teaching as one that provides "equality of opportunity" (Jake 34:15), his practice includes subtle variations that reinforce stereotypes including dismissing the poor behaviour of boys (VS1 1:08) and patronising girls (VS2 1:35). These behaviours can be traced back to his fundamental beliefs about gender.

Bree talked extensively[14] about gender in society; as an openly gay teacher her understanding of the role of a teacher was especially interesting. In comparison to Jake's firmly held beliefs about gender's close link to biology, Bree approaches the issue from a very different angle:

[14] 13.1% of the references in Bree's interview related to gender in society. Appendix 2d.

> "*Oh, that test; ridiculous! Completely ridiculous. I struggle when someone tells me to put something into categories or assign roles to specific genders… I just couldn't get down with it, I couldn't understand it*" (Bree 11:03).

Bree's understanding of society is firmly based on a model of equality and not just equity. The stance she adopts throughout the interview is that she is a teacher of both D&T and the whole child.

> "*If you're a teacher you're there for their education way outside of your subject. We're teaching them* ***facts*** *about D&T … but we're also teaching how to be a decent human being*". (Bree 22:20).

She presents her approach to teaching as working alongside her pupils to realise a more equal society (Corson 2001) and this influences the way she deals with professional boundaries and concerns about equity. Although she is approaching the issue of unequal numbers of girls in D&T and engineering from a different angle to Pete, there is a close alignment of their practice, professional behaviours and relationship with pupils. Pete's role as the head of D&T in a single sex selective STEM specialist academy is unusual. He brings a passion and energy to organising a wide range of initiatives that are deliberately and explicitly designed to encourage and support girls in STEM. Pete and Bree are both committed to teaching the facts of D&T but also actively driving for a more equitable society in D&T and STEM.

If Jake and Greg's gender essentialist beliefs are compared to Bree and Pete's social constructivist viewpoints it becomes evident that even with this small sample of teachers, the participants bring very different understandings of society to their role in tackling gender inequalities.

Finding 4 *– participants actions are informed either by gender essentialist beliefs based on understandings of faith and biology or social constructivist beliefs.*

These findings suggest that gender essentialism influences teaching practices and needs to be tackled. Just as work is being conducted across the UK with teachers to dispel neuromyths (Macdonald et al. 2017, Geake 2008) there is a place to tackle gender essentialism through professional development.

This study offers a suggestion of how that professional development could take place. The IAT provided a window onto the fundamental beliefs of the participants' that informs their professional identities and teaching practices. Although the IAT provided the conditions for the participants to share their beliefs it does not, on its own, challenge them. The video stimulated

interviews did, however, provide an opportunity to examine and challenge teaching practices This project was not designed to directly challenge the participants but the pairing of the implicit association tests and lesson videos do hold the potential to develop more equitable teaching practices through professional development. Any discussions about faith and gender are likely to be sensitive as they operate at the very heart of a teacher's professional identity. Coaching is an ideal tool to work with such beliefs (Kennewell et al. 2009). Raising these topics as part of any professional development raises ethical questions. There is a need to weigh up the potential harm inherent in challenging teachers' beliefs with the potential harm that those belief systems could have achieving gender equity.

ITT providers and those delivering the new Early Career Framework have a role to play in exposing and discussing these beliefs. This study only covers D&T teachers but there may well be a place for this work to be conducted with the wider STEM educators and could even be justified as important for all teachers. It is not just D&T and STEM teachers that providing guidance and advice to pupils. The findings of this study suggest that gender essentialist beliefs are to be found in both novice and experienced teachers. School leaders have a similar role to develop a culture in their schools that celebrates gender equity.

Theme 5 - Professional boundaries

This theme was drawn out of some of the more animated sections of the interview and focus group sessions but was not identified in any of the prepared questions or the literature review. Professional boundaries were the most widely referenced[15] aspects across all the interviews and female participants spoke almost twice as frequently[16] about professional behaviours as the male teachers; table 4-5 shows the relevant section of the matrix cross referencing participant demographic with other themes. Rather than being a feature of gender differences this may have more to do with the proportion of younger women in the sample. Younger teachers discuss the issue of professional behaviours significantly more frequently[17] than the more experienced teachers, probably because they are still developing their craft, their understanding of their professional status and questioning their roles in their schools. The fact

[15] Professional behaviours 141 references. Appendix 2n.
[16] Professional behaviour coverage for female participants 8.4%, make participants 4.9%. Appendix 2f.
[17] Professional behaviour coverage for teacher NQT to 2 years 7.7%, 3-5 years 9.6%, 6-10 years 3.4%, 11-25 3.6%. Appendix 2f.

that the Computer Science and Art teachers spoke more about the professional behaviours[18] is a reflection of the lively discussions in their focus group interview.

	Male	Female	Experience = 0-2	Experience = 3-5	Experience = 6-10	Experience = 11-25	Design and Technology	Computer Science	Art
Professional behaviours	4.9%	8.4%	7.7%	9.6%	3.4%	3.6%	5.6%	14.5%	13.2%
Teacher background	1.3%	3.7%	2.5%	4.1%	0.9%	1.7%	2.4%	0.0%	0.0%
Teacher pupil relationship	2.0%	1.0%	1.4%	2.2%	1.7%	1.7%	1.4%	2.2%	10.3%

Table 4-6 Participant demographic and code matrix, teacher effects only (Appendix 2f).

Two aspects of the Professional and Personal Conduct section of the Teacher Standards (DfE 2010) are raised in the interviews. Participants highlight a potential conflict between the need for teachers to "understand and always act within the statutory frameworks" whilst also "ensuring that personal beliefs are not expressed in ways that exploit pupils' vulnerability". The statutory framework in question is the Equality Act (2010) which clarifies the legal status of positive action, "allowing schools to target measures that are designed to alleviate disadvantages experienced by, or to meet the particular needs of, pupils with particular protected characteristics" (DfE 2014 p6). The Equality Act also describe how positive discrimination applies if girls or boys are unable to access all the curriculum.

Most of the discussions about professional behaviours were based on the approaches to, and mechanisms of, influencing the choice of pupils. Most participants were very aware of their potential to influence students and the responsibilities inherent in that role:

> "*I was always trying to tell them how it was important as a subject and how they should consider taking it and they should be ignoring any stereotypes they have or what have you. Never actually spoken to any of them individually. I don't consider that to be… I don't know… I would not like to … I'm sure I wouldn't come across like that… but I would not like to unduly influence something that they may regret.*" (Doug FG1 1:00:03).

[18] Professional behaviour coverage for Computer Science 14.5%, Art 13.2% and D&T 5.6%. Appendix 2f.

Doug's hesitation represents a concern about speaking to individual pupils. This concern about professional boundaries was raised by many of the other participants; Jake describes individual conversations as "unfair" (FG1 1:01:02), Cole is concerned that pupils could be "flattered by the adult interest*" (*FG1 1:02:41) and Lynn suggests this would "add pressure" (FG2 1:02:42). Kate suggests that individual conversations are acceptable if pupils seek out the teacher for advice (FG2 36:11) but Bree was the only participant who openly described encouraging an individual;

> "*I just convinced a girl last week, a great kid in my year nine set, she wasn't going to take the subject next year. And I just said, "you are a natural born, you're brilliant at this subject. Why are you not doing it?"* (Bree 7:42).

When questioned about this overt encouragement to follow the subject, Bree clarifies that she makes an explicit effort to try and recruit all good students, not just the girls. She also justifies her responsibility to tackle gender inequality by referencing the teacher professional standards indirectly:

> "*I mean nobody wants to foist their own agenda, political or otherwise, on a group of impressionable young people but at the same time, I don't think I'm foisting my agenda on people. I think I am speaking up for what society wants to become, and should become, and is in the direction of becoming*" (Bree 45:27).

Even with such powerful convictions Bree expresses an internal conflict about the professional boundaries associated with gender equality:

> "*Is it professional to let yourself become so connected with the pupils that you influence their social and moral fibre? Which is essentially what I think we should be doing in a way. But then it's maybe pushing the boundaries too much?"* (Bree 19:45).

Another young teacher, Ruth, is also uncertain about what she can and cannot say to pupils. She talks about feeling uncomfortable, trying to avoid things becoming political and even admits that, "I don't know what's OK to do" (Ruth 37:21). Jake, however, has a much clearer idea of where his professional duties start and end. Here he seems to use the classroom as a way of defining the scope of his involvement.

> *The way I am going to teach in the classroom is for equality of opportunity so that all of my students have the opportunity to go into engineering,* ***if they want to****.*" (Jake 34:15).

Greg presents his opinion on professional boundaries relating to gender stereotypes through questions; he seems to recognise that his beliefs may not be typical. His questions hint at the limitations of his professional responsibility and indicate that he is not comfortable tackling stereotypes with pupils;

> *"Is it incumbent on me to dispel all those [stereotypes], as a teacher? Or am I just getting the best out of my students because that's what they want to do and I'm helping them achieve that?"* (Greg 3:20).

These very different approaches from the participants is understandable; they have all come into teaching from different routes and all have different motivations for their role. A wide spectrum of understandings about the professional duty of teachers to deal with equality is found in this small sample of D&T teachers. Bree and Pete are teachers that present a strong sense of their role as educators of the whole person; actively encouraging more women in STEM and talking to parents and pupils about gender inequities. Not only do they understand how positive action can work with regards to gender and STEM, but they provide examples of how these are enacted in their daily professional lives. Bree even admits that her belief in equity occasionally means that she comes close to stepping beyond acceptable professional boundaries.

On the other hand, Greg and Jake provide a clear rationale for a more limited approach that maintains equality and avoids compromising their professional standing. They constrain their input to the classroom, avoid individual encouragement and the potential to influence vulnerable pupils. This belief in their professional role is presented as one that is neutral. An alternative perspective is that they are using one professional conduct standard to justify their reluctance to follow another, their legal duty to support positive action. There are indications in many of Greg and Jake's responses show that they are not just uncomfortable about interfering with societal norms but believe that the low numbers of women in engineering represent a natural phenomenon. To these teachers it seems that there are differences in the relative weighting of these two teacher standards. The professional conduct requirement to reign in beliefs to avoid influencing vulnerable pupils has more weight, or at least more relevance to their daily practice, than the professional standard that relates to the Equality Act.

In the centre ground, Kate, Lynn, Ruth and Mike still seem to be searching for guidance about what is, and is not, acceptable when encouraging pupils. They are struggling to align the two professional requirements. Their responses describe a complex relationship between these two demands. Not only do participants' understanding of gender stereotypes seem to affect

that way that they respond to the professional conduct standards but their understanding of the professional conduct standards seem to affect the way that they tackle gender stereotypes.

Finding 5 *– participants' understandings of professional conduct standards and the way that they tackle gender stereotypes are interconnected.*

When discussing positive action initiatives, the equitable inequalities (Tyker 1977), many of the participants express concerns about how initiatives are presented to pupils. Bree describes a deficit model of single gender positive action interventions when referring to a colleague's girls-only extra-curricular computing course:

> "*If they can see that there are just girls around, do they think that they're lacking in some way*?" (Bree 47:11).

The perceptions of other pupils are just as difficult to manage which is why Mike no longer runs single gender support sessions.

> *"At one point we did have a lunch time girls DT group. But I'm not 100% sure about whether that is discrimination. The uptake for that was good but at the same time we had the boys saying well 'how come we don't have a boy specific one?*'" (Mike 6:05).

In the school where Jake, Doug, Thom and Cole work, their subjects are taught in a carousel which allows girls and boys to be placed in separate sets. In this positive action initiative teachers are encouraged to make the reasons known to pupils. Here Doug recalls how he presented it to an all-girls set:

> "*I openly stated in the first lesson, 'look at this, these are the top ten university courses in the country, three of them are Computer Science, it's far too important to be left to smelly teenage boys!'"* (Doug FG1 47:31).

At the same time as supporting this positive action initiative Doug is conscious of the previous debate about encouraging individual pupils and makes the following statement;

> *"A one-to-one conversation could be positive discrimination or potential favouritism.*" (Doug FG1 1:00:03).

Mike and Doug both reveal some confusion between positive action, the legally acceptable encouragement of protected characteristics and positive discrimination, the unlawful practice

of selecting a candidate because of a protected characteristic. Five of the participants used the term positive discrimination at some point in the interviews when they were describing positive action.

Finding 6 *– Participants reveal confusion between the legal responsibilities of positive action and discriminatory practices.*

This confusion suggests that any positive action interventions that involve single gender teaching need to be carefully planned, employ the correct terminology and explicitly tackle any possible confusion with positive discrimination. If we extrapolate from this small sample it is not surprising that there is a perception that teachers vary considerably in what they deem to be acceptable when encouraging pupils. Various reasons are suggested why teachers influence pupils:

- Kate describes how senior leaders are thought to influence pupils based on the EBacc or staffing demands (37:10).
- Greg describes how teachers portray their subject to pupils as, "more useful for their future studies than D&T" (10:15).
- Thom believes that it is "immoral' for teachers recruit pupils to their subjects to increase numbers (FG1 1:01:05).
- Jake uses the term "propaganda" to describe how teachers to attract pupils to their subject area (IAT 29:46).
- Ruth describes how recruitment can also be about prior attainment;
  "*I feel like people try to poach certain students for their own subjects which I understand... you want to have the best cohort don't you*?" (Ruth 10:52).

Finding 7 *– Participants suggest that there are unprofessional teacher behaviours associated with the encouragement of pupils that do not place the interests of the pupils first.*

None of these accusations are backed up with any evidence but there is a perception that competitive recruitment is prevalent in all the schools. There is also a possibility that the participants are unwilling to admit to using these tactics themselves because they recognise the behaviours as bordering on the unprofessional. The "fine line between encouragement and influence" (Greg 37:31) is one that needs to be borne in mind when planning a positive action initiative to talking to pupils after a lesson; teachers, parents and pupils will have quite different perceptions about the acceptable scope of any intervention. Some parents involved in the WISE 'People Like Me' initiative noted that there was an element of a 'hard sell' (Herman, Kendall-Nicholas and Sadler 2018) and this is echoed in an anecdote from Cole;

> "*A friend of mine at university thought the way that people were trying to engage her as a Computer Scientist was bit um… "hey, there's a lack of girls, here's some money". And she didn't really appreciate that because it wasn't really assessing her skills even though she was talented*." (Cole FG1 49:08)

Although Cole's description is second-hand, it does present a sensitivity to the way positive action initiatives, guidance and encouragement are offered and the way that they can be perceived by the target groups; a heavy-handed approach can be off-putting.

The three findings identified in this theme; confusion about positive action definitions, the reciprocal relationship between gender stereotypes and professional conduct standards and unprofessional encouragement are not covered in depth in the literature on STEM. Not only could more research be carried out in this area, but more could be done relatively quickly by school leaders in their schools to encourage discussions about professional boundaries, acceptable forms encouragement and positive action initiatives.

As with all the themes covered so far, there is a suggestion that teacher training institutions and professional development programmes also have a role clarifying professional boundaries and positive action with novice and early career teachers. Professional boundaries are not limited to D&T or even STEM subjects, although these are inevitably subjects where positive action initiatives are employed. The next pair of themes also look beyond D&T teachers and explore the external influences of families and school structures.

Theme 6 – Family guidance

This theme includes the participants' perceptions of how parents and older students, including siblings, influence the choices of their pupils. Parents were mentioned frequently [19] throughout all the participants' interviews and consistently across participant gender and experience[20]. The only significant variation arose between participants working in independent, academy and maintained schools as shown in the extract of Appendix 2e in Table 4-7 below.

[19] Parents mentioned between 2.9% and 9.2% as coverage in interviews. Appendix 2d.
[20] Parents mentioned in 6.9% of male participant interviews and 7.4% of female. 7.3% coverage in all experience categories. Appendix 2f.

	Independent	Academy	Maintained	Selective = Yes	Selective = No	City	Town	Rural	500 - 749	750 - 999	1000 - 1249
Parental influence	7.5%	9.2%	4.7%	7.8%	4.7%	8.4%	4.7%	6.4%	5.6%	8.9%	7.3%
Peer influence	1.0%	0.0%	2.1%	0.8%	2.1%	0.3%	2.1%	2.1%	2.1%	0.0%	0.8%
Siblings and older pupil influ	0.8%	0.0%	2.5%	0.7%	2.5%	0.5%	2.5%	1.1%	1.8%	0.8%	0.0%

Table 4-7 Participant demographic and codes, family factors. Appendix 2e.

Parents were mentioned twice as often by teachers working in independent and academy schools. Not only are fee-paying parents more likely to be closely engaged (David 1997, Allard 2005) but the selective nature of the more likely to be invested in their children's education. Greg has taught in both independent and state schools and in reflections on differences in parental discussions he describes how fee-paying parents are "slightly more eloquent" (17:31). This eloquence makes it more difficult to judge whether parents are being truthful or diplomatic in discussions. This 'eloquence' is just one representation of cultural capital (Lamont & Lareau 1988).

When asked to rank the influences affecting the choices of pupils, parents were not seen as the most important factor[21] but were included by all the participants. Eccles' longitudinal studies demonstrate how parental gender-role stereotypes of ability and interest in STEM subjects influence their children (Eccles et al. 1983, Eccles 2015, Eccles, Jacob & Harold 1990). Both Bree and Jake share an understanding that pupil-parent relationships are complex and that the level of influence varies considerably across families:

> "*My sense is that with parents' views, that it's accepted… or it's completely disregarded and pupils will do the opposite*". (Jake IAT 16:50).

Often parental influence was perceived to vary according to pupils' prior achievement; this matches Eccles findings (2015). Doug, Mike and Jake all describe how students with strong academic grades are often guided quite forcefully by their parents.

[21] Appendix 2c. Teachers' ranking of factors influencing choice.

"The more able students, who quite often have more parental pressure, have their decision skewed… by more practical choices". (Mike 15:06).

When unpicking the mechanisms of parental influence, the participants often referred to gendered misconceptions of D&T based on parental experiences of the subject from three or four decades ago.

"*I think it stems from parents a little bit. Back in the woodwork, metalwork era… that's fed through to their children who then think they're going to be doing woodwork and metalwork. But really it's not like that anymore*". (Ruth 14:10).

"*I've heard Year 9 girls saying, 'isn't DT a boys' subject?' And I think that's from the parents. I would be 98% sure that's from the parents."* (Jake VSI2 28:30).

Research suggests that girls with parents in STEM careers are much more likely to follow a similar path (Holmes et al. 2017, Eccles 2015) and conversely, girls receive little support for pursuing STEM careers from non-STEM parents (Lloyd et al. 2018). Only Greg referred to parents in STEM or technical design careers although all the participants recalled examples from parent evening meetings where gender-role stereotypes were combined with historical misunderstandings of the subject. The following example demonstrates how the transmission of gender stereotypes can work within families but it also reveals the teacher's role in reinforcing such stereotypes by relaying the description without question or concern.

"*Parents can influence their decision in a negative but also in a positive way. Parents who come from that sort of background. Whether it be in their jobs or whether it be just something that they're interested in. Quite often you have pupils whose dad, uncle or grandfather makes this in his shed or makes that in his garage and he's fostered an interest in it from an early age and what not. And they want to carry that on*". (Greg 13:59).

Bree describes how parents can influence behaviours at school in more subtle but pervasive ways that reinforce gender-role stereotypes; her descriptions fits well with many other commentaries on gender (Fine 2010, Eccles et al. 1983).

"*I have this theory that when we're younger, our parents put our gender on us so specifically… from day one…. Boys are given stuff to pick up and move and play with. And girls are given things to imagine, or dream about, or create stories about and so on and so forth*". (Bree 15:19).

Finding 8 *– participants describe the pervasive and powerful effects of parental influence on limiting pupils' choices.*

This finding is not surprising and is matched by evidence from a wealth of previous research. The way parental influence is perceived by the participants is as a form of blocking mechanism. When parental encouragement is described it tends to be focused on misconceptions about the subject and this theme is tackled separately later. Pete is the only participant who talks about engaging positively and proactively with parents regarding the choices of girls following STEM and D&T. Pete's experiences are covered in more depth in the STEM theme and provides encouraging similarities with the model of parental engagement suggested in the 'People Like Me' campaign (MacDonald 2014, WISE 2017, Herman, Kendall-Nicholas & Sadler 2018).

Just as parental influence is supported by the literature, the influence of peers is covered at length. However, most[22] of the participants rarely mentioned peers and certainly did not rate this factor as particularly important[23] in pupils' choices. Ruth offers one possible reason for this reluctance of teachers to put any weight on peer pressure:

> "*It sounds so silly doesn't it? To choose a GCSE on what your friends are doing*". (Ruth 32:25).

This contrasts with theoretical and empirical studies that show how peer influences are a strong predictor of girls continuing in STEM education (Herzig 2002, Robnett 2013, Leaper 2015). Peers are important communicators of gender-role norms (Kessels & Hannover 2008) and STEM self-concept is closely linked to conformity for adolescent girls (Wentzel 1998). Peer influence is suggested as more important for girls as teacher relationships tend to decline in quality after transition to secondary school (Eccles et al. 1993, Lazarides & Ittel 2012). This is supported by Greg:

> "*Girls are quite a lot more influenced by their peers*" (Greg 39:52)

[22] 3 participants never mentioned peer influence at all, no participant mentioned peers more that 5% of their interview. Appendix 2d.
[23] Peer pressure was only identified by 2 of the 8 participants and even they never rated it above 4th in their ranking. Appendix 2c.

The two teachers who did judged peer influence to be an important factor in the choices of pupils both taught at rural state schools where a more limited range of opportunities and reduced parental involvement could possibly be a factor.

A surprising feature of the interviews was the regularity[24] which the participants mentioned older students and siblings in their discussions.

> "*They tend to like what their older siblings, and their older friends in other years, have taken in the past*". (Ruth 18:01).

The influence of older siblings could be closely related to parental influence but there seems to be a suggestion that there is additional weight to the influence or approval from an older sibling. The way siblings are thought to influence choice are varied and include familiarity with the subject (Lynn FG2 32:06), expectations of success (Ruth 18:11) and through direct advice (Doug FG1 1:17:17). The gender of siblings does not seem to be important and Mike describes how a girl was encouraged by her older brother to follow D&T at A-level (24:32).

The concept of familiarity fits with the EVT model; self-concept requires a pupil to readily identify with the socialiser (Eccles 2011). In many ways, siblings are more suitable as role models than teachers or peers and have the additional backing of parental approval. If a pupil can clearly see what work is being completed by their siblings and recognise the route to success, then they will be more confident in making an informed decision.

In a boarding environment, older students can take on the role of older siblings:

> "*I think [D&T] might be sold by students. I think they talk to the other students in their house. As there are fewer girls in the house who have done D&T, so their opinion is more important*". (Jake VSI2 25:55).

This could be especially important in D&T for girls where Jake identifies that there are fewer older influencers available to Year 9 girls. Jake adds that those potential influencers in may well be experiencing increased anxiety as they tackle their D&T projects (VSI2 12:19). An impasse is recognised whereby the numbers of girls following GCSE D&T is unlikely to change as a primary mechanism to enact change depends on a critical mass of girls following the

[24] 36 references to siblings across all interviews. Appendix2i.

subject. Jake seems to be describing a powerful social reproduction mechanism at work on a local scale.

Finding 9 *- the influence of peers is downplayed by the participants, but older siblings and pupils are identified as powerful influencers.*

Older siblings could merely be compounding the effect of parental influence, but it is likely that there is more involved. Pupils may have more confidence in the suggestions made their older siblings who know, on the ground and directly, what it is like to work with a particular teacher or department Pupils may recognise that their parent's views of a subject are outdated and less well informed. Peers are also unlikely to have any more knowledge about the future than they have themselves. The effect of older siblings and students may well overshadow the effect of past attainment and future career goals as it is immediate, familiar and secure.

It should be possible for departments and schools to do more to harness older students and parents, rather than leaving it to chance. This is the recommendation from a Finnish study into STEM influencers (Ikonen et al. 2018) and CDT teachers from three decades ago (Down 1986, Cattan 1988), yet only Pete seems to be acting on this advice in his school.

Theme 7 – School restrictions

The participants identified several structural aspects of their schools that they felt had a significant impact on the choices of their pupils to follow D&T GCSE. The issue that was raised most frequently, and with some strength of feeling, was the relationship between D&T and Art[25]. The English Baccalaureate (EBacc) was linked to the decline in numbers in D&T in the literature review but this was least frequently mentioned school factor. An assortment of additional school factors were mentioned by the participants with some tentative indications of how these might have an impact on boys' and girls' choices differently. This section tackles the relationship with Art first before the EBacc

general and there are some attempts to describe gendered differences. Jake identifies how creative problem solving in D&T and creative expression in Art can be gendered:

[25] Number of references - EBacc 7, Academic 65, Options 107, Art 111. Appendix 2j.

> "*I would say that girls would consider being creative an art subject… because it's an expression of creativity, of imagination and ideas. Whereas they don't see the application of creativity through problem-solving. And the boys do the opposite*". (Jake VSI1 33:30).

These two different approaches to creativity are described in the literature on engineering design as divergent and convergent thinking (Torrance & Torrance 1972, Adams et al. 2007). Engineers need to employ both models of thinking to successfully solve problems whereas artists are more likely to rely on divergent thinking when producing expressive artwork (Runco & Acar 2019). The DfE's refusal to classify D&T as a creative subject (Fellows 2017) may well be based on these different understandings of creativity as well as the technical components of the subject. Greg and Mike both suggest that aesthetics and expressive arts appeal more to girls:

> "*I think the girls are definitely more swayed, in the main, towards the focus on the aesthetic and making beautiful things rather than the function of a product*". (Greg 21:42).

The relationship between Art and D&T was raised regularly[26] by the participants; not just in terms of creativity but in terms of project-based learning. This is shown in an extract of the participant coding tally in Table 4-8 below.

	Bree	Cole	Doug	Greg	Jake	Kate	Lynn	Mike	Pete	Ruth	Thom	Total
Academic	9	0	0	5	2	1	1	3	1	3	0	25
Art	11	0	4	6	14	2	4	4	4	9	14	72
EBacc	0	0	0	3	0	2	0	0	0	1	0	6
Options and limitations	7	1	3	3	20	14	3	5	5	18	4	83

Table 4-8 Participant code tally, school factors. Appendix 2j.

Participants commented on guidance for pupils in their schools to choose only one project-based subject, often expressed as a dichotomous decision between Art and D&T.

[26] Art was mentioned 72 times across all participants. Appendix 2n.

> "*Regardless of the member of staff, there's a general consensus that says, 'it is a lot of coursework to do'… because usually they do it to stop you doing Art and DT together.*" (Bree 9:50).

When we combine Jake's interpretation of the gendered forms of creativity and the need to decide between Art and D&T, the outcome seems to be an exodus of girls towards Art:

> "*It's such a shame when we lose those girls to Art when they could be so good at DT*." (Ruth 9:49).

Finding 10 *– teachers perceive Art and D&T to be in competition as creative, project-based subjects and that the expressive creativity of Art is gendered in favour of girls.*

The problems that Bree refers to are the perceived difficulties and time commitments for project work. This message was repeated by all the participants and often linked to students with lower prior attainment.

> "*…you might find that tutors try to persuade students to take more coursework heavy subjects if they think they are going to struggle… because their recall wasn't strong.*" (Doug FG1 56:15).

The tendency for pupils to spend a lot of time on their projects can also be a problem for recruitment:

> "*I think the kids love our Key Stage 3… but then, when they realise, when they get options talks and things like that, the thing that people say to them is that it's a lot of coursework so they instantly go, 'oh, I don't want to do that'*". (Bree 7:00).

Kate confirms that the KS3 offering does not always match the GCSE because of the demands of covering curriculum content in a limited time (FG2 18:15). The problem then comes when there is a gap between a pupil's experience and their anticipated workload. This uncertainty will not help in any decision-making process of pupils. The EVT model includes a stage in the decision making based on interpretation of experience. If a pupil has limited previous experiences they will rely more heavily on the input of socialisers; the role model or adult advisors. The participants are suggesting that the inputs from these sources are also limited and the decision-making process becomes more of a gamble than an informed choice.

This is especially relevant for "girls that don't see where it's going to take them" (Greg 46:59). The importance of confidence in the decision-making process was raised in the discussion of

sibling influences and there seems to be a similar mechanism at work here. The perception of the participants is that pupils are more likely to choose subjects at GCSE where they can clearly identify the routes to success and girls are more likely to attend to the information available. Greg is making a potentially significant suggestion that girls tend to weigh up the prior investments, attainment value and relative costs more carefully than boys. This is important when considering the numerous other school-based factors that influence GCSE choices which are covered next.

Participants in the maintained sector suggested that the EBacc and Progress8 measures may be having some effect on numbers and type of pupils selecting D&T but did not relate this to the significant fall in numbers following D&T nationally (OfQual 2017). This may be because the national change has not been widely reported and the fall in numbers that each individual school experiences will be relatively small.

> "*The EBacc affects us… I know that Mike lost one of his students at the very last minute because they were told that wouldn't get into university if they didn't go and do a language… but they don't need EBacc to get into university, it's for the school to be ranked.*" (Kate 38:00).

Kate reveals a potential flaw with the EBacc that is associated with prior attainment and echoed by others. The participants frequently[27] linked their school's guidelines on the options to groups of pupils based on prior attainment. Pete (27:19), Ruth (02:50) and Greg (09:02) all describe systems in their schools that, rather counterintuitively, restricted the GCSE choices of pupils with. The requirement to take a language or humanity was not expected of pupils with lower prior attainment as their likely GCSE scores would not affect the school's EBacc rating.

This logic seems to undermine the reasoning behind the EBacc; pupils with a lower prior attainment would benefit the most from the EBacc in terms of providing opportunities for further study and work. Kate's claim that schools are gaming the system may be valid; responding to the accountability measures rather than improving outcomes for all pupils. However, the effect for D&T seems to be less about excluding girls and more about excluding higher performing pupils. Pete also describes the effect of the EBacc as 'diluting' and 'devaluing' creative subjects, sharing the sentiment of the Bacc to the Future campaign (Adams 2013).

[27] Pupil prior attainment was cross referenced 21 times to options and academic factors. Appendix 2j.

There are several other school arrangements that affect the choices of pupils across all sectors. These include starting GCSEs in Year 9, the limiting effects of option blocks, competition between departments and one school's priority to raise boys' attainment. When the participants' perceptions about pupil guidance are collated the number of reasons not to take GCSE D&T is startling:

Choose Art or D&T, not both.
Choose Art (not D&T) as an expressive creative subject.
Choose D&T (or Art) with non-examined assessments if you have lower attainment.
Choose D&T to provide a break from academic subjects.
Choose EBacc subjects (not D&T) if you have higher attainment.
Choose subjects (not D&T) where the outcome is guaranteed.

These simplifications may well reflect a form of paranoia in the D&T teachers interviewed in this study. The subject has declining numbers and teachers may be defensive and suspicious. One common theme arising out of the interviews is the potential for any misconceptions about D&T held by careers advisors, senior leaders and tutors to be transmitted in their advice to pupils:

> "*It may be that tutors, even with the best will in the world, you think you know the subjects but you don't really*". (Thom FG154:25).

> "*I think a lot of other members of staff don't have enough understanding of our subject."* (Kate FG2 1:06:41).

Whether this perception is completely valid is difficult to judge; many specialist teachers may well claim that their field is misunderstood to protect their monopoly on a field and boost their status. If we take the statements at face value, then the advice and guidance of teachers may well include misconceptions about D&T and these are taken up further in a later theme.

Most significantly for this study is the perception that boys and girls may respond to the guidance from senior leaders and tutors differently:

> "*I think girls might listen to their tutors more than the boys*". (Jake FG1 25:11).

> "*The girls… pay attention to the options talks*". (Ruth 32:40).

Finding 11 *– the participants perceive that other teachers providing guidance to pupils on their GCSE choices are poorly informed, make assumptions about D&T project work,*

*creativity and attainment **and** that more girls are more likely to take on board that advice than boys.*

One way to tackle this could be to help career advisors, senior leaders, tutors to understand how D&T has changed and what it offers (Jake IAT 12:19). The role of the subject association could be vital here; they already provide a wealth of literature to support D&T teachers and communicate with other agencies. The relationship with, and potential competition from, Art are trickier challenges. There is already evidence of D&T textiles teachers using their skills within Art instead (Hughes & Wooff 2013); effectively taking with them large numbers of girls that would have followed a D&T GCSE Textiles route. Rutland (2009) suggests that Art and D&T teachers could collaborate more closely to appreciate and understand the various forms of creativity. This blurring of the boundaries could possibly help address the gender imbalance in D&T. There is also the potential for D&T to redefine aspects of its curriculum yet again to distinguish creativity in craft outcomes from creativity in solving real world problems. This possibility is discussed further in the final chapter, but the next three themes relate to the teachers' perceptions of the pupil characteristics.

Theme 8 – Attainment and failure

The participants spoke extensively[28] about the characteristics of their pupils using numerous examples but also in general terms. There were very few differences[29] in coverage from participants in different school settings. The participants frequently preempted their descriptions of pupils with a stipulation that these were generalisations; as though to separate out their normal practice from the views expressed in the interview. The principle that stereotypes are used to streamline our daily thinking and decisions (Bordalo et al. 2016) was not fully recognised by the participants. Following Bordalo's logic, teachers are more likely to use stereotypes to make quick decisions in busy classroom environments than when discussing their pupils at leisure in interview. The discussions revolved around the individual characteristics of prior attainment, confidence, attitude and behaviour. Less frequently, competitiveness, organisation and talent were identified. Many of these traits were described in pairs interacting with each other but two area included perceptions that boys and girls had different approaches. The differences seemed to be most acute when describing response to failure and conscientiousness. The latter is dealt

[28] 385 coded references across all 10 interviews. Appendix 2h.
[29] Appendix 2e.

as a separate theme although there are links between the two. Responses to failure are closely associated with prior attainment.

"The strong candidates often don't do DT" (Bree 12:06); this sums up the large number of comments[30] relating to prior attainment when describing how stronger pupils manage the GCSE selection process. What Bree means by 'strong' is worth exploring as the participants occasionally referenced the limitations of standard assessments to represent a pupil's D&T capability. The school factors theme touched on the importance of prior attainment in choosing D&T at GCSE but also how highlighted how misconceptions about D&T are often linked to the choices made by pupils with lower prior attainment grades:

> "*I do want to make sure that it's not a subject for the lower abilities which it was back in the old, dark days. It was, 'right, let those kids do the practical work*". (Mike 24:32).

Some of the participants recognise a dilemma in how best to present the subject; they describe how D&T can provide "variety" (Ruth 6:53) and a "break from academic subjects" (Greg 24:59). These descriptions of D&T are inevitably going to appeal to pupils that may struggle and have lower prior attainment. However, participants reinforce the literature relating to the difficulties of measuring capability in D&T (Kimbell & Stables 2007). Just as standard measures of cognitive ability do not always securely predict future outcomes in D&T (Twissell 2011) they also do little to help teachers or pupils select D&T for future studies. The subject includes practical and creative skills that are not easily measured, even by the spatial reasoning questions in MidYIS assessments (Buckley 2018).

> "W*e baseline them when they come in because, you know, no matter what their baseline is in English and Maths it means nothing in DT*." (Kate FG2 11:29).

> "*Sometimes it's really surprising that you'd find out that they're not actually in set 3 and they are actually in set 1 and the other way around."* (Ruth 39:05).

There are implications for pupils' choices arising from the difficulties in assessing design capability. Eccles' EVT model (1983) suggests that children need to interpret their achievement related experiences; if D&T teachers have to apply their own measurement of achievement,

[30] 141 references to prior attainment. Appendix 2h.

pupils may not have the same faith in the reliability of these judgements compared to other subjects' assessments. Greg complicates things further when he uses the term "natural talent" (6:22) rather than capability or academic ability. He suggests that early identification of this 'talent' is important for means for the retention girls:

> "*I think it might be the case that if girls found that they were good at it they'd stick at it. Hence why you can have a higher retention rate through A-level of girls. I suppose once they've realised that they've actually got a talent for it*" (Greg 18:51).

Greg suggests that recognising talent leads to a sense of confidence (24:17) and ensures selection at GCSE and beyond. In the EVT model, this is the equivalent of boosting the attainment value. The inverse of this effect is that when girls struggle or fail, they may respond differently to boys:

> "*If they didn't think that they were doing well at it, a girl would be a lot quicker to reject it and go with something that they were more confident about*." (Greg 39:38).

Greg's suggestion, supported by Thom (FG1 32:56), is that boys tend be less concerned about failure as they "can always have another opportunity" (44:18). The implication is that male dominance in society offers more chances for boys. This recognition of socio-cultural norms is shared by many of the participants who describe the attitude of many, but not all, of the boys in their classes as much more relaxed or just "having a laugh" (Greg 28:53).

> "*I don't want to have those boys who just do not care, but that's who we generally end up with. And it sounds really horrible but … you look down the list and … it feels like they do DT for an easy option?"* (Ruth 10:52).

Ruth's suggestion is that interest value of the subject is, for many boys, more heavily weighted than attainment value. The boys with lower prior attainment who select the subject as an easy option are also likely to present more disruptive and dominant behaviour. This behaviour, and teachers' management of it, has already been shown to negatively affects the interest value of other pupils.

The consensus amongst the participants was that girls seem to be more significantly affected by both failure and success. This is reinforced by studies that show confidence and anxiety levels increase for girls when tackling open ended design activities that involve failure (Wieselmann, Roehrig & Kim 2020, Heyman, Martyna & Bhatia 2002). The central position of iterative design and failure in design in the new GCSE D&T places a responsibility on teachers to consider how these repeated failures are presented, discussed and used.

The potential for failure is also inherent in the unknown outcomes of the extended, open-ended projects that pupils tackle at GCSE. Some of the participants suggest that pupils are very conscious of the different ways that success is guaranteed or not across different subjects. Here Jake describes the 'safe bet' of History teaching and assessment which contrasts strongly with the need to embrace unknowns and risk in D&T projects.

> "*I've seen some of the teaching notes from History, they teach in a different way. It's carefully coached. The students know it's a safe bet*". (Jake FG1 9:10).

In Eccles' EVT model, the cost of selecting a subject is based on the time and effort involved but is also linked to expected outcomes. If there are few certainties of success in the project format, then this may well deter all pupils but potentially more girls. This follows research that identifies that a crucial component in STEM identity is girls' levels of openness to challenge and failure (Hughes & Roberts 2019).

Finding 12 *– participants suggest that the role of failure in iterative design and unknown project outcomes tend to be judged as having a greater attainment and cost value for more girls than boys.*

If failure is met differently by boys and girls, both in the iterative designing process and the uncertainty of the project-based approach, then this suggests that there could be a place for single sex groupings in order to implement different approaches for girls and boys. The converse of this finding, that success has more significance for more girls than boys should also be considered by teachers. Reducing the levels of anxiety with low stakes approaches and clear explanations could help more girls at KS3 understand and internalise the function of failure in D&T. Group work and short projects with opportunities to discuss and explore failures could help. Success in projects or competitions will clearly boost any pupils' concept and self-concept but could be more useful for girls. Careful scaffolding of D&T experiences across KS3 that gradually increase levels of risk and challenge could be particularly powerful in developing openness to challenge as part of girls' self-concept.

The next theme continues the exploration of teachers' perception of pupil characteristics by focusing on conscientiousness; this is closely linked to gendered approaches to failure.

Theme 9 - Conscientious girls

One of the areas that received much attention was the perceived difference in conscientious behaviour between boys and girls. An extract of Appendix 2n, showing the top twenty codes, is shown in Table 4-8; conscientious approaches are the 12th most frequently mentioned topic.

		Bree	Cole	Doug	Greg	Jake	Kate	Lynn	Mike	Pete	Ruth	Thom	Total
1	Professional behaviours	29	9	19	11	35	13	6	10	3	20	10	165
2	Inequality Equality	18	1	2	14	58	7	3	8	8	6	0	125
3	Prior attainment	18	7	15	14	21	9	2	8	5	13	2	114
4	Practical	27	0	0	6	27	9	6	12	7	12	0	106
5	Parental influence	16	5	10	8	28	8	2	7	6	8	6	104
6	Engineering	15	0	0	9	27	6	0	1	29	2	3	92
7	D&T strands	7	0	1	11	11	13	3	12	15	13	0	86
8	Options and limitations	7	1	3	3	20	14	3	5	5	18	4	83
9	Misconceptions	5	1	4	13	34	3	3	3	6	4	5	81
10	Enjoyment	13	1	6	8	11	8	5	5	9	7	1	74
11	Art	11	0	4	6	14	2	4	4	4	9	14	72
12	Conscientious approach	6	4	3	9	10	6	3	3	5	8	8	65
13	Computing	1	8	31	0	9	2	0	0	6	0	3	60
14	Value for studies and career	9	2	5	9	10	8	1	3	7	5	1	60
15	Behaviour	1	1	1	4	42	4	1	1	1	3	0	59
16	Contexts real world	15	5	1	10	6	1	2	6	10	1	0	57
17	Confidence	11	0	0	5	22	8	0	4	4	1	1	56
18	Project factors	16	0	1	1	7	15	9	1	2	4	0	56
19	Maths	6	2	8	3	9	7	1	0	12	5	0	53
20	Gender in society	25	0	1	8	13	0	1	1	1	1	2	53

Table 4-9 Top twenty codes. Appendix 2n.

Conscientiousness is wrapped up in references to organisation, neatness, perfectionism and thoroughness.

> "*I think girls are infinitely more thorough; they are more guilt driven*." (Thom FG1 32:56).

Conscientiousness is also linked to anxiety; Thom's 'guilt'. Research shows that girls do tend to be more anxious than boys in challenging situations in STEM subjects which, in turn, affects motivation (Udo, Ramsey & Mallow 2004, Goetz et al. 2013). Girls' increased thoroughness is explained by some of the participants as a fear of failure:

> "*It's the fear of failure. And that's definitely more in the girls than it is in the boys*." (Kate FG2 1:10:51).

Lynn offers three possible mechanisms at play in girls' increased anxiety that relate to both internal and external influences.

> "*I think, for girls especially, it's just the general anxiety of being behind. Is it that the pressure is put on them all equally and the girls are internalising it more or is it*

that girls are under more pressure? Or more aware of the consequences?" (Lynn FG2 1:12:07)

Girls greater awareness of the consequences of failure is echoed by Greg (44:18) and mirrors earlier concerns that male dominance has a limiting effect on girls in D&T. Increased anxiety is recognised by Mike as affecting behaviour with an apt phrase:

"*I think I've always deemed the girls as more reserved and backwards in coming forwards."* (Mike 17:50).

Jake suggests that this quietness is linked to low levels of confidence (VSI2 1:12:22). Having low confidence and being reserved are not exclusively characteristics of girls but can be linked to the amount of support pupils receive, to teacher-pupil relationships and behaviour in the classroom (Sansone 2017). Pajare's work of over twenty years ago highlighted the tendency of higher achieving girls to have lower self-concept (1996) which is directly linked to confidence (Eccles, Adler & Meece, 1984). Many of the participants relay examples of boys dominating classroom interactions and these are supported by the literature and evidence from video observations. Jake recognises a possible link between the level of support these less visible pupils get and their choices about subjects at GCSE.

"'*How much help does the teacher give when I have a problem, or how soon do they give that help?' It's a big jump to a causal link to whether pupils choose a subject or not, but it probably is… it definitely is a factor and it's probably quite a large factor in their head actually."* (Jake VSI1 35:05).

It is likely that the speed, level and type of teacher support that Jake describes is likely to be affected by implicit associations and bias (Schoon & Eccles 2014) that reinforce those very stereotypes about confidence. Self-fulfilling prophesy or teacher expectancy effects are widely recognised (Gentrup et al. 2020, Wang, Rubie-Davies & Meissel 2018) and these are as likely to influence pupil self-concept as outcomes.

There are some positive effects of anxiety; girls working together can drive up standards through a competition with each other (Kate FG2 17:34) and especially in a single sex environment:

"*Girls … like to be challenged more than boys. And you can work that to your advantage, you know, make it slightly competitive, you know… "is that the best you can do?" (makes whoosh sound) it's like a red rag to a bull…"* (Pete 9:16).

There was also a consensus that girls tended to have better focus on "presentation and quality" (Mike 13:39), tend to "perfectionism" (Pete 9:16), "keep everything organised" (Bree 39:30) and are "meticulous" (Greg 22:06). Participants suggested that these approaches were most beneficial in D&T during the non-examined assessment projects. Doug and Jake both note that this increased thoroughness of girls may not necessarily be associated with the interest value of the subject but relate to the attainment value of a task:

> "*The girls are doing the lessons fine because they are trained to do lessons properly with good behaviour, but it doesn't necessarily mean that they are invested or want to do it ever again."* (Jake VSI2 1:08:53).

> "*The girls' sets, even the girls that aren't even the slightest bit interested in the subject and were even quite vocal about how disinterested they are, when it comes time to mention assessments they all of a sudden begin to start working hard*." (Doug FG1 32:38).

Jake's phrase that describes girls as, "trained to do lessons", is noteworthy. Bree links this quiet, conscientious, thorough, organised and perfectionist behaviour to gendered societal norms.

> "*You definitely, **definitely**, get a higher percentage of females, in my experience of teaching, who are better behaved. What worries me is where that's come from or what the implications of that means. Because that essentially is… going into dangerous territory, down the line that women are more submissive and are being controlled*". (Bree 4:17).

This shift from 'conscientious' to 'submissive' is clearly not just a feature of D&T lessons and nor will it be applicable to all girls; but will into the stereotypes and perceptions of D&T teachers and suggests that there could be some fruitful work to do with teachers.

***Finding 13** – the participants suggest that the conscientious approach to D&T often seen in girls is strongly associated with a fear of failure that can be traced back to male dominance.*

The teachers' perceptions described here were delivered with conviction, were supported by specific examples and matched numerous elements of Jake's videoed lessons. The veracity of their claims provides a strong foundation for suggesting the need for changes. This is not just because girls' conscientious approaches are associated with lower self-efficacy but because of the more complex mechanism at play by which teachers are likely to be reinforcing these stereotypes through biasing effects (Tenenbaum & Leaper 2003). The strength of the

participants' perceptions that girls are more conscientious and less confident only increases the power of the stereotype (Adey & Dillon 2012). An alternative angle suggested by Bree and Jake is that girls' conscientious behaviour is a form of trained submission; this perception alone provides justification for action.

Recommendations for action could include opportunities to celebrate conscientious approaches to projects whilst also tackling the concerns about increased levels of anxiety. As with the other pupil characteristic themes, these suggestions relate to teacher behaviours and practices; it seems to be especially important for girls in D&T that teachers do not unwittingly feed high levels of anxiety and low levels of self-efficacy. The next theme is closely linked to self-efficacy and confidence but focuses on the practical element of the subject.

Theme 10 - Practical confidence

Although confidence has already been identified within earlier themes, its relationship to the practical element of D&T was frequently[31] mentioned by the participants, mostly with conviction. The D&T literature is rich with references to practical work from its handicraft foundations (Harding 1997) to its place as the poor cousin, in terms of cultural value, to academia (Bell et al. 2007, Hansen 2008).

The 'artist' participants; Ruth, Mike, Greg, Bree and Lynn, mentioned the practical aspects of D&T much more frequently[32] than the 'engineers', Jake and Pete. Although practical work is important in both fields, it fulfils different purposes and may have reduced significance for engineers. All participants frequently linked differences between boys' and girls' attitudes to practical work to both conscientiousness and confidence. Table 4-10 is an extract of the nature of D&T matrix and shows the 30 references to practical work that also include comments from participants about conscientious attitude and confidence.

[31] 136 references from participants. Appendix 2m.

[32] The Art trained teachers mentioned practical aspects most frequently Bree 9.1%, Lynn 6.8%, Mike 17.1%, Ruth 13.4%. Engineers: Jake 5.5% and Pete 3.5%. Appendix 2d.

Characteristics of pupil								STEM								External influences								School				Teacher			
Behaviour	Competitiveness	Confidence	Conscientious approach	Enjoyment	Organisation	Prior attainment	Talent	Engineering	Computing	Clubs	Competition	Speakers	Visits	Maths	Physics	STEM	Gender in society	Biological differences	Faith	Inequality Equality	Positive discrimination	Parental influence	Peer influence	Siblings and older pupils	Academic	Art	EBacc	Options and limitations	Professional behaviours	Teacher background	Teacher pupil relationship	Total
1	1	21	9	19	2	14	0	10	0	1	2	0	2	5	2	0	1	1	0	5	1	12	0	4	9	5	0	5	2	1	1	136

Table 4-10 Cross references to practical work. Appendix 2l, Nature of D&T matrix

This combination of high frequency, relevance and certainty is why practical confidence has become a theme of its own.

One of the signature pedagogies of D&T is the opportunity for students to work in a practical manner; this is often the first aspect of the subject that pupils, parents and others recognise.

> "*To be fair, their preconceptions of DT, when a year 7 student comes in, is generally biased towards practical; we make stuff".* (Mike 20:45).

Minutes later in the interview Mike reveals how these preconceptions develop when he describes a project with a 'clock' context. This highlights how many pupils understanding of D&T is being concerned with making products rather than tackling real world problems.

> "*We focus on clocks for that particular context*". (Mike 23:19).

The practical element can be immensely enjoyable for some; Bree talks about it as "not really being work" (7:42). Lynn describes losing herself in extended making sessions and realising that she "has not moved for four hours and has pins and needles from sitting cross legged" (1:14:11). For pupils too the practical work can be an enjoyable contrast to other subjects. For some pupils who are struggling in other areas of school and home, D&T can be an "escape" (Kate, 1:13:12). These are all examples of how practical work can be enjoyable because of it's potential to help pupils to be autonomous creators and support wellbeing (Stables 2014).

> "*Rather than just being a passive observer and seeing that these things exist in the world, how about, 'I can make these things exist in the world. I am a creator. I am a tinkerer. I can make this happen'. And, I think that that is very exciting, in an aspirational sense*". (Bree 34:21)

Bree's comment about tinkering relates to the RAEng engineering habits of mind (2017) and matches the iterative hand and mind designing process described by Stables and Kimbell

(2007). Tinkering is one of the few instances where practical work arises in the STEM literature on gender. Bree goes on to describe other ways that practical experiences are useful for engineers:

> "*You can be the brightest mathematician or physicist in the world, but at the end of the day, if you're talking to man who's going to build the thing and you have no concept how he would go about building it, or the materials he would use, or the way in which he would process those materials, then you're a sitting duck, pretty much because you are unable to communicate your thinking or to get them to respond to your plans."* (Bree 13:55)

Bree is making a distinction between professional engineers as designers and technicians as makers. Engineers are using their practical experiences indirectly; as a way of understanding how products are made. This is quite different to practical work to produce items or practical experimentation with designs. The participants indicate that many pupils identify only with the purpose of practical work in D&T to make fully functioning, attractive objects. Both Ruth and Bree (8:48) identify how girls and boys struggle with the difference between well-made objects and trials produced as part an iterative design process.

> "*One of my year 10 girls, she was early tearing up, it was horrible. I said to her, "what the exam board have said is that you could design a table, a coffee table, and you could just turn one of the legs and that would be an acceptable solution." And she said (in mock tearful voice), "I don't want to do that." You don't have to make a fully functioning final thing. But the kids have really struggled with that*." (Ruth 33:56).

The issue for D&T teachers is to be able to communicate the multiple purposes of practical work; to develop 'skills to make things', to develop the 'knowledge and understanding to design things that can be made' (RAEng 2017) as well as being part of an iterative interplay of 'hand and mind' in designing (Stables & Kimbell 2007). The differences are subtle and many pupils, parents and even some D&T teachers seem to struggle with these distinctions.

Practical skills were mentioned twice as often by participants working in maintained schools[33] which could reflect the importance of practical skills in trades. The technological capital

[33] Practical confidence was mentioned in 10.9% of maintained school participant interviews compared to 5.5% and 3.5% in independent and academy interviews. Appendix 2j.

afforded by the subject may not be as important as the wider social capital that advantaged pupils from independent school hold by the very nature of their socio-economic family status. Pupils from independent schools are more likely to enter high status occupations (Macmillan et al. 2013, Crawford & Vignoles 2014) and this could be linked to reduced emphasis on practical outcomes in the descriptions from some of the independent school participants;

> "*I think that they're so excited when they're in a project but when they've finished it they couldn't care less whether they took it home or not…. I talk a lot more about the sort of journey and the process of learning than I do about the outcomes*". (Bree 30:24).

The multiple functions of practical work within D&T are determined, in part, by whether teachers adopt an instrumental or a general educational perspective. Practical skills can support the development of autonomous creators and improve wellbeing whilst also preparing pupils for vocations. Practical tinkering can help pupils understand material properties, how products are made and how they work whilst also preparing students for engineering professions.

Finding 14 *– the multiple functions of practical work; tinkering, understanding materials and processes and producing products, are compounded by the participants' perspectives on D&T as an instrumental or general educational tool.*

Findings of research from the last three decades (Cattan 1988, Down 1986, Kimbell, Stables & Green 1996, Withey 2003, Salminen-Karlsson 2007, Virtanen, Räikkönen & Ikonen 2014) show that girls respond with less enthusiasm and confidence to practical work in the subject. Every participant reinforced this and referred to girls' lack of practical confidence. A detailed example from Mike decsribes the sorts of issues that D&T teachers face daily:

> "*Although the girls may produce work at a higher standard, a better quality of finish and care and understanding of style… they lack in confidence. So, the example the other day, when altering the pillar drill and changing of the drill bits, there were two year 9 girls that I'd previously shown how to do it in the lesson but ... I made an assumption that they could go and do that independently. I could immediately see that they were very uncertain; lacking in confidence to do it without somebody stood right with them. As I'm observing them from a distance, I could hear one say, 'he was telling you do it'… 'no you do it'. And I think that there's a real lack of confidence around machinery. Whereas, on the other hand, I had a young man who wanted to use the belt sander, younger than those two and had done the basic training but had*

much less experience. He had no reservations about going on that machine. Even in Year 7, the boys, whether they've been on a machine ever in their life, are much keener and more willing to be straight on there. The boys push forward, the girls drop back." (Mike 14:25).

The stark differences in the approaches of boys and girls to practical work was repeated in every interview with girls "needing reassurance" (Kate 48:39), being "particularly uncomfortable in a workshop" (Bree 15:19) or "terrified of using any machines" (Bree 41:12). The participants suggest that this may be due to conscientious perfectionism rather than a lack of experience with machines. Lynn explains that it is, "not necessarily a lack of confidence in using machines but lack of confidence that they are doing it well" (FG2 1:10:16). or later "they're not scared to do practical work; they just don't like to get it wrong" (FG2 1:15:40).

Finding 15 *– participants firmly express their perception that girls in general are much less confident with forms of practical work than boys.*

The certainty with which the participants report on gender differences in practical confidence is striking. There seems to be a strong alignment of teachers' empirical observations with actual events and a real mechanism which links girls' exposure to practical experiences and their lack of confidence. There is a distinct danger that the strength of these perceptions form part of a self-fulfilling prophesy (Lazarides & Ittel 2012, Tenenbaum & Leaper 2003, Lavy & Sand 2015) in the same way that a conscientious approach is associated with girls. Practical work has an important role in extending or closing any gender divide in the subject; the participants share their thoughts on how interventions with practical work can support gender equity in D&T.

There are positive aspects of the reported thoroughness of girls when doing practical work; in electronics a poorly soldered joint will often result in a failure that is difficult to identify. Mike describes how girls can shift from nervousness to enjoyment through electronics:

"*I think that quite often the girls engage, and they enjoy the soldering. Again, they're very reluctant because you speak initially how hot it is, what to do, what not to touch and they look at this soldering iron like it's going to explode in their hands. But once they realise that soldering is not very difficult, and they engage with that task, then they're as good as, if not better, than the boys with their care and their accuracy*." (Mike 30:41).

Pete, working in an all-girls school, talks about girls enjoying practical work without any trepidation:

> "*They do actually love getting hands on, the girls, in terms of practical in the workshop… I think because they've got nobody watching them; it's just girls. I think the influence of boys would kind of put them off*." (Pete 25:24).

This supports the argument for single sex initiatives in D&T; Pete is describing how the removal of a stereotype threat (Steele 1997) can improve outcomes for minority groups. Bree describes the issue from a different angle, comparing the single sex environment of hockey training with the male dominated workshop facilities:

> "*Why is it that a girl can wield a hockey stick like the best of them and smack somebody in the teeth with a hockey ball but then come in and try and use a saw and feel lacking in confidence in some way*?" (Bree 15:47).

With limited time available in the KS3 curriculum (Lynn FG2 46:35), D&T teachers report on their reliance on practical experiences at home and in primary schools. Mike describes pupils working on family farms (21:17), Jake bemoans the lack of play with Meccano and Lego (VSI2 1:23:44) and Bree refers to gendered toys (15:19). All these domestic experiences have the potential to boost the practical confidence of boys and girls.

Bree expands on the need for early opportunities for girls to develop practical or "tinkering" skills which can develop resilience through repeated failure as well as developing motor skills and dexterity. The development of tinkering skills and practical experimentation in a single gender environment is exemplified by Jake as he helps a pair of girls working on a problem of how to join an axle to a motor, passing parts of a model between them as they explain and check each other's understanding (Appendix 3a). Jake reflects on this sequence as enabling the practical and visuospatial skills (Salminen-Karlsson 2007) that engineers might employ.

> "*It might be that no-one has ever described anything to them in that way. By physically holding a piece of paper, rolling it in your hand and going, 'what if this was attached to that?' (motions with his hands again). And their brain goes, 'I didn't know that was a way of thinking about things*'." (Jake VSI2 1:13:35).

Other possible solutions to develop practical tinkering skills are identified by Mike and Bree in the form of improving the D&T experience in primary schools. The Design and Technology Association has been working hard in the last decade to support primary schools offering high quality D&T experiences, but specialist secondary D&T teachers could possibly do more to help their feeder schools.

In summary, the participants overwhelmingly support prior research and confirm that girls tend to hesitate when confronted with practical challenges because of a lack of prior experience, fear of failure or as a response to boys' dominance in the workshop. This is preventing many girls from developing the tinkering skills that designers and engineers use.

Primary school liaison and single sex initiatives are suggested as potential solutions to build practical experience and confidence in girls. These match suggestions from previous decades (Down 1986, Cattan 1988, Rogers 1998, Withey 2003) which raises the question why these have not been implemented more widely in D&T. The earlier confusion shown by participants between positive action and positive discrimination may have a part to play in the limited implementation of single sex initiatives.

The participants also identify, in a rather muddled manner, a series of discrete functions for practical work in D&T; practical skills to make high quality products, tinkering in an iterative design process, practical experimentation to understand materials and processes and finally, practical skills to prepare students for both vocational and professional roles. Bearing in mind how fundamental practical work is to the subject, there could be a benefit to clarify these distinct functions. Previous findings suggest that girls are perceived to weigh up cost and utility value of tasks carefully. Clarity about these tasks will help girls make better informed decisions.

The next theme follows this strand of confusion but explores how the subject of D&T is misunderstood more widely.

Theme 11 – Contexts and specialisms

The participants spoke with confidence, and at length, about how they perceived the unique features of D&T influences the choices of their pupils. They often spoke in general terms, but I have only included those that help with the focus on gender. There were only a few minor differences in the coverage of the nature of D&T between the participants; experience; gender and settings made little difference[34]. This shows that, despite the wide variety of teacher backgrounds discussed earlier, there is at least the possibility of a consensus on the nature of the subject. The two noticeable differences were that projects were mentioned much more

[34] Appendices 2e and 2f.

often[35] by the female participants and Jake spoke much more extensively[36] about misconceptions. Jake may have been responding to the difficulties in integrating D&T into a very traditional school.

In the recurring discussions about the nature of the subject, the participants regularly described the importance of real-world contexts, mirroring prior research (Hill 1998, Mettas & Constantinou 2007). Lynn sums up D&T as "solving everyday problems" (FG2 59:18). Bree describes how the contextual challenges, that now form the basis of the non-examined assessments, are a useful way to link real-world, every day and familiar experiences to D&T. In her interview she was able to describe recent experiences in her lessons where family dinners, pushchairs and social media were all part of discussions with pupils about designing.

> "*I was talking about the GCSE brief and social interactions, which is one of the contexts… We were talking about pushchairs and stakeholders and I said, 'great, if we're designing a pushchair or a high-chair, what is our stakeholder there?' And this kid went, '**Mums'** (loudly). And I just went, '**No!**'".* (Bree 17:30).

Bree goes on to describe how she directed the class discussion to explore and tackle gender stereotypes explicitly with the class. This fits with her belief that education is about the whole child and not just a means to cover a specification; she actively engages with stereotypes. In another example, Bree suggests that the forge work in a candlestick project was enjoyable for both boys and girls and yet the recipients of the finished product was often their mothers. She concludes that projects must be viewed holistically, factoring in context, target market, materials and processes, before judging whether it reinforces or tackles gender stereotypes (28:20).

The contextual challenges set by the exam board that Bree mentions have been carefully planned to avoid any gendered responses. Pete describes how a class of girls had engaged well with a security context that he had initially viewed as limiting:

> "*I'm a little bit disappointed in the exam board because, it's something to protect personal devices...so basically, it's a ruddy bike lock. But we had a brainstorm with*

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[35] Project factors coverage for female participants 5.0% compared to male participants at 0.7%. Appendix 2f.
[36] Jake mentioned misconceptions 34 times or in 6.9% of his interviews. Appendix 2d.

the girls yesterday, and they actually came up with some quite interesting takes on the project brief". (Pete 10:27).

Bree and Pete demonstrate an awareness of gender stereotyping through the choice of contexts and the way that those contexts are presented to pupils. Care is needed at both the planning and delivery of contextual challenges to avoid falling into the trap that Pete describes when making assumptions about the relevance of contexts to pupils. confidence to actively challenge them. They also recognise the dangers and opportunities in presenting contexts to pupils. It would be beneficial if all teachers could take the same care in presenting context as the exam boards do when preparing GCSE NEA contexts.

The potential for girls and boys to be motivated by different project themes was recognised by all the participants; echoing the literature (Withey 2003, Archer 2013). Some of the participants describe how they deliberately planned and modified the contexts to suit boys and girls:

Doug: "*Your work with set 2 [boys] did at one point move away from what I was doing with set 1 [girls] because you knew your audience and you knew that they were interested in and you could get more out of them*".
Jake: "*That's just differentiation though isn't it?* (FG1 48:38).

This opportunity to adapt contexts in a single sex setting is controversial; on one hand it can help with motivation and interest but can also draw attention to, and reinforce, gender differences (Spielhofer et al. 2002). Mike suggests that in a coeducational context, manipulating these themes can have a direct impact on the variation in uptake of boys and girls on GCSE courses (9:16). This approach represents an active reinforcement of stereotypes.

An alternative approach is to provide a choice for pupils. Greg and Mike describe how their respective KS3 jewellery projects could be appealing to both boys and girls depending on whether they chose to design necklaces or cufflinks. This only seems to reinforce stereotypes. Mike describes how gendered stereotypes can filter into pupils' work in another project when left unchecked:

"*We give those students an open choice. The girls will frequently go down the Art Deco, Nouveau route. The boys will frequently go down the steampunk route… generally, they pick what you would suspect and stereotypically think they would pick*". (Mike 23:19).

When pupils select stereotypically gendered themes without any challenge this could be described as passive reinforcement of gendered stereotypes.

The increasing importance of real world contexts in the new GCSE D&T provides an exciting opportunity to tackle gender role stereotypes and yet the participants describe three very different approaches; an active tackling of gender inequalities, passively reinforcing gender stereotypes through open choice and actively changing contexts which can increase engagement but reinforce stereotypes.

Finding 16 *– participants approach gender stereotypes within real-world contexts in three ways; passive reinforcement, active reinforcement and active engagement.*

Of these approaches, only active engagement with gender stereotypes will make any positive difference to gender equity. This requires, in the first instance, teachers to be more aware of the ways gender stereotypes can be reinforced, both passively and actively, through the presentation of project contexts. Planning D&T schemes of work requires the same care and consideration that exam boards apply to their GCSE contexts in order to present genuinely inclusive contexts. Teachers could possibly be provided with the tools, confidence and authority, thorough professional development, to discuss gender stereotypes in their D&T lessons.

The historically gendered strands of D&T still retain a place in the new GCSE. Basic elements of textiles, resistant materials, graphic products and electronics are covered in the curriculum but some pupils, depending on their school, can focus on any one of these specialist areas in the optional exam questions and NEA project outcomes. Of the eight schools in this study involved only Kate and Lynn described having textiles outcomes, including projects from boys. This is most likely a result of their combined experience and confidence in this specialist area. There is a suggestion that as departments struggle to cope with the breadth of the new single title D&T, some specialist textiles teachers have opted to follow Art and Design courses and effectively taken with them a large proportion of girls (Hughes & Wooff 2013). .

> "*Because the numbers aren't huge in any school for Textiles it's an easy fix to get rid of it; you can amalgamate those Textiles teachers into Art... very, very readily. You're reducing the number of traditional routes into D&T for girls, which is only going to compound the issue even further*". (Greg 49:44).

These traditional routes for girls into D&T are described by Mike as "self-selecting", highly gendered and "not missed" (6:05). However, not all the participants were positive about the

new, broader, GCSE. Pete has chosen to specialise in engineering and describes numerous electronic projects that were being completed by his girls. His decision to opt for engineering was that the D&T course had become "too diluted" (8:26) by integrating textiles, electronics and graphics with the other strands. His concern that a broad offering may not be inspiring was not voiced by other participants. Research findings (van Langen & Dekker 2005) suggest that broader, interdisciplinary approaches could appeal more to girls; this also conflicts with Pete's assertion.

In direct contrast to Pete's work on electronics with girls in a single sex school, Jake, Mike and Greg (19:01) confirm a gendered stereotype of electronics as a masculine domain. Mike's argument is that a focus on electronics reduces any creative elements (30:41) which, in turn, would be less appealing to girls. Jake's concern is that by integrating electronics, robotics and mechatronics into D&T, there is the potential to reduce the appeal of the subject to girls even further:

> "*My worry is that because we also adding in essentially computing, another 'boys' subject, into an already 'boys' subject. What we would need to do is to merge with Art".* (Jake 51:31).

Jake's suggestion of prioritising the creative elements of D&T to attract girls can be understood on a couple of levels. As an engineer he is passionate about mechatronics and robotics, but he also believes that these aspects of D&T alienate some girls. Whether he is right or not is irrelevant; it is Jake's beliefs that inform his responses, actions and interactions with pupils. These interactions, as evident in the video recordings of his lessons and explained in the Eccles' EVT, will feed his pupils' self-concepts, goals and choices. We could also interpret his suggestion as one that is not genuine; the underlying perception that electronics and coding are masculine remains.

Finding 16 *– participants perceive that the historically gendered strands of D&T remain as potential barriers to developing a more inclusive and equitable subject.*

The broader core element of the new GCSE D&T does seem to be providing some departments with the opportunity to play to their teacher's strengths which should, in turn, produce more successful outcomes. There were also indicators, with girls following electronics with Pete or boys producing textiles projects with Kate, that this is allowing pupils to move beyond the traditional gendered strands of D&T. However, all of the teachers still talk in terms of material specialisms, especially textiles and electronics, as barriers to providing an interdisciplinary offering that can broach gendered inequalities and stereotypes.

This research is being conducted when the single title GCSE is in its infancy; the D&T material specialisms may eventually become less important. However, the exam boards have employed the loopholes of a flexible NEA and optional exam questions to ensure that D&T teachers can continue to teach within their own specialist areas. Until this changes, there is no incentive for teachers to offer a truly broad foundation.

Theme 12 – Lost in STEM

Participants' perceptions of the relationship between D&T and STEM is invariably tied to their understandings of the rationale for the subject as either part of a general education or for instrumental purposes (Kimbell & Stables 2007). Whatever their underlying basis for D&T, all the participants suggested that the subject was frequently misunderstood by pupils, other staff and parents.

> "*There is this complete disconnect between, 'here's my smart phone and there's the subject of Design and Technology'. Nobody gets that we go from here to there*." (Jake IAT 45:00).

Jake is describing the function of D&T to provide a holistic critique of our technological world, identified in the National Curriculum purpose statement (DfE 2013). Jake was the only participant to explicitly make reference to this purpose, the other participants tended to focus on the instrumental purpose of the subject to gaining qualifications and experiences as preparation for vocations.

Greg's responses tend to dominate this theme[37]; his role as an RAEng ambassador provides him with both the knowledge and confidence to express his beliefs. Rather than presenting a clear message that meshes STEM and D&T, his perceptions hinge around a disconnect between D&T and engineering or other technical design careers:

> "*And that's my biggest concern at the moment; where does DT fit with engineering and STEM? We're seeing evidence of DT departments closing down left, right and centre. My personal opinion, from looking around schools and talking to other teachers, is that SLT and parents are wondering where DT fits into all this. Now*

[37] 9.4% of Greg's interview related to engineering. Appendix 2d.

workplaces are crying out for engineers and designers and creative people but the two aren't marrying up". (Greg 46:59).

Recent GCSE reforms to D&T include a greater emphasis on maths and science. This is helping to rebuild the technical basis of the subject and reconnect D&T with the wider STEM education. It should be noted that there have been no reciprocal changes to the science or maths curricula and D&T is effectively reaching out to connect these disciplines; Jake describes the integrating effect of D&T as an interdisciplinary subject (Norton 2007).

"*I don't think D&T was very well linked to STEM… but I think that it is now broader than it was, and it has the robotics/mechatronics side to it. I think it is pretty important because you are not going to cover that in Physics… so I think it is the broad application of Maths and Physics*" (Jake IAT 47:13).

The overlap between D&T and other STEM subjects is not clear cut. In principle, KS3 maths, science and computing knowledge should be adequate to tackle D&T GCSE exam questions and projects. As Jake puts it, D&T becomes the application of maths, computing and science that has been taught by others. D&T does have a unique knowledge base and still relies heavily on content taught elsewhere but the signature pedagogy of D&T is to apply this knowledge.

In direct contrast, Greg dismisses the need for a designer to understand maths at all and refers to the new D&T format rather disparagingly as "*spice racks with sums on the side"* (Greg 34:09). He is describing product designers rather than engineers when making this comment and highlights the different responses from 'engineer' and 'artist' participants to the inclusion of maths elements in D&T exams. This contradiction within the D&T community may be difficult to reconcile without clear direction and leadership.

A key aspect of STEM in schools has been the huge number of offerings at a national level. This is translated into a series of extracurricular clubs, trips and competitions. Pete seems to be most engaged with these offerings and runs them from the D&T department. These include trips to local engineering firms, the Big Bang Fair and even an international exchange based on a sustainable design challenge with a sister school in Europe. Pete prepares pupils for Arkwright scholarships and arranges talks for pupils and parents from female engineers and ex-students studying engineering degree apprenticeships. Other examples of competitions that Pete's girls take part in include Talent 20/30 (a girls-only design competition), Land Rover 4x4 and an internal robotics competition with the finals run as part of a parents' evening.

In his role as RAEng ambassador, Greg offers a rather cynical view of why schools may enter girls into these competitions; he also repeats the confusion about positive discrimination and positive action:

> "*There are a group of VEX competition girls, another group of girls that are doing the Asda Challenge and another doing the Solar Powered thing. And its positive discrimination in order to get girls into this sort of thing*. *I admit that in certain situations having a group of girls probably bolsters your chances of succeeding as well. And so therefore obviously there's a knock-on effect for the kudos of the department, by doing that*". (Greg 13:39).

Extracurricular STEM activities are not always national initiatives and many of the participating schools run their own internally organised courses and clubs. These range from a lunchtime woodwork club (Mike 14:25) to an aspiring engineering programme for sixth form students not following D&T A-level (Greg 12:00). In both cases the teachers report that they are dominated by boys which suggests that the self-selecting nature of the school activities can reinforce stereotypes and misunderstandings about the subject.

The purpose of extracurricular STEM activities is twofold, "*to increase the flow of qualified people into the STEM workforce; and STEM literacy in the population*". (STEM 2006 p2). The utility value of these activities as vocational and career preparation can be contrasted with the value of D&T:

> "*Students have got wind of the fact that they don't require D&T as a qualification to go into engineering… Which is true and which I will often broach at parents evening and raise with parents, "No, you do not technically need this qualification.* ***Why*** *you don't, I have no idea. It's bizarre that universities don't view this as a credible, intelligent, academic subject*". (Bree 12:06).

Bree's position is quite remarkable considering her background as a practicing artist and her previous role as an art technician. It suggests a strength of feeling about the subject and a belief that it does have a role to play in the formation of engineers. The literature suggests that this relationship is complex and has changed over the last two decades; from a complete absence of D&T in engineering literature to a dawning realization of the subject role (RAE 2018).

A very different understanding of the utility value of D&T for engineering was evident in the maintained rural schools. Kate's description suggests that the students were less well informed about potential career paths and entry requirements:

"*But specifically, for engineering, what our students don't really realise is how much Physics you need. Because of lot of them come thinking, 'we'll do DT and then we be an engineer*"'. (Kate FG2 52:45).

This difference between the approach of the pupils and parents at Bree's selective independent school and the pupils at Kate's maintained school provide just one example of how cultural capital (Archer, MacLeod & Moote 2020, Allard 2005) plays out. In the maintained schools in this study, the D&T departments do not take a particularly active role in STEM opportunities (Kate FG2 1:23:31). Kate, Greg and Mike all refer to D&T as a route to semi-skilled manufacturing workforce rather than professional engineering. This harks back to an instrumental and economic approach to the subject (Atkinson, Gregg & McConnell 2006) and reinforces the associated class and gender stereotypes:

"*In my previous [maintained] school when I used try and motivate these disenfranchised boys, I'd say, "look, if you don't want to leave school and you want to go and work in a factory, I can be the difference between you being a manual worker and a skilled manual worker and that , in effect, can add another third onto your wage". But here [independent school] it's not so much the case*." (Greg 25:45).

Many of the participants suggest that STEM extracurricular activities can encourage girls to follow engineering, but Bree and Pete have different experiences on how this then impacts D&T:

"*On the back of last year's exchange competition, I had three girls ask if they could change their options to do DT*". (Pete 22:51).

In direct contrast, Bree explains why a "hugely academic*"* girl aiming for a Russell Group university engineering degree continued with an extracurricular F1 in Schools activity but dropped D&T because, "she didn't need to take it." (Bree 41:18):

"*It's almost as if we've over provisioned to the sense where she can access all of that stuff without even needing to take the lessons*". (Bree 42:27).

Bree's warning about the 'over-provision' of extracurricular STEM offerings, whether linked to national initiatives or organised internally, could well be damaging the place of D&T. Whilst D&T has low value for entry to engineering at degree level, some D&T staff are busy providing extracurricular STEM activities that are acknowledged by the same universities as useful.

Most importantly for this project is how these STEM offerings affect boys and girls differently. Many of the participants share the feeling that boys and girls engage differently with discussions about the value of D&T to their future:

> "*The boys don't make their decisions based on what they are going to do in the future, they make their decisions based on what they like right now. The girls just seem to be a little bit more… levelheaded, maybe calculating, but in a positive manner, as to where they're going and what they're doing.* (Greg 41:27).

> "*The girls take it more seriously at that age. Year 9 definitely. Especially the brighter ones. They'll take it really seriously and actually think about things. The boys at that age are going, 'what's most fun, what do I enjoy the most?' and then do that. I think, and that's just the maturity of boys and girls at that age*." (Jake VSI1 29:18).

These suggestions from Jake and Greg are repeated from earlier themes, that girls are more conscious of the utility, cost and attainment value of subjects in general and boys rate the enjoyment value of a subject more highly. This suggestion extends the reach of the cultural milieu in Eccles' EVT model to influence directly the way in which pupils make choices; shown as an additional red link in Fig 4-1 below. The reasons for this mechanism are likely to be related to the relative risk associated with failure for girls and boys in our society.

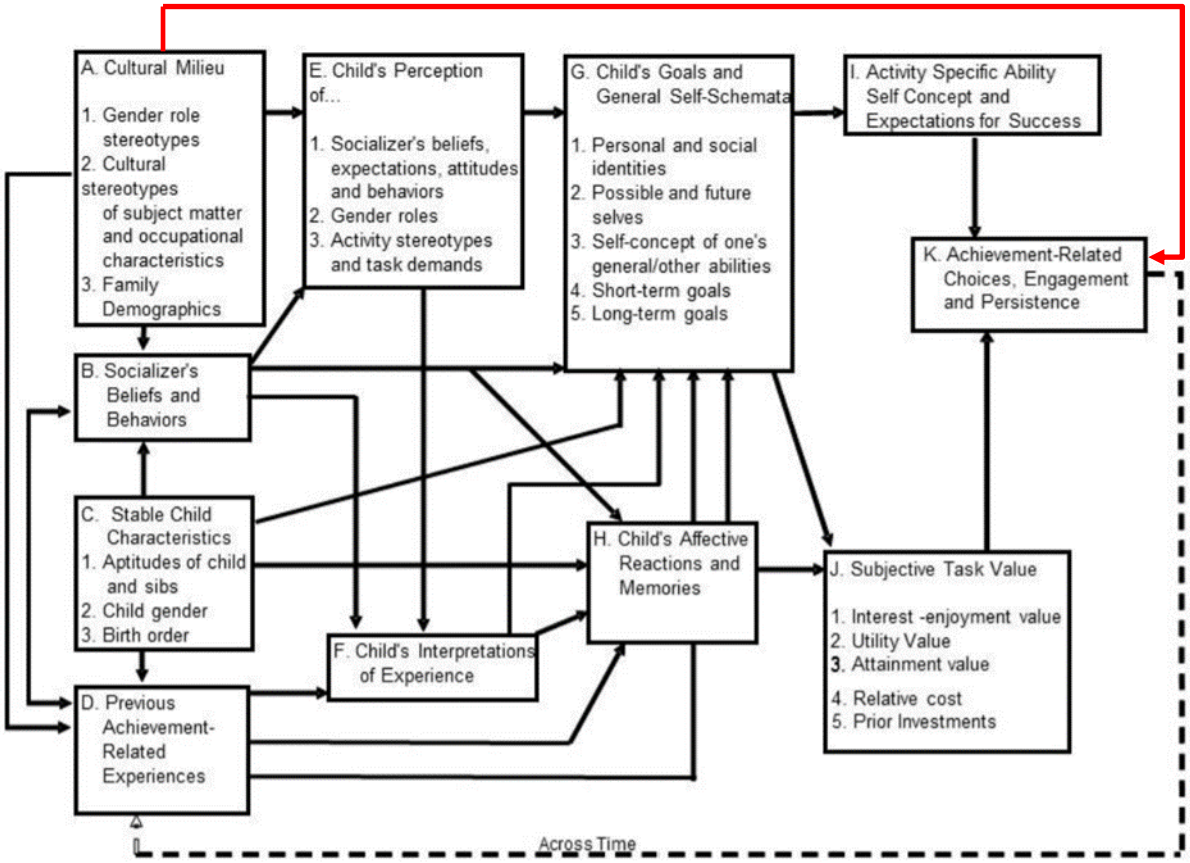

Figure 4-1 Model of achievement related choices (Eccles 2011), amended.

Combining Bree's "over provision", the difference between utility value of D&T and STEM activities and the perception that girls have a greater awareness of utility value has significant implications for the subject:

> "*Design Technology seems to have lost its way a bit… girls don't see it as a valid subject because they don't see where it's going to take them. If the girls are turning off, then the boys will eventually follow… we would do well to listen to what's happening with girls in Design Technology*". (Greg 46:59)

In summary, participants report on very different levels of engagement with STEM initiatives and the integration of maths and science into the new GCSE D&T. On one hand Jake understands of D&T as the practical application of Maths and Physics, Pete is making significant efforts to provide STEM activities for girls and Bree passionately defends D&T as a effective route to engineering. On the other hand, Kate's believes that her pupils are unaware of the relative utility value of various STEM subjects, Greg provides an argument against including Maths in D&T and is cynical about girls' teams in STEM competitions. These different

perceptions about the value of the subject to STEM reveal areas of potential conflict within the D&T community.

Where schools do offer extracurricular STEM activities there are suggestions that these have greater utility value for engineering than D&T. When combined with the perception that more girls have a greater awareness of utility, cost and attainment value than boys then this may go some way to identifying why D&T is less attractive to girls.

Finding 18 *– the highly variable provision of STEM activities is perceived to have a greater utility value than D&T and this is more readily understood by girls.*

The relationship between D&T and STEM is possibly the knottiest and the most difficult conundrum to untangle. The literature review did not hint at the intensity of feeling or variation in approaches that D&T teachers have to STEM. This variation is a fitting way to conclude the findings chapter as it ties back to the first theme, a description of how the engineer and artist participants are both firmly, yet differently, bound to D&T.

D&T's relationship with STEM also brings into question the fundamental purpose of the subject, as preparation for technical design careers and vocations or for a general education, raising technological literacy in society. Both internal contradictions prevent the subject from developing a cohesive vision or clear disciplinary boundaries. This disjointed approach is part of the reason for declining numbers of pupils and why, most significantly, girls are leaving in droves.

There are glimmers of hope within this web provided by the participants; the final chapter draws together the findings and provides a series of recommendations for a variety of stakeholders.

Chapter 5 Recommendations and conclusions

This final chapter provides an evaluation of the research and a discussion of the limitations of the study. This sets the scene for recommendations for practice that are drawn from the findings. Recommendations for potential areas of further research are described before presenting the conclusions in the form of answers to the original research questions.

Evaluation

Working within a critical realist framework throughout the study affected numerous decisions along the journey. This included choosing methods that offered multiple layers of understanding; the focus groups, video stimulated interviews and implicit association tests were all designed to reveal real, actual and empirical understandings. The framework provided the opportunity to combine a thematic analysis with an interpretive method of evidence building. This helped when interrogating the interview transcripts from multiple angles to unpick participant perceptions and described events from possible structural mechanisms. One difficulty of interpreting the participants' responses after the interviews is determined by how far to go in inferring what the participants were thinking or unconsciously voicing.

Judging the quality of this form of research depends on four forms of authenticity identified in Chapter 2 (Lincoln & Guba 1989):

> Ontological authenticity: enlarges personal constructions.
>
> Educative authenticity: leads to the improved understanding of constructions of others.
>
> Catalytic authenticity: stimulates to action.
>
> Tactical authenticity: empowers action.

Elements of the first forms of authenticity can be identified in the commitment to offering the teachers' personal beliefs both in their raw state and with interpretation. This includes sharing contradictory responses from participants without judgement. There were moments identified within the interviews where the voiced an increase in awareness of the systems in place and their place in it. Two of the participants were less open to discussions of gender stereotypes and, in presenting their own perspectives, are likely to have been reinforcing their own beliefs about social gender roles. Jake and Greg certainly seemed resistant to change when reminded about potential biases, a phenomenon identified in other research of this type (Wegner, Clark & Petty 2006). The focus group sessions provided the most obvious form of educative authenticity; participants engaging in a dialogue and building shared understandings.

It is much more difficult to judge the catalytic and tactical authenticity of this project. Although the purpose of the research was to identify personal agency, the limited contact time does not allow any way to identify whether the research directly stimulated action or empowered the teacher participants. The recommendations that follow should provide possibilities for change but, to increase the authenticity further, post interview follow ups would be beneficial.

During the project there were efforts to maintain authenticity with a series of measures; these are reflexivity, triangulation, collaboration, an audit trail and rich descriptions.

Reflexivity is evidenced in the position chapter and in sections of the analysis and presentation of the findings. There are difficulties conducting insider research and needing to step back to identify alternative viewpoints. Elements of my positionality that required regular attention included my own engineering training, my pro-feminist standpoint and balancing an instrumental and general rationale for education. One area for further development is in the use of the research journal, extracts were integrated into the thesis rather than being quoted separately. Reflexivity was also part of the interview design, the dangers of leading questions, power differentials and practical timing were all identified in the pilot. This helped to build more effective interview schedules with prepared follow-up questions and probes.

The research design included triangulation of theory with Bourdieu's cultural capital, Archer's morphogenesis and Eccles' Expectancy Value Theory. Triangulation of method and data were developed less strongly in the Implicit Association Tests, interviews and video stimulated interviews. There was little opportunity for investigator triangulation and the contribution of the participants never developed into the collaborative effort I had hoped for, primarily due to the difficulties of balancing the time constraints of their work and the demands of the collaboration.

The significant number of participants' interview extracts provide a rich description of their contexts, concerns and perceptions without breaching confidentiality and anonymity. Extracts of lesson video, IAT results and focus group minutes are also included to help provide the reader with opportunities to judge the quality of the triangulation methods used.

Collaboration was limited to the use of focus groups and member checking of the transcripts. Opportunities to draw participants more fully into the review, analysis, or even co-authoring, were limited available time but would have helped to improve the authenticity of the study.

I believe that the strongest aspect of the drive for quality is in the audit trail. Full transcription of the interviews took place with complete coding rather than working to saturation. There were multiple rounds of categorisations, including top down and bottom up approaches, which

are reported in the analysis chapter with examples of the software tools used. In the reporting of the findings, the coding details are reported in footnotes and linked to matrices in the appendix. This transparency provides a decision trail through the coding and analysis phases and supports the trustworthiness of the findings (Koch 1994).

The research findings go some way to building on, and adding to, the limited literature on gender in D&T. This importance of utility and interest value in pupils', and especially girls', subject choices stemmed from explorations of Jacquelynne Eccles' Expectancy Value Theory and were reinforced strongly in the teachers' perceptions. Many of the teacher beliefs about individuals and groups identified in the EVT were replicated in the findings, including elements of gender essentialism. The findings also suggest that the EVT model could be extended to include a direct influence of the cultural milieu on the choices made by pupils. Rather than purely being fed and informed by the previous stages, there is likely to be a direct effect of societal norms on the decisions made by most girls that are different to those made by most boys. Participants regularly suggest that the decision-making process is attended to much more carefully by girls than boys, girls tend to consider a wider variety of factors and girls tend to judge utility value as more important than intrinsic value.

Louise Archer's science capital model provided a useful foundation for considering how technological literacy, networks, attitudes and behaviours play out for girls in D&T. Teachers suggested that parental and sibling influence played a powerful part in building this technological capital and recommendations build on this potential. The teachers used all four aspects of the model in describing how girls navigate D&T and how D&T is related to STEM. However, the terminology and vocabulary used by the participants varied considerably and a shared understanding of the power of technological capital could go a long way to clarifying the importance of the D&T to a wider range of stakeholders. This is detailed in the recommendations.

Margaret Archer's separation of agency, structure and culture provides a model that actively seeks to identify transformative practices. However, the findings were dominated by modes of reproduction and morphostasis at both an individual and structural level. This was disappointing as the driving force for this study was to identify opportunities for change. Very few of the recommendations are being currently implemented by the participants and so few claims can be made that the recommendations will be effective.

Other limitations relate to the scale of the study. This project was restricted by my resources as a solitary, part-time, self-funded researcher. The findings of this small research project are not generalisable but should be relatable to the reader (Bassey 2001). The detailed descriptions of

context and prevalence of participant voice should support the reader in making judgements on how the findings might relate to other settings.

There was an effort to recruit participants with a broad demographic and from various educational settings but, due to locality and the extent of my contacts, none of the schools had a particularly high proportion of either Free School Meal or ethnic minority pupils. The compounding effect of gender, class and race is therefore not fully explored. Only one participant was able to reflect on experiences in two very different settings and their comparative reflections provide some important insights that others could not offer.

The potential of the video stimulated interview process was also not fully exploited. Limitations of time to transcribe and analyse video were compounded by the difficulties in arranging access; especially at a time when gatekeepers in schools were concerned about changing regulations surrounding GDPR. By limiting this element of the project to only one participant, the opportunities for comparative work across settings were lost.

The project focuses on the voices of teachers and yet there are numerous other stakeholders. Expanding the interviews to include representatives from DATA, STEM, RAEng and government agencies would provide a much rounder picture. The omission of parents and pupil voice means that this project can only provide a partial understanding.

Despite all my efforts to maintain quality, rigour and authenticity, there will undoubtedly be sections of this work where my voice overshadows that of my participants or blinkers prevent me from seeing other features of the landscape. It is difficult to unpick how elements of my positionality, as pro-feminist, engineer and insider researcher, will have unconsciously crept into judgments and descriptions. There is a limit to how far anyone can step back from these perspectives and I have instead shared them with the reader.

The process of acting as an insider researcher led to a sense of isolation; whilst attempting to fulfill the roles of both researcher and teacher there was often a conflict of mindset and workload. It became impossible to hold both functions at the same time and it was necessary to shift between them in a disciplined manner. Rather than becoming both researcher and teacher, I often felt like neither role was being performed effectively. The adopted solution was to separate out the roles between term and school holidays. This only increased the level of isolation and reduced the opportunities for collaboration with the participants and other researchers.

In the next section, the recommendations for possible future studies tackle some of the limitations of the original study but also follow up on the more complex questions that were raised in the interviews, analysis and discussion.

Recommendations for further research

Five potential areas of further research have been identified from the findings and evaluation.

The perceptions of D&T teachers in secondary schools highlighted the important role of parents and primary school experiences in the social conditioning of girls. In searching for practical solutions to make a difference this could be a fruitful avenue of investigation. Understanding how D&T offerings at primary school are perceived by teachers, pupils and parents would provide a valuable extension to this study.

Single gender teaching and interventions remain a highly controversial topic in education and divisions exist even within this small sample of the D&T teaching community. Positive action requires a commitment to educating staff, parents and students (Spielhofer et al. 2002). Although there is a growing body of literature evaluating the effectiveness of these equitable inequalities in STEM, there is currently very little focusing on D&T. Possibilities for extending the research include quasi-experimental studies on single sex teaching in D&T or longitudinal studies on pupils' subject choices and career paths.

Although there was an effort to cover a broad a range of settings; there was not the opportunity to study the compounding effects of class and ethnicity on gender in D&T. Exploring intersecting demographics at a national scale could complement a rich ethnographic study.

One of the key findings relates to the continued confusion about the disciplinary boundaries of D&T. In building a consensus and shared vision it would be useful to have a profile of current D&T teachers that covers gender, age and experience but also disciplinary foundations and training. This would help to inform the future direction of the subject, specifically regarding recruitment and training of D&T teachers.

An area only touched on briefly in the findings was the role of the lesson video in providing stimuli for interviews. It was difficult to find readings on VSI amongst the wealth of literature on video in teacher professional development. The potential for video to act as both CPD and research tool on two sides of a mobius strip is exciting (Marchionini & Wildemuth 2006). The overlap in terminology across research and CPD fields is strong; reflection (Reitano 2005), coaching (Kennewell et al. 2009),) dialogue (Rich and Hannafin 2009), lesson study (McDonald 2010, McDonald, Kissan & Hurst 2009, Lewis 2002) and focus groups (Sherin & van Es 2009) are

all drawn from CPD but also have research applications. More detailed work on the potential of video to tackle gendered implicit associations of D&T teachers could help to provide new and different understandings.

Recommendations for practice

Forty subthemes were created from the thematic analysis of the transcripts and these have been arranged into twelve overarching themes that loosely align with the three research questions. The discussion of these themes in the previous chapter generated eighteen findings, each with an associated recommendation. In a professional doctorate there is an incentive to provide pragmatic pointers to improve practice. Who those pointers should be aimed at is interesting,; Greg provides his view:

> *"The people that could really influence this are education ministers, DATA and particularly the exam boards … we can shout as much as we want and open up a new Design Technology forum and whatnot, but it won't influence those people that are making decisions*." (Greg 46:59).

The recommendations have been associated with key groups of stakeholders including D&T teachers, department and STEM leads, school leaders and CPD providers, including ITT and ECF trainers, the subject association DATA and exam boards. Table 5-1 provides a summary of the research questions, themes, recommendations and stakeholders. Each of the key stakeholder groups is then covered in turn, highlighting the relevant findings and proposals for practice. These are identified within the text by letters from the table, F-a and R-a representing finding 'a' and its associated recommendation 'a'. Many of the recommendations involve more than one group of stakeholders but those that are best placed to make a difference are targeted, with secondary stakeholders identified in the table in italics.

Research question	Theme	Findings	Recommendation	Stakeholders
How do D&T teachers perceive how gender stereotypes play out in the subject?	1. Teacher background	a. D&T can attract teachers from the quite disparate disciplines of art and engineering, both highly stereotyped gendered fields.	Clarity of messaging about D&T's interdisciplinary approach that crosses disciplinary boundaries and gender stereotypes.	DATA
	2. Teacher gender	b. Women D&T teachers understand stereotype effects very differently from their male counterparts and the levels of understanding for male teachers is highly variable.	Raising awareness of stereotyping effects through training of teachers, especially men.	STEM ITT, ECF and CPD providers
	3. Classroom relationships	c. The intrinsic value and enjoyment of girls and higher attaining pupils was negatively affected by 'rowdy' boys in their sets **and** some teachers' controlling behaviour management strategies.	Coaching in positive behaviour management made available for D&T teachers. Consider single-sex initiatives.	D&T ITT, ECF and CPD providers
	4. Teacher models of society	d. Some participants hold gender essentialist beliefs based on faith and biology.	Using IAT/VSI to expose and tackle gender essentialism with all teachers, not just D&T, STEM, or ECTs.	All ITT, ECF and CPD providers
	5. Professional boundaries	e. Participants' understandings of professional conduct standards and the way that they tackle gender stereotypes are interconnected. f. Participants reveal confusion between the legal responsibilities of positive action and discriminatory practices.	Clarification of the impact of the Equality Act on positive action and discrimination on the professional duties of teachers.	School leaders (*STEM providers*)
		g. Participants suggest that there are unprofessional teacher behaviours associated with the encouragement of pupils that do not place the interests of the pupils first.	Discuss and identify acceptable forms of encouragement.	School leaders.
How do D&T teachers perceive how boys and girls make choices about GCSE subjects?	6. Family guidance	h. Participants describe the pervasive and powerful effects of parental influence on limiting pupils' choices.	Engage proactively with parents to reveal gender stereotypes and explain positive action initiatives.	D&T leads
		i. The influence of peers is downplayed by the participants, but older siblings and pupils are identified as powerful influencers.	Leverage older students as role models to explain the detail of GCSE, A-level D&T and further studies or careers.	D&T leads
	7. School restrictions	j. Art and D&T are perceived to be in competition as creative, project-based subjects **and** that the expressive creativity of Art is gendered.	Collaborate with Art departments to discuss forms of creativity.	D&T leads
		k. Participants perceive that other teachers providing guidance to pupils on their GCSE choices	Clarity of messaging about the role of project-based learning	School leaders (*D&T leads,*

		are poorly informed, make assumptions about D&T project work, creativity and attainment **and** that more girls are more likely to take on board that advice than boys.	in D&T for pupils, parents and teachers. Provide guidance for all teachers on how to advise pupils on future studies and careers.	*DATA*)
	8. Attainment and failure	l. Participants suggest that the role of failure in iterative design and unknown project outcomes tend to be judged as having a greater attainment and cost value for more girls than boys.	Provide progressively more challenging experiences throughout KS3 celebrating the role of failure in iterative design. Ensure opportunities for success with increasingly challenging open-ended projects. Consider single sex groupings.	D&T teachers (*D&T leads, DATA*)
	9. Conscientious girls	m. Participants suggest that the conscientious approach to D&T often seen in girls is strongly associated with a fear of failure that can be traced back to male dominance.	Balance an emphasis on thoroughness in portfolios with an awareness of anxiety levels in girls. Avoid reinforcing gendered stereotypes linking quiet behaviour, confidence and girls.	D&T teachers (*D&T leads, DATA*)
	10. Practical confidence	n. The multiple functions of practical work, although recognised as a fundamental feature of D&T, is compounded by the participants' perspectives on D&T as an instrumental or general educational tool.	Make clear the different functions of practical work at a departmental level and potentially through a curriculum revision.	DATA
		o. Participants firmly express their perception that girls in general are much less confident with forms of practical work than boys.	Review the progression of practical experiences in KS3 curriculum including liaison with primary feeder schools.	D&T leads
How do D&T teachers perceive how the subject fits into the gender-in-STEM debate?	11. Contexts and specialisms	p. Participants approach gender stereotypes within real-world contexts in three ways; passive reinforcement, active reinforcement and active engagement.	Raise awareness of the active and passive mechanisms for stereotype reinforcement and provide permission and training to actively tackle stereotypes.	ITT, ECF and CPD providers
		q. Participants perceive that the historically gendered strands of D&T remain as potential barriers to developing a more inclusive and equitable subject.	Review the role of material specialisms as optional exam questions and flexible NEA approaches.	DATA (exam boards)
	12. Lost in STEM	r. The highly variable provision of STEM activities is perceived to have a greater utility value than D&T **and** this is more readily understood by girls.	Review the role that STEM initiatives, especially those related to engineering have in D&T.	DATA (*D&T leads, STEM leads*)

Table 5-1 Research questions, themes, recommendations and stakeholders.

Professional development providers (T2 – teacher gender, T3 – classroom relationships, T4 – models of society)

The central role of positive pupil-teacher relationships to high quality teaching and in turn, enjoyment of the subject and ultimately to the choices made by pupils was noted by all the participants. Although this follows on from Sansone's (2017) research, there were contradictions from the teachers about how this works in practice for boys and girls. Most agreed that boys tended to dominate proceedings in a way that was not always related to learning and detrimental to the learning of girls and quieter boys, matching Younger and Warrington's work (2005). The participants all recognised that this generalisation is a stereotype; clearly not all boys are loud or all girls quiet in lessons. The male teachers were less aware of stereotyping effects (F-b) and some provided examples of outdated gender essentialist views (F-d). This was most noticeable when presenting contextual challenges for D&T tasks and the participants reported how they handled gender stereotypes in their classrooms in three quite different ways; active reinforcement, passive reinforcement and active engagement (F-p).

The participants' responses indicated that motivations for teaching have a part to play in the behaviour management of D&T classes. Even in this small sample, the male teachers followed Wall's (2012) findings that teaching as a back-up career matched their reports of negative behaviour management techniques (F-c). The admission of a male D&T teacher playing the role of chief wolf to control rowdy boys whilst alienating girls was striking; especially when linked to that teacher's failed product design career. With other participants there were less reliable judgements made about classroom behaviour and teacher responses. Evidence from observations often conflicted with self-reported teacher actions, a tendency supported by literature (Hook & Rosenshine 1979).

There are three recommendations for practice that stem from these findings and could be delivered through ITT and ECT programmes or CPD providers. These could apply to all disciplines but primarily useful for those teaching STEM subjects. The first is the need to raise awareness in teachers of the power of gender essentialism (R-d) and stereotyping effects (R-b). The next recommendations are only relevant to D&T teachers, whatever their experience. These include coaching in positive behaviour management techniques (R-c) and training on the presentation of context-based challenges that reduce gender stereotyping (R-p). The Design and Technology Association could play a part in the delivery of this CPD to practicing, rather than novice, teachers.

Tools that could be useful for these recommendations include those that have been used in this research study. The Implicit Association Tests provide a useful starting point for discussions about social gender roles and video feedback could provide a powerful tool in coaching equitable behaviour management techniques.

There were suggestions in the literature, and from the participants, that single gender approaches could eliminate some of these behaviour management obstacles; although many of the participants also have concerns that such interventions could reinforce gender inequality. Rather than propose this as a recommendation for practice, this is a recommendation for further research.

School leaders (T5 – professional boundaries, T7 – school restrictions)

Although the next recommendations are aimed at school leaders there may be a part to play for ITT providers and the Chartered College of Teaching in helping to clarify how teacher standards of professional conduct apply to positive action initiatives. These are issues wrapped in uncertainty, uniqueness and value conflict and are examples of Schön's 'indeterminate zones of professional practice' (1995).

The participants all expressed a desire for leadership to clearly define forms of acceptable encouragement to help teachers maintain a professional approach (F-g). Guidance on how best to conduct talent identification programmes, one-to-one career talks and prepare marketing materials for parents are just some of the examples suggested (R-g). One tool that could be usefully lifted from this research study is the power of focus groups to provide a platform for meaningful discussions about professional practice and gender equity.

The participants also shared a concern that guidance for pupils about D&T was often based on limited information, or even misinformation (F-k). School leaders could ensure, if they are not already, an equitable opportunity for optional subjects, including D&T, to present a clear message to parents, pupils and teachers about their subject (R-k). This is particularly important for girls who, if the participant perceptions are confirmed, take on board advice more readily than boys. This would provide a platform to clarify the unique offering of each subject, outline the demands and counter any misconceptions about gender roles. In D&T this could involve the department leads specifically explaining the function of project work and creativity to parents, pupils and other teachers.

Statutory requirements on inequality (DfE 2014) outline that teachers are responsible for actively employing positive action to change, rather than replicate, societal inequities. Most of

the participants struggled with this concept, confusing positive action with positive discrimination. Positive action initiatives also caused conflict for the teachers with strong gender essentialist beliefs based on biology and faith. The participants suggest that school leaders could do more to clarify how the Equality Act can be managed through school initiatives such as single sex setting arrangements or extracurricular clubs (F-e, F-f). This is more than providing permission to run a girls-only STEM club, but actively promoting and explaining the purpose to pupils, parents and teachers (R-e, R-f).

Design and Technology leaders (T6 – family guidance, T7 – school restrictions, T10 – practical confidence)

Parents were frequently described as obstacles to providing equitable opportunities for girls in D&T with complaints of outdated perceptions of the subject and more pervasive social stereotyping processes (F-h). As the key socialisers, parents are a crucial part of both the problem and the solution. Yet only one participant spoke of active engagement with parents despite examples from recent STEM (Archer, MacLeod & Moote 2020) and WISE (2017) initiatives. D&T leaders could do well to actively engage parents to challenge some of the outdated and gendered misconceptions about the subject (R-h).

Although the participants seem to dismiss the research evidence on the importance of peers as socialisers, they do usefully suggest that older pupils and siblings can have a more significant impact as role models (F-i). The work of numerous STEM initiatives (IOP 2010, WISE 2017) includes engaging role models to help girls link their self-concept with STEM identities (Eccles 2011). D&T leaders could consider how to use older girls in their schools for inspiration and guidance of younger pupils (R-i).

In most of the schools, the participants perceive Art and D&T to be in a complex relationship which hinges around an element of competition (F-j). D&T leaders could possibly do more to engage with Art departments and discuss how creativity is developed in pupils in similar and different ways across the two subjects (R-j). This would hopefully provide clarity at a school level about how Art and D&T can both offer powerful ways to nurture and develop creativity in boys and girls without any gendered stereotyping.

The importance of practical work in D&T is explored in a recommendation for the Design and Technology Association later. However, there could be useful steps made by D&T leaders in schools to provide opportunities for girls to develop practical tinkering skills. The participants perceive that the gender-role stereotypes associated with practical work are firmly embedded by Year 9 and that girls tend to, although not exclusively, have had fewer previous opportunities to

develop these skills (F-o). Proposals from the participants match suggestions from CDT teachers from over three decades ago (Down 1986, Cattan 1988). These include both single gender positive action initiatives and working closely with primary schools on tinkering skills (R-o). The number of primary D&T specialist teachers is limited, and secondary D&T teachers could make a significant impact in this area.

Design and Technology teachers (T8 – attainment and failure, T9 – conscientious girls)

The teachers all confirmed the place of project-based learning at the heart of D&T education. Projects help to develop resilience, critical thinking, problem solving, creativity, organisation, teamwork and communication skills. These are all taught, developed and assessed in D&T whilst being sought after by universities and employers alike. The D&T community should celebrate this significant contribution to the wider education of all pupils; whatever their career route. There is a perception of the participants that girls tend to outperform boys in most of these areas (F-m) and this could be leveraged to good effect. The participants report that organised and conscientious girls tend to cope better with the longer projects; although some teachers even describe a need to moderate some girls' effort. Managing levels of anxiety in girls is an important part of the role of teachers but this comes with a warning that gendered stereotypes of conscientiousness and anxiety must be handled with care (R-m).

There are however, two features of project-based learning that could be deterring girls. Teachers perceive that girls tend to place greater emphasis on success and respond to failure much more acutely than boys (F-l). The end point of a D&T GCSE non-examined project is rarely known in advance and this uncertainty about the precise form of success is problematic for more girls than boys. Decisions about GCSEs are based on expectancies of success (Eccles et al. 1983, Eccles 2005, 2007, 2011) and so it is important that the process of project work is prioritised over the practical outcomes, especially at KS3. The higher weighting of process over product already exists in the non-examined assessment mark schemes but practical outcomes currently dominate perceptions of the subject. The second feature of project work also relates to failure; the iterative design process revolves around a series of useful failures (Stables 2020). More training about the value of these failures may be needed for girls than with boys as a way of counteracting effects of socialisation.

The following recommendation is already part of DATA's recent work on KS3 but deserves reinforcement. Teachers could prepare pupils, boys and especially girls, better for the new GCSE by providing progressively more challenging experiences throughout KS3 that build on failure within iterative design and provide increasingly open-ended problems (R-l). Being explicit about

the role of failure and uncertainty, whilst also ensuring an element of success, is a particularly difficult challenge for D&T teachers but the participants suggest is crucial for girls' enjoyment and confidence.

Design and Technology Association (T1 – teacher background, T10 – practical confidence, T11 – contexts and specialisms, T12 – lost in STEM)

The final set of recommendations revolve around a significant shift in approaches to the subject and relate to a combination of celebrating an interdisciplinary approach, a repositioning of practical work and removing material specialisms. These are radical propositions and I recognise that are stretching the influence of the findings from such a small study. But radical changes may be needed to ensure the survival of the subject and, most importantly, to ensure that the subject provides an equitable offering for boys and girls.

The recommendations focus on the role of the Design and Technology Association to identify a shared vision, provide strong leadership and a powerful lobbying force. Despite growing membership, DATA is self-funded. This provides a level of autonomy but also limits its potential as lobbying force. Redefining a more equitable and valuable D&T curriculum may therefore also require the weight of DATA, STEMNET and RAEng and exam boards.

The teachers in this small study presented quite different understandings of the purposes of D&T and the subject's disciplinary boundaries. These contrasting responses can be traced back to their various undergraduate degrees and industrial experience (F-a). The poorly defined boundaries of D&T (Bell 2015) have an impact on the utility value of the subject and, according to the participants, this is recognised most acutely by girls.

D&T offers an interdisciplinary approach to tackle real world problems; integrating moral, social, ethical and environmental factors in a critical manner alongside mathematical techniques and scientific knowledge. These are skills and approaches that are valued by all employers and not just STEM degree admissions tutors. These signature pedagogies develop precisely the sort of technological capital that will support all pupils, and especially girls, in their future lives as consumers or technical designers. Teachers in this study recognise the signature pedagogies of D&T but not consistently and certainly without a shared understanding of their importance to future studies, lives and careers. These signature pedagogies could be celebrated more widely by the Design and Technology Association so that all socialisers, adult influencers, parents, tutors and career advisors are much better informed (R-a).

The participants present quite varied understandings of practical work as a signature pedagogy of D&T (F-n). Not only does practical work have multiple purposes within D&T but the participants reinforce how practical ways of knowing and thinking are recognised as second class to academic forms of knowledge (Mitchell 2019). The role of designing using 'hand and mind' in an iterative process is well understood by the participants (Kimbell and Stables 2007). Less clearly defined is the difference between the role practical skills have in preparing pupils for vocations or trades or in developing understanding of technology for professional engineering routes. Practical work is also understood as a pedagogical approach, through experiential learning, to understanding material science and manufacturing processes.

How best to distinguish between these three purposes of practical work is complex (R-n). One possibility could be to recognise, on a national scale, extracurricular craft-based projects in a similar model to the CREST scheme. There is even the potential to tie this into apprenticeships and vocational training. Finding the time in the curriculum to develop craft skills has always caused conflict for D&T teachers and confusion for the public. There are also numerous time, budgetary and health and safety implications that affect the support that D&T, in its current form, has in maintained schools. This recommendation is not about removing practical work from D&T altogether but merely to provide a clearly defined and alternative pathway for the development of craft skills. Pure craft-based skills could then be released from the D&T curriculum to provide room for the third recommendation in this series.

Although there was consensus on some of the key pedagogies of the subject from the 'engineer' and 'artist' participants, they repeatedly referred to the recent GCSE material strands which are historically highly gendered (F-q). The newly reformed GCSE has a single title, but these strands remain and are now hidden within optional routes of study and assessment questions.

Teachers of D&T need more support and direction in providing a truly inclusive approach. Part of this provision could involve further development of the exam board specifications by reintegrating the gendered options fully into the core offering (R-q). This can be justified in a public admission that D&T has had a part to play in reinforcing stereotypes but also the potential to help break down gender-role stereotypes. "Once the historically contingent nature of any bias has been shown, then it should be easier to see that there is no reason to continue in such a manner" (Sargent 2004 p866).

The relationship between D&T and STEM is perceived quite differently by the participants; those in the maintained sector suggest a particularly weak link between the two. In the fee-paying institutions and specialist academy many of the extracurricular STEM offerings, that

are valued by universities as providing desirable skills, are being provided by D&T teachers. The participants perceive that this STEM provision is recognised by pupils, and girls especially, as having greater utility value than the subject of D&T (F-r).

The final recommendation may seem rather radical, but it echoes elements of Stable's (2014) suggestion to turn the D&T curriculum outside in by drawing the extracurricular interdisciplinary project-based STEM activities into lessons (R-r). It also matches Bell's (2017) cry to establish its identity as a subject of inherent value providing equitable access for all pupils to a STEM curriculum. This could go a long way to divorcing D&T from its historically gendered roots; especially if it were to be rebranded.

D&T teachers have a wealth of experience in facilitating interdisciplinary, open ended projects solving wicked real-world problems. They know how to supervise student-led projects and develop research, analysis, creative skills. These are appealing for schools, students and universities alike. There may even be the potential to compare these D&T or STEM projects to Higher and Extended Project Qualifications. HPQs and EPQs are GCSE and post-16 level schemes are recognised by many universities as developing useful traits for independent study; resilience, enquiry-based approaches, rigour, analysis and synthesis.

The participants in this study perceive that girls take their career decisions and subject choices very seriously and the current confusion about the place of D&T and what it offers may well be part of the problem. If D&T, or a version of it, is valued by schools, universities and industry, then girls will be more likely to consider it seriously.

Conclusion

The STEM field, and engineering in particular, has long recognised the shortage of supply of qualified people into its ranks and especially the very low numbers of women. This is primarily discussed as an economic concern, occasionally as an equity issue and, less frequently still, to improve the quality of engineering solutions (Gibbs, 2014, Watson & Froyd 2007).

At the same time, D&T continues to struggle to finds its place in the British education system with vague disciplinary boundaries, historically vocational purpose and the fundamental role of practical work which has low cultural value. Yet D&T has the potential to play an important part in the development of pupils' capability to positively contribute to society, STEM careers or even engineering. The attitudes, behaviours and technical literacy developed through interdisciplinary, real-world, value-led and iterative projects are highly valued in many fields and not just STEM.

The primary focus of the research has been at the first point in pupils' lives when they make a conscious choice about which subjects, and potentially careers, they drop or follow. The study uses the perceptions of teachers to describe the overwhelming number of forces that undermine girls' agency but also to identify some potential solutions.

Underpinning this project are a set of developmental philosophies that can be traced back to constructivism (Dewey 1916), participative enquiry (Reason & Rowan 1981) reflective practice (Schön 1987), and ethnographic and insider researcher perspectives (Chavez 2008). The professional doctorate draws on three traditions: an action-based pragmatism that emphasises the interdependence of knowing and doing, a constructivist perspective that sees the learner as making sense of situations from an individual and autonomous position, and a critical realist philosophy where there is a concern to create and learn from change through enquiry-driven processes.

The first aim of the research was to identify how teachers perceive gender stereotypes are played out in the subject. The findings suggest that gender stereotypes continue to be played out in the historical material specialisms, despite recent reforms to the D&T curriculum. These specialisms are associated with the teachers' own technical or artistic training, which is also gendered. Some of the male teachers present outdated views on gender social roles that have elements of gender essentialism. These participants are less able to identify stereotype effects and demonstrate a link between negative motivations for teaching and negative behaviour management techniques. Their effect is to actively reinforce gender stereotypes. The majority of teachers are passive participants, allowing gender stereotypes to permeate their teaching and pupil work. A third group of teachers actively engage with, and tackle, gender stereotypes in their lessons, planning and actions with pupils and parents.

The perceptions of all participants demonstrated uncertainty about positive action and positive discrimination when considering initiatives to support minority groups such as girls in STEM. Professional standards and boundaries surrounding providing advice and encouragement to pupils were also questioned. There were suggestions that pupil needs were not considered at an individual level and gender stereotypes were being fed into advice from other teachers.

The second aim of the research is to identify how D&T teachers perceive how boys and girls make choices about GCSE subjects. Pervasive and powerful effects of parents and older siblings on pupil choice were identified by the participants through numerous examples and observations. Their concern was that these effects are based on limited knowledge and gendered social roles. Numerous restrictions were identified at a school level that compound

rapidly to deter girls from D&T, these include a complex relationship with Art and effects of the EBacc.

The participants made a number of connections between gender, pupil attitudes and choice making process. There is a recognition throughout the study that these observations can move from specific examples to generalisations and gender stereotypes. Participants suggest that the role of failure in iterative design and unknown project outcomes has much greater cost value for girls than boys. A conscientious approach, also associated with girls, is understood as positive for progress but also detrimental effect on levels of pupil anxiety. The most securely presented perception, with many examples, is that girls in mixed settings are much less confident with practical work than boys. The role of practical work was tied in to differing perceptions of the purpose of education, instrumental or general. Practical work was identified as having three key functions, but these were not shared by all the participants, suggesting ambiguity about its purpose with D&T.

The final aim of the research is to identify how D&T teachers perceive how their subject relates to the gender in STEM debate. The participants share widely different perceptions about D&T and its relationship with STEM; from dismissal to critique and positive engagement. The provision of extracurricular STEM initiatives, including those deemed to be positive action initiatives, are rarely part of the maintained sector D&T offering. The fee paying and academy D&T departments often provide many such activities. There were perceptions that these STEM activities have more utility value than D&T qualifications and that girls were more able to recognise these values.

The perceptions of the participants are that girls are more aware of both the cost and utility value of D&T qualifications and STEM activities. Participants also suggest that girls are more aware of the lack of disciplinary clarity in D&T, including the role of practical work and relationship with STEM. A combination of these two features may well be driving girls away from the following the subject.

I believe that these findings make a small contribution to professional knowledge; the literature on gender in Design and Technology is relatively limited and this study goes some way to bridging the gap with many of the understandings from the significant body of work in STEM and gender more generally. The focus on teachers' perceptions provides a limited viewpoint but hopefully provides a deeper insight into how gender is handled by D&T teachers in practice. As befitting a critical realist approach, there is a search for multiple layers of understanding of how gender is enacted in D&T. Eccle's Expectancy Value Theory has been pivotal in understanding how many of the structural forces work to restrict and enable girls' choices.

Many of the teachers' perceptions and observations support these mechanisms and add useful detail to the links from the cultural milieu to socialiser's beliefs and behaviours on to pupils' perceptions, goals and self-identities. The participants also propose an additional element to the EVT; they suggest that girls' and boys' appreciation of enjoyment value, utility value and cost is directly, and differently, affected by gender role stereotypes. The EVT model describes how gender role stereotypes feed into the pupil's perceptions which then influence their goals, self-concept and choices in turn. The suggestion is that gender role stereotypes are brought to consciousness for girls when making choices that depend on the relative value of utility and cost; in other words, there is a direct link between cultural milieu and choices.

The findings suggest a series of recommendations for a series of stakeholders from D&T teachers, D&T leaders, DATA, school leaders and CPD providers, including those delivering ITT and ECF programmes. Many of the participants in the study demonstrated a raised awareness of the structural barriers for equitable provision of their subject. Many were also seen to identify their own role in both enabling and preventing equitable choices. At a personal and local level, my own teaching practices and planning are being modified to include many of these recommendations to provide a more equitable experience for boys and girls. I continue to seek opportunities to share this research with other teachers and the Design and Technology Association. I believe that this project has fulfilled its purpose in contributing, even if in only a small way, to professional practice and hope that it can contribute to a more equitable provision in schools

I welcome feedback and reach out to join with others in a dialogue about gender equity with D&T and STEM.

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Younger, M., and Warrington, M., (2005). *Raising Boys' Achievement.* DfES Report 636. Norwich: HMSO.

VIII. Appendix I - Schedules

1a - Interview schedule

Administration
1. Recording kit charged and checked (including back-up). 2. Check time available for interviewee. 3. Access to a PC for IAT checked. 4. Wifi arranged for IRIS. 5. Set up room with kit.
Preamble
1. Thank you for agreeing to take part in this interview. It should take no longer than an hour. I hope that gives you time to get to your next task? 2. The study is part of my professional doctorate at the University of Sheffield; I am funding it myself; like you, I am a D&T teacher. 3. I am keen to investigate teachers approaches to gender in the subject; the working title of the thesis is '*Teachers' perceptions of gender in D&T'*. 4. To meet the ethical standards expected at Sheffield University I will first outline the interview so that you can ask questions and finally, if you are happy to continue, I will ask you to sign a participant consent form. 5. With your permission I am going to record the interview using two systems as a form of redundancy. This digital recorder and the IRIS system (a camera on the iPad and tripod connected to the iPod acting as microphone). 6. The reason for the recording is to ensure that I don't interrupt your flow with note taking; I want to listen carefully to what you say. 7. The video is purely to ensure that your non-verbal responses (shrugs, head shaking etc.) can be recorded into the transcript. 8. The video and voice recordings are not going to be used beyond the research team (you, me and my supervisor and assessors). They will be destroyed 6 months after graduation and the video is stored on a secure server at IRIS, not on my devices. 9. Parts of the transcript may be included in the thesis. I will send you a draft of this so that you can amend as you see fit. 10. You may skip questions and ask for clarification at any point. You can also withdraw from the project at any point and you don't need to provide a reason. 11. Your school and your own confidentiality and anonymity will be maintained throughout the thesis.

12. Please see this as an invite to be involved as a co-researcher. I want this process to be a collaborative inquiry into gender issues in our subject. This is not research conducted on you but with you.
13. Are you happy with the arrangements before we begin?
14. Sign both copies of the form

General questions

1. How long have you been teaching at this school (and in total)?
2. What is your current role and how long have you been doing this?
3. What is your training and experience before teaching?
4. How many pupils are at your school… and what proportion are boys and girls?
5. When do your pupils make formal choices about which GCSEs (Level 2, BTEC Tech Awards, KS4) to follow?

Research Question 1 - How do D&T teachers perceive how gender stereotypes play out in the subject?

1. What proportions of pupils choose D&T for GCSE (and A level)? *May need to get this detail later.*
2. What factors do you believe influence their choices? *Write these down to share later in the interview.*
3. Could you rank the weight of those influential factors on the pupils?
4. Now that you have ranked those influential factors could you identify the relative importance of your role in each?
5. What is the proportion of boys and girls in the current Y10 and Y11 groups?
6. What is the proportion of boys and girls in the current Y12 and Y13 groups?
7. Going back to your ranking of influential factors on choice, do you think that there is a difference or not between boys and girls?
8. Could you identify a few characters that have chosen D&T for GCSE and describe how those factors play out? Repeat the question to try to get at least 4 students including boys and girls as appropriate.
9. Could you identify a few characters that have ***not*** chosen D&T for GCSE and describe how those factors play out?

Research Question 2 - How do D&T teachers perceive how boys and girls make choices about GCSE subjects?

1. What role (or roles) do you feel the subject of D&T has in society today? If STEM careers are not mentioned, explore how strong or weak do you believe the link between D&T and STEM careers is?
2. How do you feel the new single title GCSE D&T meets those roles (the purpose) of the subject?
3. Which D&T titles did you offer before… and what was the proportion of boys and girls on each?
4. Why do you think that predominantly the national pattern is that girls dominated textiles GCSE and boys dominated electronics/systems and control GCSE?
5. Do you believe the new single title D&T specification is having (or will have) an effect or not on pupil's choice to follow GCSE?
6. How are you tackling the core and specialist elements? If yes, ask how?... and whether the integration of the D&T 'strands' is having an effect on choices of boys and girls in the same or different way.

Research Question 3 - How do D&T teachers perceive how the subject fits into the wider gender-in-STEM debate?

I would be very grateful if you could work through this Science/Gender Implicit Association Quiz online. I completed one recently, they take about 10 minutes. The data is used by Harvard University and results are confidential. The outcome will be mentioned in the thesis but there is no statistical significance as the sample is way too small. Your thoughts on the outcome are what I want to talk about.

1. Your first thoughts? *Give respondent time to voice concerns, issues etc.*
2. What was your implicit association strength?
3. Are you happy to share your responses to the earlier questions about opinions?
4. What did you put for your belief of the validity of the exercise at the end?
5. What do you feel when you compare your outcome with the ranges shown below for the general public? *(Show graph at bottom).*
6. Do you think that this has an effect on your teaching or not?
7. How do you believe that this affects the choices made by the pupils, if at all? *Why, why not?*

Interview conclusion

1. Are there any other aspects of the topic of gender in D&T that you feel we haven't covered?
2. I would like to invite you to try some of these sorts of questions again but sat in front of some video of one of your Y9 lessons as a prompt.
3. At that stage we would need consent from your head teacher but you would have control of the video with your own IRIS log on and therefore I would effectively be observing only those parts

of a lesson that you were willing to share. This use of data fits with the legal basis of a public task in that professional development is a statutory requirement for teachers.

4. Could I take pictures of the projects we have talked about, it could help hugely in the explanations on the thesis? Just as with the interview all efforts to anonymise the pictures would be taken and you always have the right to withdraw your permission for their use for whatever reason.
5. Please email or even 'phone me if anything springs to mind based on your own reflections, interesting incidents; my details are on the consent form.
6. I will transcribe the interview in the next week and send you a copy for approval or amendments.
7. Is there someone whom you can suggest that I could interview for my research?
8. Thank you for your time today.

1b - Video Lesson checklist

Sample selection
• Teachers approached directly or via gatekeepers (head teacher or deputy head responsible for staff and professional development). • Gatekeeper approval.
Pre-visit preparation
• Dates selected for access based on Year 9 lessons and time for interview on the same day. • Consent forms sent to school and distributed to teacher, pupils in that set and their parents via the deputy or teacher. • Recording equipment set up for wi-fi access with IT service team at school. • IRIS log-on arranged for teacher. • Charge equipment.
Video arrangements

• Introductions to include final checks on consent forms.
• Locate a suitable room that is acoustically suitable and where the interview is unlikely to be interrupted. Ideally this would be 'home ground' for the co-researcher and a place where they feel comfortable and in control.
• Equipment preparation in classroom, checking power, Wi-Fi and Bluetooth connections; plenty of time required for this:
  o iPad on tall tripod at side or rear of class facing the teacher's normal position.
  o iPad on small tripod at front or side of class facing the pupils normal positions.
  o iPod in teachers pocket (or on lanyard) with lavalier (omni-directional condenser lapel) microphone.
  o iPod in case in central desk (or possibly hanging from ceiling) with high sensitivity, omni-directional microphone (Edutige EIM-001)
  o Reflections laptop set up as back-up (Wi-Fi issues).
• Video equipment starts recording before the class enters the room, I leave to minimise reactivity.
• Teacher explains to pupils that the lesson is being recorded but only he/she and the research team will see the content as explained in the consent form sent to their parents. The focus of the research is the teacher.

1c - Video Stimulated Recall Interview schedule

Administration

1. IRIS connect system
    a. IRIS Connect cued up on screen.
    b. Desk positioned so that both can see the same screen and both interviewer and participant can access the controls.
2. Recording kit (recorder and iPhone):
    a. Charged
    b. Updates checked
    c. Set-up.
3. Invitations for all participants to include:
    a. Timings (1 hour minimum)
    b. Location
    c. Consent form

Preamble

1. Thank you for agreeing to take part in this interview. It should take no longer than an hour. I hope that gives you time to get to your next task?
2. The study is part of my professional doctorate at the University of Sheffield; I am funding it myself and investigating teachers' perceptions of gender in STEAM.
3. This follows on from our interviews and has two key aims:
    - To understand your perceptions of how boys and girls work in D&T.
    - To explore your decision making in D&T lesson with boys and girls.
4. To meet the ethical standards expected at Sheffield University I will first outline the procedures in place so that you can ask questions.
5. With your permission I am going to record the interview using two systems as a form of redundancy. This digital recorder and the IPhone.
6. The reason for the recording is to ensure that I don't interrupt your flow with note taking; I want to listen carefully to what you say but will also be moderating the process to ensure everyone has a chance to contribute and to keep the conversation on track and on time.
7. The voice recordings are not going to be used beyond the research team (you, me and my supervisor and assessors). They will be destroyed 6 months after graduation.
8. The IRIS video is held on a secure server and will also be deleted at the same time.
9. Parts of the transcript may be included in the thesis. I will send you a draft of this so that you can amend as you see fit.
10. You may skip questions and ask for clarification at any point. You can also withdraw from the project at any point and you don't need to provide a reason.
11. Your own confidentiality and anonymity will be maintained throughout the thesis.
12. I want this process to be a collaborative inquiry into gender issues in our subject. This is not research conducted on you but with you.

13. Are you happy with the arrangements before we begin?

Introduction (5 min)

1. For the sake of completeness could you describe the context for the lesson (aims, sequence in a module, time of day and term)?
2. Do you remember any particularly interesting features of that lesson that you think would be worth viewing and exploring? *Reassure the teacher that this moment will be identified.*

Recall questions – set formation (10 min)

As you scroll through the lesson feel free to pause it at any time if something comes to mind. I may ask you to do the same. In particular I would like to explore: *Now scroll through the lesson and allow the teacher to identify moments.*

1. What were your thoughts when doing this (general activity)?
2. What were you thinking when you decided to do this (particular action)?
3. Why did you decide to do that?

Conclusion

1. Are there any other aspects of the topic of gender in D&T that you feel we haven't covered?
2. Please contact me if anything springs to mind based on your own reflections, interesting incidents.
3. I will transcribe the interview in the next month and send you a copy for approval or amendments.
4. Thank you for your time today.

1d - Focus Group schedule (v2)

<table>
<tr><td colspan="2">Administration</td></tr>
<tr><td>4. Participants invited to the meeting.
5. Recording kit (voice and IRIS):
a. Charged
b. Updates checked
c. Wi-fi checked
d. Set-up.</td><td>6. Invitations for all participants to include:
a. Timings (1 hour minimum)
b. Location
c. Consent form (soft copy)
d. Request to bring mark-book.
7. Paperwork available for each participant:
a. Consent form (hard copy)</td></tr>
<tr><td colspan="2">Preamble</td></tr>
<tr><td colspan="2">14. Thank you for agreeing to take part in this focus group. It should take no longer than an hour. I hope that gives you time to get to your next task?
15. The study is part of my professional doctorate at the University of Sheffield; I am funding it myself and investigating teachers' perceptions of gender in STEAM.
16. This focus group follows on from a series of 1:1 interviews with teachers and will explore your perceptions of the choices made by your current Y9 students.
17. To meet the ethical standards expected at Sheffield University I will first outline the focus group format so that you can ask questions and finally, if you are happy to continue, I will ask you to sign a participant consent form.
18. With your permission I am going to record the interview using two systems as a form of redundancy. This digital recorder and the IRIS system (a camera on the iPad and tripod connected to the iPod acting as microphone).
19. The reason for the recording is to ensure that I don't interrupt your flow with note taking; I want to listen carefully to what you say but will also be moderating the process to ensure everyone has a chance to contribute and to keep the conversation on track and on time.
20. The video may also be used to ensure that your non-verbal responses (shrugs, head shaking etc.) can be recorded into the transcript. It will also help identifying who says what and when.
21. The video and voice recordings are not going to be used beyond the research team (you, me and my supervisor and assessors). They will be destroyed 6 months after graduation and the video is stored on a secure server at IRIS, not on my devices.
22. Parts of the transcript may be included in the thesis. I will send you a draft of this so that you can amend as you see fit.
23. You may skip questions and ask for clarification at any point. You can also withdraw from the project at any point and you don't need to provide a reason.
24. Your own confidentiality and anonymity will be maintained throughout the thesis.</td></tr>
</table>

25. Please see this as an invite to be involved as a co-researcher. I want this process to be a collaborative inquiry into gender issues in our subject. This is not research conducted on you but with you.
26. Are you happy with the arrangements before we begin?
27. Sign both copies of the **consent form**

Interview conclusion

5. Are there any other aspects of the topic of gender in D&T that you feel we haven't covered?
6. I would recommend you, and possibly your students, have a go at the Science / Gender IAT Harvard University to explore stereotypes and bias a little further.
7. Please contact me if anything springs to mind based on your own reflections, interesting incidents.
8. I will transcribe the interview in the next month and send you a copy for approval or amendments.
9. Thank you for your time today.

Gender stereotypes in D&T questions

4. What proportions of boys and girls choose D&T for GCSE (and A level)?
5. What factors do you believe influence their choices?
6. Could you rank the weight of those factors on the pupils?
7. Do you think that there is a difference or not between boys and girls in the way they deal with those factors?
8. Could you identify the relative importance of your teaching role in those factors?

D&T with STEM questions – set formation (10 min)

1. What role (or roles) do you feel the subject of D&T has in society today?
2. How do you feel the new single title GCSE D&T meets those roles (the purpose) of the subject?
3. How do you feel the new GCSE D&T fits into the drive for a more diverse STEM workforce?

Gender questions – GCSE choices (30 min)

Evidence suggests that our subjects nationally were heavily gendered at GCSE and beyond. The proportion of students in each of the specialisms is shown in the charts.

1. Why do think that there is a significant difference in take-up at GCSE for boys and girls in these specialisms?
2. Do you believe the new single title D&T specification is having (or will have) an effect or not on pupil's choice to follow GCSE?
3. What role do we teachers have in GCSE choices?

1e - Teacher Information Sheet

1. **Research Project Title**: Gender in STEM: Exploring Design and Technology teachers' perceptions and practices.

2. **Invitation**

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

3. **What is the project's purpose**?

The project is an exploration of teachers' perceptions of gender issues in STEM subjects and more specifically how these perceptions can affect the practices of teaching and learning in Design and Technology. The aim is to add to the understanding of how to engage constructively with gender issues in STEM subjects.

4. **Why have I been chosen**?

You have been chosen as one of eight teachers of Design and Technology with sets including unusual boy/girl proportions.

5. **Do I have to take part**?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep (and be asked to sign a consent form) but you can still withdraw at any time. You do not have to give a reason.

6. **What will happen to me if I take part**?

It is expected that you will allow at least one of your lessons to be video taped, after which you and I will review the footage as soon as practically possible. We will explore together the issues of gender that arise in that lesson and discuss the implications.

8. **What are the possible disadvantages and risks of taking part**?

The initial reviewing of your own teaching on video is often an unsettling process. You will have the option of viewing your footage alone before sharing with anyone else. You could also decide to have a lesson video-taped that does not form part of the study, i.e. for your use only.

9. **What are the possible benefits of taking part**?

The understanding developed through the project will hopefully build on a growing body of research evidence concerned with the shortage of women scientists, engineers and mathematicians. There may also be additional benefits of developing aspects your own teaching.

10. **What if something goes wrong**?

If you have a complaint about your treatment during the research that cannot be addressed within the group meetings then you should contact the research supervisor, Dr Jon Scaife. Should you feel that this complaint is not handled to your satisfaction by the Supervisor, you can contact the University's 'Registrar and Secretary'.

11. **Will my taking part in this project be kept confidential**?

All the information that I collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any reports or publications unless you agree separately to any specific video clips being used; see below.

12. **Will I be recorded, and how will the recorded media be used**?
Video recordings of your activities made during this research may be used for analysis but no one outside the project will be allowed access to the original recordings. These will be destroyed one year after the completion of the thesis. Only clips that you have specifically agreed to, with separate written permission, may be used for illustration in conference presentations, lectures, thesis publication or archived. You will have the option of blurring your image in the clip.

13. **What happens if the research study stops earlier than expected?**
If this is the case the reason(s) will be explained to you and the actions to be taken with the video footage will be explained.

14. **What will happen to the results of the research project?**
The results, or interim reports, of the research may be published in subject specific or general educational journals and presented at conferences. You will not be identified in any report or publication unless as a co-researcher. The data generated during the course of the project might be used for additional or subsequent research.

15. **Who is organising and funding the research?**
Assistance for this research is being provided by Ampleforth College and IRIS is providing the platform for recording and sharing the video securely.

16. **Who has ethically reviewed the project?**
This project has been ethically approved via The University of Sheffield Education Department ethics review procedure. The University's Research Ethics Committee monitors the application and delivery of the University's Ethics Review Procedure across the University.

17. **Contact for further information**

Researcher
Brendan Anglim
bja@ampleforth.org.uk
St Bede's House
Ampleforth College
York
YO62 4EX
01439 766414
Supervisor
Dr Jon Scaife
j.a.scaife@shef.ac.uk
School of Education
The University of Sheffield
388, Glossop Road
Sheffield
S10 2JA

You will be given a copy of this information and consent form sheet to keep.
Thank you for supporting this research study.

1f - Participant Consent Form

Title of Research Project: Teachers' Perception of Gender in Secondary Design and Technology Education in the UK.

Researcher: **B. J. Anglim (bja@ampleforth.org.uk)**

Participant Identification Number for this project: ☐

Please tick the boxes below:

1. I confirm that I have read and understand the information sheet dated explaining the above research project and I have had the opportunity to ask questions about the project. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. ☐

3. I understand that my responses will be kept strictly confidential. I give permission to the researcher to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research. ☐

4. I agree for the evidence generated from me to be used in future research and publication. ☐

5. I agree to take part in the above research project. ☐

_____	_____	_____
Name of Participant	Date	Signature

To be signed and dated in presence of the participant

_____	_____	_____
Researcher	Date	Signature

To be signed and dated in presence of the participant

Copies:
Once all parties have signed this participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be placed in the project's main record (e.g. a site file), which must be kept in a secure location.

1g - Single sex initiative results

Review of Y9 Art/D&T/Computer Science carousel
Held on: 17/06/2019
Present: BJA, Jake, Doug, Thom, Cole.

Item | Action

Intro
Feedback from teachers of Y9Art, Computer Science and Design & Technology from a 1 hour meeting is summarised below under headings in no particular order.

Aims
The aim of the carousel was to provide a more condensed offering from each of our subjects to maximise our contact time by reducing the length of time between lessons, and minimising the impact of missed lessons (end of term, Exeat, exams etc). This would hopefully improve the students' progress which in turn would prepare them more effectively for GCSE. We also wanted to avoid any impression that subjects with less contact time are less important subjects… which may improve take up at GCSE.
The aim of the sex division of sets was to explicitly raise social stereotyping as the first step in breaking down those stereotypes. The aim was to have 3 girls and 3 boys sets but due to the lower numbers of girls it looked like:

Set	Girls	Boys
1	100	0
2	0	100
3	57	43
4	0	100
5	64	36
6	0	100

Relationships with students
Computer Science teachers found it easier to return to the same set in the latter rotations because they already knew the students. This helped build stronger relationships, made differentiation and report writing more effective.
Art and D&T swapped groups around between teachers, in D&T this allowed two very different modules to be taught easily and allowed the students to meet both teachers. In Art the feeling was that because students mature significantly over the year they really needed the same teacher to work alongside them in the journey of developing skills.

Change or keep teacher?

Length of time
There is always a confidence issue with a number of students based on the huge variation in prep school offerings for Art, D&T and Computing. The more condensed module approach doesn't seem to provide the time to slowly develop confidence.
Although we only had to get to know one group at a time it was difficult to really get to know students very well in such a short time. There was also a feeling that first impressions on both sides (teacher and student) were difficult to undo.
The length of time for each module varies depending on the particular half term. We adjusted our teaching to add or extract various elements (worked well in Computing, less so in Art).

Factor extensions in to planning

Some students did ask whether they needed to do the last rotation in a subject they were not going to do.
Cole changed the focus to appeal to the different make up of students (computational thinking in sport for set 6 boys).
In the last half term of the summer the studio wasn't available in Art.
D&T ran something very different (bridge competition) as many had already chosen

Consider alternative activity for last rotation

their options.

End of year exam

Computing kept an end of year exam but it did not provide a useful comparison between students. The last groups in Computing were top sets so worked hard to do well in the exam even though they had less time. The first groups were disadvantaged by length of time since last covered the content.

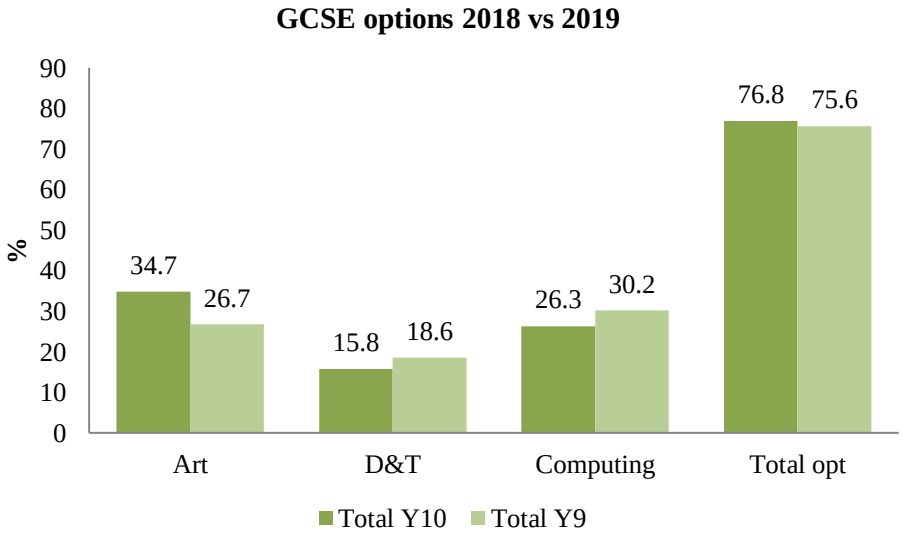
Consider end of module FA not end of year exam

D&T used end of module FAs effectively; this maintained student focus more positively than previous years and progress was noticeably improved for may of the sets.

Art used FAs that included progression of work over the modules. An end of year exam doesn't really work in Art – 1 hour doesn't match the sort of work done.

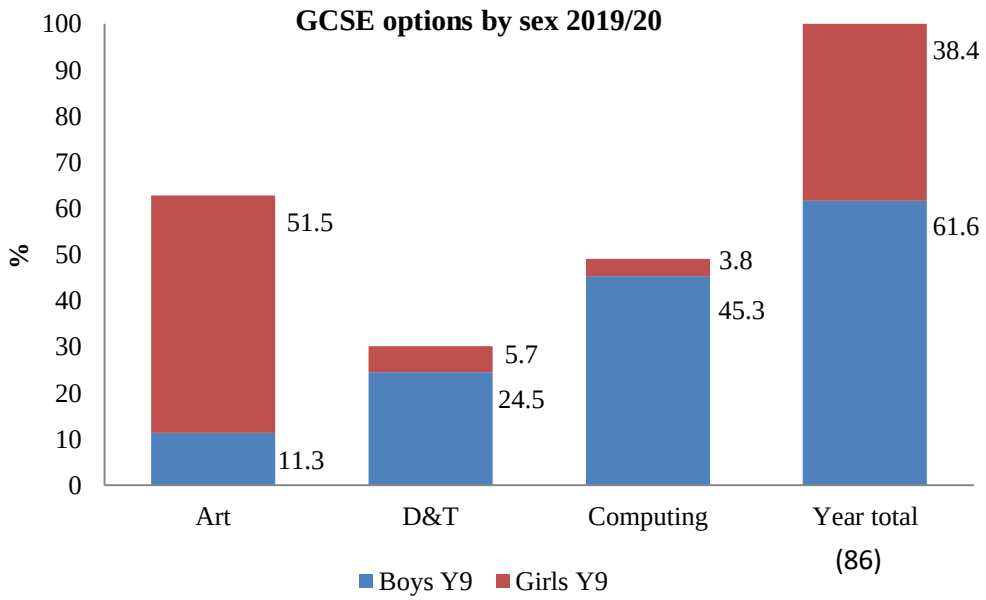
GCSE choices (see results)

No significant difference was noted in the percentage of students taking up each subject at GCSE between 2018 (no carousel, mixed classes) and 2019 (with carousel and gender split). Slightly less have opted for Art this year possibly because of the teacher disruption?



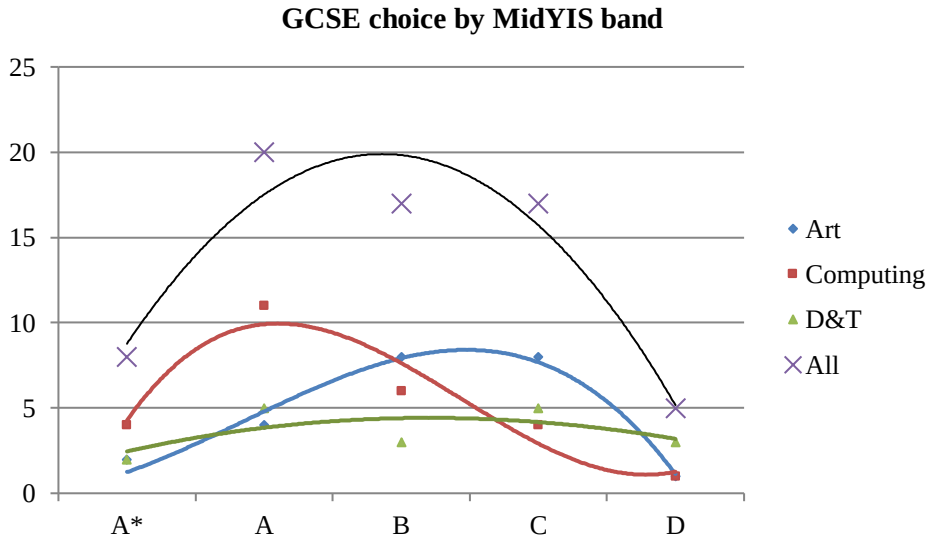
In addition the pattern of selection remains significantly affected by sex (with very little change from 2018).

Item	Action



A lengthy discussion about the factors influencing students choices took place. These factors are briefly described:
Whether they like the teacher is likely to be a significant factor. Any negative vibes in the classroom from the teacher can make a difference.
Prior attainment is a factor in that more students with higher MidYIS scores take Computer Science than Art. D&T has a more even spread acoss all MidYIS bands.

Consider a joint presentation to students, tutors and parents

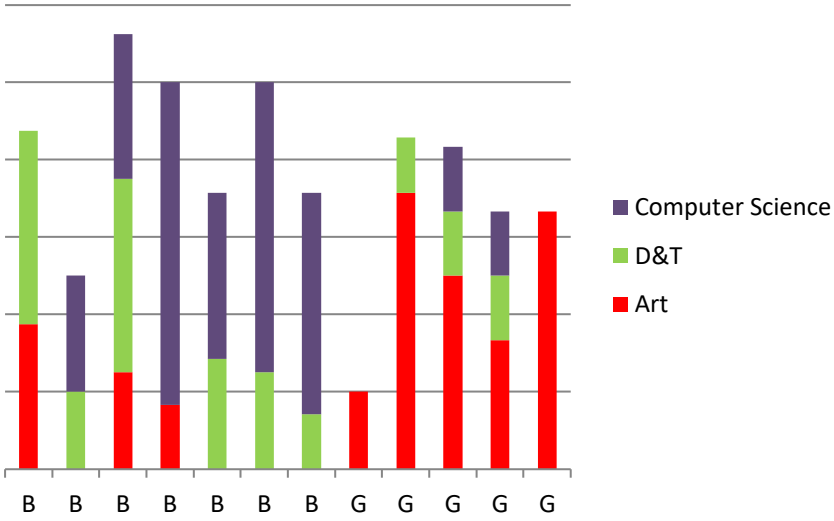


Families have a large impact on choice. Parental expecations, experiences and ambitions influence the students (and their siblings who in turn have an impact).
Every student will have had one module in each subject before choices are made but for many this will their first taste of the subject outside some unusual prep school experiences.
The carousel provides only one opportunity to communicate with parents via a report for only two of the subjects before the Parents Day. This does not seem to be enough time or space to inform the parents about what the subjects can offer their children.
The school does not have a separate options day and the Options Booklet can be very dry.

Communication required at end of every halfterm

BJA to check with SENCO.

Decisions are then made over the following months in houses. As well as the sex differences (* = girls' tutor group), tutors seem to have a significant role to play with patterns within houses reflecting very differently (*tutor groups identified by gender*):

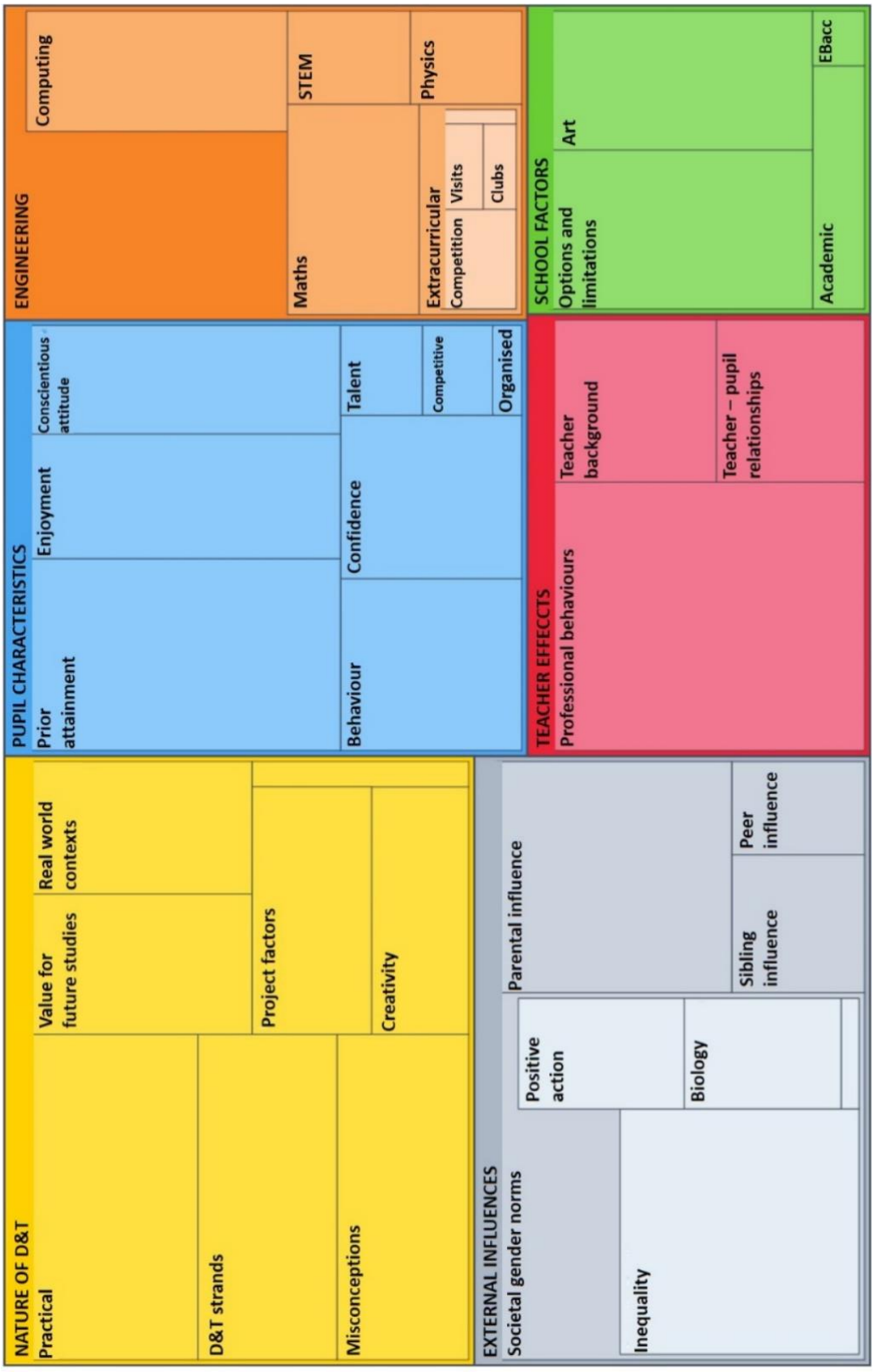


It would be useful to provide a space for some whole school information sharing process to help tutors and houseparents (who are specialist teachers) to keep an open mind and guide tutees in a professional manner.
It would be interesting to hear what specific guidance the school provides to students and their parents in making GCSE options regarding balance, combinations beyond the Options booklet.

Administration
The regular changeover of sets required some communication to ensure that allocations of teachers to sets were made correctly (one mistake this year).
At the first changeover tutors and students were informed. This was not necessary after that.
It was important to inform tutors about the exam schedule, what subjects were and were not included.
Identifying which sets would get reports at the next slot is important as this would allow us teachers to write the reports at the same time as we had the group.
ISAMs emails (such as SEN feedback) includes all teachers even if we do not have that student at the time. Clarification needed from SENCO whether the variable feedback from the three subjects has been a problem.

IX. Appendix 2 – Coding results

2a - Hierarchy of themes



2b - Choice factor frequency

Factors influencing GCSE D&T subject choice	Frequency
Enjoyment	6
Parental advice	6
Sibling advice	4
School structures	4
Prior attainment	3
Career requirements	3
Teacher quality and relationship	3
Creative opportunities	2
Peer advice	2
Perceived difficulty	1

2c – Factors influencing choices of pupils

	Jake	Greg	Ruth	Pete	Bree	Mike
1	Enjoyment	Passion / enjoyment	Practical enjoyment	Enthusiastic staff	Quality of teaching	Enjoyment
2	Academic pressures (tutors)	Talent / aptitude	Break from academic work	Project engagement	Coursework loading (Art + D&T)	Career paths
3	Parents	Career requirement	Open evening, careers talks	Competitions, trips	Practical confidence	Parents
4	Relationship with teachers	Family, parents	Siblings and friends	Siblings	Academic pressures	Peers
5	Older students	EBacc, Progress 8	Parents own experiences	Parents	Parents	Final allocations
6	Marketing (results)	Creativity	Agricultural career needs			
7	Creativity		Peers			

2d - Participant coverage of codes by percentage

	Individual coverage of codes by percentage	Bree	Cole	Doug	Greg	Jake	Kate	Lynn	Mike	Pete	Ruth	Thom
Characteristics of pupil	02 : Behaviour	0.5%	8.6%	0.6%	3.2%	8.1%	4.4%	1.9%	0.7%	0.1%	2.5%	0.0%
	03 : Competitiveness	0.0%	0.0%	1.7%	0.0%	0.3%	0.3%	0.0%	0.0%	0.9%	0.0%	7.4%
	04 : Confidence	6.4%	0.0%	0.0%	2.2%	3.8%	6.1%	0.0%	6.0%	1.2%	0.9%	1.1%
	05 : Conscientious approach	2.4%	11.0%	2.4%	5.1%	1.8%	4.0%	3.1%	2.0%	1.3%	4.9%	10.5%
	06 : Enjoyment	3.9%	0.7%	3.5%	3.1%	1.8%	4.2%	5.2%	2.7%	3.0%	5.7%	1.5%
	07 : Organisation	1.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	08 : Prior attainment	5.8%	10.1%	11.7%	5.6%	4.0%	5.1%	1.5%	7.0%	2.3%	8.6%	0.7%
	09 : Talent	0.0%	2.0%	0.6%	1.7%	1.0%	0.2%	0.0%	0.0%	0.0%	0.0%	1.5%
STEM	10 : Engineering	3.9%	0.0%	0.0%	9.4%	4.5%	4.2%	0.0%	1.0%	21.0%	1.9%	2.5%
	11 : Computing	0.1%	10.5%	24.5%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
	12 : Extracurricular offerings	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	13 : Clubs	0.2%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	2.4%	0.0%	0.0%	0.0%
	14 : Competition	0.5%	0.0%	0.8%	0.5%	0.3%	1.1%	0.0%	0.0%	11.5%	0.0%	0.0%
	15 : Speakers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	0.0%	0.0%
	16 : Visits	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.8%	1.4%	0.0%	0.0%
	17 : Maths	0.2%	0.8%	1.7%	0.7%	0.5%	0.6%	0.2%	0.0%	0.7%	0.6%	0.0%
	18 : Physics	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	19 : STEM	0.1%	0.0%	2.1%	0.5%	0.6%	1.1%	0.7%	0.0%	2.3%	0.0%	0.7%
External influences	21 : Gender in society	13.2%	0.0%	1.9%	9.1%	3.1%	0.0%	0.5%	1.0%	0.9%	0.7%	3.3%
	22 : Biological differences	1.8%	0.0%	0.0%	3.8%	4.9%	0.1%	0.0%	0.0%	0.0%	0.0%	1.3%
	23 : Faith	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	24 : Inequality Equality	6.3%	4.4%	3.2%	8.1%	12.1%	2.9%	4.1%	6.8%	3.3%	3.0%	0.0%
	25 : Positive discrimination / action	2.5%	2.0%	1.6%	0.5%	3.4%	0.7%	0.0%	2.3%	1.0%	0.0%	0.0%
	26 : Parental influence	8.8%	6.1%	5.7%	7.3%	6.3%	4.9%	3.1%	4.0%	9.2%	6.1%	8.9%
	27 : Peer influence	0.0%	0.0%	4.4%	0.8%	2.0%	3.9%	2.0%	1.3%	0.0%	1.1%	0.7%
	28 : Siblings and older pupil influence	1.2%	0.4%	1.0%	0.0%	1.3%	3.5%	5.1%	1.9%	0.0%	1.4%	0.0%
Nature of D&T	30 : Contexts real world	5.4%	9.2%	1.0%	3.9%	1.0%	0.4%	0.8%	4.6%	4.3%	0.3%	0.0%
	31 : Creativity	2.6%	5.4%	0.0%	5.1%	3.5%	0.0%	0.0%	5.4%	4.5%	3.9%	0.0%
	32 : D&T strands	0.6%	0.0%	0.2%	3.3%	2.0%	4.4%	1.3%	4.7%	5.1%	4.6%	0.0%
	33 : Misconceptions	0.8%	2.0%	2.3%	4.9%	6.9%	2.7%	4.7%	3.8%	2.5%	3.0%	4.9%
	34 : Practical	9.1%	0.0%	0.0%	2.8%	5.5%	2.5%	6.8%	17.1%	3.5%	13.4%	0.0%
	35 : Primary school experiences	0.3%	0.8%	1.5%	0.0%	1.0%	0.0%	0.0%	1.8%	0.8%	0.0%	3.8%
	36 : Project factors	4.0%	0.0%	1.6%	0.3%	1.5%	8.6%	9.6%	0.3%	1.5%	3.6%	0.0%
	37 : Value for future studies and career	2.1%	5.7%	6.0%	6.6%	2.6%	6.4%	1.5%	3.8%	2.4%	3.2%	4.3%
School factc	39 : Academic	0.0%	0.0%	0.0%	1.1%	0.1%	0.0%	0.0%	0.0%	0.0%	2.2%	0.0%
	40 : Art	4.1%	0.0%	2.9%	1.9%	2.2%	1.8%	6.2%	2.1%	3.9%	5.3%	17.2%
	41 : EBacc	0.0%	0.0%	0.0%	1.5%	0.0%	1.8%	0.0%	0.0%	0.0%	1.2%	0.0%
	42 : Options and limitations	2.0%	1.4%	2.0%	0.6%	3.2%	7.7%	3.7%	8.8%	5.5%	11.4%	5.6%
Teacher	Professional behaviours	8.9%	14.0%	14.7%	3.4%	5.1%	6.9%	8.4%	5.0%	1.0%	8.3%	13.2%
	Teacher background	1.4%	0.0%	0.0%	0.9%	1.4%	6.3%	27.2%	1.4%	2.2%	1.9%	0.0%
	Teacher pupil relationship	0.4%	5.0%	0.7%	1.7%	2.5%	3.1%	2.6%	1.3%	0.5%	0.3%	10.3%
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

2e School demographics against coding by percentage

	School demographic and coding matrix by percentage	Independent	Academy	Maintained	Selective = Yes	Selective = No	100% girls	50% girls	40% girls	City	Town	Rural	500 - 749	750 - 999	1000 - 1249
Characteristics of pupil	2 : Behaviour	3.4%	0.1%	2.3%	2.9%	2.3%	0.1%	2.3%	3.4%	1.2%	2.3%	6.4%	4.5%	0.3%	3.2%
	3 : Competitiveness	0.4%	0.9%	0.1%	0.5%	0.1%	0.9%	0.1%	0.4%	0.2%	0.1%	1.1%	0.6%	0.3%	0.0%
	4 : Confidence	3.9%	1.2%	4.2%	3.5%	4.2%	1.2%	4.2%	3.9%	3.8%	4.2%	2.8%	3.4%	4.6%	2.2%
	5 : Conscientious approach	3.4%	1.3%	3.4%	3.1%	3.4%	1.3%	3.4%	3.4%	2.9%	3.4%	3.3%	3.4%	2.0%	5.1%
	6 : Enjoyment	2.9%	3.0%	4.2%	2.9%	4.2%	3.0%	4.2%	2.9%	3.4%	4.2%	1.9%	3.0%	3.6%	3.1%
	7 : Organisation	0.5%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.5%	0.6%	0.0%	0.0%	0.0%	0.7%	0.4%
	8 : Prior attainment	5.5%	2.3%	6.3%	5.0%	6.3%	2.3%	6.3%	5.5%	4.9%	6.3%	5.2%	5.8%	4.6%	5.6%
	9 : Talent	0.8%	0.0%	0.1%	0.7%	0.1%	0.0%	0.1%	0.8%	0.5%	0.1%	1.0%	0.6%	0.0%	1.7%
STEM	10 : Engineering	5.1%	21.0%	2.1%	7.6%	2.1%	21.0%	2.1%	5.1%	9.7%	2.1%	3.4%	2.8%	9.8%	9.4%
	11 : Computing	1.9%	0.0%	0.0%	1.6%	0.0%	0.0%	0.0%	1.9%	0.1%	0.0%	4.8%	2.5%	0.1%	0.0%
	12 : Extracurricular offerings	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	13 : Clubs	0.1%	0.0%	0.9%	0.1%	0.9%	0.0%	0.9%	0.1%	0.1%	0.9%	0.0%	0.4%	0.1%	0.2%
	14 : Competition	0.4%	11.5%	0.3%	2.2%	0.3%	11.5%	0.3%	0.4%	3.1%	0.3%	0.3%	0.3%	4.3%	0.5%
	15 : Speakers	0.0%	2.3%	0.0%	0.4%	0.0%	2.3%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	0.8%	0.0%
	16 : Visits	0.1%	1.4%	0.3%	0.3%	0.3%	1.4%	0.3%	0.1%	0.3%	0.3%	0.3%	0.3%	0.5%	0.0%
	17 : Maths	0.5%	0.7%	0.4%	0.6%	0.4%	0.7%	0.4%	0.5%	0.5%	0.4%	0.7%	0.5%	0.4%	0.7%
	18 : Physics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	19 : STEM	0.5%	2.3%	0.4%	0.7%	0.4%	2.3%	0.4%	0.5%	0.7%	0.4%	0.7%	0.6%	0.9%	0.5%
External influences	21 : Gender in society	8.1%	0.9%	0.6%	6.9%	0.6%	0.9%	0.6%	8.1%	9.0%	0.6%	2.7%	1.7%	8.9%	9.1%
	22 : Biological differences	2.9%	0.0%	0.0%	2.5%	0.0%	0.0%	0.0%	2.9%	2.0%	0.0%	3.5%	1.9%	1.2%	3.8%
	23 : Faith	0.2%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.6%	0.3%	0.0%	0.0%
	24 : Inequality Equality	7.9%	3.3%	4.4%	7.1%	4.4%	3.3%	4.4%	7.9%	6.1%	4.4%	9.3%	7.0%	5.2%	8.1%
	25 : Positive discrimination	2.1%	1.0%	1.0%	1.9%	1.0%	1.0%	1.0%	2.1%	1.5%	1.0%	2.8%	1.9%	1.9%	0.5%
	26 : Parental influence	7.5%	9.2%	4.7%	7.8%	4.7%	9.2%	4.7%	7.5%	8.4%	4.7%	6.4%	5.6%	8.9%	7.3%
	27 : Peer influence	1.0%	0.0%	2.1%	0.8%	2.1%	0.0%	2.1%	1.0%	0.3%	2.1%	2.1%	2.1%	0.0%	0.8%
	28 : Siblings and older pupil i	0.8%	0.0%	2.5%	0.7%	2.5%	0.0%	2.5%	0.8%	0.5%	2.5%	1.1%	1.8%	0.8%	0.0%
Nature of D&T	30 : Contexts real world	3.5%	4.3%	1.9%	3.7%	1.9%	4.3%	1.9%	3.5%	4.7%	1.9%	1.5%	1.7%	5.0%	3.9%
	31 : Creativity	3.3%	4.5%	3.0%	3.5%	3.0%	4.5%	3.0%	3.3%	3.8%	3.0%	2.8%	2.9%	3.3%	5.1%
	32 : D&T strands	1.6%	5.1%	4.3%	2.1%	4.3%	5.1%	4.3%	1.6%	2.5%	4.3%	1.4%	2.8%	2.2%	3.3%
	33 : Misconceptions	3.7%	2.5%	3.4%	3.5%	3.4%	2.5%	3.4%	3.7%	2.5%	3.4%	5.7%	4.6%	1.4%	4.9%
	34 : Practical	5.5%	3.5%	10.9%	5.2%	10.9%	3.5%	10.9%	5.5%	5.9%	10.9%	3.8%	7.2%	7.2%	2.8%
	35 : Primary school experienc	0.6%	0.8%	0.7%	0.6%	0.7%	0.8%	0.7%	0.6%	0.3%	0.7%	1.3%	1.0%	0.5%	0.0%
	36 : Project factors	2.0%	1.5%	4.5%	1.9%	4.5%	1.5%	4.5%	2.0%	2.3%	4.5%	1.3%	2.8%	3.1%	0.3%
	37 : Value for future studies a	3.7%	2.4%	4.2%	3.5%	4.2%	2.4%	4.2%	3.7%	3.5%	4.2%	3.4%	3.8%	2.2%	6.6%
School facto	39 : Academic	0.3%	0.0%	0.6%	0.3%	0.6%	0.0%	0.6%	0.3%	0.4%	0.6%	0.0%	0.3%	0.0%	1.1%
	40 : Art	3.3%	3.9%	3.2%	3.4%	3.2%	3.9%	3.2%	3.3%	3.4%	3.2%	3.4%	3.3%	4.0%	1.9%
	41 : EBacc	0.4%	0.0%	0.9%	0.3%	0.9%	0.0%	0.9%	0.4%	0.5%	0.9%	0.0%	0.4%	0.0%	1.5%
	42 : Options and limitations	2.1%	5.5%	8.7%	2.6%	8.7%	5.5%	8.7%	2.1%	2.4%	8.7%	3.1%	5.8%	3.2%	0.6%
Teacher	Professional behaviours	7.1%	1.0%	6.7%	6.1%	6.7%	1.0%	6.7%	7.1%	5.3%	6.7%	7.8%	7.3%	6.2%	3.4%
	Teacher background	1.1%	2.2%	5.3%	1.3%	5.3%	2.2%	5.3%	1.1%	1.4%	5.3%	1.0%	3.0%	1.7%	0.9%
	Teacher pupil relationship	1.8%	0.5%	1.7%	1.6%	1.7%	0.5%	1.7%	1.8%	0.8%	1.7%	3.1%	2.4%	0.5%	1.7%

2f - Participant demographic against code by percentage

	Participant demographic to code matrix by percentage	Male	Female	Experience = 0-2	Experience = 3-5	Experience = 6-10	Experience = 11-25	Design and Technology	Computer Science	Art
Characteristics of pupil	2 : Behaviour	3.5%	1.5%	3.7%	3.0%	3.2%	0.3%	2.8%	3.4%	0.0%
	3 : Competitiveness	0.6%	0.1%	0.1%	0.8%	0.0%	1.2%	0.2%	1.1%	7.4%
	4 : Confidence	2.7%	5.1%	4.4%	4.0%	2.2%	2.9%	3.9%	0.0%	1.1%
	5 : Conscientious approach	3.2%	3.1%	2.8%	3.4%	5.1%	2.4%	2.8%	5.4%	10.5%
	6 : Enjoyment	2.6%	4.3%	3.3%	4.0%	3.1%	2.8%	3.3%	2.5%	1.5%
	7 : Organisation	0.1%	0.6%	0.5%	0.0%	0.4%	0.0%	0.3%	0.0%	0.0%
	8 : Prior attainment	5.0%	5.9%	5.5%	7.4%	5.6%	3.8%	5.1%	11.1%	0.7%
	9 : Talent	0.9%	0.0%	0.4%	0.4%	1.7%	0.1%	0.5%	1.1%	1.5%
STEM	10 : Engineering	8.2%	3.4%	3.6%	2.7%	9.4%	12.1%	6.8%	0.0%	2.5%
	11 : Computing	2.0%	0.1%	0.7%	8.5%	0.0%	0.1%	0.2%	19.6%	0.8%
	12 : Extracurricular offerings	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	13 : Clubs	0.4%	0.1%	0.1%	0.1%	0.2%	0.9%	0.3%	0.0%	0.0%
	14 : Competition	2.6%	0.5%	0.3%	1.0%	0.5%	6.3%	1.9%	0.5%	0.0%
	15 : Speakers	0.5%	0.0%	0.0%	0.0%	0.0%	1.3%	0.3%	0.0%	0.0%
	16 : Visits	0.5%	0.0%	0.2%	0.0%	0.0%	1.1%	0.4%	0.0%	0.0%
	17 : Maths	0.6%	0.3%	0.4%	1.0%	0.7%	0.4%	0.5%	1.4%	0.0%
	18 : Physics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
	19 : STEM	0.9%	0.3%	0.3%	1.5%	0.5%	1.3%	0.6%	1.4%	0.7%
External influences	21 : Gender in society	3.8%	8.3%	7.3%	0.6%	9.1%	1.2%	5.8%	1.2%	3.3%
	22 : Biological differences	2.4%	1.1%	2.5%	0.1%	3.8%	0.1%	2.0%	0.0%	1.3%
	23 : Faith	0.3%	0.0%	0.3%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%
	24 : Inequality Equality	7.4%	5.1%	7.7%	3.0%	8.1%	4.2%	6.8%	3.6%	0.0%
	25 : Positive discrimination	1.8%	1.6%	2.4%	1.0%	0.5%	1.3%	1.8%	1.7%	0.0%
	26 : Parental influence	6.9%	7.4%	7.3%	5.1%	7.3%	7.3%	7.1%	5.8%	8.9%
	27 : Peer influence	1.2%	1.0%	0.9%	4.1%	0.8%	0.5%	1.0%	2.8%	0.7%
	28 : Siblings and older pupil influence	0.7%	1.8%	1.4%	2.7%	0.0%	0.7%	1.2%	0.8%	0.0%
Nature of D&T	30 : Contexts real world	3.1%	3.5%	3.2%	0.6%	3.9%	4.0%	3.3%	3.8%	0.0%
	31 : Creativity	4.1%	2.2%	3.1%	0.0%	5.1%	4.4%	3.5%	1.9%	0.0%
	32 : D&T strands	3.1%	1.9%	1.5%	3.0%	3.3%	4.5%	2.8%	0.1%	0.0%
	33 : Misconceptions	4.6%	1.7%	3.3%	2.5%	4.9%	3.2%	3.5%	2.2%	4.9%
	34 : Practical	5.3%	8.5%	7.9%	1.6%	2.8%	8.0%	7.0%	0.0%	0.0%
	35 : Primary school experiences	0.9%	0.2%	0.5%	0.5%	0.0%	1.5%	0.5%	1.3%	3.8%
	36 : Project factors	0.9%	5.0%	3.2%	6.2%	0.3%	0.9%	2.7%	1.0%	0.0%
	37 : Value for future studies and career	4.1%	3.0%	2.5%	6.3%	6.6%	3.1%	3.5%	5.9%	4.3%
School	39 : Academic	0.3%	0.4%	0.3%	0.0%	1.1%	0.0%	0.4%	0.0%	0.0%
	40 : Art	2.9%	4.0%	3.5%	2.2%	1.9%	4.5%	3.1%	1.9%	17.2%
	41 : EBacc	0.4%	0.5%	0.1%	1.2%	1.5%	0.0%	0.5%	0.0%	0.0%
	42 : Options and limitations	3.7%	4.5%	3.6%	5.7%	0.6%	6.7%	4.1%	1.8%	5.6%
Teacher	Professional behaviours	4.9%	8.4%	7.7%	9.6%	3.4%	3.6%	5.6%	14.5%	13.2%
	Teacher background	1.3%	3.7%	2.5%	4.1%	0.9%	1.7%	2.4%	0.0%	0.0%
	Teacher pupil relationship	2.0%	1.0%	1.4%	2.2%	1.7%	1.7%	1.4%	2.2%	10.3%

2h - Pupil Characteristics matrix

Characteristics of pupil	STEM										External influences								Nature of D&T								School factors				Teacher			
	Engineering	Computing	Extracurricular offerings	Clubs	Competition	Speakers	Visits	Maths	Physics	STEM	Gender in society	Biological differences	Faith	Inequality Equality	Positive discrimination	Parental influence	Peer influence	Siblings and older pupil influence	Contexts real world	Creativity	D&T strands	Misconceptions	Practical	Primary school experiences	Project factors	Value for future studies and career	Academic	Art	EBacc	Options and limitations	Professional behaviours	Teacher background	Teacher pupil relationship	
Behaviour	1	1	0	0	0	0	0	2	0	0	1	1	0	0	0	4	0	1	0	1	0	2	1	1	0	1	0	0	0	0	0	2	19
Competitiveness	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0	0	1	0	1	0	0	3	0	0	0	0	0	12
Confidence	0	0	0	1	1	0	0	0	0	0	1	0	0	3	1	3	4	1	0	2	0	1	21	0	8	2	4	2	0	3	4	0	1	63
Conscientious approach	2	3	0	0	2	0	0	1	0	0	2	1	0	2	0	3	1	0	1	4	0	0	9	0	5	1	3	5	0	3	2	0	1	51
Enjoyment	2	4	0	0	2	0	1	2	0	0	0	1	0	1	0	9	2	0	3	2	6	0	19	0	15	3	2	5	0	8	1	1	5	94
Organisation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	1	0	3	1	0	0	0	0	0	10
Prior attainment	9	11	0	0	1	0	0	7	3	0	0	1	0	2	0	19	3	3	2	2	2	3	14	1	6	8	12	6	1	9	9	0	7	141
Talent	1	2	0	0	0	0	0	1	0	0	1	1	0	1	3	0	1	0	0	2	0	1	0	0	1	1	0	3	0	0	3	0	0	22
	16	22	0	1	7	0	1	13	3	0	5	5	0	9	4	42	13	5	6	14	8	7	67	2	37	16	24	25	1	23	19	1	16	**412**

2i - Gender in Society matrix

External influences	Characteristics of pupil								STEM								Nature of D&T								School factors				Teacher			
	B : Behaviour	C : Competitiveness	D : Confidence	E : Conscientious approach	F : Enjoyment	G : Organisation	H : Prior attainment	I : Talent	J : Engineering	K : Computing	L : Extracurricular offerings	M : Clubs	N : Competition	O : Speakers	P : Visits	Q : Maths	R : Physics	S : STEM	U : Contexts real world	V : Creativity	W : D&T strands	X : Misconceptions	Y : Practical	Z : Primary school experienc	AA : Project factors	AB : Value for future studies	AD : Academic	AE : Art	AF : EBacc	AG : Options and limitations	AI : Professional behaviours	AJ : Teacher background	AK : Teacher pupil relationsh	
Gender in society	1	0	1	2	0	0	0	1	6	0	0	0	0	0	0	1	2	3	1	1	3	3	1	0	0	0	3	1	0	0	19	0	1	50
Biological differences	1	0	0	1	1	0	1	1	5	0	0	0	0	0	0	0	0	0	1	1	2	0	1	0	1	0	0	1	0	1	3	0	1	22
Faith	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5 : Inequality Equality	0	0	3	2	1	0	2	1	22	1	0	0	0	0	0	0	0	0	3	0	5	7	5	0	0	5	1	1	0	0	19	1	2	81
Positive discrimination	0	0	1	0	0	0	0	3	4	2	0	5	4	0	0	0	0	1	0	2	1	0	1	1	0	1	0	0	0	0	11	0	0	37
Parental influence	4	1	3	3	9	3	19	0	6	5	0	4	2	1	2	4	1	1	5	8	3	13	12	0	6	11	11	8	2	13	13	0	9	182
Peer influence	0	2	4	1	2	0	3	1	0	2	0	0	1	0	0	0	0	0	0	2	0	1	0	0	3	1	0	1	0	1	0	0	1	26
Siblings and older pupil influence	1	0	1	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	4	0	3	0	0	1	0	1	0	4	1	22
	7	3	13	9	13	3	28	7	44	11	0	9	7	1	2	5	3	5	10	14	14	26	24	1	13	18	15	13	2	16	65	5	15	

2j - School factors matrix

School factors	Pupil								STEM									External								Nature of DT									Teacher		
	A : Behaviour	B : Competitiveness	C : Confidence	D : Conscientious approach	E : Enjoyment	F : Organisation	G : Prior attainment	H : Talent	I : Engineering	J : Computing	K : Extracurricular offerings	L : Clubs	M : Competition	N : Speakers	O : Visits	P : Maths	Q : Physics	R : STEM	S : Gender in society	T : Biological differences	U : Faith	V : Inequality Equality	W : Positive discrimination	X : Parental influence	Y : Peer influence	Z : Siblings and older pupil influer	AA : Contexts real world	AB : Creativity	AC : D&T strands	AD : Misconceptions	AE : Practical	AF : Primary school experiences	AG : Project factors	AH : Value for future studies and	AI : Professional behaviours	AJ : Teacher background	AK : Teacher pupil relationship	
Academic	0	0	4	3	2	3	12	0	2	0	0	1	0	0	0	0	0	0	3	0	0	1	0	11	0	0	0	3	0	4	9	0	4	3	0	0	0	65
Art	0	3	2	5	5	1	6	3	6	4	0	0	3	0	0	9	0	5	1	1	0	1	0	8	1	1	1	12	3	4	5	0	5	2	7	7	0	111
EBacc	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	1	2	0	0	7
Options and limitations	0	0	3	3	8	0	9	0	3	4	0	1	1	0	1	3	0	0	0	1	0	0	0	13	1	1	2	5	8	7	5	0	5	8	14	0	1	107
	0	3	9	11	15	4	28	3	11	8	0	2	4	0	1	12	0	5	4	2	0	2	0	34	2	2	3	21	11	15	19	0	14	14	23	7	1	

2k - Engineering matrix

STEM	Characteristics of pupil								External influences									Nature of D&T										School factors				Teacher			
	B : Behaviour	C : Competitiveness	D : Confidence	E : Conscientious approach	F : Enjoyment	G : Organisation	H : Prior attainment	I : Talent	K : Gender in society	L : Biological differences	M : Faith	N : Inequality Equality	O : Positive discrimination	P : Parental influence	Q : Peer influence	R : Siblings and older pupil influence	T : Contexts real world	U : Creativity	V : D&T strands	W : Misconceptions	X : Practical	Y : Primary school experiences	Z : Project factors	AA : Value for future studies and career	AC : Academic	AD : Art	AE : EBacc	AF : Options and limitations	AH : Professional behaviours	AI : Teacher background	AJ : Teacher pupil relationship	
Engineering	1	1	0	2	2	0	9	1	6	5	1	22	4	6	0	0	7	8	12	16	10	1	1	23	2	6	0	3	8	4	0	161
Computing	1	1	0	3	4	0	11	2	0	0	0	1	2	5	2	1	2	1	3	9	0	1	0	7	0	4	0	4	7	0	1	72
Clubs	0	0	1	0	0	0	0	0	0	0	0	0	5	4	0	0	0	0	0	1	1	0	0	2	1	0	0	1	4	0	0	20
Competition	0	1	1	2	2	0	1	0	0	0	0	0	4	2	1	0	3	2	0	0	2	1	2	2	0	3	0	1	0	0	0	30
Speakers	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Visits	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	2	0	1	1	2	0	0	0	0	0	0	1	0	0	0	10
Maths	2	0	0	1	2	0	7	1	1	0	0	0	0	4	0	0	0	7	4	2	5	0	0	15	0	9	0	3	2	6	0	71
Physics	0	0	0	0	0	0	3	0	2	0	0	0	0	1	0	0	0	1	2	0	2	0	0	8	0	0	0	0	0	4	0	23
STEM	0	0	0	0	0	0	0	0	3	0	0	0	1	1	0	0	0	4	2	2	0	2	0	2	0	5	0	0	1	0	0	23
	4	3	2	8	11	0	31	4	12	5	1	23	16	26	3	1	14	23	24	31	22	5	3	59	3	27	0	13	22	14	1	411

2l - Nature of D&T matrix

Nature of D&T	Characteristics of pupil								STEM											External influences								School				Teacher			
	B : Behaviour	C : Competitiveness	D : Confidence	E : Conscientious approach	F : Enjoyment	G : Organisation	H : Prior attainment	I : Talent	J : Engineering	K : Computing	M : Clubs	N : Competition	O : Speakers	P : Visits	Q : Maths	R : Physics	S : STEM	U : Gender in society	V : Biological differences	W : Faith	X : Inequality Equality	Y : Positive discrimination	Z : Parental influence	AA : Peer influence	AB : Siblings and older pupil influence	AD : Academic	AE : Art	AF : EBacc	AG : Options and limitations	AI : Professional behaviours	AJ : Teacher background	AK : Teacher pupil relationship	
Contexts real world	0	0	0	1	3	0	2	0	7	2	0	3	0	2	0	0	0	1	1	0	3	0	5	0	0	0	1	0	2	3	0	0	36
Creativity	1	1	2	4	2	0	2	2	8	1	0	2	0	0	7	1	4	1	1	0	0	2	8	2	0	3	12	1	5	2	1	1	76
D&T strands	0	0	0	0	6	0	2	0	12	3	0	0	0	1	4	2	2	3	2	0	5	1	3	0	0	0	3	0	8	1	11	0	69
Misconceptions	2	0	1	0	0	0	3	1	16	9	1	0	0	1	2	0	2	3	0	0	7	0	13	1	2	4	4	0	7	3	1	2	85
Practical	1	1	21	9	19	2	14	0	10	0	1	2	0	2	5	2	0	1	1	0	5	1	12	0	4	9	5	0	5	2	1	1	136
Primary school experiences	1	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	8
Project factors	0	1	8	5	15	1	6	1	1	0	0	2	0	0	0	0	0	0	1	0	0	0	6	3	3	4	5	0	5	2	0	1	70
Value for future studies and career	1	0	2	1	3	0	8	1	23	7	2	2	0	0	15	8	2	0	0	0	5	1	11	1	0	3	2	1	8	7	1	0	115
	6	3	34	20	48	3	38	5	78	23	4	12	0	6	33	13	12	9	6	0	25	6	58	7	9	23	32	2	40	20	15	5	

2m - Teacher matrix

Teachers	Pupils								STEM									External influences								Nature of DT								School factors				
	Behaviour	Competitiveness	Confidence	Conscientious approach	Enjoyment	Organisation	Prior attainment	Talent	Engineering	Computing	Extracurricular offerings	Clubs	Competition	Speakers	Visits	Maths	Physics	STEM	Gender in society	Biological differences	Faith	Inequality Equality	Positive discrimination	Parental influence	Peer influence	Siblings and older pupil inf	Contexts real world	Creativity	D&T strands	Misconceptions	Practical	Primary school experience	Project factors	Value for future studies an	Academic	Art	EBacc	Options and limitations	
Professional behaviours	0	0	4	2	1	0	9	3	8	7	0	4	0	0	0	2	0	1	19	3	0	19	11	13	0	0	3	2	1	3	2	0	2	7	0	7	2	14	149
Teacher background	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	6	4	0	0	0	0	1	0	0	0	4	0	1	11	1	1	0	0	1	0	7	0	0	42
Teacher pupil relationship	2	0	1	1	5	0	7	0	0	1	0	0	0	0	0	8	4	1	1	1	0	2	0	9	1	1	0	1	0	2	1	0	1	0	0	0	0	1	38
	2	0	5	3	7	0	16	3	12	8	0	4	0	0	0	8	4	1	20	4	0	22	11	22	1	5	3	4	12	6	4	0	3	8	0	14	2	15	229

2n - Participant coding

	Participant and codes	Bree	Cole	Doug	Greg	Jake	Kate	Lynn	Mike	Pete	Ruth	Thom	
Pupils	Behaviour	1	1	1	4	42	4	1	1	1	3	0	59
	Competitiveness	0	0	1	0	2	1	0	0	2	0	6	12
	Confidence	11	0	0	5	22	8	0	4	4	1	1	56
	Conscientious approach	6	4	3	9	10	6	3	3	5	8	8	65
	Enjoyment	13	1	6	8	11	8	5	5	9	7	1	74
	Organisation	4	0	0	1	0	0	0	0	0	0	0	5
	Prior attainment	18	7	15	14	21	9	2	8	5	13	2	114
	Talent	0	1	1	6	4	1	0	0	0	0	1	14
STEM	Engineering	15	0	0	9	27	6	0	1	29	2	3	92
	Computing	1	8	31	0	9	2	0	0	6	0	3	60
	Extracurricular offerings	0	0	0	0	0	0	0	0	0	0	0	0
	Clubs	1	0	0	1	0	1	0	5	0	0	0	8
	Competition	2	0	1	2	2	2	0	0	12	0	0	21
	Speakers	0	0	0	0	0	0	0	0	3	0	0	3
	Visits	0	0	0	0	2	0	0	1	7	0	0	10
	Maths	6	2	8	3	9	7	1	0	12	5	0	53
	Physics	3	0	4	3	6	2	0	0	2	0	0	20
	STEM	3	0	2	2	2	2	1	0	9	0	1	22
External influences	Gender in society	25	0	1	8	13	0	1	1	1	1	2	53
	Biological differences	3	0	0	4	28	1	0	0	0	0	1	37
	Faith	0	0	0	0	4	0	0	0	0	0	0	4
	Inequality Equality	18	1	2	14	58	7	3	8	8	6	0	125
	Positive discrimination	6	1	3	3	13	3	0	6	4	0	0	39
	Parental influence	16	5	10	8	28	8	2	7	6	8	6	104
	Peer influence	0	0	3	1	9	5	1	2	0	2	1	24
	gs and older pupil influence	1	1	1	0	11	10	5	1	0	5	0	35
Nature of DT	Contexts real world	15	5	1	10	6	1	2	6	10	1	0	57
	Creativity	7	1	0	8	17	0	1	4	4	4	0	46
	D&T strands	7	0	1	11	11	13	3	12	15	13	0	86
	Misconceptions	5	1	4	13	34	3	3	3	6	4	5	81
	Practical	27	0	0	6	27	9	6	12	7	12	0	106
	Primary school experiences	1	1	1	0	3	0	0	1	2	0	1	10
	Project factors	16	0	1	1	7	15	9	1	2	4	0	56
	or future studies and career	9	2	5	9	10	8	1	3	7	5	1	60
School	Academic	9	0	0	5	2	1	1	3	1	3	0	25
	Art	11	0	4	6	14	2	4	4	4	9	14	72
	EBacc	0	0	0	3	0	2	0	0	0	1	0	6
	Options and limitations	7	1	3	3	20	14	3	5	5	18	4	83
Teacher	Professional behaviours	29	9	19	11	35	13	6	10	3	20	10	165
	Teacher background	9	0	0	5	5	10	12	1	6	5	0	53
	Teacher pupil relationship	4	4	2	1	15	5	3	2	4	1	6	47
	Total	**309**	**56**	**134**	**197**	**539**	**189**	**79**	**120**	**201**	**161**	**77**	2062

X. Appendix 3 – Video transcripts

3a – Girls tinkering experiences

	28:15 Jake (brown) models a proposal for a layout to Clara (blue) and Bella (green).
	28:28 Jake positions cylinder between two motors.
	28:32 Clara grabs the cylinder to measure.
	28:36 Jake takes it back to carry on explaining.
	28:44 Jake hands cylinder back to Clara.
	28:51 Clara walks off with cylinder to change it.

3b – Conscientious boys

	27:54 Larry's hand goes up for help. Jake (circled) is helping Nick in far corner of classroom.
	33:01 Jake is still helping Mike and Tim, Larry's hand is up, they should be next in the queue but Nick (circled) has stood up and moved over to Jake to get help.
	33:52 Jake – " Who was stood up behind me a second ago?" Nick, "Me, sir". Even though Larry has eye contact and his hand up and is next in the queue, Jake walks past him to help Nick.
	33:57 Jake is helping Fred on his way over to Nick, bypassing Larry with his hand up.

	34:26 Larry's hand is up, Jake is back with Nick in exactly the same position as at 27:54 (6.5 minutes)
	36:11 Jake finally gets eye contact with Larry and goes to help.