<u>University of Southampton</u>

Faculty of Environmental and Life Sciences

<u>School of Psychology</u>

Exploring the Impact of Gender Identity and Stereotypes on Secondary Pupils' Computer Science Enrolment Interest

by

Eleanor Mary Beck

<u>Thesis for the degree of Doctor of Educational Psychology</u>

June 2020

University of Southampton

Abstract

Faculty of Environmental and Life Sciences

School of Psychology

Thesis for the degree of Doctor of Educational Psychology

Exploring the Impact of Gender Identity and Stereotypes on Secondary Pupils' Computer Science Enrolment Interest

by

Eleanor Mary Beck

Despite recent government initiatives, there continues to be a shortage of individuals working in Science, Technology, Engineering and Mathematics (STEM) industries. There is a particular underrepresentation of female STEM workers, with females opting out of STEM fields at each step of the 'STEM pipeline', from classroom to boardroom. This thesis identifies and explores the impact of different factors on interest in choosing STEM subjects at post-16 level and how gender identity and stereotypes impact upon computer science enrolment interest.

A systematic review of the literature that explores influences on STEM subject choice at post-16 level highlighted thirteen key factors that predict STEM subject choice; these factors could be categorised as either intrinsic or extrinsic to the individual. A fourteenth factor, an individual's sex, interacted with the majority of these identified factors. This systematic literature review highlights the insufficiency of theories of decision-making in explaining the decision-making that occurs during STEM subject choice, since an individual's biological sex appears so influential. The empirical study investigates whether gender identity and other well-evidenced influences predict enrolment interest in computer science. It aims to explore whether stereotypical cues in a learning environment affect students' interest. Year 9 students (n= 168) completed measures assessing gender identity. They were shown either a stereotypical or a non-stereotypical computer science classroom and completed measures assessing their enrolment interest in computer science, belonging, stereotype threat, self-efficacy and utility value. Femininity significantly predicted enrolment interest, and this relationship was mediated by stereotype threat. The stereotypicality of the classroom did not moderate the mediation of stereotype threat on femininity and enrolment interest. This empirical study extends previous research by showing that it is one's gender identity, rather than simply their sex, that predicts enrolment interest. We

highlight the need to consider and challenge stereotypes that continue to exist in relation to subjects such as computer science, in order for all students to feel included.

Table of Contents

Table of Tables

Table of Figures

Research Thesis: Declaration of Authorship

Print name: ELEANOR MARY BECK

Title of thesis: Exploring the Impact of Gender Identity and Stereotypes on Secondary Pupils' Computer Science Enrolment Interest

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission.

Signature: Date: 6.6.20

Acknowledgements

I want to express my sincerest thanks and gratitude to my supervisors, Dr Cora Sargeant and Dr Sarah Wright, for your support and encouragement which has kept me upbeat and looking forward. Your positivity has been invaluable and I cannot thank you enough.

Thank you to the participants of this research, along with their parents and schools. Thank you also to Allison Master and colleagues who were happy to answer any questions I had and very kindly allowed me to use their materials for this research.

A heartfelt thank you to the Southampton Educational Psychology course team for your teaching, advice and excitement for psychology during these three years. Thanks also go to the amazing TEPs who have kept me motivated and provided support throughout our time on the course.

A big thank you to my mum, dad, brother, sister and friends, for always taking the time to ask "How is your thesis going?" and giving me words of encouragement. Lastly, a huge thank you to my fiancé Nick for being patient, cheering me on and providing me with a steady stream of tea and biscuits.

Definitions and Abbreviations

CSRI	Children's Sex Role Inventory
Core-STEM	Physics, mathematics, further mathematics, chemistry, computing, information communication technology, design and technology and other sciences (WISE, 2019)
EVT	Expectancy-value theory
Extrinsic	External to oneself
Femininity	The extent to which an individual identifies with traits or attributes considered characteristic of females
GCSE	General Certificate of Secondary Education
Gender	A social construction relating to behaviours and attributes based on labels of masculinity and femininity (Office for National Statistics, 2019)
Gender identity	The extent to which [individuals] identify with stereotypical masculine or feminine traits (McGeown & Warhurst, 2020; p. 103)
Gendered norms	The informal rules that define acceptable and expected behaviour for males and females in a society
ICT	Information communication technology
IIRM	Interests as Identity Regulation model
Intrinsic	Internal or inherent to an individual
LL	Lower limit of confidence interval
M	Sample mean
Masculinity	The extent to which an individual identifies with traits or attributes considered characteristic of males

Non-STEM-aspiring	A student who does not intend to choose STEM subjects
Norms	Standards of acceptable behaviour
STEM-aspiring	A student who intends to choose STEM subjects
TPB	Theory of planned behaviour
OECD	Organisation for Economic Co-operation and Development
SD	Standard deviation
SE	Standard error
SDT	Self-determination theory
Sex	The biological aspects of an individual as determined by their anatomy, which is produced by their chromosomes and hormones
STEM	Science, technology, engineering and mathematics
Stereotype	An over-generalised set of beliefs or expectations about the qualities and characteristics of the members of a group
Stereotype threat	A concern or anxiety that one’s performance or actions can be seen through the lens of a negative stereotype (Shapiro & Williams, 2012; p. 175)
T	The sample value of the t-test statistic
T	The sample value of Kendall’s Tau
UK	United Kingdom
UL	Upper limit of confidence interval

Chapter 1 What are the factors that influence post-16 STEM (Science, Technology, Engineering and Mathematics) subject choice?

1.1 Background and aims

For the last few decades there has been increasing concern over how to boost productivity and economic growth in a time of technological advancement. There is currently a shortage of STEM graduates in the UK, with employers reporting a shortfall of 173,400 workers (STEM Learning, 2018); this shortage is seen as one of the country's "key economic problems" (The United Kingdom House of Commons Committee of Public Accounts, 2018). There is an underrepresentation of females both in the UK (WISE, 2019) and globally (UNESCO, 2017) in STEM professions. It has been argued that encouraging females to work in STEM might be one way to reduce workforce shortages and promote economic growth (European Institute for Gender Equality (n.d.). Furthermore, a more sex-diverse workplace has been found to facilitate innovation (Østergaard, Timmermans & Kristinsson, 2011).

Although major government initiatives introduced in 2009 have increased the proportion of females in STEM occupations to 24% of the workforce (WISE, 2019), the increase has not been equal across STEM areas; the percentage of females in technology roles has remained constant for the last ten years at approximately 16% of the workforce (WISE, 2019). Since those who work in STEM have some of the greatest earning potential in the jobs market (Social Market Foundation, 2016), it appears that females, in particular, are opting out of a lucrative jobs market.

In relation to the imbalance between males and females entering STEM, researchers and policy-makers refer to the so-called 'leaky pipeline'; as individuals move through their education and into their careers fewer students overall (OECD, 2008), and females in particular (Watson & Froyd, 2007), carry on to the next step of the STEM ladder. Indeed, research shows that females who express an interest in male-dominated fields (such as STEM) in early adolescence often move towards more female-dominated fields by adulthood (Frome, Alfeld, Eccles & Barber, 2006). Despite females performing around the same (within a percentage point) or better in STEM subjects than males at GCSE level (WISE, 2019), females make up only 39% of maths and 23% of physics A Level entrants, two key subjects that are often entry requirements for core STEM degrees or higher-level apprenticeships. To understand why STEM careers are being taken up more by males than females researchers have begun to examine the beginning of the 'leaky pipeline', when adolescents have the opportunity to make choices regarding the subjects that study at higher levels and explore reasons why adolescents, and particularly female adolescents, opt out of STEM subjects. In England pupils are expected to make subject choices at 13 or 14 for their GCSEs, at 16 for post-16 education and, for some, at 18 for higher or further education. The attrition of females from STEM occurs at every stage of this pipeline (Harding, 2009). A number of psychological theories can be applied to help us to understand why individuals might select or reject certain subjects during their school careers.

Self-determination theory (SDT; Deci & Ryan, 1985) focuses on the motivation behind an individual's behaviour. It states that an individual can be 'self-determined' when three specific psychological needs are met. Applying this to STEM subject choice, one must feel competent (i.e. feel skilled and experience mastery in STEM), connected to others (i.e. feel a sense of relatedness or belonging within the subject), and autonomous (i.e. feel in control of their decision-making and goal-setting) in order to experience intrinsic motivation to choose STEM subjects. Not surprisingly therefore, students' self-determined motivation has been found to predict interest in STEM careers (Lavigne, Vallerand & Miquelon, 2007).

The theory of planned behaviour (TPB; Ajzen, 1991) has been found to predict STEM university course and career choice in students, with attitude and intention the most predictive variables (Moore & Burrus, 2019). The TPB suggests that the intention to carry out a behaviour is predicted by *attitudes*, *subjective norms,* and *perceived control*. Attitudes can be separated into two dimensions (Fishbein & Ajzen, 2010): experiential attitudes are an individuals' feelings towards an object or behaviour (e.g. physics is exciting), while instrumental attitudes are the individual's beliefs around the utility of the object or behaviour (e.g. physics will help me to achieve my career goal). Subjective norms have also been separated into two dimensions (Fishbein & Ajzen 2010): injunctive norms are rules around what ought to be done (e.g. parental pressure to choose STEM) and descriptive norms are what most people do (e.g. friends are continuing to study STEM). Finally, perceived behaviour control relates to how successful someone feels at carrying out the behaviour in question. It could be suggested that attitudes, subjective norms, and perceived control influence one's intention and subsequent choosing of STEM.

Expectancy-value theory (EVT; Eccles et al., 1983) suggests that individuals' decision-making, persistence and performance are based upon their expectations of their success and value of the activity (Wigfield & Eccles, 1992), which is why some choose STEM and others do not. According to this model, expectations of success and task value are influenced by individual characteristics (e.g. genetics, skills, previous experiences, affect) and environmental factors (e.g.

cultural norms, socialisers' beliefs). Students' expectancy-value beliefs have been found to predict STEM career intentions (Lauermann, Tsai & Eccles, 2017).

Taken together, the theoretical models suggest that a range of factors are key in understanding why individuals make subject choices. The attitude of the individual and social norms are two main areas of commonality regarding influences on motivation, decision-making and subsequent behaviour enactment (Figure 1). However, these models explain broader decision-making and not STEM subject choice specifically.

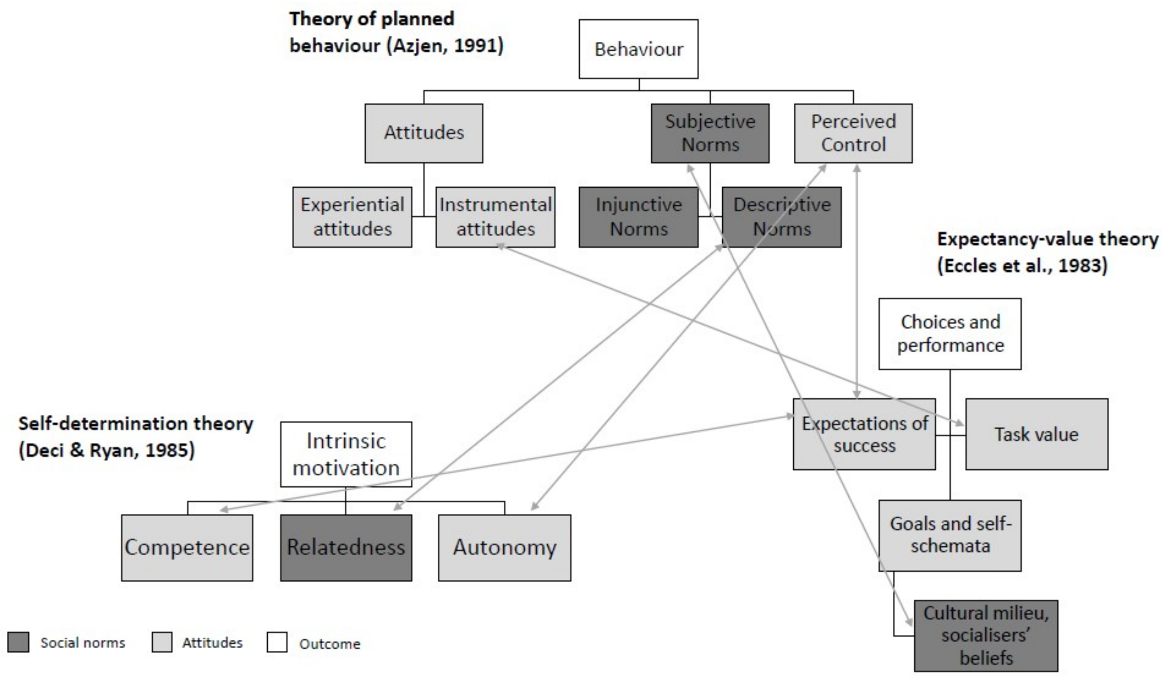


Figure 1 Commonalities between the theoretical models. Arrows indicate links between concepts

As the world enters the 'Fourth Industrial Revolution' (Department for Business, Energy and Industrial Strategy, 2019), in which STEM is at the forefront of change, it is crucial that we encourage a greater number of individuals to work in these fields. However, there continues to be an attrition of individuals in STEM, with many students opting-out of these subjects while still at school. It is valuable to explore what attracts students to STEM when they are making their early career-related decisions. This systematic literature review will identify the factors that influence STEM subject choice at post-16 and whether the three theoretical models discussed earlier are sufficient in explaining the processes that occur during STEM decision-making. It is hoped that this will highlight areas to develop and implement early, targeted interventions to promote STEM uptake at post-16.

1.2 Method

1.2.1 Search strategy

Three electronic databases were used to search for relevant papers: PSYCInfo, Education Resources Information Center (ERIC), and Scopus. The database search was carried out between September and November 2019. Search terms were developed based upon the systematic literature review question and an initial scoping search using Google Scholar. Search terms included synonyms and alternative spellings to ensure thorough searching (see Appendix A). Once search terms were established an initial search found 531 papers.

1.2.2 Inclusion and exclusion criteria

Once duplicate papers were removed (n= 72) the remaining 459 papers' titles and abstracts were screened to assess fit with the inclusion criteria (see Appendix B). The search terms generated a large number of studies and it was necessary to consider the changing landscape of subject uptake as a result of government initiatives introduced within the last 10 years. As such, this date limit was chosen to allow for sufficient breadth and depth to gain a detailed understanding of contributing factors. A hand search of the reference lists of the eligible papers located a further six papers meeting inclusion criteria. A total of 31 papers are included in this review (see Figure 2, The PRISMA Group, 2009).

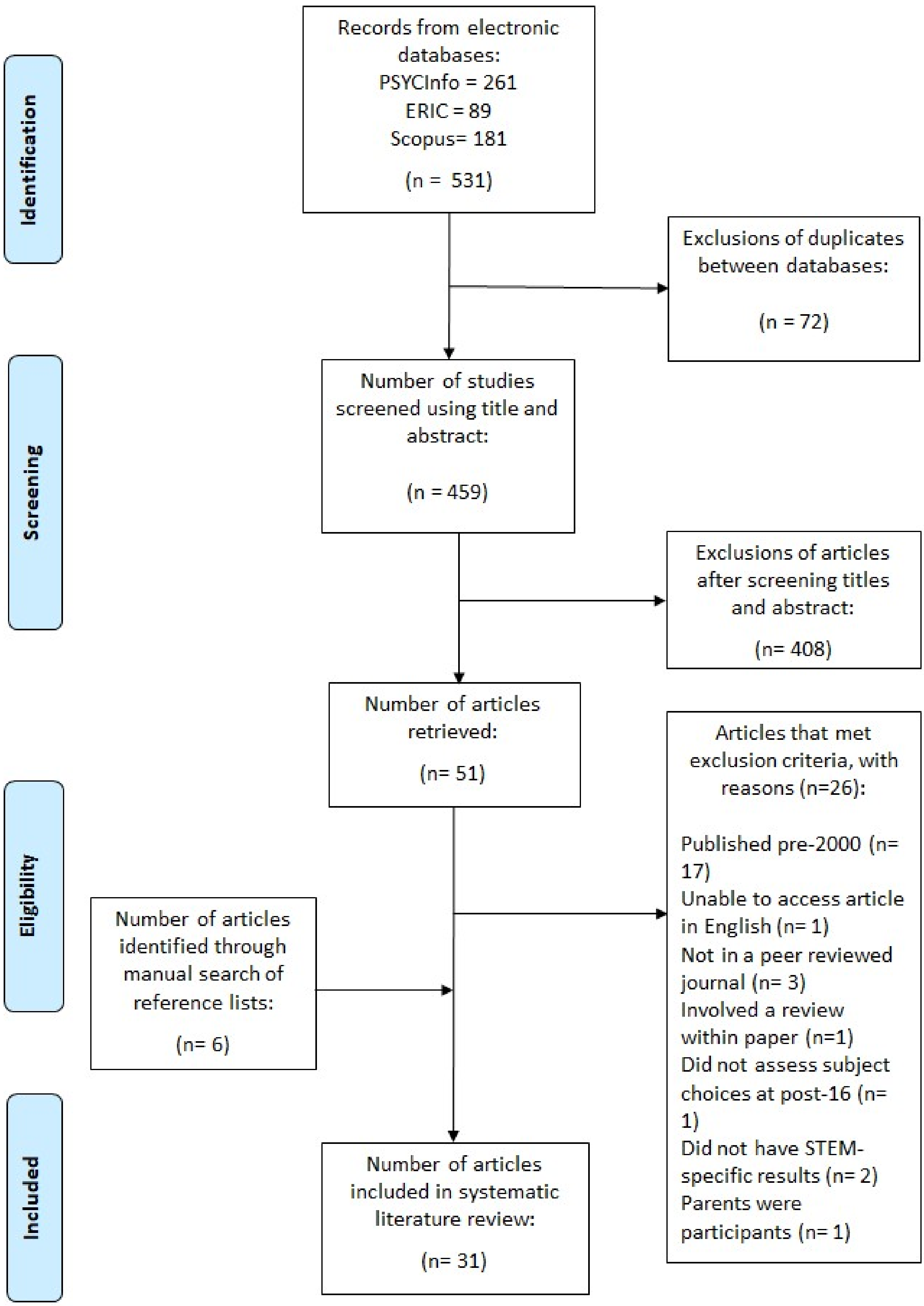


Figure 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram outlining the systematic search process

1.2.3 Data extraction

Thirty-one papers were included in the final literature review. Data extracted included information about the sample, the academic subject(s) assessed, the study design, measures used, factors explored, and relevant results (see Appendix C).

1.2.4 Quality assurance

An evaluative model developed by Bond, Woods, Humphrey, Symes, and Green (2013) was used to quality assess both quantitative and qualitative studies. Quantitative papers were considered against 16 criteria, including having a clear research question or hypothesis and using appropriate statistical analyses. Using scoring thresholds reported in Tomlinson, Bond and Hebron (2019), scores of 0-5 were considered 'low' quality, 6-10 as 'medium' and 11-15 as 'high'. Qualitative papers were considered against 12 criteria, such as an analysis close to the data and valid and transferable conclusions. Scores of 0-5 were considered 'low' quality, 5.5-9.5 'medium' and 10-14 'high' (Tomlinson et al., 2019). Studies which used mixed methods were coded using both models and were given the higher rating of the two (Tomlinson et al., 2019). Approximately 20% of papers (n= 6) were coded separately by two researchers to provide an opportunity to discuss, review and improve the lead researcher's use of the quality assessment tools. Following discussion, a final score was given based on the average. Two studies were considered 'low' quality, 20 'medium' quality and nine 'high' quality (Table 1; see Appendix D).

Table 1 Quality assurance table with paper reference numbers included in alphabetical order

Quality rating	Paper
Low	(1) Bartholomew & Mooed (2012); (22) Pike & Dunne (2011)
Medium	(2) Bennett, Lubben & Hampden-Thompson (2013); (4) Cleaves (2005); (7) DeWitt, Archer & Moot (2019); (8) Giannakos (2014); (9) Gill & Bell (2013); (10) James (2007); (12) Korpershoek, Kuper, Van der Werf & Bosker (2010); (15) Mendolia & Walker (2014); (16) Mujtaba & Reiss (2013a); (17) Mujtaba & Reiss (2013b); (18) Mujtaba & Reiss (2014); (19) Mujtaba & Reiss (2016); (20) Nagy, Trautwein, Baumert, Köller & Garrett (2006); (21) Nashon & Nielsen (2007); (23) Sheldrake (2016); (27) Smyth & Hannan (2006); (28) Stokking (2000); (29) Taylor (2015); (30) Van Langen, Rekers-Mombarg & Dekkers (2006a); (31) Van Langen, Rekers-Mombarg & Dekkers (2006b)

High	(3) Bøe (2012); (5) Crombie, Sinclair, Silverthorn, Byrne, DuBois & Trinneer (2005); (6) Davies, Davies & Qui (2017); (11) Jeffries, Curtis & Conner (2019); (13) Korpershoek, Kuper & Van der Werf (2012); (14) Master, Cheryan & Meltzoff (2016); (24) Sheldrake, Mujtaba & Reiss (2014); (25) Sheldrake, Mujtaba & Reiss (2015); (26) Sheldrake, Mujtaba & Reiss (2019)

1.3 Results

Thirty-one studies identified factors that influence adolescents' choice of STEM subject at post-16 school level and were published between 2000 and 2019. Twenty-three papers used quantitative methodology, four used qualitative, and four used mixed methods. Participant sample sizes ranged from 43 to 231,982. Methods of data collection varied among the included papers. Twenty-four studies assessed what factors increased the likelihood or predicted the selection of STEM subjects based upon survey and/or demographic data, four studies asked participants directly what influenced their subject choice (in the form of ranking surveys or interviews), two studies assessed STEM enrolment interest experimentally, and one study used a case study method. Eleven studies used longitudinal methods. Research was carried out in the UK (n=16), The Netherlands (n=5), Canada (n=2), Ireland (n=1), Australia (n=1), New Zealand (n=1), Greece (n=1), United States of America (n=1), Germany (n=1), Norway (n=1) and one study recruited participants in both Finland and Portugal as part of the International Baccalaureate programme. As such, the education systems of the adolescents included in these studies and the age at which students make their post-16 choices varies (Table 2). It is important to note that science is compulsory at International Baccalaureate Diploma post-16 level, but students elect the choice of level (either standard or higher) and number of science subjects taken, so this paper was included within the review. As such, when referring to James' (2007) research, I will only discuss the factors related to higher level students' subject choice.

The factors identified from the included papers can be grouped into 'intrinsic' or 'extrinsic' factors. These groups will be used to structure this review. Due to a high number of papers (n= 22) running inter-group analyses based upon participant sex, and the difference in male and female STEM participation discussed earlier in this review, each factor will be discussed according to whether it was a general factor identified in adolescents when looked at as a homogenous group, one found to differ between sexes, or one found to differ between members of the same sex. For ease of reading the included studies are numbered. Study numbers are included in the quality assurance table (Table 1). Full citations will be used only for clarity in reporting.

Table 2 Country of included studies and age at which students make their post-16 subject choices

Country	Age at which students choose subjects for post-16 study
UK	Year 11 (age 15/16)
Netherlands	At the end of 9th grade (age 14/15), students choose one of four possible combinations of school subjects
Ireland	At the end of transition year (age 15/16), students choose subjects to study at senior cycle level
Australia	Year 10 (typically age 15/16)
New Zealand	Year 10 (typically age 14/15)
United States of America	Varies by state and area: middle-school (age 14), senior high school (age 15)
Canada	Grade 9 (age 14) choose elective subjects for senior high school
Norway	Grade 10 (age 15); ICT is compulsory
Germany	Gymnasium: Grade 10 (age 15)
Greece	Lyceum: Age 16
International Baccalaureate	Diploma Programme: Age 15

1.3.1 Intrinsic Factors

Four intrinsic factors influencing STEM subject choice were identified from the papers included in this review. These were: interest and enjoyment, self-efficacy, perceptions of teachers and lessons and personality and identity. These will be discussed in order and in relation to whether they were found in adolescents as a homogenous group, or found to differ between, or within, sexes.

Table 3 Intrinsic factors

Factor	Students generally	Between-sex differences	Within-sex differences
Interest/enjoyment	✓	✓	✓
Self-efficacy	✓	✓	✓
Perceptions of teachers/lessons	✓	✓	✓
Personality/identity	✓	✓	✓

Interest or enjoyment. Students who are interested or express enjoyment in STEM subjects were more likely to choose to study them further. This factor is defined in research as a student's interest in STEM subjects [11, 26, 27, 28], enjoyment of STEM subjects [7] or the intrinsic value they attach to the subject [17].

The effect of subject enjoyment on the intention to study or take-up of STEM has been found in physics [27, 4], maths [27], and science [23, 11, 7, 1, 10]. Males, more so than females, stated that they considered enjoyment as important in their decision making process: for those who intended to study science [10] and physics [17] interest and enjoyment influenced that intention for males more so than for females. Females experienced a lower enjoyment of STEM subjects [11] and this, alongside enjoyment being of less importance in the decision making process, contributed to explaining their lower intention to study the subjects. However, STEM-orientated females were more likely to find physics [17] and maths [19] enjoyable than their non-STEM-aspiring peers.

Self-efficacy. Students' self-efficacy influences their post-16 STEM subject choice. Students' self-efficacy in STEM subjects has been described broadly within the papers included in this review: 'self-efficacy' has been described as one's "confidence in their future capabilities" (Sheldrake, 2016; p. 1258), 'self-concept' as one's "current confidence" in the subject (Sheldrake, 2016; p. 1258) and academic subject-specific beliefs of prior ability (Bong & Skaalvik, 2003), 'self-image' as a student's rating of their academic ability (Smyth & Hannan, 2006), and 'self-confidence' as the belief that one will do well if one works hard (Stokking, 2000). For the purpose of this review, I will refer to 'self-efficacy' to capture the results that highlighted the influence of students' academic confidence, both present and future.

Having high self-efficacy in STEM predicts biology [20], physics [28, 18], science [23], maths [20, 25], and general STEM subject intentions and choice [11]; high self-efficacy in one's general academic ability predicts chemistry choice [27]. However, the predictive power of self-efficacy on future enrolment depends on participants' levels of confidence. Under-confident individuals' enrolment interest is influenced by their perceived current ability, while the enrolment interest of those who are more accurate in their self-assessment or over-confident was more influenced by their anticipated achievement potential in science [23] and maths [24]. It appears that under confident individuals may not select STEM due to a limited insight into their future potential to achieve.

Self-efficacy predicts the selection of STEM in males: females are less likely to study STEM subjects than men overall and this is due, in part, to their lower levels of self-efficacy [11]. Indeed, of those who intended to study physics, males reported higher self-efficacy in physics than females [17, 19], and STEM-aspiring female physics students report higher self-efficacy than their non-STEM-aspiring peers [17]. However, it also appears that this factor exerts greater influence on females, with self-efficacy predicting enrolment intention in maths [5] and biology [20] for females but not for males. Greater self-efficacy increases the likelihood of choosing to study STEM for both sexes. However, females are more likely to be influenced by their self-efficacy than males, but since females generally feel lower levels of self-efficacy, it appears that this impacts upon their reduced intention to study STEM.

Perceptions of teachers and lessons. Positive perceptions of STEM subject teachers and of the lessons themselves have been found to influence STEM subject enrolment. Students are more likely to intend to choose physics if they express positive views of their physics teachers [16, 17]. Interviews and questionnaire data have identified that teachers' enthusiasm, knowledge and understanding, and overall attitudes towards the subject are 'crucial factors' in influencing student enrolment in physics [21]. "Boring" delivery of teaching was noted as a factor of potential disengagement in a female interviewee intending on studying physics at post-16 level [19]. Indeed, females who intend to study physics are significantly more likely to report positive perceptions of their subject teachers than females who do not intend to study physics [17, 19] or maths [19]. Holding positive perceptions of one's teacher predicts STEM choice; however, overall, males report more positive perceptions of their physics teachers than females [17]. Despite this overall difference, STEM-aspiring male and female students feel equally positive about their physics [17, 19] and maths [19] teachers.

Holding positive perceptions of physics lessons also significantly predicts intentions to study physics [16, 17, 18]; STEM-aspiring females are more likely to have positive perceptions of, and a more positive emotional response to, their physics [17, 19] and maths [19] lessons than non-STEM-aspiring females. However, males are more likely to report positive perceptions of lessons than females [17] and of those who intend to study STEM, females are less likely to report positive experiences of, and a less positive emotional response to, lessons than males in physics [16, 17, 19] and maths [19]. Positive perceptions of STEM teachers and lessons increases one's STEM subject intentions or choice but males report holding more positive perceptions of both their lessons and their teacher than do females, providing another possible explanation of females' reduced STEM subject choice. Since STEM-aspiring females experience fewer positive perceptions of their lessons than do STEM-aspiring males, it is possible that perceptions of teachers and lessons exert less influence on females who aim to take STEM subjects.

Personality and identity. Students who express particular personality traits are more likely to study STEM subjects at a higher level. Students who score lower on extraversion are more likely to intend to choose physics [18] and science and technology subjects [12, 13]. Overall, females score higher on extraversion than do males [13] though females who study STEM score lower on extraversion than females who do not [13]; females' propensity to be extraverted reduces the likelihood of them choosing STEM. Students who choose STEM score lower on agreeableness and higher on emotional stability than students who choose to study other subjects [12, 13]. Males who intend to study physics score higher on emotional stability than their female counterparts [17].

Students who feel that their success comes from things external to themselves (external locus of control) are significantly less likely to choose post-16 maths or science [15] and males who intend to take physics report higher scores on locus of control (indicating an internal locus of control) than females who intend to take physics [17]. However, research has also found that females who choose to study science at post-16 have significantly higher scores on autonomy than males who choose to study science [12] and STEM-aspiring female physics students score higher on competitiveness than both STEM-aspiring males and non-STEM-aspiring females [17].

Identifying strongly with STEM has been found to promote STEM subject choice: qualitative research described how two females who chose all three science subjects identified strongly with science, seeing it as part of who they were [22]. Students who took physics at post-16 level frequently described themselves as problem-solvers during interviews [21]; those who hold STEM-related views about their identity and skill set are more likely to choose these subjects. However, the two studies here were rated methodologically low or medium-low quality, due to limited comment regarding the data collection process and how bias was minimised, and clarity on how evidence from the themes identified related to the implications given. As such, it would be beneficial to carry out more research into the predictive value of STEM identities and STEM subject choice.

Personality and identity appears to impact on students' STEM subject choice, particularly female students'. The research suggests that females who choose STEM are not as inclined to see their success as attributable to their own actions, but conversely they have to be more autonomous and competitive than their non-STEM-aspiring counterparts. In addition, females who choose STEM identify particularly strongly with STEM. It is possible that females have more social barriers to break down in order to pursue these subjects which is why they are more highly competitive and autonomous. However, much of the research identifying 'personality' as a factor was carried out by Korpershoek and colleagues, who used the Dutch version of the Five-Factor

Personality Inventory (FFPI; Hendricks, Hofstee & De Raad, 1999), a 100-item self-report questionnaire. Though the FFPI has been found to be reliable and valid (Hendricks, Kuyper, Offringa & Van der Werf, 2008), it comprises a large number of questions for adolescents to complete and there was no suggestion made by the authors that counterbalancing was used to manage the risk of fatigue, which might have increased the likelihood of participants misreporting during the final questions. Furthermore, neither study reported the level of attrition or how they dealt with missing values. In order to strengthen the evidence that personality is a factor that influences STEM subject choice, it would be helpful to replicate these studies, both in the Netherlands and in other countries, perhaps using different measures.

It is evident that a variety of intrinsic factors influence the choice of STEM subjects. STEM choosers tend to be interested and enjoy the subjects, have positive perceptions of their STEM lessons and teachers, hold certain personality traits (be less extraverted, more agreeable and emotionally stable and hold internal loci of control), identify strongly with STEM, and perceive themselves to have a specific set of skills needed to succeed in STEM study. The results of the studies included in this review suggest that, although females who choose STEM tend to experience these factors more so than females who do not choose STEM, males tend to experience these factors more so than females, overall.

1.3.2 Extrinsic Factors

Nine extrinsic factors that influence STEM subject choice were identified from the literature included in this review: utility value, academic attainment, gender role expectations, stereotypes and belonging, school structure, influence of others, time, ethnicity/cultural background, other subject choices, and parental education. The factors will be discussed in order and in relation to whether they were found in adolescents as a homogenous group, to differ between or within sexes.

Table 4 Extrinsic factors

Factor	Students generally	Between-sex differences	Within-sex differences
Utility value	✓	✓	✓
Academic attainment	✓	✓	x
Gender-role expectations, stereotypes and belonging	x	✓	✓
School structure	✓	x	✓
Influence of others	✓	✓	✓
Time	✓	✓	x
Ethnicity/cultural background	✓	x	x
Other subject choices	x	x	✓
Parental education	✓	✓	✓

Utility value. Fourteen studies identified and explored the importance of individuals' utility value of subjects when it comes to selecting STEM subjects. This factor was defined broadly within the studies in this review, encompassing students' perceptions of the utility and personal value of subjects in general life [23] or to provide entry to further study and for one's future career [16]. Utility value has been defined as "extrinsic usefulness as doing something as a means to gain wider benefits or outcomes" (Sheldrake, Mujtaba & Reiss, 2019; p. 1811), while 'extrinsic material gain motivation' is the belief that something is "useful for some quantifiable reward" (Mujtaba & Reiss, 2014; p. 377).

Holding the belief that STEM subjects help you in life predicts STEM subject choice. Those with a greater personal value of science (seeing STEM as important in understanding and appreciating the world [23, 11]) and utility of maths [27, 5], physics [16, 26] and computer science [8] were more likely to enrol in that STEM subject [8, 16, 23, 26, 27] or a STEM subject more generally [11]. Out of a number of intrinsic and extrinsic factors, such as self-efficacy and peer influence, students' perceived utility of science was one of the strongest predictors of students' intentions to study science at post-16 level ($\beta = .457$) and this effect was seen most strongly in those who were under-confident of their science ability (as measured by participants' STEM task-level confidence when compared to their STEM task ability) [23]. Though utility value of STEM predicted STEM subject choice, females overall were more likely to reject STEM subjects due to holding a lower personal value of science [11], while this factor exerts a greater influence on the decision-making of male students who go onto to study science [10] and maths [5] than on their female equivalents.

Extrinsic material gain motivation has been defined as "students' intentions to study [STEM] because of material gains they will receive for studying it post-16" (Mujtaba & Reiss, 2013b, p. 2989) and predicts maths enrolment intention [25]. However, among all students, males were more likely to score higher on extrinsic material gain motivation to study physics than females [17] and report that studying physics will help them in the future [16]. Correspondingly, STEM-aspiring females in physics [17, 19] and maths [19] had higher levels of extrinsic material gain motivation than non-STEM-aspiring females. Mujtaba and Reiss (2016) interviewed two STEM-aspiring females, who reported that extrinsic material gain motivation influenced their choice of physics: "I need it [subject choice] for what I want to do in the RAF: maths and physics. But I like physics" (p. 319). Indeed, females with a higher extrinsic motive for choosing subjects were found to be significantly more likely to choose science or maths than females who have an intrinsic motive [30, 31]. Males with intrinsic subject choice motives are more likely to choose STEM than those with extrinsic motives [30, 31]. This corresponds with the earlier finding that males, more so than females, stated that they considered 'enjoyment' as important to decision-making.

There is contradictory evidence when assessing the difference between male and female STEM-aspiring students and extrinsic material gain motivation: STEM-aspiring males scored significantly higher on extrinsic material gain motivation than STEM-aspiring females in physics [19] but earlier research did not find a statistically significant difference between these groups [17]. One reason why this difference might have occurred is due to greater variance in one of the datasets, despite both studies using the same secondary data (Understanding Participation Rates in Post-16 Mathematics And Physics; UPMAP), as data was from different UK Year 10 cohorts. Mujtaba and Reiss (2016) reported an effect size of 0.26, which is considered small (Cohen, 1988) while the mean t-test score of STEM-aspiring females and males was 4.81 and 5.01 respectively, whereas for Mujtaba and Reiss (2013b) these scores were 4.27 and 4.42. Both studies were considerably powered, with around 5,000 participants; it is possible to find a statistically significant difference with even a very weak effect. It is feasible that there was lower variance in Mujtaba and Reiss' (2016) cohort data which is why this study found a statistically significant result, though this does not necessarily mean the difference is useful or meaningful. More research (both quantitative and qualitative) is needed to determine whether STEM-aspiring male and females vary on how they experience this factor, especially as it is a well-evidenced predictor of STEM subject choice.

Despite extrinsic material gain motivation predicting STEM subject choice, and evidence finding that STEM-aspiring males having higher levels of extrinsic material gain motivation than STEM-aspiring females, the research also suggests that males are more influenced to take STEM for intrinsic reasons. It appears as though females focus more on the utility of a subject, or potential material gain, when choosing STEM, but since females tend to have lower levels of extrinsic material gain motivation, this might explain why they do not choose STEM subjects as frequently as males.

Six studies included in this review identified that students' future plans and careers influenced their STEM subject choice. James (2007) found that university course requirements and chosen career were two of the top four rated influences on science subject choice decision-making. Studies that analysed individual items rather than constructs found significant moderate correlations and effect sizes between students' intention to study physics and questionnaire items relating to one's belief that studying physics will help them to get the jobs they want (Mujtaba & Reiss, 2013a, $r = 0.67$; Mujtaba & Reiss, 2014, effect size= 1.37) or "better jobs in the future" (Taylor, 2015, $r = 0.60$). Future plans also appear to be an important influence on students' STEM subject intentions, and this appears to differ by sex: males rated a potential career as more influential in their choice of science than did females who chose science [10] while the utility of science to gain a place on a university course is a greater influence on females who choose science at post-16 than both their STEM-aspiring male and non-STEM-aspiring female counterparts [3].

Specific occupational aspiration was found to predict subject choice at upper secondary level (post-16) in Irish students: those who aspired to medical careers were more likely to choose to study science and those who aspired to careers in the field of engineering were more likely to choose physics and chemistry [27]. This appears to be more influential in males than females: male students who hoped to have a career in science were more likely to choose to study physics, but this was not the case for females who aspired to science careers [27], consistent with research suggesting that males are more influenced by future job prospects, when choosing STEM, than females [10]. STEM students who attended schools deemed 'high-uptake' for STEM tended to report subject selection strategies deemed 'aspirational', or related to their intended career or university course, more so than their low-uptake school counterparts [2]. However, the interview data obtained in this case study was not recorded in a particularly clear or rigorous way, rather researchers used a rating, from no data recorded for a strategy, to 'almost all [students]' describing a subject selection strategy. In two sets of schools (out of four), students in low-uptake schools were given the same rating as their high-uptake counterparts, so though this data corresponds with other literature it is difficult to draw firm conclusions regarding the preferred strategies of those attending schools who have a high-uptake of students who choose post-16 science, which was reflected in the 'medium' quality rating this research was given for its methodology.

One paper included in this review has also suggested that students' knowledge of graduate earnings influences STEM subject choice. A large-scale randomised control trial in the UK found that, following an hour long lesson on graduate salaries, participants were significantly more likely to report intentions to study mathematics than controls [6]. However, this same study found that after adjustments for prior interest, those in the experimental group were less likely than controls to intend to choose biology and computing following a lesson on graduate wages, leading to questions around how effective this strategy is for encouraging STEM subject uptake overall. This research was rated as methodologically high quality, due to a large sample size, stratification and random sampling strategies. Furthermore, the authors measured participants' subject choice intentions and wage estimations prior to the intervention, to ensure that differences could be attributed to the intervention.

Utility of STEM, extrinsic material motivation, university and career prospects and knowledge of graduate earnings all influence STEM subject choice. Females express less utility value and extrinsic material motivation overall than males which may account for their lower STEM enrolment. However, females who choose STEM were more likely than males to do so for access to the university course to which they aspired, and females who are more motivated by extrinsic material gain than intrinsic gain were more likely to take STEM, a finding not seen in males.

Academic attainment. Students are influenced to take STEM subjects if they are higher achieving academically, and specifically in STEM subjects. Attainment (measured by considering a student's best five GCSE grades) increased the likelihood of choosing physics at post-16 level [11]. Students with higher achievement in science [27] and mathematics [11] and whose best GCSE grade was in science [9] were more likely to choose to study STEM-subjects [11], physics [9], or chemistry [27]. Students' expectations of achievement in the subject is used as a strategy during decision-making but this often occurs alongside factors such as self-efficacy or interest in the subject [2]. This aligns with Jeffries et al.'s (2019) mediation analysis that showed that prior achievement mediated the effect of student attitudes (personal value, enjoyment and self-concept) on STEM subject choice. In other words, the more positive a student's attitudes towards STEM, the higher their STEM achievement and the greater likelihood that they will choose STEM subjects at post-16 level.

Females appear to be more influenced by academic attainment when choosing STEM subjects: the increased likelihood for students who achieved well lower down the school to take science subjects at upper-secondary school was found to be more marked for female students than males [27], while the effect of prior attainment (best five grades at GCSE level) seen for males and females on subsequent post-16 physics subject choice is greater for females [9]. Similarly, the effect of choosing to study physics if one's best GCSE grade were science was greater in females than in males [9]. This is consistent with the earlier finding that females are more influenced to choose STEM by extrinsic motives; it appears that females rely more on receiving positive feedback regarding their ability in order to choose STEM.

Gender-role expectations, stereotypes and belonging. Gender-role expectations and accompanying stereotypes have been found to impact upon interest in enrolling in STEM subjects. Female students with less traditional gender-role expectations are significantly more likely to take chemistry than those who have more traditional gender-role expectations [27]. Females who reported a better fit with computer science stereotypes (the extent to which an individual identifies with prevailing cultural stereotypes of computer science) reported significantly higher interest in enrolling in a computer science course following exposure to a stereotypical classroom image than females who expressed less of a fit [14]. These findings indicate that females who consider themselves to be less traditionally 'feminine' (and therefore identify more with cultural STEM stereotypes) are more likely to choose or show interest in STEM subjects.

The more an individual experiences belonging, the more likely they will choose STEM: in an experimental study, females expressed significantly less interest than males in enrolling on a computer science course when the classroom that they were presented with (either an image or a description) consisted of stereotypical objects due to experiencing lower feelings of belonging, but this sex difference was smaller when participants were shown a non-stereotypical image of a computer science classroom [14]. Qualitative data from another included study provides a context for this finding: an interview with a post-16 female physics student highlighted the need for positive female role models in STEM: "Perhaps if there were more positive female role models in physics, that might have attracted more girls. I find sometimes physics can get competitive in class… it's just a certain type of people [that] do well in that kind of environment" (Nashon & Nielsen, 2007; p. 100); cues within the environment can promote or decrease feelings of belonging via the stereotypes they communicate and appear to have a unique effect on females. This review has identified that sex affects the other factors that influence STEM subject choice. In addition, Master et al.'s (2016) research was rated as methodologically high quality, due to the authors conducting an initial survey and pilot to create the classroom images, random condition allocation, pre- and post-measures to ensure that the effect was being measured and clear links to previous research into this influence on American college student subject choice.

School structure. Another factor which impacted on STEM subject choice was school structure, in terms of state or independent education, the sex of other students, streaming, and extra-curricular opportunities. One study provided a large amount of evidence for this factor [9]. This research was considered of medium-high methodological quality as it used a large-scale database of all A Level results in England (the National Pupil Database; n= 231,982 students) and multilevel modelling to assess which pupil and school factors influenced the uptake of A Level physics. Students are more likely to choose physics if they studied their GCSEs at grammar or independent schools. Nevertheless, clear sex differences emerge when inter-group analyses are run: males who studied for their GCSEs at comprehensive schools are more likely to study physics than those at independent or grammar schools, while the opposite was true for females [9].

The sex of the students at one's school appears to influence subject choice: male students in entirely mixed-sex schools were more likely to select physics at post-16 level than males in entirely single-sex schools, or those in single-sex schools up until sixth-form. Females in entirely single-sex schools were more likely than females in entirely mixed-sex schools to choose physics [9]. It is possible that this finding links to the previous factor of belonging, which affected females uniquely: females in all female schools are more likely to choose STEM subjects because they identify more strongly with those around them and receive cues that they belong (as all members are the same sex).

The ability of other students (both in lessons and the school in general) influenced STEM subject choice. Students who attended schools that 'stream' (grouping students according to academic ability) were more likely to study physics post-16 than those in schools that operate mixed-ability classes [27]. This finding was also highlighted in a qualitative study, whereby all of the students who had chosen to continue studying science at post-16 level had been taught in higher-ability groups [22]. Looking at the attainment of the school in general, females are more likely to study physics in schools of overall higher ability, while the opposite is true for males [9]. Schools that teach the three sciences separately (as opposed to a double-science model) have a higher uptake of science at post-16 level [2], while students who take physics as a separate GCSE are more likely to take physics at A Level [9]. However, schools often only offer separate science GCSEs (triple-award) to high achievers (Francis et al., 2017). It is possible that students who attend schools that are single-sex, stream or have ability grouping seen in single, double or triple science are less likely to see themselves differently to their peers (in terms of attainment), which may strengthen self-efficacy, enjoyment, and belonging; factors found to impact on STEM subject choice. This makes it difficult to establish whether it is the structure of the school or the students' views and perceptions which is driving this effect.

Extra-curricular activities that are provided by a school have been found to promote STEM subject choice. Bennett et al. (2013) found that in schools that had a 'high-uptake' of post-16 science, two of the four had tailored work experience placements, matched carefully with students' career interests, as opposed to their matched low-uptake schools, whose work experience programmes were used more to develop students' experience of the world of work generally. This links with 'utility value', discussed earlier, and the importance for students of selecting subjects based upon future study or career prospects.

Influence of others. Parents, teachers and peers were all found to have an impact on the uptake of STEM subjects, either through providing pressure, advice, or from achieving well themselves. Students' intention to study computer science was influenced by the encouragement and pressure of "important" people in their lives [8]; females who intend to take physics or maths report receiving more advice and pressure from others than females who do not, but less advice/pressure from others than males who intend to take physics or maths [17, 19]. Students whose parents expressed expectations for their child to study physics [29] and supported achievement in physics [18, 26] were significantly more likely to intend to study physics; parental advice was reported as a reason for choosing science at post-16 level [1]. Parental aspiration influences students' choice of physics [27] and science [31]. Females who intend to take physics [17, 19] and maths [19] receive more parental support than females who do not. However, females receive less home support for achievement in physics and achievement in general than males [17], while STEM-aspiring females report receiving less home support than STEM-aspiring males in physics [17, 19] and maths [19]. Parental aspirations for their child's final educational level was found to significantly predict science and mathematics subject choice [30], although this effect was found only in pre-university students in this Dutch study, not general secondary students, which might reflect the fact that pre-university education is seen as academically more rigorous than general secondary education.

Parents' child rearing style (autonomy granted to the child) had a small, but significant predictive effect on science and maths subject take-up at post-16 level [30, 31] and STEM-aspiring females reported more positive relationships with their parents than did females who did not intend to study physics [17].

Teachers also played a role. Students were more likely to take physics if they received encouragement and advice to study physics from teachers [16, 18, 26, 28, 29]; a similar result was found for science in general [23]. Peers also influenced STEM choice: students were more likely to choose science at post-16 if their friends were achieving in science [23] or taking the subject themselves [1].

In summary, parents, teachers and peers all influence STEM subject choice. Despite females achieving similarly to males in STEM, they also report receiving less advice or pressure to study STEM than males overall and this sex difference occurs even in those who choose STEM. Females who choose STEM do so despite receiving less advice; it can be suggested that they are more greatly influenced by other factors.

Time. Three studies included in this review identified that time influences STEM subject choice. A qualitative study explored the formation of post-16 subject choices over time and developed profiles for different types of science choosers [4]. The majority of the science choosers (eight students) included in the research made their choices following a 'precipitating' trajectory (they initially selected a breadth of subjects and it took time for their science focus to emerge).

Intention to study STEM can change over time. Year 8 students grouped by maths task confidence did not differ in maths subject choice intentions, but two years later, those who previously held a more accurate view of their ability had the highest maths intentions, while over-confident students reported the lowest intentions to study maths [24]. The authors suggested that this might be because maths is compulsory lower down the school, when participants were first asked about their intentions, and over-confident feelings promote effort and minimise negative affect at this time. It is possible that at Year 10, post-16 subject choice is closer and since academic attainment increases the likelihood of choosing STEM, receiving attainment feedback over time may lead once over-confident students to acknowledge that they are not as successful as they previously considered themselves to be.

One study [19], rated as 'medium' in methodological quality due to the research's longitudinal design, inclusion of procedures to maximise participant response and use of multiple measures, found that females were particularly susceptible to losing initial interest in choosing STEM subjects over time. In Year 8, females who expressed intentions to study physics and maths had a significantly higher self-concept in physics and maths than males who had no intentions to study physics or maths at post-16. However, by Year 10, there was no significant difference between these same groups of females and males. Moreover, for both maths and physics the mean t-test scores for initially non-STEM-aspiring males increased over time, whereas the mean t-test scores for initially STEM-aspiring females decreased. This finding is particularly interesting since self-efficacy predicts STEM subject choice [11]; it is likely that a decrease in reported self-concept at the time during which subject choice occurs will result in lower uptake of STEM. The influences of gender-role expectations, stereotypes, and belonging might explain why time affects subject choice more so for females than males; it is possible that gender-role expectations and stereotypes increase over time and become more important to older adolescents, particularly females, who are subject to unique challenges around STEM stereotypes, and their decision-making.

Ethnicity/cultural background. Students' ethnicity and cultural background influences their choice of STEM subjects. Students of Black heritage [18] and those of Bangladeshi, Caribbean, Irish, White and Black African and White and Black Caribbean heritage [9] are less likely than White British students to choose physics at A Level, while students classified as 'any other ethnic group' [18], those of South-Asian/Indian [26], Chinese and 'Other Asian' heritage [9] are significantly more likely to choose physics than those of White heritage. In an Australian study, immigrant status impacted on STEM subject choice, with those classified as 'native students' (those who had at least one parent born in Australia) less likely to choose to study STEM subjects than those who came from first- or second-generation migrant backgrounds [11].

Other subject choices. The subject choices that students have made previously influence STEM subject choice. One study found that male students who choose to study vocational subjects at lower secondary level (e.g. woodwork, metalwork) are less likely to select biology than male students who have not chosen vocational subjects [27]. Female students who chose vocational subjects previously are more likely to choose to study physics, while females who have not taken any vocational subjects are more likely to choose to study chemistry than those who have taken vocational subjects [27]. Since this factor was only identified in one research study, rated low-medium methodological quality (due to limited information on the data collection method or management of bias) this factor will need to be explored in different contexts to provide more evidence to confidently state that this factor influences STEM subject choice.

Parental education. Students whose parents studied to tertiary education level are more likely to choose physics at post-16 than those who do not choose physics [27]. Students with 'very high' levels of cultural capital (which was measured in this study by assessing level of parental education, books in the home and visits to museums) are more likely to choose physics than those with 'low' levels [7]. However, this study measured the number of STEM-aspiring students in each cultural capital category using percentages, rather than more detailed inferential statistics, so it is unclear whether there are statistical differences between the cultural capital groups. Parental education appears to exert a greater influence of female students' STEM subject choice than males': female biology and physics students are more likely than their male counterparts to come from professional backgrounds [27]. Females who have higher parental levels of education are more likely to take STEM subjects and this effect is mediated by parental aspiration [31]. This links back to the factor 'influence of others', which found that females receive less home support to study STEM subjects overall, which appears to contribute to females' lower interest in choosing STEM. However, females are more likely to choose STEM if their parents are educated to a higher level as they hold higher aspirations for their child, potentially resulting in greater home support and encouragement.

In summary, a range of extrinsic factors influence post-16 STEM subject choice. Students who choose STEM subjects tend to see them as useful, be high achievers and attend grammar or independent schools (and attend schools with particular structures in place for the teaching of STEM). They also receive advice, support and pressure from others, are influenced by the timing of their choice, their ethnicity or cultural backgrounds, have made vocational subject choices previously, and have parents who have a higher level of education. Research included in this review has identified that academic achievement mediates the relationship between three well-evidenced intrinsic and extrinsic factors also identified in this review (personal value, enjoyment, self-efficacy) and STEM subject choice, demonstrating how influential high achievement is on

STEM subject choice. The results of the studies included in this review suggest that there are differences in the way these factors impact on an individual depending on their sex. These extrinsic factors contribute to our understanding of how students make their STEM subject choices and why there is significantly lower STEM uptake by females than males.

1.4 Discussion

This systematic review sought to explore literature from the last 20 years to answer the question: what are the factors that influence adolescents' post-16 STEM subject choice? Factors that emerged from the 31 papers reviewed were categorised as either 'intrinsic' or 'extrinsic' to the individual. Since sex appeared to impact upon many of these factors, this question cannot be answered without considering students' sex as a key influence.

The review identified four intrinsic factors that impact on STEM subject choice. A student is more likely to choose a STEM subject if they are interested in or enjoy the subject, have a high level of self-efficacy, positively perceive their subject teachers and lessons, hold certain personality traits (they are less extraverted and agreeable, more emotionally stable and hold an internal locus of control), a STEM-related identity or skill set. Sex was found to interact with all four factors: females express less interest and enjoyment in STEM, lower levels of self-efficacy, less positive perceptions of teachers and lessons, higher levels of extraversion and lower levels of emotional stability than males.

This review identified nine extrinsic factors that also play a role in students' STEM subject choice. Students are more likely to choose STEM if they believe STEM subjects to be useful to them, achieve well academically, feel that they belong in STEM environments, attend grammar or independent schools, and attend schools that stream and/or allow students to take science as individual subjects (triple-award). Students are also more likely to choose STEM if they receive support from others, belong to a particular ethnic group or are from particular cultural backgrounds (South-Asian/Indian, Chinese and 'Other Asian' heritage), have made vocational subject choices previously, and are from homes of higher levels of education. Students' study intention also varies depending on when they are asked. Sex interacts with many of these factors: females expressed lower levels of utility value and extrinsic material gain motivation overall and received lower levels of support, advice and pressure from others, felt lower levels of belonging, and their self-efficacy for STEM decreased more over time.

1.4.1 Using the theoretical models to frame the results

Commonalities between the three theoretical models of decision-making introduced earlier can be used to frame the findings of this review. Student attitudes were found to influence

STEM subject decision-making: *enjoyment or interest* was a major influence on students' STEM subject choice, and students' positive *perceptions of teachers and lessons* also influenced this behaviour. Both factors are determined by one's attitudes to STEM and the teaching of STEM. Correspondingly, a component of the theory of planned behaviour (TPB; Ajzen, 1991) is the influence of experiential attitudes (one's enjoyment or interest) on carrying out a behaviour, such as selecting STEM subjects. *Utility value* was identified by many of the studies included in this review to predict STEM subject choice. The TPB and expectancy-value theory (EVT; Eccles et al., 1983) highlight the influence of an individual's judgment of the utility of the behaviour on enactment. *Self-efficacy* was also identified as an influence by many of the studies included within this review; individuals are more likely to choose STEM if they feel confident in their ability. This factor sits within the model of self-determination theory (SDT; Deci & Ryan, 1985), which states that humans need to feel competent to feel intrinsically motivated to carry out a behaviour. Likewise, EVT suggests that one's expectations of success is a major driver of behaviour.

Social norms, defined as "standards of behavior that are based on widely shared beliefs" (Fehr & Fischbacher, 2004; p. 185), influence STEM decision-making. The *influence of others*, such as through pressure or advice to choose STEM, influences STEM subject choice. Parental aspiration and pressure was found to be linked to *parental education*, a further factor identified in this review. Those from high-achieving backgrounds are more likely to be influenced to make subject choices deemed as challenging and prestigious. This corresponds with the TPB and EVT, which suggest that subjective norms and 'cultural milieu', the context in which one lives, influence our decision-making and behaviour enactment. Another factor identified in this review is that of *gender-role expectations, belonging and stereotypes*. The TPB and EVT describe the influence of stereotypes on social norms which influence decisions and behaviour, while SDT highlights the importance of experiencing feelings of relatedness, or belonging, on intrinsic motivation to carry out a behaviour, such as choosing STEM subjects.

The commonalities between the three theoretical models can be used to categorise some of the factors identified in this review but they are insufficient to explain all identified factors comprehensively. The factor *school structure* cannot be sufficiently captured by either student attitudes or social norms. Students who attend selective schools (grammar or independent) and schools that offer a greater variety of extra-curricular activities are more likely to choose STEM. It is likely that this links to the factor of academic attainment, as those who socialise with high achieving peers are more likely to choose subjects that are considered by society as cognitively demanding. It also links to the factors of parental aspiration and education, as students attending selective and/or fee-paying schools are likely to have parents with higher levels of education and socioeconomic status. However, *school structure* itself cannot be categorised as either an 'attitude' or 'social norm'. *Academic achievement* was also highlighted by this review as an influence on STEM subject choice and can be viewed as being partially shaped by social norms via parental pressure and education. However, biological differences and early learning experiences might also explain why some achieve highly in and select STEM subjects. *Personality and identity* was found to predict STEM uptake; if one expresses certain personality traits and/or identifies strongly with STEM, one is more likely to choose STEM. The development of personality and identity is subject to the nature-nurture debate. Although it can be considered as partially shaped by the responses an individual receives from others, via social norms, personality and identity is also shaped by genes and non-social environmental differences. *Time* affected STEM subject choice, with adolescents' interest decreasing as they aged. This is likely to be linked to attitudes and social norms but does not fit conclusively within the models.

Finally, this review found that *ethnicity/cultural background* and *sex*, two individual characteristics, affect STEM subject choice. However, the theoretical models do not specifically refer to these factors. Social norms are likely to be influencing the effect of *ethnicity/cultural background* on STEM subject choice via socioeconomic status, parental education and the value placed on STEM by different cultures. However, simply being a member of a particular ethnic group does not predetermine one's interest in choosing STEM. Similarly, a student's *sex* influences STEM subject choice, but appears to influence both attitudes and social norms. This review identified the difference in uptake between males and females and that students experience many of the factors included in this review differently depending on their sex, for example, females feel lower self-efficacy and utility value in STEM than males and are uniquely affected by lower feelings of belonging. However, previous research assessing decision-making around exercise has found no major effect of ethnicity or sex on the components of the theoretical models described here. A study exploring the moderating effect of ethnicity on TPB relationships found no moderating effects on the relationships between intention and affective attitudes and subjective norms, only between intention and perceived behavioural control (Blanchard et al., 2007). Furthermore, a meta-analysis highlighted that SDT's principles are universal and there are no differences between males and females on motivational constructs and processes (Guérin, Bales, Sweet & Fortier, 2012). Results such as these suggest that the ethnic and sex differences seen in this review are STEM-specific. Since there is a well-documented underrepresentation of females in STEM and this review highlighted the breadth of research showing a sex difference, I will now discuss why sex appears to have such an influence on STEM subject choice.

1.4.2 Sex differences and stereotypes

There continues to be an underrepresentation of females in STEM and the majority of studies included in this review demonstrated that sex is a major influence on many factors that predict STEM uptake. Large-scale, international research suggested that the majority of adults implicitly associate STEM with males (Nosek et al., 2009) and it is likely that STEM subjects activate sex-related attitudes and beliefs which generally affect females' performance and decision-making more than males'. Research has shown that gender priming can affect how females feel about STEM and how confident they are at completing a STEM-related activity. Priming females with the concept of 'female' (via words such as 'dress' and 'lipstick') led them to express more stereotypical attitudes towards STEM and a preference for art-related activities than females primed with male or neutral words (Steele & Ambady, 2006). Stereotype threat can be considered a form of priming; it occurs when members of a stereotyped group feel that their performance on a task will be negatively evaluated based upon stereotypes regarding their in-group status and can prime females to reflect upon sex differences in certain domains, such as STEM. Stereotype threat has been found to impact negatively on STEM performance: when induced experimentally, females perform worse than males in a maths test, but of all female participants, performance is better when exposed to information regarding equal representation and success within STEM (Shaffer, Marx & Prislin, 2012). This suggests that although STEM evokes stereotype threat and affects both interest and performance, there is the potential that this effect can be lessened by providing information that defies stereotypes.

A high level of female representation appears to increase the likelihood of choosing STEM. This review reported that females in entirely single-sex schools are more likely to study physics at post-16 level than females in entirely mixed-sex schools. One possible explanation for this is that single-sex environments increase the likelihood of identifying with others and access to role models, which increases feelings of belonging and acts as a buffer for the impact of STEM stereotypes, thus increasing STEM uptake. Researchers are beginning to examine the effects of diversifying role models within STEM: females who had a female science professor had a stronger implicit science identity, viewed their professor as a role model and were less likely to stereotype science as masculine (Young, Rudman, Buettner & McLean, 2013).

The literature exploring the influences on STEM subject choice at post-16 level demonstrates an interaction between student attitudes, social norms and sex. Despite males and females achieving similarly in STEM, it is possible that females' awareness of the social norms and expectations that STEM subjects are 'masculine' and therefore better suited to males, impact negatively upon the intrinsic and extrinsic influences identified in this review, such as their level of interest and enjoyment and how much utility value they hold for STEM subjects, therefore lowering the likelihood that they choose STEM subjects.

1.4.3 Review strengths and limitations

A strength of this systematic literature review is that the research included was conducted in multiple countries and used a variety of research methods. As such, we are able to understand that the results are not UK-specific, the evidence base is broad and deep, and research uses multiple methodologies. A further strength is that thorough searching (using multiple search terms and hand-searching relevant studies' reference lists) ensured confidence in the identification of relevant papers.

A limitation of this review is that research not published in peer-reviewed journals was excluded from the search. As such, it is possible that the findings were open to publication bias. Future reviews might assess the similarities and differences between factors identified in published and unpublished literature to add to or question our current understanding of the factors that influence STEM subject choice.

The studies included in this review were based in a variety of countries around the world. Cultural or education system-specific differences were not considered in detail, such as the time in which students make their choices for post-16 education, which might impact upon choice. Furthermore, there may be cultural differences in how the countries view STEM and this may have impacted upon individual study findings. This consideration might have provided an alternative perspective and put the findings in a context.

Broad factors were identified in order to structure this review and the studies included used a variety of different measures to explore similar (but often distinct) concepts. Differences in the measures or questions, and the impact that might have had on participants' responses, were not discussed. Future reviews could attend to this limitation by setting more specific inclusion and exclusion criteria for the measures used.

1.4.4 Implications for educational practice

This review found that self-efficacy was a key predictor of STEM subject choice. Self-efficacy has been found to be more predictive of young people's career aspirations than their actual academic achievement (Bandura, Barbaranelli, Caprara & Pastorelli, 2001). This has clear implications for practitioners, as research shows that self-efficacy can be increased if one is given opportunities for mastery experiences, access to social models, experiences social persuasion and feels a lower sense of stress around the activity (Bandura, 1994). Qualitative research suggests that the most important areas of STEM self-efficacy for females are vicarious experience and social persuasion, whereas mastery experiences are more influential for males (Zeldin & Pajares, 2000). Educational practitioners could focus their efforts on providing these opportunities and this could be differentiated accordingly. However, although self-efficacy predicts career aspirations better than actual performance, interventions that attempt to boost students' self-efficacy independent of their actual academic attainment can actually worsen the performance of those with lower academic attainment (Forsyth, Lawrence, Burnette & Baumeister, 2007). Consequently, it will be valuable for practitioners to focus on increasing self-efficacy in specific skills that are needed to perform well in the activity.

A well-evidenced extrinsic factor that should also be fostered in students is the utility value of STEM, particularly extrinsic utility value (material gain). Providing students with information about the value of STEM in terms of personal skill development, university and career prospects, will be important to promoting the personal benefits of studying STEM to higher levels. Providing STEM-based work experience opportunities will allow students to experience jobs first-hand and provide a wider context and purpose for their study.

In order to increase the number of females within STEM, it will be crucial to challenge stereotypes that exist within our culture. Educators must reflect upon their own STEM biases and stereotypes to ensure that they provide the same advice and support to all students, regardless of their sex. Teaching students about a diverse range of STEM role models throughout their time at school and allowing students to meet such individuals, through external speakers or via work experience placements, will help to promote the idea that all students belong in STEM. Mentoring schemes and peer role models might also provide a buffer against the stereotypes around STEM and increase feelings of belonging. Adjusting learning environments to ensure that they are not indirectly communicating that some groups do not belong will also be important to encourage more diversity within STEM. Finally, explicit teaching and discussion of the stereotypes that exist within STEM will provide an opportunity for students to explore and potentially reject these stereotypes for themselves. It may be that the challenging of stereotypes has a knock-on effect on other intrinsic and extrinsic factors identified, such as interest, self-efficacy, utility value and pressure/advice from others.

1.4.5 Directions for future research

Research shows that students' cultural background can impact upon their career choices (Akosah-Twumasi, Emeto, Lindsay, Tsey & Malau-Aduli, 2018) and this review highlighted that students' ethnic and cultural backgrounds influence STEM subject choice. However, it appears that the influence of ethnicity on STEM decision-making has not been researched as much as student sex. It would be valuable for future research to explore whether ethnicity and cultural background interacts with the factors identified within this review, just as sex has been found to.

The research included in this review was all carried out in OECD countries, the majority of whom (83%) are considered individualist cultures (Hofstede, Hofstede & Minkov, 2010). Since the shortage in STEM workers is seen globally, it would be worthwhile exploring similarities and differences in factors identified in students living in more collectivist cultures (where the pursuit of collective interests is favoured over individual interests) and how best to attract students to study STEM further within these cultures.

Parental education was identified as an influence on STEM subject choice and future research could explore whether this factor mediates the effects of other factors identified in this review. Parental aspiration and pressure have been found to mediate the relationship between parental education and STEM subject choice in females; it is therefore possible that parental education is also related to ethnicity and cultural background, for example, which determines access to private education or grammar schools. Conducting mediation analyses in this area might determine how strongly parental education affects STEM subject choice and might highlight a group of students to target specifically based on their ethnic or cultural background or socioeconomic status.

Though STEM-related gender stereotypes exist in elementary school-age children (Cvencek, Meltzoff & Greenwald, 2011), this review identified that time affects students' STEM study intention; students' attitudes towards and interest in STEM change as they age. It would be helpful to research attitudes towards and interest in STEM in younger students and the impact of challenging stereotypes in STEM at a time when children are still shaping their identities. Additionally, research exploring the effect of female STEM teachers on female STEM subject uptake might help to further our understanding of the function of role models and identification with STEM in STEM subject choice.

Master et al. (2016) found that feeling more of a 'fit' with computer science stereotypes predicted enrolment interest and it would be helpful to explore the impact of sex in-group identification upon STEM subject choice; whether females who view themselves as highly 'female' or 'feminine' are less likely to choose STEM and vice versa. Exploring this notion of femininity, or indeed masculinity, on STEM subject choice, may further our understanding of why some females choose STEM and some males do not. Considering gender identity on a continuum would enable us to explore whether it is actually society's notion of 'masculinity' and how much an individual identifies with this notion, as opposed to sex, that predicts STEM subject choice. It could be that the overrepresentation of males in STEM belies a more nuanced exclusivity within this field, that there is a group of both males and females who identify with more stereotypically 'feminine' societal qualities and norms who feel excluded from this career and we are actually excluding more individuals from STEM than we think.

1.4.6 Final conclusions

This systematic literature review highlights the factors that influence adolescents' STEM subject decision-making. By exploring the literature from the last 20 years, we found that sex was a major influence on the vast majority of these factors. This review showed that three theoretical models of decision-making are inadequate to fully explain decision-making in STEM, as many of the factors identified did not fit within the models. Since a sex difference in STEM persists despite UK initiatives, a continued study of the mechanisms at play within STEM interest and subject choice warrants further exploration.

Chapter 2 Exploring the impact of gender identity and stereotypes on secondary pupils' computer science enrolment interest

2.1 Introduction

Despite STEM (Science, Technology, Engineering and Mathematics) graduates having higher than average earning potential (Inside Careers, 2016), with STEM job demand expected to be double that of other industries by 2023 (Social Market Foundation, 2016), there is currently a shortage of graduates to fill STEM jobs, both in the UK and around the world (STEM Learning, 2018). The shortage of individuals in STEM begins when school students make their subject choices: in 2018, only 36% of A Level entries were in STEM subjects (Ofqual, 2019). There is a well-documented difference in STEM take-up between males and females: despite female GCSE students performing at a similar, and often higher level to males in compulsory STEM subjects, 30% more males than females choose STEM at post-16 level (WISE, 2019), while females make up just 24% of the core-STEM workforce (WISE, 2019). Recent government efforts have focused on attracting students, particularly females, to choose STEM subjects at the key transition between Key Stage 4 and 5, or post-16. Such initiatives have started to have an impact, with the number of females choosing A Level maths almost doubling since 2002 (WISE, 2019). Consequently, this is beginning to affect the STEM workforce, with a greater than 50% increase in females in STEM roles in the last ten years (WISE, 2019). However, progress is slow and subject specific; the percentage of females filling engineering roles has doubled in ten years, while those in technology roles has remained constant, at 16%. This is despite technology roles making up a quarter of the STEM workforce (WISE, 2019) and being the area of STEM predicted to be the most in-demand in the next few years, with the highest number of job openings of the STEM subjects (Social Market Foundation, 2016). It is imperative that researchers, policy-makers and educators focus their efforts on identifying barriers and facilitators, particularly in STEM industries that are making slower progress to change, in order to attract more students at an earlier point in their careers.

2.1.1 Decision-making in adolescence

Adolescents are less future-oriented than adults (Steinberg et al., 2009) and areas of the brain associated with planning and foresight continue to develop into adulthood (Casey, Tottenham, Liston & Durston, 2005). Adolescence is also a time of identity formation (Erikson,

1972) and brain scan data reflects the greater influence of emotions and social context on decision-making than at other ages (Blakemore & Robbins, 2012). In the UK, and many other countries around the world, students are given the chance to select school subjects to study further, often when they reach the age of 16. This decision-making can affect students' subsequent career paths but occurs at a time of major change. Since students are less future-oriented at this age it is likely that longer-term considerations, such as earning potential and job opportunities, will be less influential and therefore decrease the likelihood of students choosing STEM. As such, it is valuable to consider what factors influence adolescents' STEM decision-making.

A well-evidenced influence on students' STEM subject decision making is the utility value of STEM. Utility value ranges from intrinsic gain (the benefit to developing one's knowledge and skills) to extrinsic gain (for example, to gain access to university courses and job prospects). Students are more likely to choose STEM subjects if they have a greater sense of personal utility for STEM (Mujtaba & Reiss, 2013b) and have a greater extrinsic material gain motivation for taking STEM subjects (Sheldrake, Mujtaba & Reiss, 2015), such as gaining a place on a desired university course (James, 2007) or job (Mujtaba & Reiss, 2014). Research has also highlighted how the utility value of STEM can be promoted: secondary school students were more likely than controls to express intention to choose some STEM subjects following an intervention that provided them with information regarding the earning potential of STEM graduates (Davies, Davies & Qui, 2017). Informing students about the utility of STEM on their futures appears to influence their decision-making.

Another factor that has been found to influence STEM subject choice is self-efficacy. Self-efficacy has been defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Self-efficacy is a powerful motivator and can be fostered from a young age; elementary school children provided with hands-on STEM experience are more likely to show STEM self-efficacy and interest than controls (Master, Cheryan, Moscatelli & Meltzoff, 2017). Research has highlighted that self-efficacy, both current and future, influences students' STEM subject choice (Nagy et al., 2006; Stokking, 2000; Mujtaba & Reiss, 2014; Smyth & Hannan, 2006; Sheldrake, 2016; Sheldrake, Mujtaba & Reiss, 2015; Jeffries et al., 2019).

2.1.2 Sex differences in STEM

A student's sex has been found to influence whether or not they choose STEM and how they experience factors such as self-efficacy and utility value. Females are less likely to report that they enjoy STEM (Jeffries, Curtis & Conner, 2019), report lower STEM self-efficacy (Jeffries et al., 2019), extrinsic material gain motivation for STEM (Mujtaba & Reiss, 2013b) and less positive perceptions of STEM lessons (Mujtaba & Reiss, 2013b) than males. Master, Cheryan and Meltzoff (2016) found that feelings of belonging on a computer science course mediated the relationship between sex differences in enrolment interest in computer science, suggesting that females tend to choose STEM subjects less than males due to being female and therefore not feeling a sense of belonging within STEM. Sex is an influential personal characteristic, with understanding of sex grouping and labelling emerging as early as 18 to 24 months old (Martin & Ruble, 2010). Cultural stereotypes promote the idea that those who pursue STEM careers are less socially or physically attractive, creative and emotional, more intelligent and hold more masculine than feminine characteristics (Kessels, 2015). Research shows that children hold the cultural stereotype that STEM is better suited to males: children associate STEM subjects more with males than females and male children identify more strongly with STEM than their female counterparts (Cvencek, Meltzoff & Greenwald, 2011). A meta-analysis of 'Draw a Scientist' studies over 50 years found that children overall drew 73% of scientists as male (Miller, Nolla, Eagly & Uttal, 2018). Female participants drew 30% of scientists as male at age six, by age 16 this was 75%. For males, the change in drawing the scientist as male was 83% to 98%. This indicates that as children age, their stereotypes strengthen. The stereotypes around STEM tend to be disparaging to both males and females, but that the act of engaging in STEM is considered unfeminine is a barrier that applies predominantly to females (Kessels, 2015). Stereotype threat - the threat that one is at risk of confirming a negative stereotype about a group to which they belong - has been found to negatively affect females' performance in stereotypically 'male' activities, despite similar levels of academic attainment (Spencer, Steele & Quinn, 1999).

Some STEM subjects have responded well to government initiatives and now attract as many, if not more, females than males. Females are more likely to choose biology and chemistry A Level than males (63% and 54% of entrants in 2019 were female, respectively; WISE, 2019) but much less likely to choose physics, maths and computer science. Research that explored biases in STEM professors' judgements of post-doctoral candidates' competence and employability found a gender bias in favour of males in physics but not in biology (Eaton, Saunders, Jacobson & West, 2020). It is possible that females who wish to pursue STEM are more likely to select subjects such as biology as they are less likely to expose them to the negative effects of bias and evoke stereotype threat.

2.1.3 The difference between 'sex' and 'gender'

The sex difference within STEM is well-documented and until recently much of the research assessing male and females within STEM has categorised individuals according to their biological sex. However, there is variation in how strongly individuals experience stereotypes, with those who identify more with their in-group more susceptible to stereotype threat (Schmader, 2002). Recent literature and research has begun to acknowledge the distinction between 'sex' and 'gender': "Sex usually refers to the biological aspects of maleness or femaleness, whereas gender implies the psychological, behavioural, social, and cultural aspects of being male or female (i.e., masculinity or femininity)" (American Psychological Association, 2015; p. 450). While it is often helpful to design research to group participants in a binary way, it can overlook the diversity that exists within these groups. Gender identity, defined as "the extent to which [individuals] identify with stereotypical masculine or feminine traits" (McGeown & Warhurst, 2020; p. 103), has been found to predict interest in gender-typed activities (Athenstaedt, Mikula & Bredt, 2009), susceptibility to types of eating disorders (Lampis, Cataudella, Busonera, De Simone & Tommas, 2019) and academic behaviours and school performance (Kessels & Steinmayr, 2013) in adolescents. McGeown and Warhurst's (2020) definition of gender identity will be used for the purpose of this study. Research has highlighted the variance within groups categorised by sex, with female students who reported feeling more of a 'fit' with computer science stereotypes more likely to choose to enrol in this subject than females who felt less of a fit (Master et al., 2016). The Interests as Identity Regulation model (IIRM; Kessels & Hannover, 2004, 2007) links the development of one's interests to their identity. This model is able to explain why many females experience a greater misfit between their identity (developed in part by gendered stereotypes) and STEM when compared with males. This model also helps to explain why some females do not experience such a misfit: they may not perceive STEM as masculine as other females, or are less likely to perceive themselves as 'highly feminine' (Kessels, Heyder, Latsch & Hannover, 2014). Indeed, females who hold 'being a woman' as less important to their identity have more positive maths attitudes (Nosek, Banaji & Greenwald, 2002), perform better on a maths exam and are more likely to express interest in a maths career than those who hold it as more important (Kiefer & Sekaquaptewa, 2007). It could be argued that the difference in STEM subject uptake by males and females is not about sex differences but about the stereotype threat created by the dissonance between one's gender and the gendered norms of the subject an individual might choose to study.

It appears that some STEM subjects are more susceptible to this effect. A review highlighted that, among other factors, stereotypes around the type of individual who pursues certain STEM subjects, such as computer science and physics, along with sex-specific stereotypes regarding female ability within these fields, accounts for the variability in female interest in STEM subjects (Cheryan, Ziegler, Montoya & Jiyang, 2017). Computer scientists are often stereotyped as having an "obsession with machines" (Beyer, Rynes, Perrault, Hay & Haller, 2003; p. 52), are socially awkward (Beyer et al. 2003), intelligent (Ehrlinger et al., 2018) and male (Cheryan &

Plaut, 2010). This stereotype is also evident in younger children: 71% of elementary school children drew a male when asked to draw a 'computer scientist' (Hansen et al., 2017). These stereotypes do not just exclude females but candidates who identify with stereotypically 'feminine' characteristics, regardless of their sex.

Considering the IIRM and research exploring stereotype threat, it is possible that STEM subjects are less likely to be chosen by individuals who conform to stereotypically feminine norms and roles, regardless of their biological sex. Since STEM-related stereotypes relate to notions of masculinity, femininity and gender roles, while students' thoughts, responses and decision-making around STEM are unique to the individual, it is valuable to explore both sex- *and* gender-related differences within this area of research.

2.1.4 Research rationale, aims and objectives

The present study set out to assess whether gender identity ("the extent to which [individuals] identify with stereotypical masculine or feminine traits"; McGeown & Warhurst, 2020; p. 103) predicted UK secondary-school pupils' enrolment interest in computer science A Level, and what effect belonging, stereotype threat and classroom stereotypicality had on this relationship, when controlling for the influence of self-efficacy and utility value. Previously, research in this area has categorised participants according to their sex and found that female students, exposed to classroom environments that communicate STEM stereotypes, are less likely than male students to express computer science enrolment interest, mediated by lower feelings of belonging (Master et al., 2016). The present study will extend research in this area by exploring whether the extent to which an individual identifies with masculine and feminine traits (their gender identity), regardless of their sex, impacts upon their computer science enrolment interest.

2.1.5 Research questions

This research aims to answer the following research questions:

1. Does sex predict enrolment interest in computer science?[1]
2. Does femininity and/or masculinity predict enrolment interest in computer science?
3. Do stereotype threat and/or belonging mediate the relationship between femininity and enrolment interest, when controlling for self-efficacy and utility value?
4. Does the stereotypicality of the proposed classroom environment moderate the mediated relationship between femininity and enrolment interest, such that classroom

[1] This research question was designed to check an assumption about the data based upon previous research in this area.

stereotypicality strengthens the relationship between gender and stereotype threat and between gender and belonging, while controlling for self-efficacy and utility value.

2.1.6 Hypotheses

Based on the research questions of this research, the hypotheses are:

1. Females will be significantly less interested in enrolling in computer science than males.
2. There will be a significant negative relationship between femininity and enrolment interest.
3. There will be a significant positive relationship between masculinity and enrolment interest.
4. The negative relationship between femininity and enrolment interest will be partially mediated by both stereotype threat and belonging. Femininity will be positively related to stereotype threat, and stereotype threat negatively related to enrolment interest. Femininity will be negatively related to belonging and belonging negatively related with enrolment interest. Stereotype threat will be negatively related to belonging.[2]
5. The negative relationship between femininity and stereotype threat and belonging, in their roles as mediators of the relationship between femininity and enrolment interest, will be moderated by the stereotypicality of the classroom.

2.2 Method

2.2.1 Participants

Using opportunity sampling methods, we recruited 195 participants from two average-sized secondary schools in South West England. Participants were in Year 9 (age 13 or 14) at the time of survey completion. Forty-six participants attended School 1. We collected data from School 1 in the Summer term of Year 9. Participants in School 1 were completing a three-year GCSE programme and so had made their GCSE choices a year prior to data collection, in Year 8. All participants from School 1 were members of two history classes. Participants would make their post-16 choices in Spring term of Year 11. Students at School 1 had undertaken a compulsory ICT curriculum in Key Stage 3 (Year 7 and 8). One hundred and forty-nine participants attended School

[2] We based this hypothesis on Master et al.'s (2016) finding that females experienced lower enrolment interest, greater stereotype threat and lower feelings of belonging than males at baseline (pre-measure).

2 and we collected data in the Autumn term of Year 9. Participants in School 2 were due to complete a two-year GCSE programme and so would not be making their GCSE subject choices until Spring term of Year 9. They had received no input from the school over subject decision-making prior to data collection. Participants attending School 2 were currently undertaking a compulsory computing curriculum during Key Stage 3 (Year 7 to Year 9); data collection took place at the beginning of five computing classes. Students at School 2 were due to make their post-16 choices during the Spring term of Year 11.

Participants' data was excluded from the final analysis due to participants not starting the survey (n= 15), having whole measures missing (n= 3) or failing the attention check (getting less than 3 out of 4 questions correct; n= 9). Of the 195 participants who attempted the survey, the final sample comprised 168 Year 9 pupils. The present study was considered sufficiently powered based upon Harris' (1985) suggestion that the number of participants should exceed the number of predictors plus 50.

2.2.2 Measures

Gender identity. The Children's Sex Role Inventory, short form (CSRI; Boldizar, 1991) is a self-report measure comprising 30 questions that are measured on a 4-point scale (ranging from 1= not true of me at all to 4= very true of me). The CSRI measures traditional masculine characteristics (e.g. assertive: "It's easy for me to tell people what I think, even when I know that they will probably disagree with me"), feminine characteristics (e.g. affectionate: "When I like someone, I do nice things for them to show them how I feel") and neutral items (e.g. likeable: "People like me"). The ten neutral items were excluded from the analysis. We found high reliability for masculine (10 items, $\alpha = 0.80$) and feminine characteristics (10 items, $\alpha = 0.84$) of the CSRI.

The following dependent measures were the same as those used by Master et al. (2016) in their second experiment: enrolment interest, belonging, stereotype threat, self-efficacy and utility value. These measures were provided with permission from the authors.

Enrolment interest. Participants' interest in taking computer science was measured prior to and following exposure to the classroom image, using two items (e.g. 'How much do you want to take this course?')[3]. These items were measured on a 7-point scale (ranging from 1= not at all to 7= extremely). The two items were averaged to create an enrolment score both pre- and post-

[3] We measured three variables pre- and post- image viewing. This allowed us to assess participants' baseline levels and whether the stereotypicality of the classroom affected these variables (Appendix E; Appendix F).

image viewing. We found that reliability of these items was high for both the pre-measure (α= .89) and post-measure (α= .94).

Belonging. Participants' feelings of belonging on a computer science course was measured prior to and following exposure to the classroom image, using four items (e.g. 'How similar are you to the students that take this course?'). These items were measured on a 7-point scale (ranging from 1= not at all to 7= extremely). The four items were averaged to create a belonging score both pre- and post- image viewing. We found high reliability for these items both pre- (α= .89) and post-measure (α= .91).

Stereotype threat. Participants' feelings of stereotype threat in relation to their inclusion on a computer science course was measured prior to and following exposure to the classroom image, using four items (e.g. 'How much would you worry that your ability to do well in this course would be affected by your gender?'). These items were measured on a 7-point scale (ranging from 1= not at all to 7= extremely). The four items were averaged to create a stereotype threat score both pre- and post- image viewing. We found high reliability for these items both pre- (α= .93) and post-measure (α= .94).

Attention check. The attention check questions were the same as those used by Master et al. (2016), provided with permission. Participants were asked to read some information about two fictional computer science courses and asked five questions, with multiple-choice answers (e.g. 'Based on what you learned, how many different classrooms are there to choose from?'. One, two or three). The rationale for providing an attention check was to ensure that participants were attending to all of the information that they were reading; those who did not answer a minimum amount of questions correctly would be excluded from the analysis. The attention check also provided the opportunity to provide the participants with a context to the classes. The information stated that there were two classes, both classes studied the same subject (computer science), were given the same amount of homework, had teachers of the same sex (male) and had the same amount of male and female students. Providing this information to participants allowed us to attend to potential participant assumptions about the classes, for example, unequal homework demands or sex balance, to avoid their assumptions becoming confounding variables.

Images. We were given permission to use the two classroom images developed and used by Master et al. (2016). The objects included within the two images (stereotypical and non-stereotypical classrooms) were rated on 7-point Likert scales by 106 high-school students according to how much they associated each object with computer science. Internal consistency measured using Cronbach's alpha found acceptable reliability for both sets of objects (stereotypical, α= .74, non-stereotypical, α= .86; Master et al., 2016). We created dummy variables for the purpose of data analysis (stereotypical = 0, non-stereotypical = 1).

Self-efficacy. Participants' self-efficacy on a computer science course was measured using two items (e.g. 'How well do you think you would do on this course?'). These items were measured on a 7-point scale (e.g. ranging from 1= not at all well to 7= extremely well). This measure was only used post-image viewing, in line with Master et al. (2016), who used these questions in Experiment 2 of their study following participants' reading of a written description of the stereotypical or non-stereotypical classroom. We found that these measures had high reliability (α= .89).

Utility value. Participants' utility value of computer science was measured using two items (e.g. 'How useful do you think computer science will be for what you want to do after you graduate and go to work?'). These items were measured on a 7-point scale (e.g. ranging from 1= not at all useful to 7= very useful). Again, this measure was only used post-image viewing, in line with Master et al. (2016). We found that these measures had high reliability (α= .80).

Gender. Participants were asked 'How would you describe your gender?' and were invited to choose from four options (male, female, other, prefer not to say). This question was added to the survey following data collection in School 1. Out of 127 participants who were asked this question, 49 described themselves as 'female', 73 as 'male' and five selected 'prefer not to say'.

2.2.3 Procedure

Following ethical approval from the University of Southampton Ethics Committee (see Appendix G), three schools known to the lead researcher were contacted, one in the South East and two in the South West of England (see Appendix H). One school declined at this stage. With senior leadership approval, school information and parental information sheets were sent to the two remaining schools, both based in the South West of England. Both schools selected Year 9 classes to participate due to exam commitments and timetabling convenience. School 1 sent hard copies of parent information sheets home to eligible participants, while School 2 sent an e-copy of the sheet home (and sent hard copies to parents who had not signed up to the school's online letters system). The research utilised an 'opt-out' method for maximum participation. One parent (School 1) opted their child out of the research (see Appendix I).

In School 1, two GCSE history classes came separately to the computer suite to complete the survey. In School 2, the survey was carried out in five separate computing classes at the start of the lesson. Participants were given a participant information sheet to read (see Appendix J). The participants needed to provide their assent by checking a box in order to access the online survey. At this point, one participant opted-out of the research (School 2). A prize draw to win a voucher was used as an incentive to take part. Survey responses were collected on the University of Southampton's iSurvey online system. The lead researcher was present during the survey to answer any questions that participants had.

Participants completed the pre-measures (enrolment interest, belonging, stereotype threat). They then completed the gender identity measure. Next, participants answered the attention-checking questions. They were then randomly allocated to either the stereotypical image condition or the non-stereotypical image condition and were shown the appropriate classroom image. Participants completed the post-measures (enrolment interest, belonging, stereotype threat) along with self-efficacy and utility value measures. Finally, participants from School 2 were asked to describe their gender (n= 122). See Appendices K to S for survey measures.

2.2.4 Data cleaning

In total, 195 participants attempted and 180 started the survey. Participants' data was removed if they had missed four or more questions of any of the key measures (n= 3). The data of participants who had omitted three or fewer answers within a measure was averaged based upon their other responses for that measure. A five-question attention check was used. However, one question was omitted from this attention check because it provided unusual results, which was likely due to confusing wording of the question rather than inattention of a high number of participants. Participants' data was excluded if they got two or more incorrect out of four remaining attention checking questions (n= 9). The data of 168 participants was used in the final analysis. See Appendix T for descriptive statistics, skew and kurtosis levels for the main variables, prior to data cleaning.

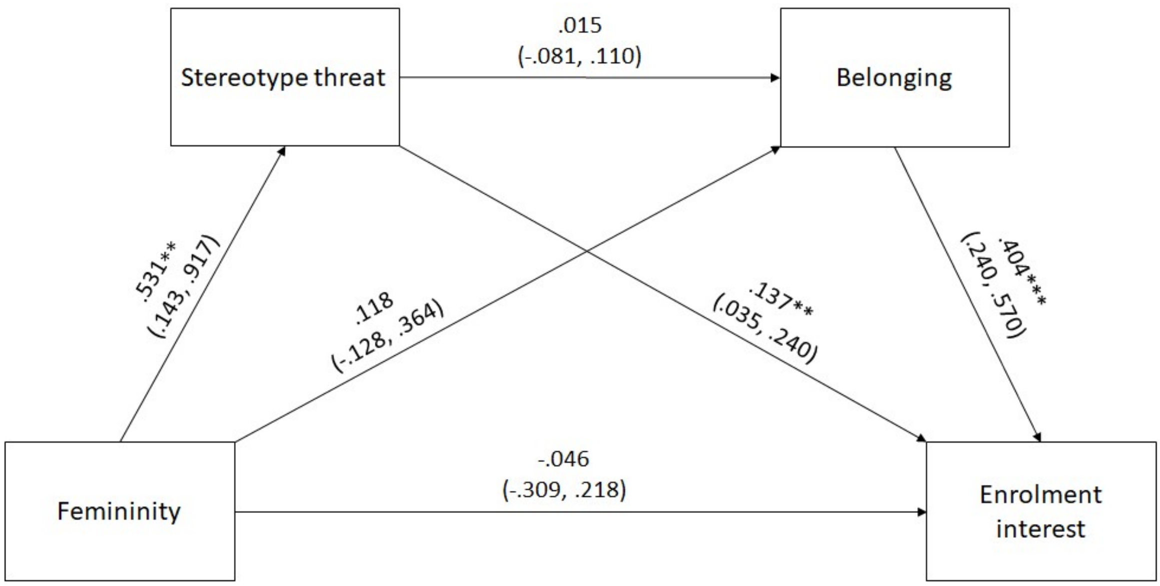
2.3 Results

Data was prepared and analysed using IBM SPSS Statistics (version 26).

Hypothesis 1: We ran an independent samples t-test to assess pre-measure enrolment interest and sex (participants who described their gender as either 'female' or 'male'). Male participants reported significantly higher enrolment interest in computer science than females (male participants, M= 2.79, SD= 1.63; females, M= 1.92, SD= 1.08), $t(119.98)= -3.54$, $p= .001$.

Hypothesis 2 and 3: Parametric assumptions were checked. Histograms for masculinity, femininity and enrolment interest indicated that enrolment interest was non-normally distributed. We ran a non-parametric one-tailed correlation to assess relationships between the variables. Kendall's tau was chosen because the data had a large number of tied ranks and it is less sensitive to outliers (Kendall, 1962), of which there were some present in the data. There was a negative, non-significant relationship between masculinity and enrolment interest ($\tau= -.090$, *p*= .111). Femininity was significantly negatively correlated with enrolment interest to a small degree (τ= -.105, *p*= .033). Self-efficacy (τ= .549, *p*= <.001) and utility value (τ= .439, *p*= <.001) significantly predicted enrolment interest. Masculinity was significantly correlated with femininity (τ= .183, *p*= <.001).

Hypothesis 4: Since the correlation between femininity and enrolment interest was statistically significant at the .05 level, we tested a serial mediation model (PROCESS Model 6; Hayes, 2013) to assess whether stereotype threat and belonging partially mediated the relationship between femininity and enrolment interest (with self-efficacy and utility value as covariates; Figure 3). We used a bootstrapping approach, resampling the dataset 5000 times, with both 95% and 99% confidence intervals to establish the statistical significance of the findings.



Note. Confidence intervals are in brackets; reported coefficients are unstandardised *B* coefficients; ** *p*= <.01, *** *p*= <.001. Self-efficacy and utility value were covariates.

Figure 3 PROCESS Model 6. A serial mediation analysis to assess the direct and indirect effects of femininity on enrolment interest

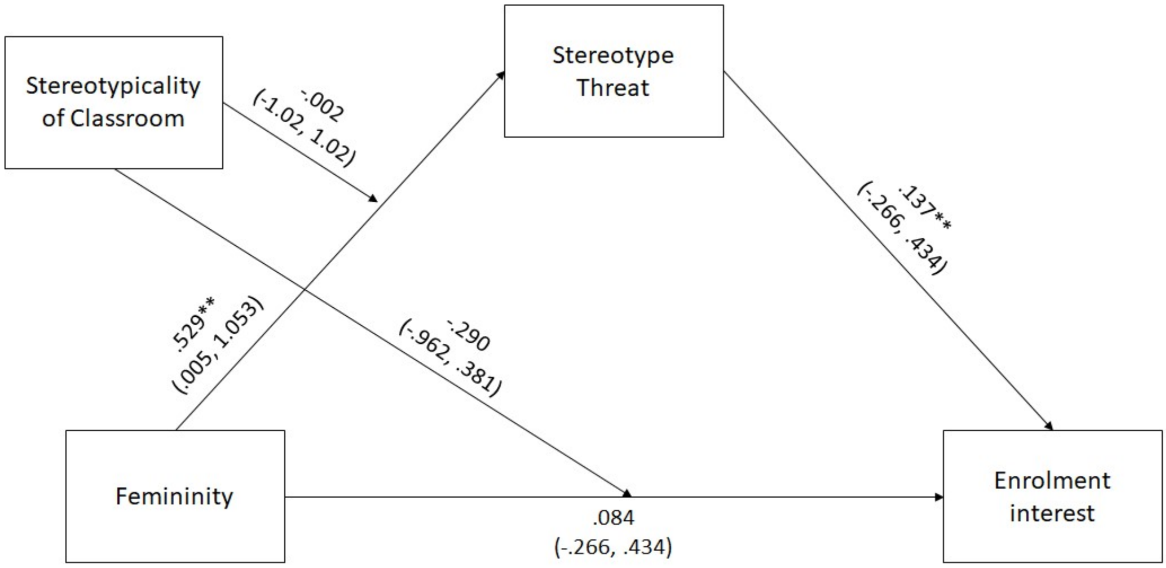
The results showed non-significant total or direct effects of femininity on enrolment interest; femininity was not significantly related to enrolment interest, either with or without self-efficacy and utility value controlled for (see Appendix U). The total indirect effects of femininity were not significant; there was no change in magnitude in the relationship between femininity and enrolment interest when controlling for stereotype threat and belonging. One significant specific indirect effect was found: there was a significant positive indirect pathway for femininity through stereotype threat, since the 95% confidence interval of the point estimate did not cross zero (*B*= .073, SE= .043, LL= .006, UL= .169). The proportion of variance in enrolment interest, predicted by femininity, is explained to a significant degree by their mutual relationship with stereotype threat. This was an inconsistent mediation effect. A mediation effect was indicated but it is possible that an additional effect in the other direction was interfering with this. Higher levels of femininity led to higher levels of stereotype threat which resulted in lower enrolment interest. However, since stereotype threat and enrolment interest were found to be significantly positively related, it is possible that greater enrolment interest might also cause higher stereotype threat in those with higher femininity. No indirect effect of belonging was found for femininity on enrolment interest; belonging did not change the magnitude of the relationship between femininity and enrolment interest.

Hypothesis 5: We tested a moderated mediation model (PROCESS Model 8; Hayes, 2013) to assess whether classroom stereotypicality moderates the relationships between femininity and stereotype threat and femininity and enrolment interest (with self-efficacy, utility value and belonging as covariates; Figure 4). Results showed that classroom stereotypicality did not moderate this effect, since the 95% confidence interval of the point estimate crossed zero (*B*= -.000, SE= .057, LL= -.091, UL= .139). Table 5 shows descriptive statistics for the included variables in each image condition.

Table 5 Descriptive statistics for the variables included in the mediated moderation analysis

	Stereotypical image		Non-stereotypical	
	M	SD	M	SD
Enrolment interest	2.44	1.59	2.33	1.41
Masculinity	2.53	.54	2.53	.60
Femininity	2.77	.58	2.84	.34
Stereotype threat	2.08	1.36	2.06	1.44
Belonging	2.67	1.30	2.57	1.36
Self-efficacy	2.97	1.47	2.85	1.55

Utility value	3.59	1.57	3.40	1.58



Note. Confidence intervals are in brackets; reported coefficients are unstandardised *B* coefficients; * *p*= <.05,** *p*= <.01. Belonging, self-efficacy and utility value were covariates.

Figure 4 PROCESS Model 8. A moderated mediation analysis to explore whether stereotypicality moderates the mediation of stereotype threat on femininity and enrolment interest

2.4 Discussion

The present study aimed to extend previous research by exploring whether gender identity, measured as the extent to which an individual identifies with stereotypical masculine and feminine characteristics, influences enrolment interest in computer science, and whether feelings of belonging and stereotype threat mediate this relationship. This study also aimed to explore whether exposure to an image of classroom showing objects stereotypically linked to STEM would moderate the mediation of belonging and stereotype threat on gender and enrolment interest. By understanding some of the influences and underlying mechanisms on computer science enrolment interest, it was hoped that we would gain understanding of potential barriers and promote inclusion in STEM through specific targeting of individuals.

Those who consider themselves to hold a high number of traditionally feminine characteristics are those who are threatened more by stereotypes related to STEM which explains their lower enrolment interest in computer science. This effect was seen in those who scored high in femininity, irrespective of their sex. This finding can be explained using the Interests as Identity Regulation model (IIRM; Kessels & Hannover, 2004, 2007) introduced earlier: individuals are more likely to abstain from domains that do not fit with their self-concept, which has been developed via their interest and effort, and experience more interest in domains that fit. Indeed, interest predicts STEM subject choice (e.g. Sheldrake, 2016), as does seeing STEM as part of one's identity (Pike & Dunne, 2011). The IIRM suggests that individuals make choices based upon their cognitive constructions of themselves and their environments. Therefore, individuals will not select STEM if their self-concept conflicts with the stereotypes around STEM. Stereotypically 'feminine' characteristics, as measured by the Children's Sex Role Inventory (CSRI; Boldizar, 1991), such as compassion, warmth and affection, are related to an individual's interactions with others. It is plausible that those who score highly on such a measure are less likely to express interest in subjects that are stereotyped as being socially isolated (Cheryan, Master & Meltzoff, 2015) and object- rather than people-oriented (Su & Rounds, 2015) than those who score lower in their identification with feminine characteristics. The present study also found stereotype threat mediated the relationship between femininity and enrolment interest; those who identified more strongly with feminine characteristics were more likely to experience stereotype threat, which led to decreased enrolment interest. This can also be explained by the IIRM, which posits that some see STEM as less 'feminine' than others and are more likely to feel threatened by STEM-related gender stereotypes as they do not cohere with their self-concept (Kessels, 2015), while others, who view STEM as more 'feminine' feel less threatened. Experimental research corresponds with this theory: females in the field of STEM hold weaker implicit gender-related stereotypes around STEM than females who held a degree in different subjects (Nosek & Smyth, 2011).

Those who described themselves as male were significantly more interested in enrolling in computer science than those describing themselves as female, offering contemporary UK support for previous research into STEM subject choice highlighting a sex difference in STEM subject interest (e.g. Mujtaba & Reiss, 2013a; Jeffries, Curtis & Conner, 2019). When looking at gender identity, we found a negative relationship between masculine characteristics and enrolment interest; higher masculinity was related to lower enrolment interest. Despite this finding not reaching statistical significance, it is still interesting to consider why this unexpected result might have occurred. The CSRI was used in the present study to assess gender identity. This measure allows participants to score highly on both masculine and feminine characteristics, score higher on one over the other, or score low on both set of characteristics. The 'masculine' characteristics assessed within this questionnaire included 'competitive', 'assertive', 'athletic' and 'acts like a leader' (Boldizar, 1991). It is possible that masculinity, as measured in the present study, which we expected would be positively associated with STEM enrolment interest, actually described the characteristics of somebody not stereotypically similar to those who study STEM. For example, Ehrlinger et al. (2018) asked undergraduates to describe a computer scientist and an engineer. Factor analysis of the descriptors highlighted two key areas; one focused on a lack of athleticism and one on high intelligence. If these stereotypes are related to the reality of STEM, and who chooses to enter the field, then a measure that associates high athleticism with high masculinity, for example, may find an inverse relationship with an interest in computer science. By continuing to reinforce low masculinity, low femininity stereotypes (as measured by the CSRI), it is possible that STEM industries are losing access to athletic, socially confident and emotionally sensitive candidates.

Despite previous research highlighting that sex-related differences in computer science enrolment interest following exposure to a stereotypical classroom are driven by feelings of belonging (Master et al., 2016), our research did not find that belonging mediated the relationship between femininity and enrolment interest, either independently or alongside stereotype threat. It is interesting to consider why, when assessing participants according to their sex, belonging mediates the relationship between sex and enrolment interest (Master et al., 2016) but when assessing gender identity, it is stereotype threat, and not belonging, that mediates the relationship between femininity and enrolment interest. It is possible that there are two separate effects occurring when we view sex and gender as distinct concepts; one dependent upon the extent to which one identifies with belonging to the category of ‘female’ or ‘male’ and another that is dependent upon the extent to which one identifies with traditionally ‘feminine’ or 'masculine’ traits. As discussed earlier, despite the variation in how strongly individuals identify with their sex (e.g. Kiefer & Sekaquaptewa, 2007), research often groups individuals by sex. The questions that were used in the present study to assess belonging used terms such as ‘fit’, ‘belong’ and ‘similar’. Those who describe themselves as female might look at the STEM community and see fewer individuals with whom they can identify with and feel ‘similar’ to, resulting in one’s sense of belonging mediating the relationship between sex and enrolment interest (Master et al., 2016). However, this relationship between the variables might not be the case for all females but the nuance within this heterogeneous group is more challenging to explore when grouping participants in a binary way. The items used to assess stereotype threat in Master et al.’s (2016) research and the present study involved phrases such as ‘confirming a negative stereotype’ and ‘worry’ that others would ‘draw conclusions’; phrases related to an individual’s perceptions of others’ views and biases. It appears that those who identify strongly with feminine norms and roles, regardless of sex, feel more threatened by the cultural STEM stereotypes that communicate that STEM is not for them as the nature of STEM stereotypes is that STEM is unfeminine and not suited to their interests and personality. This highlights the variation within those who might normally be considered as a homogenous group; some individuals who would be typically grouped as ‘female’ might report a low sense of belonging and express that they do not ‘fit’ in STEM, simply because they are female and therefore a minority, but these same individuals might not be threatened by STEM stereotypes because they enjoy the subject and feel capable of achieving. The same can be applied to those typically grouped as ‘male’, but vice versa.

In the present study every participant was shown either an image of a stereotypical computer science classroom or a more neutral, non-stereotypical classroom. It was expected that by making STEM stereotypes salient to half of the participants, and minimising stereotypes to the other half, we would see a stronger relationship between femininity and enrolment interest, mediated by stereotype threat, in the presence of a stereotypical classroom. Unexpectantly, the stereotypicality of the classroom did not moderate this relationship. This might be in part due to cultural differences and the images not generalising to UK participants. Master et al. (2016) conducted a pilot study with American students (high-school students ranked objects according to their STEM stereotypicality) and their subsequent research was carried out in American high schools. It is possible that the computer science stereotypes included in the stereotypical classroom image, along with the arrangement of the classrooms in both images, were less accepted by similar-age British secondary school students and so had little impact on their stereotype threat and computer science enrolment interest. It is also possible that stereotypes communicated via the environment do not activate stereotype threat and subsequent enrolment interest in highly feminine individuals as much as other expressions of stereotypes, such as the attitudes or behaviour of others.

The present study has extended previous research by highlighting the mediating influence of stereotype threat on individuals who identify more strongly with stereotypically feminine characteristics, regardless of their sex. Stereotypes can affect a range of individuals, and though females are uniquely affected by STEM stereotypes, we must not overlook the possibility that there is a diverse group of individuals currently missing from STEM. As a society, our focus on a lack of females in STEM ignores a wider social issue: that STEM welcomes a certain type of person and that the stereotypes around who is welcome in STEM exclude those with more stereotypically feminine (and masculine) traits, both male and female. In the UK, we have not been able to find the solution to the gender bias within STEM, and specifically, computer science. The findings of the present study indicate that we might be focusing on the wrong group of individuals to target and that the lack of diversity in STEM is not just about sex, but also about gender identity.

2.4.1 Strengths and limitations

The present study extended previous research that highlighted the influence of belonging, stereotype threat, self-efficacy, utility value and sex in STEM enrolment interest. We considered participants' gender identity as a predictor of enrolment interest in order to understand why so many individuals, both female and male, do not choose STEM subjects at post-16. Assessing individuals' gender in this way allowed for a more nuanced exploration, since STEM is an area in which gendered stereotypes continue to exist. It allowed us to explore and show that interest in computer science and the effect of related stereotypes is influenced by more than just one's sex.

A limitation of the present study is that information regarding participants' further education intentions was not collected. It is compulsory for all students in England to undertake further education once they have turned 16 and around 56% of school leavers in the UK move on to study level 3 qualifications at Key Stage 5 (A Levels or equivalent; Department for Education, 2020). However, it is possible that some of the participants in the present study might not have intended to study A Levels. Future research might address this limitation by excluding students who do not intend to take level 3 qualifications to ensure that responses are only provided by those who might plausibly choose computer science to study further at Key Stage 5.

Since the schools were following different GCSE curriculums and were at different stages in their education, there is a possibility that the responses of the participants attending School 1 (n= 41) were biased against enrolling in computer science. Participants attending School 1 followed a three-year GCSE curriculum (Year 9 to Year 11) and so had made their GCSE subject choices a year previously and had already studied a year of their GCSE programme. These participants were members of two humanities classes which were selected for convenience. The participants attending School 2 (n= 127) were surveyed in the Autumn term of Year 9, were due to select their subjects from March of the following year and had not received input on GCSE subject choice prior to participating in this research. We collected School 2 data at the start of the participants' computing lessons as they were all completing a compulsory Key Stage 3 computing curriculum, prior to selecting and studying for their GCSEs. Although studying computer science at GCSE is not an entry requirement for selecting it at A Level (Cife, n.d), it is possible that by rejecting computer science prior to participation, which participants in School 1 might have already done, the prospect of choosing this subject at A Level was less of a consideration for these participants than those who had yet to make any kind of subject choices. We attended to the possibility that some participants were less likely than others upon entering the study, to select computer science in the future, by running an independent samples t-test which showed that the two schools were not statistically different in their enrolment interest at pre-measure, $t(166)= .20$, $p= .843$.

Table 6 Descriptive statistics for the two school samples

School	N	M	SD
School 1	41	2.46	1.60
School 2	127	2.41	1.48

The images used in the present study were the same as those used in the first experiment of Master et al.'s (2016) research. Stereotypicality of the classroom did not moderate the mediation effect of stereotype threat on the relationship between femininity and enrolment interest, despite Master et al. (2016) finding that females expressed lower enrolment interest when shown the stereotypical classroom when compared with the non-stereotypical classroom. It is possible that the images did not provoke the activation of stereotypes, as intended, due to cultural bias, and so did not generalise to a UK sample. The objects within the rooms were selected by American high-school students and so might have been stereotypical of STEM within the American culture, but the same objects might not be considered stereotypically 'STEM' by British students. Although Master et al. (2016) assessed the reliability of the objects in each classroom, we did not carry out our own reliability checks using a UK sample.

The research at both schools took place in the students' computer science classroom for convenience. However, it is possible that administering the survey in such a location primed participants' responses, especially as part of the survey involved considering the environment of a computer science classroom. Many participants might have dismissed the images as unrealistic, due to the reality of taking a computer science A Level course in the classroom in which they were carrying out the survey. Future research might consider priming effects and consider carrying the research out in a more neutral environment. In addition, future research might use images of participants' actual computer science classroom with added stereotypical or non-stereotypical cues, or a description of a stereotypical or non-stereotypical classroom environment, to encourage participants to visualise their own classrooms, just as Master et al. (2016) did in their second experiment.

Research has showed that those who score lower on extraversion and higher on emotional stability (Korpershoek, Kuper, Van der Werf & Bosker, 2010; Korpershoek, Kuper & Van der Werf, 2012) are more likely to choose STEM subjects. However, we did not control for personality in the present study despite it being possible that there was high collinearity between personality and the sex-roles measured by the CSRI. Males who study physics score higher on emotional stability than their female counterparts (Mujtaba & Reiss, 2013b); this sex difference highlights that STEM uptake might not be inherently about personality traits but how the personality traits link with gender norms.

The present study found that masculinity and femininity were positively correlated, suggesting that scoring highly on one measure of the CSRI was related to scoring highly on the other, and vice versa. This measure is almost 30 years old and comprises statements pertaining to 'traditional' masculine and feminine stereotypes. Recent social and cultural shifts in our understanding and recognition of sex and equality, alongside UK government legislation such as The Equality Act (2010) and the Gender Recognition Act (2004) have challenged traditional sex roles and ideas around gender and it is likely that our participants were less aware of the cultural connotations of the statements used in this measure, than adolescents 30 years ago. This measure did not associate with enrolment interest as strongly as we expected so future research might benefit from using an updated measure of gender identity. Since gendered stereotype threat is experienced subjectively, a more subjective gender measure might useful in this kind of research, such as asking participants where they would rate themselves on 'masculine' and 'feminine' continuums according to their own judgement of their gender identity. Future research could involve developing a more modern measure which would allow researchers to explore how gender identity influences a variety of views, activities and behaviours. It might also be interesting to explore the extent to which labelling certain characteristics as 'masculine' and 'feminine' perpetuates the association of these characteristics with males and females, respectively.

2.4.2 Implications for future research and educational practitioners

The present study showed that those who have a higher feminine gender identity have lower enrolment interest in computer science than those who score lower and this is driven by their higher stereotype threat. To better understand this finding, it would be valuable to explore these results in a qualitative way to give a voice to a cross-section of both STEM and non-STEM students who score highly on 'femininity' and find out what these stereotypes look and feel like to them. Exploring ways in which schools specifically – and society more generally – can challenge stereotypes and broaden the appeal of STEM subjects to a more diverse set of individuals would be beneficial in continuing to develop our understanding of stereotypes and how best to overcome them in the field of STEM. It is important for anyone working in education to be aware of the power of stereotypes and biases and how these might be communicated to children and adolescents via the environment, behaviour and language. This could be explored from pre-school upwards, as children continue to shape their identities throughout their childhood and into adolescence.

It is important for policy-makers to also consider how STEM stereotypes affect those from other groups underrepresented within STEM, such as Black students (Mujtaba & Reiss, 2014) and those from households with lower parental education levels (Smyth & Hannan, 2006). It would be interesting for future research to explore whether these demographics interact with the factors explored in the present study to identify whether sub-groups of students would benefit from more tailored STEM-promotion programmes.

Cultural stereotypes, which suggest that a certain type of individual is welcome in STEM, remain and this research suggests that they are still influential to STEM subject choice. As a result, it appears that society is continuing to exclude a diverse group of individuals, both male and female. Undoubtedly, many individuals do not enjoy STEM and have skills elsewhere. However, it is concerning that there may be a large number of individuals who, although capable, have knowledge of STEM stereotypes and as a result of feeling threatened by such stereotypes, rule it out without having the opportunity to explore whether it might be a potential career path for them. An area that educational practitioners and policy-makers could explore further is the availability and diversity of STEM role models available to school students, particularly at an early age, when stereotypes and gender roles are beginning to develop (Chick, Heilman-Houser & Hunter, 2002). Research has shown that children's perceptions of what a 'computer scientist' looks like can be influenced by their experiences: elementary school children's drawings of computer scientists went from 71% male to 51% male after being taught computer science by a female teacher (Hansen et al., 2017). Allowing children and young people opportunities to access a variety of STEM role models, from a wide range of backgrounds, might challenge any existent stereotypes and promote the idea that STEM fields are inclusive and not accessible only by those who fit a certain stereotype. Schools who offer bespoke STEM work experience have higher uptake (Bennett, Lubben & Hampden-Thompson, 2013), so providing a greater number of students from a variety of backgrounds access to work experience within STEM will allow them to understand what STEM subjects involve and might also go some way to challenging the stereotype that such fields are socially isolating, exclusively object-focused and only accessible to those who lack inter-personal skills.

2.4.3 Final conclusions

In the present study, we have found that femininity is negatively associated with enrolment interest in computer science A Level for UK students, irrespective of the students' sex. Stereotype threat mediated the relationship between femininity and computer science enrolment interest, providing evidence that stereotypes around STEM affect the enrolment interest of those who identify strongly with stereotypical 'feminine' characteristics, specifically. The present study highlighted that previously researched sex differences in STEM enrolment interest, mediated by belonging, and gender identity differences, mediated by stereotype threat, are two separate effects. It is possible that STEM stereotypes conflict with one's self-concept, developed via interests and effort and it should be a concern to educational practitioners that STEM stereotypes remain. By leaving STEM stereotypes unchallenged, students who have a highly ‘feminine’ gender identity are more likely to be deterred from enrolling on STEM subjects at post-16 level, leading to a less diverse STEM workforce. It is important that we ensure that everybody feels welcome within STEM, especially those subjects more susceptible to stereotypes, in order to encourage individuals from all walks of life to a profession that will be crucial for society as we move into an increasingly technological future.

Appendix A Search terms used for systematic literature review

Database(s)	Search terms used
PSYCInfo and ERIC	("subject choice*" OR "subject interest" OR "choice* of subject" OR "intention* to participate" OR "intention* to study" OR "plan* to study" OR “plan* to participate” OR "desire* to study" OR “desire* to participate” OR "wish* to study" OR “wish* to participate” OR "aspir* to study" OR “aspir* to participate” OR “desire* to enrol” OR “desire to enroll” OR “desire* in enrolment” OR “desire* in enrollment” OR “enrolment desire*” OR “enrollment desire*” OR “interest to enrol” OR “interest to enroll” OR “interest* in enrolment” OR “interest* in enrollment” OR “enrolment interest” OR “enrollment interest” OR "interest in taking" OR "interest in choosing") AND (child* OR pupil* OR student* OR adolescen* OR teen* OR "young people" OR "young person") AND (factor* OR influence* OR cause* OR reason*) AND ("science, technology, engineering and math*" OR STEM OR science OR physics OR biology OR chemistry OR math* OR engineering OR technology OR computing OR "computer science" OR "information communication technology" OR "computer science")
Scopus	TITLE-ABS-KEY (("subject choice*" OR "subject interest" OR "choice of subject*" OR "intention* to participate" OR "intention* to study" OR "plan* to study" OR "plan* to participate" OR "desire* to study" OR "desire* to participate" OR "wish* to study" OR "wish* to participate" OR "aspir* to study" OR "aspir* to participate" OR "desire* to enrol" OR "desire* to enroll" OR "desire* in enrolment" OR "desire* in enrollment" OR "enrolment desire*" OR "enrollment desire*" OR "interest to enrol" OR "interest to enroll" OR "interest* in enrolment" OR "interest* in enrollment" OR "enrolment interest" OR "enrollment interest" OR "interest in taking" OR "interest in choosing") AND (child* OR pupil* OR student* OR adolescen* OR teen* OR "young people" OR "young person") AND (factor* OR influence* OR cause* OR reason*) AND ("science, technology, engineering and math*" OR stem OR science OR physics OR biology OR chemistry OR math* OR engineering OR technology OR computing OR "computer science" OR "information communication technology"))

Appendix B Inclusion and exclusion criteria applied to relevant papers

	Inclusion criteria	Exclusion criteria
Population	Participants were 13-18 years old	Participants were < 13 or > 18 years old
	Study focused on the participants' own choice of subject	Study focused on other individuals' thoughts around student subject choice
	Those who are attending or once attended mainstream high/secondary school	Those who are not attending or did not attend mainstream high/ school
	Studies focused on subject choice at post-16 level	Studies not focused on subject choice at post-16 level
Academic subject	STEM-specific results	Does not have STEM-specific results
	Post-compulsory choice	Compulsory education
Date	Published post-2000	Published pre-2000
Type of publication	Academic research study	Literature review
Publication requirements	Studies published in a peer reviewed academic journal	Studies not published in a peer reviewed academic journal
		Book reviews
		Unpublished dissertations, theses
		Conference papers
Language requirements	Published in English	Not published in English

# Appendix C	Data extraction table

Authors Country	Quality assessm ent	Sample	Subject	Design	Measures	Factors explored	Relevant findings
(1) Bartholomew & Mooed (2012) New Zealand	3	T1: 273 Y10 students T2: 171 Y11 students (128 had taken previous survey, 28 had not)	Science	Quantitative Survey Longitudinal		Whether subject is 'cool' Wanting to get NCEA qualification Subject related to everyday life Cannot take due to timetabling Subject is easy I get high marks Need for career/further study Parental advice Teacher advice Liking subject's teacher Friends take the subject Enjoy the practicals Enjoy the subject	Year 11: Subject enjoyment and gaining NCEA qualification were the two major reasons for taking science. Careers/future study noted, as well as parental advice.
(2) Bennett, Lubben & Hampden-Thompson (2013) England	7	Four matched pairs of high-uptake and low-uptake schools A1/2, B1/2, C1/2, D1/2	Chemistry and physics	Case study Qualitative (interviews and database analysis)	Interview data (key staff and student focus groups – chemistry and/or physics choosers and non-science choosers); grounded theory	Focus group key selection strategies: Related to career aspiration Related to university course aspiration Enjoyment, selection of university course and selection of subjects	**Student factors:** Strategies used by students attending high-uptake schools: A1/B1: motivated by chosen careers or targeted university courses C1: Select based on interest or role models, self-efficacy D1: being a 'science person' (identity)

						Personality and the area of knowledge that one will enjoy Confidence in abilities Reduction of risk Keeping options open Selected subjects that go well together Subjects I have enjoyed Who has taught them previously Subjects that one is good at Availability on timetable Told to take the subject by teachers or parents	Students attending low-uptake schools: A2/B2: variety of selection strategies than those who attend low-uptake schools C2: aiming for 'best' career (either best paid for or most challenging), emphasis on physics being 'hard' D2: prior experience of and ability in science
(3) Bøe (2012) Norway	11	1628 students Year 12 students	Science	Quantitative Survey	Interest/enjoyment Self-realisation Fit to personal beliefs Utility value for university admission Expectation of success Relative cost		Science students scored much higher than HumSoc (languages, social sciences, economics) students in 'importance of utility value for university admission' The utility value for university admission was also more important to Science females than to Science males. Science females sig more likely to choose 'importance of utility value for university admission' than HumSoc females. Science females were less likely to choose interest-enjoyment and fit with personal beliefs than females who studied HumSoc.
(4) Cleaves (2005) England	7	69 students Year 9 T1 & T2 Year 10, 11	Science	Qualitative: Interviews Longitudinal	Interviews	Participants who had chosen science were grouped according to their trajectory: 'directed' (N=4),	One student from each trajectory except 'funnelling identifier' was selected and a sketch portrait was created. **Directed** – Students had stable career ideas over 3 years, which lead directly to their choices

						‘partially resolved (N=6)’ and ‘precipitating’ (N=8). ‘funnelling identifier’ (N=2) ‘multiple projection’ (N=1)	**Partially resolved** – Students’ choices were traditional science and maths combinations, which could have led to a career in science, but they tended not to have decided upon a specific career in science by the end of year 11 and had usually selected maths to improve career prospects. Physics and maths were considered to be intellectually demanding, strong and versatile subjects and not, at that stage, because the student wanted specifically to pursue a career as a mathematician or a scientist. **Funnelling identifier** – Lack of confidence in her ability to pursue science further which contributes to decisions. **Precipitating** - Students used their own experiences to put together a broad combination of subjects, of which science was a component.
(5) Crombie, Sinclair, Silverthorn, Byrne, DuBois & Trinneer (2005) Canada	11	540 pupils Grade 9: 14 years old	Maths	Quantitative: Survey	Competence beliefs Perceptions of the usefulness of maths and the intrinsic value of maths (Parsons et al., 1980) Maths performance: measured by the students’ final	Utility value Intrinsic value Competence beliefs Prior attainment	For all students, there was a significant indirect effect of prior grades on enrolment intention. For males, there was also a direct effect. For females, there was a significant direct path from competence beliefs on enrolment intention, not observed for males The path from utility value to enrolment intentions was smaller in magnitude for females than for males.

					maths grades in each of the two years of study		
(6) Davies, Davies & Qiu (2017) England	13	5,593 students Year 11	Science and maths	Quantitative Experimental, between subjects design. Intervention (one hour lesson on a) graduate wages or b) advice on Russell Group university requirements)	Students' characteristics and motivations towards choice of subject National Pupil Database to assess actual subject choice		Students in Lesson A (graduate salaries) were more likely to take maths (52% vs. 42%) and chemistry (33% vs. 25%) than those in Lesson B. Students in Lesson A were 48% more likely to take maths, 43% more likely to choose chemistry and 36% more likely to choose physics, but were 35% less likely to choose computing.
(7) DeWitt, Archer & Moot (2019) England	7	Over 13,000 students Year 11; 24 interviewees	Physics (and biology & chemistry)	Mixed methods Longitudinal Survey Interviews	Data from ASPIRES project	Aspirations (in science and generally) Subject preferences Attitudes towards school science Self-concept in science Images of scientists Participation in science-related activities outside school Parental expectations Parental school involvement Parental attitudes towards science	35.8% of males were planning to study physics but only 14.2% of females. Higher proportion of Asian and Middle Eastern students intended to study physics than White and Black students. More likely to study physics if higher cultural capital (parental education) Most popular reason chosen for subject choice (science+p and science-p): 'how useful the subject is for my future job or career', followed by enjoyment and to help me get into university. This was also true of interview data.

						Peer attitudes towards school Peer attitudes towards school science	Science+p students were significantly more likely to report enjoyment and less likely to report usefulness as their main justification. 12/13 science+p interviewees reported aspirations linked to their choice (e.g. wanting a career in engineering or physics). Science-p reported that physics is not required for their intended careers. Interviews: science-p viewed physics as abstract, but science+p found abstractness appealing
(8) Giannakos (2014) Greece	6	126 students age 14 (71 attended 3rd of gymnasium) or age 17 (55 attended 3rd of Lyceum)	Computer science	Quantitative Survey	Performance expectancy Satisfaction Self-efficacy Social influence Perceived behavioural control Intention to study		Intention to study computer science was significantly related to: performance expectancy, satisfaction, social influence and perceived behavioural control. Students with low perceived behavioural control who were attending ICT courses had the same intention to study computer science than students with medium PBC who were attending the Programming course.
(9) Gill & Bell (2013) United Kingdom	10	231,982 students All had taken at least one A Level Age 17 at start of academic year	Physics	Quantitative Data held on the National Pupil Database	Data held on the National Pupil Database:	Gender School type (at KS4 and KS5) School 'gender' GCSE science taken Ethnicity GCSE science best grade GCSE maths best grade	Males more likely to have taken physics at A Level than females. Prior attainment increased the probability of taking physics (the effect was greater for females than males). Best GCSE grade in a science subject = more likely to take physics. The effect of having their best grade in science was greater for females than males. This was also true of maths being best grade.

		133,537 ethnicity/neighbourhood data					A higher percentage of students at grammar & independent schools took physics than those at comprehensive schools. Male students were more likely to take physics if they were at comprehensive schools (than independent, FE college or sixth form), while female students were more likely at independent and grammar schools. Students who took physics as a separate science GCSE more likely to take physics at A Level than those taking other science at GCSE. Effect greater for females than males. Male students in entirely mixed schools = more likely to take physics than those in entirely single sex schools. Female students in entirely single sex schools = more likely to take physics than those in entirely mixed schools (7.7% of females in female-only schools with a female-only sixth form took physics, which compares to only 3.6% of females in the population) Female students' probability of taking physics was higher in a school with higher ability pupils. Male students' probability was lower in a school of higher ability students. Chinese and 'other Asian' students more likely than White British students to take physics, while Bangladeshi, Caribbean, Irish, White & Black African and White & Black Caribbean students were less likely.
(10) James (2007)	9	Four schools, students who had chosen	Group 4: Chemistry, biology, physics,	Mixed methods	Rating scale (3-point scales) for given factors for		Factors ranked from most chosen on survey (Higher level and standard level): 1. Interest 2. Ability

Finland and Portugal		Group 4 subjects at Post-16 International Baccalaureate Diploma Programme (82 Survey responses, 35 interviews)	design technology, computer science	Initial survey Semi-structured interviews	choosing Group 4 subjects		3. University course requirement 4. Job requirement 5. Challenge 6. Teaching quality 7. Potential for well-paid job 8. Ease 9. Father 10. Media image 11. Advisor 12. Mother 13. Family member 14. Sibling 15. Friends' choices 16. Friends' opinions Factors ranked by frequency from Interviews (stated 9+ times): 1. University course requirement 2. Interest 3. Career requirement 4. Enjoyment 5. Keeps doors/options open 6. Ability 7. It explains what happens, how things work
(11) Jeffries, Curtis & Conner (2019) Australia	13	7442 students Year 12 (age 16)	STEM (science, technology, engineering and maths)	Quantitative Telephone survey & secondary data	Programme for International Student Assessment (PISA) and Longitudinal Surveys of Australian Youth (LSAY) data	Personal value of science Enjoyment of science Self-concept in science Achievement in science Achievement in maths Achievement in science and maths STEM subject choice	More likely to enrol on STEM course if: Male From first- and second-generation migrant families Higher personal value of science Greater enjoyment of science Higher self-concept Higher achievement in science and maths

							Indirect effect of gender mediated by attitudes (personal value, enjoyment and self-concept) towards science and achievement in science and maths was significant. Indirect effect of immigrant status mediated by personal value and enjoyment of science and achievement in science and maths was significant. The influence of attitudes on STEM enrolment was mediated by achievement. The indirect effect of self-concept in science mediated by achievement in science and maths was significant.
(12) Korpershoek, Kuper, van der Werf & Bosker (2010) The Netherlands	8	3992 students 9th grade (pre-university education)	Science profile	Quantitative Survey	Study profile (Statistics Netherlands) Five-Factor Personality Inventory (FFPI; Hendricks et al., (1999) Maths ability	Extraversion Agreeableness Conscientiousness Emotional stability Autonomy	Science profile students had lower scores on Extraversion and Agreeableness than other students Science profile students had higher scores on Emotional stability than other students Science profile students had (on average) higher scores on Conscientiousness than other students Science profile males have significantly lower scores on Autonomy than science profile females
(13) Korpershoek, Kuper & Van der Werf (2012) The Netherlands	11	1740 students 9th grade (pre-university education)	Science profile	Quantitative Survey	Students' study profiles (Statistics Netherlands) Five-Factor Personality Inventory (FFPI; Hendricks et al., (1999)	Extraversion Agreeableness Conscientiousness Emotional stability Autonomy	Extraversion was negatively related to students' choice of science profile Extraversion partially mediated the relation between gender and students' choices of science profile Autonomous females opted for the science profile more often than less autonomous females

					Maths assessment at 7th grade (Cito) Maths assessment 9th grade (Cito), The Groningen Intelligence Test for Secondary Education		
(14) Master, Cheryan & Meltzoff (2016) USA	13	E1: 165 students, 14-17 years E2: 104, 14-21 years old	Computing	Quantitative Experimental, between-subjects Survey	E1: Two images images of a computer science classroom Attention checks Enrolment interest Belonging Negative stereotype concerns Fit with stereotypes E2: Two images of a computer science classroom Attention checks Enrolment interest Belonging Expectations of success Utility value	Belonging Stereotypes	Experiment 1: Females were significantly more interested in the course in the non-stereotypical classroom compared with the stereotypical classroom. There was no significant difference in interest between the different classrooms for males. Females who reported greater fit with computer science stereotypes reported significantly more enrolment interest in the premeasure and the stereotypical classroom than females who had lower fit with stereotypes. Females who reported greater fit with stereotypes reported significantly higher belonging in the premeasure than females who reported lower fit with the stereotypes. Females' lower interest in the course with the stereotypical classroom than males was mediated by their sense of belonging. Experiment 2: Females were significantly less interested than males when the course was in the stereotypical classroom but this gender difference was smaller in the non-stereotypical classroom.

							Females' lower interest in the course with the stereotypical classroom than males was mediated by their sense of belonging. Belonging predicted interest in computer science even after controlling for females' expectations of success and the value they placed on computer science.
(15) Mendolia & Walker (2014) England	9	Around 5500 students Followed from Y9 – post-16 Year 9 (interview) GCSE data, A Level choice data	Maths and Science	Mixed methods Survey and interview Longitudinal	Longitudinal Study of Young People in England measures (locus of control, work ethics, self-esteem) Interview	Locus of control Self-esteem Work ethic	Individuals with external locus of control and low self-esteem are significantly less likely to choose to study maths or science at A Level. Individuals with high work ethics are significantly more likely to choose science at A Level.
(16) Mujtaba & Reiss (2013a) England	10	5034 Students Year 10	Physics	Quantitative Survey	UPMAP survey, using items rather than constructs	Students' perceptions of: Physics teachers Physics lessons Physics as a subject	Strongest associations between items and intended participation in physics post-16: Perceptions of teachers: My teacher thinks I should study physics after the age of 16. My physics teacher is good at explaining physics. I like my physics teacher . My physics teacher is interested in me as a person. Perceptions of physics lessons: I look forward to physics classes. I enjoy my physics lessons. I can see the relevance of physics lessons.

							Perception of physics: I think physics will help me in the job I want to do in the future (gender effect) I think physics is an interesting subject (gender effect) I think physics is a useful subject (gender effect)
(17) Mujtaba & Reiss (2013b) United Kingdom	10	5,642 year 10 students predicted to get A∗ –D in GCSE maths and physics/science Four groups: Males/ females who intend to study physics and males/females who do not intend to study physics	Physics	Quantitative Survey	UMAP survey	Views on physics lessons Physics self-concept Conceptual ability Confidence in conceptual tasks Motivation and value of learning Support, advice and learning Students' perceptions of their physics teacher, their parents and their schools	Physics intention = more positive perceptions of lessons, higher levels of physics extrinsic social gain motivation, higher extrinsic material gain motivation (EMGM), receive more advice and pressure to study physics, more social support for physics learning, held more positive perceptions of their teachers, higher sense of school belonging. Females physics intention = levels of confidence in conceptual tasks at similar levels to males who did not intend to participate, despite statistically higher conceptual task scores. They also had similar levels of sense of school belonging to males who intended to participate. Females who intended to participate had the highest access to social support for physics learning. Significant differences between males and females who intend to study physics: Males had more positive perceptions of lessons, a more positive emotional response towards lessons, higher physics self-concept, higher confidence in conceptual tasks, higher levels of intrinsic value of physics, advice and pressure to study physics, home support for achievement in physics, higher emotional stability levels. There was no

							significant difference in EMGM between males/females who intended to participate.
(18) Mujtaba & Reiss (2014) England	9	5034 students Year 10 (on track to achieving A*-D in GCSE maths and physics/science)	Physics	Quantitative Survey	UPMAP survey National Pupil Database and Student Level Annual School Census data	Home support for achievement in physics Perceptions of physics teachers Emotional response to physics lessons Perceptions of physics lessons Physics self-concept Advice-pressure to study physics Social support in physics learning Intrinsic value Extrinsic material gain motivation Competitiveness Self-direction Emotional stability Extroversion	Advice-pressure to study (teachers), home support for achievement in physics, student intrinsic value, extrinsic material gain motivation, physics self-concept related to intention to study Largest effect size: extrinsic material gain motivation Extroversion associated with lower levels of intended participation Students of Black heritage less likely to intend to study physics Females less likely to express intentions to study than males
(19) Mujtaba & Reiss (2016) England	9	Quantitative: High/low aspiring students: 4,762 physics 5,119 maths T1: Year 8 T2: Year 10 Grouped into high-aspiring	Maths and physics	Mixed methods: Survey and interview Longitudinal	Constructs that measured students' encouragement for continuing subjects Semi- structured interviews with two high-aspiring	Advice-pressure to study physics Extrinsic material gain motivation Intrinsic perceived value of physics/maths Physics/maths self-concept Perceptions of physics/maths lessons	Self-concept: **Maths** HA females had a lower self-concept at T1 & T2. At T1, HA females had higher than LA males but at T2 there was no sig difference. Statistically sig increase in self-concept of LA males from T1 to T2 **Physics** HA females had a lower self-concept than HA males at T1 & T2. HA females higher than LA males & females at T1, no sig difference between HA females and LA males at T2. *The*

		(HA) and LA (LA) at T1 Qualitative: 2 female participants (age 15, 16, 17)			and high-attaining girls (one interview with each female in Years 10, 11, and 12).	Emotional response to physics/maths lessons Home support for achievement in physics/maths Extrinsic social gain motivation Perceptions of physics/maths teachers	*student interviews demonstrated how females could doubt their own ability despite being high achievers* Extrinsic material gain motivation (EMGM): **Maths** HA females had a lower EMGM than HA males at T1 & T2. HA females higher EMGM than LA males and females at T1 & T2. **Physics** HA females higher levels of EMGM than LA males & females. At T2, there was no sig difference between level of physics EMGM HA females and LA males Social gain motivation (SGM): **Maths** HA females reported lower maths SGM than HA males at T1 but this difference had disappeared by T2. Female HA had higher maths SGM than LA males and females **Physics** At T1 & T2, HA females had similar levels of physics EMGM than HA males. At T1, HA females higher than LA males, by T2 this difference had disappeared Intrinsic value (IV): **Maths** HA males had higher maths IV than HA females at T1 & T2. HA females higher maths IV than LA males and females at both time points. **Physics** HA males had higher physics IV than HA females at both time points. At T1, HA females had higher physics IV than LA males, by T2 this sig difference had disappeared Perceptions of maths and physics lessons: **Maths** HA females reported less positive perceptions of maths lessons than HA males at

							T1 & T2. HA more pos than LA males & females at T1 & T2. **Physics** At T1, HA females reported sig more positive perceptions of physics lessons that LA males and females. At T2, no sig difference between HA females and LA males Emotional responses to lessons: **Maths** HA females less pos emotional response to maths lessons than HA males at T1 & T2. HA females more pos than LA males and females at T1. **Physics** At T1 HA females no sig difference in physics lessons to HA males, by T2 sig differences. HA females more pos emotional responses than LA males and females at T1. At T2 HA females reported similar levels as LA males Perceptions of teachers **Maths** At T1 & T2: HA males and females similar levels about maths teacher. HA females more positive perceptions than LA males and females. **Physics** At T1 and T2 HA males and females reported similar levels about physics teacher. At T1 HA females more pos perceptions of physics teacher than LA males and females. At T2, there was no diff between HA females and LA males Advice/pressure to study: **Maths** At T1 and T2 HA females reported receiving less advice/pressure to study maths than HA males. At T1 and T2 HA females received more advice/pressure maths than LA males/females.

							Physics T1 HA males and females received same level of advice/pressure, T2 HA females reported less than HA males. At T1 HA females more advice/pressure than LA males; no sig difference at T2 Home support: **Maths** HA females reported less home support than HA males at T1 & T2. At T1 HA females reported more home support than LA students. By T2 HA females reported similar levels to , LA males. **Physics** HA females reported less home support than HA males at T1 & T2. At T1 HA females reported more home support than LA students. By T2 HA females reported similar levels to , LA males.
(20) Nagy, Trautwein, Baumert, Köller & Garrett (2006) Germany	10	1148 students Grade 10 and 12	Maths and Biology	Quantitative: Survey Longitudinal	Maths achievement scores (taken from studies carried out by International Association for the Evaluation of Educational Achievement (IEA) and from an investigation carried out at the Max Planck Institute for Human Development)	Self-concept (maths and biology) Intrinsic value Achievement	Males were more likely than females to report maths intentions. Females were significantly more likely to report biology intentions. Maths achievement predicted choice of maths. Subject-specific self-concepts and intrinsic values were positively correlated with course enrolment in the same domain, but negatively related to course enrolment in the other domain. Intrinsic value impacted upon course enrolment, above and beyond the impact of self-concept. The effect of maths achievement on the choice of an advanced biology course was not significant for females, but was substantial for males.

					Biology achievement scores Domain-specific self-concepts of ability Intrinsic value of maths and biology Course level in maths and biology		A high maths self-concept discouraged both males and females from opting for an advanced biology course, but the effect was stronger for males. Biology self-concept had stronger impact on the choice of an advanced biology course for females than for males.
(21) Nashon & Nielsen (2007) Canada	6	43 students (36 chemistry/biology, 7 physics) Interviewed: 23 students (10 chemistry/biology, 3 physics)	Physics	Qualitative Interview and questionnaire		Students' competence in maths Characteristics of physics teachers Perceived difficulty of physics Students' prior experience of physics Students' comprehension and communication skills Students' self-perceptions as problem-solvers	One student acknowledged that enthusiastic teachers inspired her to take more science courses, including physics. Another believed that he had a deep understanding of physics concepts, in addition to real-world experience that was successfully conveyed to the students. Students who took physics, frequently saw themselves as problem solvers.
(22) Pike & Dunne (2011) England	4	Four colleges (1 FE college, 2 sixth form, 1 11-18) 49 students (individual interviews)	Science	Qualitative Semi-structured interviews	Individual student, focus group and staff. Discourse analysis.	Themes - Pedagogical experiences - Discourses of differentiation between different subjects - Future aspirations	Students showed extreme feelings of identification with or alienation from the subject. Students who identified strongly with science appreciated its visible epistemology that presented them with 'hard facts'.

		3 staff (individual) 27 students (focus groups)					It is those in higher achieving science groups – develop positive identities in science (all those who chose science had been in top-sets) Those who chose science were comfortable with the 'separate' knowledge received from subjects with strong classification, faming and visible epistemology. Career aspirations featured highly in interviews with those who chose science.
(23) Sheldrake (2016) England	10	1523 students Years 9 - 11	Science	Quantitative Survey	Trends in International Mathematics and Science Study (TIMSS) 2011 (ability assessment) Task-level confidence Science study intention	Science confidence (self-concept and self-efficacy), Potential influences on confidence (mastery experiences/norms, peer-comparisons etc), Potential influences of intentions (interest/intrinsic value, utility/extrinsic value) Wider factors (influences from others, perceived control etc.), Background characteristics	The largest predictors of students' science intentions were: Students' perceived utility of science Personal value of science Self-efficacy Subjective norms/influences with parents Interest in science
(24) Sheldrake, Mujtaba & Reiss (2014) England	12	2490 students T1: Year 8 T2: Year 10	Maths	Quantitative: Survey Longitudinal	UPMAP survey data and ability tasks - Calibration bias of ability - Students' skills in algebra and interpreting graphs	- Maths academic subject-specific self-concept - Subject-specific intrinsic and extrinsic motivational beliefs - Students' emotional responses to maths - Perceptions of maths lessons - Perceptions of maths teachers	Reported intentions to study maths did not differ across the task calibration groups at T1. At T2, students in the accurate group were more inclined to study maths further compared with under-confident and over-confident students. The differences between the groups were greater for males than females.

					(Kuchemann, 2008; OECD, 2009). - Students' confidence in their answers - Calibration measures (Pajares and Graham, 1999)	- Advice or pressure to study maths - Home support for maths achievement - Competitiveness - Extroversion - Internality (locus of control)	
(25) Sheldrake, Mujtaba & Reiss (2015) England	12	1085 students T1: Year 10 T2: Year 12	Maths	Quantitative: Survey Longitudinal	UPMAP survey data and ability tasks - Students' skills in algebra and interpreting graphs (Kuchemann, 2008; OECD, 2009). - Students' confidence in their answers - Key Stage 3 (KS3) scores and GCSE grades were provided by the Department for Education	- Self-concept - Maths intrinsic motivation - Maths extrinsic motivation - Perceptions of maths lessons - Emotional responses to maths - Perceptions of maths teachers - Advice or pressure to study maths - Home support for maths achievement	At T1, the reported advice or pressure to study maths, self-concept and extrinsic motivation associated with maths had the largest relative influences on students' reported intentions at Year 10 to study maths into Year 12. Self-concept, advice or pressure and the students' emotional response to doing maths were the significant influences with the largest changes in odds of the students studying maths in Year 12. Under-confidence of self-beliefs of ability was associated with higher intentions to study maths
(26) Sheldrake, Mujtaba & Reiss (2019) England	11	2258 students T1: Year 8 T2: Year 10	Physics	Quantitative Survey Longitudinal	Self-concept beliefs Interest value Utility value Perceived advice		T1: Ethnicity (significantly more likely to intend to take physics if South Asian/Indian than White and being South East Asian/Chinese than White), gender (more likely if male)

					Guidance and/or suggestions from others Perceived home support for physics Intentions to study physics Socio-economic statuses		The expectancy-value and planned-behaviour factors mediated ethnicity difference T2: Ethnicity (significantly more likely to intend to take physics if South Asian/Indian than White), gender (more likely if male) From T1 to T2, 22% of the sample moved into a cluster with more-positive attitudes, beliefs and intentions to study, 61.6% remained in the same cluster and 16.4% moved into a less positive cluster. More males than females remained within cluster A (most likely to choose physics) in the three-cluster, four-cluster and five-cluster models. Those with slightly higher prior attainment were more likely to remain in cluster A for the three-cluster and four-cluster models.
(27) Smyth & Hannan (2006) Ireland	6	3,948 students Lower secondary (age 12-16) and upper secondary (16-18 years)	Science	Quantitative Survey	Science take-up, Data on pupil background (gender, social background, parental education), Ability test score Likert scales on take-up of subjects and levels, attitudes to school, perceptions of school	Parental education, ability level, grouping of class, timing of lessons/subject choice, relationships with teachers, student attitudes (science/maths useful, interesting, difficult), academic self-image, gender role expectations, occupational orientations	**Lower secondary:** Perceived utility of science = more likely to study biology. Perceived utility of maths = more likely to study physics. Students in streamed schools more likely to take physics. Earlier subject choice = boys more likely to take physics. Females in top/bottom classes in streamed schools less likely to take biology. Students with higher academic self-image more likely to take Chemistry. Females more likely to take physics if teacher interactions are positive; males less likely.

					climate and interaction with teachers, pupil stress levels and other aspects of personal/social development		Females with less traditional gender role expectations (GRE) are more likely to take Chemistry. Males with less traditional GRE less likely to take Chemistry. Females with scientific occupation orientation less likely to take physics. Males with scientific occupation orientation more likely. Males who take vocational subjects (e.g. metalwork, woodwork, mech. drawing) are less likely to take Biology, females are more likely to take physics. **Upper secondary:** Males more likely to take Chemistry when there is a clash with another subject; females less likely. Females more likely to take Chemistry when physics is provided as a separate subject. Female students who take any science subject tend to be a higher ability and from professional backgrounds. Males taking Physics and Biology tend to be from a range of different ability levels and backgrounds.
(28) Stokking (2000) The Netherlands	8	159 students (pre-university) Two cohorts: Second-third grade (13-14 years old) and third-fourth	Physics	Quantitative: Survey Rating textbooks Longitudinal (Four time points)	Survey (Jorg et al, 1990)	**Textbook level** - the textbook in use - the characteristics of the physics textbook used (scale scores, based on expert evaluations) **Class level** - percentage of female students within class	Females less often intended to choose physics and less often chose physics. Students choosing physics scored significantly higher than those not choosing physics on: interest, future relevance, appreciation, clarity, self-confidence and marks for maths and physics. Students choosing physics scored lower on difficulty.

		grade (14-15 years old)				- percentage of students within class intending to choose physics, and choosing physics **Student level** - social background (professional and educational background of father and mother) - gender - physics attainment - advice on choice obtained from teacher and/or counselor - intended choice (5-point scale) and actual choice of physics (no/yes) - motive(s) influencing the choice (open question) - Survey: - interest in topics related to physics - attributed future relevance of physics - experienced difficulty of physics - appreciation of physics lessons - self-confidence with regard to physics - the extent to which male and female students (in general) are perceived to differ	The extent to which the subject material brought forward the practical value of physics was higher for students choosing physics than for those who did not (the latter apparently perceived this to a lesser extent). Students choosing physics more often received advice to choose physics. Interest, appreciation and self-confidence decreased for students not choosing physics whereas they did not for those choosing physics. Clarity and future relevance decreased for students not choosing physics whereas they increased for those choosing physics. Key predictors for physics subject choice: future relevance, appreciation, self-confidence and interest.

						in interest, affinity, and effort with regard to physics	
(29) Taylor (2015) United Kingdom	6	555 students (higher-tier GCSE science students) Year 11	Physics	Quantitative Survey	Direct measures: Attitude Behavioural intention Perceived behavioural control Subjective norm Indirect measures: Behavioural beliefs Normative beliefs Control beliefs		Significant correlations between physics intention and all theory of planned behaviour variables - attitude and subjective norm (perceptions of social pressure from significant others) = highest correlations Expectations of parents was most strongly related to students' intentions to study physics Students with higher intentions to study physics believed that studying physics would open up more opportunities for them in the future, help them get a better job and help them get a place on their chosen degree course
(30) Van Langen, Rekers-Mombarg & Dekkers (2006a) The Netherlands	9	2,286 students: 1,299 students (senior general secondary education) 987 students (pre-university education); at final examinations - age 17/18 years old	Maths and science	Quantitative Database information, assessments, survey (1st and 3rd years)	Data VOCL'93 1st and 3rd grade: Dutch language assessment Maths assessment, Pupil, parent, school directorate Survey 1st grade only: Non-verbal intelligence assessment	Sex, ethnicity, parental level of education Capabilities/achievement: nonverbal IQ score, math score, Dutch language score, enjoyment of maths and Dutch language, aspired final level of education, self-image, achievement motivation, level of education and number of years employment experience of mother, number of parents, position in family, number of books at home, sex-role opinions & child-rearing style of parents, frequency of parent-child school talk,	Females with an extrinsic motive chose more STEM than those with an intrinsic motive. Males with an extrinsic motive chose fewer STEM than males with an intrinsic motive. **Senior general secondary education:** More likely to choose STEM if they have high educated parents **Pre-university education:** BME females choose more STEM subjects if parents low education. Parental level of aspiration – more likely to take STEM Degree of urbanisation of school – less likely Females where grading committee involved – less likely to take STEM.

						parental aspirations of final educational level of child, size of school, minimum requirements for subject take-up, guidance offered, involvement of teachers/grading committee, emphasis on grades, importance that the school puts on subjects	
(31) Van Langen, Rekers-Mombarg & Dekkers (2006b) The Netherlands	9	987 students (pre-university education), age 17/18	As above	Quantitative As above	As above	As above	**Pre-university education:** Parental level of aspiration – more likely to take STEM Females with extrinsic choice motives more likely to choose science and maths subjects than females with intrinsic choice motives Path analyses: Females - parental aspirations mediates parental level of education on subject choice

The University of Manchester

Appendix D Example of quality assessment

D.Ed.Ch.Psychol. 2017

Review framework for quantitative investigation research

Author(s): Master, Cheryan & Meltzoff (2016)

Title: Computing Whether She Belongs: Stereotypes Undermine Girls' Interest and Sense of Belonging in Computer Science

Criterion	Score	R1	R2	Final	Comment
Data gathering					
Clear research question or hypothesis *e.g. well-defined, measureable constituent elements*	**1 0**	1	1	1	
Appropriate participant sampling *e.g. fit to research question, representativeness.*	**1 0**	1	1	1	No mention of generalisability No mention of how schools were approached Correct age, gender split fairly equal
Appropriate measurement instrumentation. *e.g. sensitivity; specificity*	**1 0**	1	1	1	Pilot study to select objects incorporated into pictures of classrooms Methodology had been used before. Although some scales had very few items – which actually the authors mention as a limitation
Comprehensive data gathering *e.g. multiple measures used; context of measurement recorded (e.g. when at school vs at home)*	**1 0**	1	1	1	Carried out at school Multiple measures used
Appropriate data gathering method used *e.g. soundness of administration*	**1 0**	0	1	1	Does not state whether researcher/s attended Does not report on set-up of environment, computer set-up etc There was no detail about how data was collected – so difficult to say how sound. But given they had an extensive limitation section and

					no wonders were raised re data collection I would be tempted to give the point.
Reduction of bias within participant recruitment/ instrumentation/ administration *e.g. harder-to-reach facilitation; accessibility of instrumentation*	**1 0**	0	0	0	
Response rate/ completion maximised *e.g. response rate specified; piloting; access options*	**1 0**	1	1	1	Opt-out for maximum participation Response rate noted (~ 85%)
Population subgroup data collected *e.g. participant gender; age; location*	**1 0**	1	1	1	Gender, age, ethnicity
Data analysis					
Missing data analysis *e.g. Level and treatment specified*	**1 0**	1	1	1	Some data excluded – 'The pattern of results remained the same if these students were included'
Time trends identified *e.g. year on year changes*	**1 0**	0	0	0	
Geographic considerations *e.g. regional or subgroup analyses*	**1 0**	0	0	0	
Appropriate statistical analyses (descriptive or inferential) *e.g. coherent approach specified; sample size justification.*	**1 0**	1	1	1	
Multi-level or inter-group analyses present *e.g. comparison between participant groups by <u>relevant</u> location or characteristics*	**1 0**	1	1	1	Gender – stereotypical/non-stereotypical image - intentions
Data interpretation					
Clear criteria for rating of findings *e.g. benchmarked/ justified evaluation of found quantitative facts*	**1 0**	1	1	1	Effect size reported in discussion for main result, controlling other variables

Limitations of the research considered in relation to initial aims *e.g. critique of method; generalizability estimate*	**1 0**	1	1	1	Done in some detail
Implications of findings linked to rationale of research question *e.g. implications for theory, practice or future research*	**1 0**	1	1	1	
Total	*Max 15*	12	13	13	

References

Choi, B.C.K. (1998). Perspectives on epidemiological surveillance in the 21st century. *Chronic Diseases in Canada, 19*(4), 145-151.

Cohen, L. , Manion, L., & Morrison, K. (2007) *Research Methods in Education (6th edition).* London: Routledge.

Geneady, A.M., Lemasters, G.K., Lockey, J., Succop, P., Deddens, J., Sobeih, T., & Dunning, K. (2007). An epidemiological appraisal instrument – a tool for evaluation of epidemiological studies. *Ergonomics, 50*(6), 920-960.

Wallace, M. & Wray, A. (2011). *Critical Reading and Writing for Postgraduates (2nd edition)*. London: Sage Publications.

Appendix E Assessing differences between participants' enrolment interest, belonging and stereotype threat pre- and post-measure

A paired samples t-test was used to assess whether there were any significant differences between pre- and post-measures in all participants. There was no significant difference in enrolment interest from pre- to post-measure ($t(167)=.47$ $p= .634$). There was no significant difference in belonging from pre- to post-measure ($t(167)= .72$, $p= .472$). There was a significant difference in stereotype threat from pre- to post-measure, with participants expressing lower stereotype threat at post-measure ($t(167)= 2.72$, $p= .007$).

	Enrolment interest		Belonging		Stereotype threat	
	M	SD	M	SD	M	SD
Pre-measure	2.42	1.51	2.67	1.32	2.26	1.50
Post-measure	2.38	1.50	2.62	1.33	2.07	1.40

Appendix F Assessing differences between participants’ enrolment interest, belonging and stereotype threat pre- and post-measure, by image condition

A paired samples t-test was used to assess whether there were any significant differences between pre- and post-measures. Data was split by image condition. For the participants in the stereotypical condition, there was no significant difference in enrolment interest from pre- to post-measure ($t(85)= .67$ $p= .505$). There was no significant difference in belonging from pre- to post-measure ($t(85)= .92$, $p= .361$). There was a significant difference in stereotype threat from pre- to post-measure, with participants expressing lower stereotype threat at post-measure ($t(85)= 2.11$, $p= .037$).For the participants in the non-stereotypical condition, there was no significant difference in enrolment interest from pre- to post-measure ($t(81)= -.06$, $p= .955$). There was no significant difference in belonging from pre- to post-measure ($t(81)= -.09$, $p= .931$). There was a significant difference in stereotype threat from pre- to post-measure, with participants expressing lower stereotype threat at post-measure ($t(81)= 1.71$, $p= .090$).

Image condition		Enrolment interest		Belonging		Stereotype threat	
		M	SD	M	SD	M	SD
Stereotypical	Pre-measure	2.52	1.57	2.76	1.35	2.31	1.60
	Post-measure	2.44	1.59	2.67	1.30	2.08	1.36
Non-stereotypical	Pre-measure	2.32	1.43	2.56	1.28	2.20	1.41
	Post-measure	2.33	1.41	2.57	1.36	2.06	1.44

Appendix G Ethics committee approval

Approved by Faculty Ethics Committee - ERGO II 47320.A3

UNIVERSITY OF Southampton

ERGO II – Ethics and Research Governance Online https://www.ergo2.soton.ac.uk

Submission ID: 47320.A3
Submission Title: Exploring whether cues in the environment affect young people's interest in taking computer science at A Level (Amendment 3)
Submitter Name: Eleanor Beck

Your submission has now been approved by the Faculty Ethics Committee. You can begin your research unless you are still awaiting any other reviews or conditions of your approval.

Comments:

-

Appendix H School information sheet

Study Title: **Exploring whether cues in the environment affect young people's interest in taking computer science at A Level.**

Researcher: Eleanor Beck

ERGO number: 47320

About this research

I hope to recruit participants from your school to contribute to a research project exploring whether the environment of a computer science classroom affects young people's interest in choosing computer science to study at A Level and why computer science generally appeals more to boys than to girls. I intend to build upon a previous study that found that environmental cues (stereotypical 'computer science' objects in a classroom) reduce feelings of belonging and therefore interest in taking computer science, the effect of which was seen more strongly in females. Both men and women can express themselves in more feminine and/or masculine ways and can possess more feminine or masculine interests. Therefore, as well as asking participants about their gender using male, female, other (with text box for optional written response) and prefer not to say categories, I will also explore gender using two separate scales: masculinity and femininity. I will explore gender in this way to see whether students' masculinity or femininity influences their interest in taking computer science at A Level after viewing a particular image of a classroom.

I am a Trainee Educational Psychologist studying for the Doctorate in Educational Psychology at the University of Southampton. This research project will be supervised by Dr Sarah Wright, Programme Director for the Doctorate in Educational Psychology at the University of Southampton and Dr Cora Sargeant, Academic Tutor for the Doctorate in Educational Psychology at the University of Southampton.

Participants

I am looking to recruit around 150+ participants. Participants must be in Years 9 to 11 when they take part in the survey. We hope to begin collecting data in summer term 2019 and the Autumn/Spring terms 2019/20.

Assent/Consent

If you choose to take part, I would provide you with an information sheet to send to parents of eligible pupils to inform them of the purpose of the study. Parents would have the opportunity to opt-out of the research if they do not consent for their child to take part. If parents choose to opt-out on their child's behalf, and their child is aged 13-15, their child will not take part in the research. However, if a young person is 16, they are able to give their full consent to participate in research independently of their parents/ guardians and may wish to participate, despite parental opt-out. We will let the young person know that their parent has opted-out of the research, but they might still choose to take part.

On the day of survey administration, pupils whose parents have not opted-out will be asked to provide assent (ages 13-15) or consent (age 16) to take part. The child may choose to opt-out at this point and so will not take part in the research.

Procedure

The surveys will take place at a time and place appropriate for your school. The researcher (Eleanor Beck) will be available to set-up and be present during survey administration. The survey will be available using a university survey system called 'iSurvey' and can be accessed via an internet link. If you have a computer room or a few laptops and a fairly quiet room available, this would be preferable.

Participants will have access to an individual computer. The survey will take approximately 15 minutes to complete. The lead researcher will be present during survey administration to answer any questions, to ensure that participants are attending to the survey and to support any participant who wishes to stop the survey prior to submission and withdraw their data. All participants will be provided with an information sheet and asked to provide informed assent (if they are 13 – 15 years old) or consent (if they are 16 years old). Once completed, participants will first be asked about their interest in taking computer science at A Level. They will then be asked some questions related to gender. They will be shown some information about a computer science course and asked a few questions about the information. Next, they will be shown an image of a classroom and asked some questions about whether they would want to take this course, how much they would feel that they belong on this course, whether stereotypes would affect them, whether they feel like they would do well on this course and how important the course is to them.

Are there any benefits in our school taking part?

Your participation will help to improve our current understanding on why computer science interests boys more than girls. It will help us to explore the impact of stereotypes in the environment on one's feelings of belonging and subsequent enrolment interest in computer science. The project will be written up with the intention of publication to a journal. Once the project is complete, you will be given a brief summary of the results.

If your school gives permission, we will offer young people entry into a raffle to have the chance to receive a £10 Amazon voucher as a thank you for taking part.

If your school uses outside speakers to talk about academic and career paths, I am also able to offer you my time to come in and speak to pupils about academic and career paths within the field of psychology and my own experiences of this subject.

Are there any risks involved?

Potential risks involved in taking part in the research are small. Some questions will explore gender and related stereotypes as well as feelings of belonging. The participants will be able to take a break during the survey or decide not to continue if they wish (prior to submission, as the data will be stored anonymously). All participants will be fully debriefed and will be given the contact details of the researchers if they have any questions.

What data will be collected?

All answers given will be collected on iSurvey, the university's online survey system. The survey will be anonymous. Personal data shared on consent forms (names) will be kept separate from the iSurvey data. We will need to store school contact details for the duration of the study (until July 2020) so that the researcher can stay in contact with the school. Upon completion of the study, consent forms and iSurvey data will remain stored on University of Southampton servers for 10 years in line with their data policy.

If you think your school will be interested in taking part in this research, or have any further questions, please email Eleanor Beck: eb2g08@soton.ac.uk. Many thanks.

Appendix I Parent information sheet

Study Title: Exploring whether cues in the environment affect young people's interest in taking computer science at A Level.

Researcher: Eleanor Beck
ERGO number: 47320

Your child is being invited to take part in the above research study. Please read the information below.

What is the research about?

I am a Trainee Educational Psychologist studying for the Doctorate in Educational Psychology at the University of Southampton. We want to find out why computer science generally appeals more to boys than to girls by conducting a research project exploring whether the environment of a computer science classroom affects young people's interest in choosing computer science to study at A Level

Both men and women can express themselves in more feminine and/or masculine ways and can possess more feminine or masculine interests. Therefore, as well as asking participants about their gender using male, female, other (with text box for optional written response) and prefer not to say categories, I will also explore gender using two separate scales: masculinity and femininity. I will explore gender in this way to see whether students' masculinity or femininity influences their interest in taking computer science at A Level after viewing a particular image of a classroom. The research will be supervised by Dr Sarah Wright, Programme Director for the Doctorate in Educational Psychology at the University of Southampton and Dr Cora Sargeant, Academic Tutor for the Doctorate in Educational Psychology at the University of Southampton.

Why has my child been asked to participate?

I am inviting your child to participate in this research as they attend secondary school and are in Year 9, 10 or 11. We hope to recruit approximately 150+ participants.

What will happen to my child if they take part?

The questions will be administered on a computer. Your child will be asked to provide informed assent (if your child is 13-15 years old) or consent (if your child is 16 years old) to take part in this study. They will be asked about their interest in taking computer science at A Level. They will be asked some questions related to gender. Then, participants will be shown some information about a hypothetical computer science course and asked a few questions about the information. They will be shown an image of a classroom and asked some questions about whether they would want to take this course, how much they would feel that they belong on this course, whether stereotypes would affect them, whether they would feel like they would do well on this course and how important the course is to them. The survey will take approximately 15 minutes to complete.

Are there any benefits in my child taking part?

Your child's participation in this research project will allow your child to contribute to the wider community. It will help to improve our current understanding of why more boys choose to study computer science than girls. It will also help us to better understand the impact of stereotypes in the environment on one's feelings of belonging and subsequent interest in taking computer science at A Level. We will enter participants into a raffle to have the chance to receive an Amazon voucher worth £10.

Are there any risks involved?

Potential risks involved in taking part in the research are small. Some questions will explore gender and related stereotypes as well as feelings of belonging. Your child will have the contact details of the researchers if they have any questions following the survey. They will be able to take a break or decide not to continue if they wish. A debriefing statement will be made available to all participants.

What data will be collected?

All answers given will be collected on iSurvey, the university's online survey system. The survey will be anonymous but the survey will ask your child to share their age and current year group. Personal data shared on consent forms (names) will be kept separate from the iSurvey data. We will need to store school contact details for the duration of the study (until July 2020) so that the researcher can stay in contact with the school in regards the raffle prizes. Upon completion of the study, consent forms and iSurvey data will remain stored on University of Southampton servers for 10 years in line with their data policy.

Will my child's participation be confidential?

Your child's participation and the information we collect during the course of the research will be kept anonymous and confidential.

Only members of the research team and responsible members of the University of Southampton may be given access to the data for monitoring purposes and/or to carry out an audit of the study to ensure that the research is complying with applicable regulations. Individuals from regulatory authorities (people who check that we are carrying out the study correctly) may require access to the data. All of these people have a duty to keep your child's information, as a research participant, strictly confidential.

All data collected through iSurvey will be handled securely during collection and data analysis, using password protected access. The data collected will be anonymous as there will be no identifiable data linking the iSurvey responses to your child. The personal data shared on consent forms (names) will be kept separate from the iSurvey data. The only individuals with access to this data will be the student researcher and her two supervisors.

What happens if my child changes their mind?

Your child has the right to change their mind and withdraw at any time while completing the survey without giving a reason and without their participant rights being affected. They will be prompted to speak to the lead researcher in the room if they choose to stop and withdraw from the survey. Please note that your child cannot withdraw their data after it has been submitted, as it is anonymous data.

What will happen to the results of the research?

The data we collect will be stored anonymously and we will not have access to any personal details about your child. Research findings made available in any reports or publications will not include information that can directly identify your child. The project will be written up with the intention of publication to a journal. Once the project is complete, a member of school staff will be notified with a brief summary of the results. Your child will not be directly identifiable within the research.

Where can I get more information?

If you have any further questions regarding this research, please email Eleanor Beck: eb2g08@soton.ac.uk.

What happens if there is a problem?

If you have a concern about any aspect of this study, you should speak to the researcher who will do their best to answer your questions. If you remain unhappy or have a complaint about any aspect of this study, please contact the University of Southampton Research Integrity and Governance Manager (023 8059 5058, rgoinfo@soton.ac.uk).

Eleanor Beck – eb2g08@soton.ac.uk
Sarah Wright – s.f.wright@soton.ac.uk
Cora Sargeant – c.c.sargeant@soton.ac.uk

Does my child have to take part?

You can decide whether or not you wish for your child to take part in this research. However, if your child is 16 years old, they are able to give their full consent to participate in research independently of their parents and guardians and may wish to participate, despite parental opt-out. We will let your child know if you do not provide your permission.

If **you give permission for your child to take part**, you do not have to take further action.
If **you do not give permission for your child to take part**, please complete and return the slip on the next page to the school office by: [date]

I **do not** want my child to take part in the study exploring the impact of the environment on interest in taking computer science at A Level.

Please write your name and your child's name below.

Your name __________________________ Your signature __________________________________

Your child's name _______________________________________ School year _________________

-----✂---

Data Protection Privacy Notice

The University of Southampton conducts research to the highest standards of research integrity. As a publicly-funded organisation, the University has to ensure that it is in the public interest when we use personally-identifiable information about people who have agreed to take part in research. This means that when you agree to take part in a research study, we will use information about you in the ways needed, and for the purposes specified, to conduct and complete the research project. Under data protection law, 'Personal data' means any information that relates to and is capable of identifying a living individual. The University's data protection policy governing the use of personal data by the University can be found on its website (https://www.southampton.ac.uk/legalservices/what-we-do/data-protection-and-foi.page).

This Participant Information Sheet tells you what data will be collected for this project and whether this includes any personal data. Please ask the research team if you have any questions or are unclear what data is being collected about you.

Our privacy notice for research participants provides more information on how the University of Southampton collects and uses your personal data when you take part in one of our research projects and can be found at http://www.southampton.ac.uk/assets/sharepoint/intranet/ls/Public/Research%20and%20Integrity%20Privacy%20Notice/Privacy%20Notice%20for%20Research%20Participants.pdf

Any personal data we collect in this study will be used only for the purposes of carrying out our research and will be handled according to the University's policies in line with data protection law. If any personal data is used from which you can be identified directly, it will not be disclosed to anyone else without your consent unless the University of Southampton is required by law to disclose it.

Data protection law requires us to have a valid legal reason ('lawful basis') to process and use your Personal data. The lawful basis for processing personal information in this research study is for the performance of a task carried out in the public interest. Personal data collected for research will not be used for any other purpose.

For the purposes of data protection law, the University of Southampton is the 'Data Controller' for this study, which means that we are responsible for looking after your information and using it properly. The University of Southampton will keep identifiable information about you for 10 years after the study has finished after which time any link between you and your information will be removed.

To safeguard your rights, we will use the minimum personal data necessary to achieve our research study objectives. Your data protection rights – such as to access, change, or transfer such information - may be limited, however, in order for the research output to be reliable and accurate. The University will not do anything with your personal data that you would not reasonably expect.

If you have any questions about how your personal data is used, or wish to exercise any of your rights, please consult the University's data protection webpage (https://www.southampton.ac.uk/legalservices/what-we-do/data-protection-and-foi.page) where you can make a request using our online form. If you need further assistance, please contact the University's Data Protection Officer (data.protection@soton.ac.uk).

Thank you for taking the time to read the information sheet and considering taking part in the research.

Appendix J Participant information sheet

Study Title: Exploring whether cues in the environment affect young people's interest in taking computer science at A Level.

Researcher: Eleanor Beck
ERGO number: 47320

You are being invited to take part in the above research study. To help you decide whether you would like to take part or not, it is important that you understand why the research is being done and what it will involve. Please read the information below carefully and ask questions if anything is not clear or you would like more information before you decide to take part in this research. You may like to discuss it with others but it is up to you to decide whether or not to take part. If you are happy to participate you will be asked to sign a consent form.

What is the research about?

I am a Trainee Educational Psychologist studying for the Doctorate in Educational Psychology at the University of Southampton. We want to find out why computer science generally appeals more to boys than to girls by conducting a research project exploring whether the environment of a computer science classroom affects young people's interest in choosing computer science to study at A Level. Both men and women can express themselves in more feminine and/or masculine ways and can possess more feminine or masculine interests. Therefore, as well as asking participants about their gender using male, female, other (with text box for optional written response) and prefer not to say categories, I will also explore gender using two separate scales: masculinity and femininity. I will explore gender in this way to see whether students' masculinity or femininity influences their interest in taking computer science at A Level after viewing a particular image of a classroom. The research will be supervised by Dr Sarah Wright, Programme Director for the Doctorate in Educational Psychology at the University of Southampton and Dr Cora Sargeant, Academic Tutor for the Doctorate in Educational Psychology at the University of Southampton.

Why have I been asked to participate?

I am inviting you to participate in this research as you attend secondary school and are in Year 9, 10 or 11. I hope to recruit approximately 150+ participants.

What will happen to me if I take part?

The questions will be administered on a computer. You will be asked to provide assent (if you are 13 – 15 years old) or consent (if you are 16 years old) to take part in this study. You will first be asked about your interest in taking computer science at A Level. You will be asked some questions related to gender. You will be shown some information about a computer science course and asked a few questions about the information. You will be shown an image of a classroom and asked some questions about whether you would want to take this course, how much you feel you belong on this course, whether stereotypes would affect you, whether you feel like you'd do well on this course and how important the course is to you. The survey will take approximately 15 minutes to complete.

Are there any benefits in my taking part?

Your participation in this research project will allow you to contribute to the wider community. It will help to improve our current understanding of the impact of cues in the environment on one's feelings of belonging and subsequent interest in taking computer science at A Level. If you wish, we will enter you into a raffle to have the chance to receive an Amazon voucher worth £10 as a thank you for taking part.

Are there any risks involved?

Potential risks involved in taking part in the research are small. Some questions will explore gender and related stereotypes as well as feelings of belonging. You will have the contact details of the researchers if you have any questions following the survey. You will be able to take a break or decide not to continue if you wish. You will receive a debriefing statement.

What data will be collected?

All answers given will be collected on iSurvey, the university's online survey system. The survey will be anonymous but the survey will ask you to share your age and current year group. Personal data shared on the initial assent or consent form (your name) will be kept separate from the iSurvey data. We will need to store school contact details for the duration of the study (until July 2020) so that the researcher can stay in contact with the school in regards the raffle prizes. Upon completion of the study, assent and consent forms and iSurvey data will remain stored on University of Southampton servers for 10 years in line with their data policy.

Will my participation be confidential?

Your participation and the information we collect about you during the course of the research will be anonymous.

Only members of the research team and responsible members of the University of Southampton may be given access to data about you for monitoring purposes and/or to carry out an audit of the study to ensure that the research is complying with applicable regulations. Individuals from regulatory authorities (people who check that we are carrying out the study correctly) may require access to your data. All of these people have a duty to keep your information, as a research participant, strictly confidential.

All data collected through iSurvey will be handled securely during collection and data analysis, using password protected access. The data collected will be anonymous as there will be no identifiable data linking the iSurvey responses to you. The personal data shared on consent forms (your name) will be kept separate from the iSurvey data. The only individuals with access to this data will be the student researcher and her two supervisors.

Do I have to take part?

No, it is entirely up to you to decide whether or not to take part. If you decide you want to take part, you will need to sign an assent form (if you are 13 – 15 years old) or consent form (if you are 16 years old) to show you have agreed to take part.

What happens if I change my mind?

You have the right to change your mind and withdraw at any time while completing the survey (before you finish and submit the survey) without giving a reason and without your participant rights being affected. Please speak to the lead researcher in the room if you choose to stop and withdraw from the survey. Please note that you cannot withdraw your data after it has been submitted, as it is anonymous data.

What will happen to the results of the research?

The data we collect will be stored anonymously and we will not have access to any personal details about you. Research findings made available in any reports or publications will not include information that can directly identify you.

The project will be written up with the intention of publication to a journal. Once the project is complete, a member of school staff will be notified with a brief summary of the results. You will not be directly identifiable within the research.

Where can I get more information?

If you have any further questions regarding this research, please email Eleanor Beck: eb2g08@soton.ac.uk.

What happens if there is a problem?

If you have a concern about any aspect of this study, you should speak to the researchers who will do their best to answer your questions.

If you remain unhappy or have a complaint about any aspect of this study, please contact the University of Southampton Research Integrity and Governance Manager (023 8059 5058, rgoinfo@soton.ac.uk).

Eleanor Beck – eb2g08@soton.ac.uk
Sarah Wright – s.f.wright@soton.ac.uk
Cora Sargeant – c.c.sargeant@soton.ac.uk

Data Protection Privacy Notice

The University of Southampton conducts research to the highest standards of research integrity. As a publicly-funded organisation, the University has to ensure that it is in the public interest when we use personally-identifiable information about people who have agreed to take part in research. This means that when you agree to take part in a research study, we will use information about you in the ways needed, and for the purposes specified, to conduct and complete the research project. Under data protection law, ‘Personal data’ means any information that relates to and is capable of identifying a living individual. The University’s data protection policy governing the use of personal data by the University can be found on its website (https://www.southampton.ac.uk/legalservices/what-we-do/data-protection-and-foi.page).

This Participant Information Sheet tells you what data will be collected for this project and whether this includes any personal data. Please ask the research team if you have any questions or are unclear what data is being collected about you.

Our privacy notice for research participants provides more information on how the University of Southampton collects and uses your personal data when you take part in one of our research projects and can be found at http://www.southampton.ac.uk/assets/sharepoint/intranet/ls/Public/Research%20and%20Integrity%20Privacy%20Notice/Privacy%20Notice%20for%20Research%20Participants.pdf

Any personal data we collect in this study will be used only for the purposes of carrying out our research and will be handled according to the University's policies in line with data protection law. If any personal data is used from which you can be identified directly, it will not be disclosed to anyone else without your consent unless the University of Southampton is required by law to disclose it.

Data protection law requires us to have a valid legal reason ('lawful basis') to process and use your Personal data. The lawful basis for processing personal information in this research study is for the performance of a task carried out in the public interest. Personal data collected for research will not be used for any other purpose.

For the purposes of data protection law, the University of Southampton is the 'Data Controller' for this study, which means that we are responsible for looking after your information and using it properly. The University of Southampton will keep identifiable information about you for 10 years after the study has finished after which time any link between you and your information will be removed.

To safeguard your rights, we will use the minimum personal data necessary to achieve our research study objectives. Your data protection rights – such as to access, change, or transfer such information - may be limited, however, in order for the research output to be reliable and accurate. The University will not do anything with your personal data that you would not reasonably expect.

If you have any questions about how your personal data is used, or wish to exercise any of your rights, please consult the University's data protection webpage (https://www.southampton.ac.uk/legalservices/what-we-do/data-protection-and-foi.page) where you can make a request using our online form. If you need further assistance, please contact the University's Data Protection Officer (data.protection@soton.ac.uk).

Thank you for taking the time to read the information sheet and considering taking part in the research.

Appendix K Children's Sex Role Inventory (short form; Boldizar, 1991)

You will now be asked some questions. Please indicate how true the statement is of you.

	Not true of me at all	A little true of me	Mostly true of me	Very true of me
It's easy for me to fit into new places				
It makes me feel bad when someone else is feeling bad				
I am a kind and caring person				
People like me				
When I play games, I really like to win				
I can control a lot of the kids in my class				
I like acting in front of other people				
I have many friends				
I make a strong impression on most people I meet				
When a decision has to be made, it's easy for me to take a stand				
I am a moody person				
I'm always losing things				
I feel bad when other people have something that I don't have				
I am sure of my abilities				
I am good at taking charge of things				
I am a cheerful person				
I never know what I'm going to do from one minute to the next				

I always do what I say I will do				
It's easy for me to tell people what I think, even when I know they will probably disagree with me				
I care about what happens to others				
I am a gentle person				
I like to do things that girls and women do				
I am a warm person				
I am a leader among my friends				
I am good at sports				
I stand up for what I believe in				
I like to do things that other people do				
When I like someone, I do nice things for them to show them how I feel				
When someone's feelings have been hurt, I try to make them feel better				
I like babies and small children a lot				

Appendix L Enrolment interest measure (Master et al., 2016)

The following questions are about taking a computer science/ ICT course at A Level.

	Not at all						Extremely
	1	2	3	4	5	6	7
How much do you want to take this course at A Level?							
How likely are you to choose this course?							

Appendix M Belonging measure (Master et al., 2016)

	Not at all						Extremely
	1	2	3	4	5	6	7
How similar are you to students who take this course at A Level?							
How much do you think you belong on this course?							
How well would you fit into the general environment of this course?							
How well would you fit in with the students on this course?							

Appendix N Stereotype threat measure (Master et al., 2016)

	Not at all						Extremely
	1	2	3	4	5	6	7
How much would you worry that your ability to do well in this class would be affected by your gender?							
If you took this class, how anxious would you be about confirming a negative stereotype about your gender?							
If you took this class, how much would you worry that people would draw conclusions about **your gender** based on your performance?							
If you took this class, how much would you worry that people would draw conclusions about **you**, based on what they think about your gender?							

Appendix O Attention check questions (Master et al., 2016)

Please read the descriptions on this page carefully, because you will be asked about them later.

There are two classrooms that are being used to teach computer science at A Level (Classroom A and Classroom B). Shortly, you will see a picture of one of those classrooms.

Both classes are *identical* in terms of:

- What you would be learning
- The number of hours of homework

The teachers for Class A and Class B are both male.

Students in these classes are typically 50% male and 50% female.

Next page:

1. Based on what you learned, how many different classrooms are there to choose from?

a. One
b. Two
c. Three

2. Based on what you learned, which of the following is true about these two classes?

a. Both classes have only male students
b. Both classes have only female students
c. Both classes have an equal number of male and female students

3. Based on what you learned, which of the following is true about these two classes?

a. The teachers are male
b. The teachers are female
c. One teacher is male and one teacher is female

4. Based on what you learned, what would you learn in these classes?

a. English
b. Art
c. Computer Science
d. Maths

5. How does the homework of the two classes compare to each other?

a. Class A has more homework
b. Class B has more homework
c. They have the same amount of homework

Appendix P Images of the computer science classrooms (Master et al., 2016)

Look carefully at this image of a computer science A Level classroom.

Appendix Q Self-efficacy measure (Master et al., 2016)

	Not at all well						Extremely well
	1	2	3	4	5	6	7
How well do you think you would do on this course?							

	The worst						The best
	1	2	3	4	5	6	7
If you were to rank all the students on this course from worst to best in computer science, where would you put yourself?							

Appendix R Utility value measure (Master et al., 2016)

The following questions are about computer science in general.

	Not at all useful					Very useful
	1	2	3	4	5	6	7
How useful do you think computer science will be for what you want to do after you graduate and go to work?							

	Not at all important						Very important
	1	2	3	4	5	6	7
For you, being good at computer science is __________							

Appendix S Gender measure

How would you describe your gender?

a. Male

b. Female

c. Prefer not to say

d. Other (box provided)

Appendix T Descriptive statistics, skewness and kurtosis levels

Descriptive statistics, skewness and kurtosis levels for the main variables prior to data cleaning.

Variable		M	SD	Skewness	Kurtosis
Enrolment interest	Pre-measure	2.44	1.52	1.15	.49
	Post-measure	2.40	1.51	1.28	.89
Belonging	Pre-measure	2.68	1.32	.84	-.07
	Post-measure	2.64	1.34	.78	-.19
Stereotype threat	Pre-measure	2.24	1.48	1.28	.84
	Post-measure	2.07	1.40	1.25	.51
Femininity		2.29	.51	-.04	-.24
Masculinity		2.80	.56	-.20	-.34
Self-efficacy		2.93	1.50	.45	-.75
Utility value		3.49	1.59	.39	-.72

Appendix U Serial mediation analysis to identify direct and indirect effects between femininity and enrolment interest

Effect	Path	Coefficient	SE	95% CI	
				LL	UL
Direct effect of F on ST	a^1	.531***	.196	.143	.917
Direct effect of F on B	a^2	.118	.125	-.128	.364
Direct effect of ST on B	a^3	.015	.049	-.081	.110
Direct effect of ST on EI	b^1	.137***	.052	.035	.240
Direct effect of B on EI	b^2	.404***	.084	.240	.570
Total effect of F on EI, without accounting for SE or UV	c	.078	.141	-.201	.356
Direct effect of F on EI when accounting for SE and UV	c′	-.046	.133	-.309	.218
Total indirect effect	ab	.124	.073	-.005	.275
Indirect effect via ST	a^1b^1	.073*	.043	.007	.173
Indirect effect via B	a^2b^2	.048	.062	-.067	.174
Indirect effect via ST and B	$a^1a^3b^2$	.003	.013	-.022	.030
EI total effect model[a] (R^2 = .57***)					

Notes Coefficient, unstandardised *B* coefficients; SE, standard error; CI, 95% confidence interval; LL, lower limit; UL, upper limit; F, femininity; ST, stereotype threat; B, belonging; EI, enrolment interest; SE, self-efficacy; UV, utility value; 5,000 bootstrapped samples

[a] Self-efficacy and utility value were covaried

*** p= < 0.01, * p= < 0.05

List of References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179-211. Doi: 10.1016/0749-5978(91)90020-T

Akosah-Twumasi, P., Emeto, T. I., Lindsay, D., Tsey, K., & Malau-Aduli, B. S. (2018). A systematic review of factors that influence youths career choices – the role of culture. *Frontiers in Education, 3*(58), 1-15. Doi: 10.3389/feduc.2018.00058

American Psychological Association. (2015). In G. VandenBos (Ed.). *APA dictionary of psychology (2nd ed.)*. Washington, DC: American Psychological Association.

Athenstaedt, U., Mikula, G., & Bredt, C. (2009). Gender role self-concept and leisure activities of adolescents. *Sex Roles*, *60*(5-6), 399-409. Doi: 10.1007/s11199-008-9543-y

Bandura, A. (1986). *Social foundations of thought and action*. Englewood Cliffs, NJ: Prentice-Hall Inc.

Bandura, A. 1994. Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior 4* (pp. 71-81). New York: Academic Press.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development*, *72*(1), 187-206. Doi: 10.1111/1467-8624.00273

Bartholomew, E. R., & Moeed, A. (2012). Reasons behind science subject choices in a New Zealand secondary school: A survey of year 10 and 11 students. *International Journal of Learning*, *18*(5). Doi: 10.18848/1447-9494/CGP/v18i05/47607

Bennett, J., Lubben, F., & Hampden-Thompson, G. (2013). Schools that make a difference to post-compulsory uptake of physical science subjects: Some comparative case studies in England. *International Journal of Science Education*, *35*(4), 663-689. Doi: 10.1080/09500693.2011.641131

Beyer, S., Rynes, K., Perrault, J., Hay, K., & Haller, S. (2003). Gender differences in computer science students. In *Proceedings of the 34th SIGCSE technical symposium on computer science education* (pp. 49-53). Doi: 10.1145/792548.611930

Blakemore, S. J., & Robbins, T. W. (2012). Decision-making in the adolescent brain. *Nature Neuroscience*, *15*(9), 1184-1191. Doi: 10.1038/nn.3177

Blanchard, C. M., Kupperman, J., Sparling, P., Nehl, E., Rhodes, R. E., Courneya, K. S., Baker, F. & Hunt, T. (2007). Ethnicity as a moderator of the theory of planned behavior and physical activity in college students. *Research Quarterly for Exercise and Sport*, *78*(5), 531-541. Doi: 10.1080/02701367.2007.10599452

Bøe, M. V. (2012). Science choices in Norwegian upper secondary school: What matters?. *Science Education*, *96*(1), 1-20. Doi: 10.1002/sce.20461

Boldizar, J. P. (1991). Assessing sex typing and androgyny in children: The Children's Sex Role Inventory. *Developmental Psychology*, *27*(3), 505-515. Doi: 10.1037/0012-1649.27.3.505

Bond, C., Woods, K., Humphrey, N., Symes, W., & Green, L. (2013). Practitioner review: The effectiveness of solution focused brief therapy with children and families: A systematic and critical evaluation of the literature from 1990–2010. *Journal of Child Psychology and Psychiatry*, *54*(7), 707-723. Doi: 10.1111/jcpp.12058

Bong, M., & Skaalvik, E. M. (2003). Academic self-concept and self-efficacy: How different are they really?. *Educational Psychology Review*, *15*(1), 1-40. Doi: 10.1023/A:1021302408382

Casey, B. J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: what have we learned about cognitive development?. *Trends in Cognitive Sciences*, *9*(3), 104-110. Doi: 10.1016/j.tics.2005.01.011.

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology*, *6*(49), 1-8. Doi: 10.3389/fpsyg.2015.00049

Cheryan, S., & Plaut, V. C. (2010). Explaining underrepresentation: A theory of precluded interest. *Sex Roles*, *63*(7-8), 475-488. Doi: 10.1007/s11199-010-9835-x

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others?. *Psychological Bulletin*, *143*(1), 1-35. Doi: 10.1037/bul0000052

Chick, K. A., Heilman-Houser, R. A., & Hunter, M. W. (2002). The impact of child care on gender role development and gender stereotypes. *Early Childhood Education Journal*, *29*(3), 149-154. Doi: 10.1023/A:1014528424032

Cife (n.d). All about A Level computer science. Retrieved from https://www.cife.org.uk/article/guide-individual-a-level-subjects/level-computer-science/

Cleaves, A. (2005). The formation of science choices in secondary school. *International Journal of Science Education*, *27*(4), 471-486. Doi: 10.1080/0950069042000323746

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillside, NJ: Lawrence Erlbaum Associates.

Crombie, G., Sinclair, N., Silverthorn, N., Byrne, B. M., DuBois, D. L., & Trinneer, A. (2005). Predictors of young adolescents' math grades and course enrollment intentions: Gender similarities and differences. *Sex Roles*, *52*(5-6), 351-367. Doi: 10.1007/s11199-005-2678-1

Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). Math–gender stereotypes in elementary school children. *Child Development*, *82*(3), 766-779. Doi: 10.1111/j.1467-8624.2010.01529.x

Davies, P., Davies, N. M., & Qiu, T. (2017). Information and choice of A-level subjects: A cluster randomised controlled trial with linked administrative data. *British Educational Research Journal*, *43*(4), 647-670. Doi: 10.1002/berj.3289

Deci, E. L. & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behaviour.* New York: Plenum.

Department for Business, Energy and Industrial Strategy (2019). Regulation for the fourth industrial revolution. Retrieved from https://www.gov.uk/government/publications/regulation-for-the-fourth-industrial-revolution/regulation-for-the-fourth-industrial-revolution

Department for Education (2020). Destinations of key stage 4 and 16-18 students, England, 2017-18. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/860135/Destinations_main_text_2020_REV.pdf

DeWitt, J., Archer, L., & Moote, J. (2019). 15/16-year-old students' reasons for choosing and not choosing physics at A Level. *International Journal of Science and Mathematics Education*, *17*(6), 1071-1087. Doi: 10.1007/s10763-018-9900-4

Eaton, A. A., Saunders, J. F., Jacobson, R. K., & West, K. (2020). How gender and race stereotypes impact the advancement of scholars in STEM: Professors' biased evaluations of physics and biology post-doctoral candidates. *Sex Roles*, *82*(3-4), 127-141. Doi: 10.1007/s11199-019-01052

Eccles J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). San Francisco, CA: W. H. Freeman.

Ehrlinger, J., Plant, E. A., Hartwig, M. K., Vossen, J. J., Columb, C. J., & Brewer, L. E. (2018). Do gender differences in perceived prototypical computer scientists and engineers contribute to gender gaps in computer science and engineering?. *Sex Roles*, *78*(1-2), 40-51. Doi: 10.1007/s11199-017-0763-x

Erikson, E. H. (1972). *Childhood and society*. Harmondsworth, Middlesex: Penguin Books.

European Institute for Gender Equality (n.d.). How gender equality in STEM education leads to economic growth. Retrieved from https://eige.europa.eu/gender-mainstreaming/policy-areas/economic-and-financial-affairs/economic-benefits-gender-equality/stem

Equality Act (2010). Retrieved from http://www.legislation.gov.uk/ukpga/2010/15/contents

Fehr, E., & Fischbacher, U. (2004). Social norms and human cooperation. *Trends in Cognitive Sciences*, *8*(4), 185-190. Doi: 10.1016/j.tics.2004.02.007

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. New York: Taylor & Francis.

Forsyth, D. R., Lawrence, N. K., Burnette, J. L., & Baumeister, R. F. (2007). Attempting to improve the academic performance of struggling college students by bolstering their self–esteem: An intervention that backfired. *Journal of Social and Clinical Psychology*, *26*(4), 447-459. Doi: 10.1521/jscp.2007.26.4.447

Francis, B., Archer, L., Moote, J., DeWitt, J., MacLeod, E., & Yeomans, L. (2017). The construction of physics as a quintessentially masculine subject: Young people's perceptions of gender issues in access to physics. *Sex Roles*, *76*(3-4), 156-174. Doi: 10.1007/s11199-016-0669-z

Frome, P. M., Alfeld, C. J., Eccles, J. S., & Barber, B. L. (2006). Why don't they want a male-dominated job? An investigation of young women who changed their occupational aspirations. *Educational Research and Evaluation*, *12*(4), 359-372. Doi: 10.1080/13803610600765786

Gender Recognition Act (2004). Retrieved from http://www.legislation.gov.uk/ukpga/2004/7/contents.

Giannakos, M. N. (2014). Exploring students intentions to study computer science and identifying the differences among ICT and programming based courses. *Turkish Online Journal of Educational Technology-TOJET*, *13*(3), 68-78.

Gill, T., & Bell, J. F. (2013). What factors determine the uptake of A-level physics?. *International Journal of Science Education*, *35*(5), 753-772. Doi: 10.1080/09500693.2011.577843

Guérin, E., Bales, E., Sweet, S., & Fortier, M. (2012). A meta-analysis of the influence of gender on self-determination theory's motivational regulations for physical activity. *Canadian Psychology/Psychologie Canadienne*, *53*(4), 291-300. Doi: 10.1037/a0030215

Hansen, A. K., Dwyer, H. A., Iveland, A., Talesfore, M., Wright, L., Harlow, D. B., & Franklin, D. (2017). Assessing children's understanding of the work of computer scientists: The draw-a-computer-scientist test. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (pp. 279-284). Doi: 10.1145/3017680.3017769

Harding, R. (2009). *Women's enterprise and SET*, London: National Policy Centre for Women's Enterprise.

Harris, R. J. (1985). *A primer of multivariate statistics* (2nd ed.). New York: Academic Press.

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* New York, NY: The Guilford Press.

Hendriks, A. A. J., Hofstee, W. K., & De Raad, B. (1999). The five-factor personality inventory (FFPI). *Personality and Individual Differences*, *27*(2), 307-325.

Hendriks, A. A. J., Kuyper, H., Offringa, G. J., & Van der Werf, M. P. C. (2008). Assessing young adolescents' personality with the Five-Factor Personality Inventory. *Assessment, 15*(3), 304–316. Doi: 10.1177/1073191107313761

Hofstede, G., Hofstede, G. J. & Minkov, M. (2010). *Cultures and organizations: Software of the mind* (3rd ed.). New York: McGraw-Hill.

Inside Careers (2016). UK STEM graduates 'earn nearly 20% more than their peers'. Retrieved from https://www.insidecareers.co.uk/2016/07/uk-stem-graduates-earn-nearly-20-more-than-their-peers/

James, K. (2007). Factors influencing students' choice (s) of experimental science subjects within the International Baccalaureate Diploma Programme. *Journal of Research in International Education*, *6*(1), 9-39. Doi: 10.1177/1475240907074787

Jeffries, D., Curtis, D. D., & Conner, L. N. (2019). Student factors influencing STEM subject choice in year 12: A structural equation model using PISA/LSAY data. *International Journal of Science and Mathematics Education*, *18*(3), 441-461. Doi: 10.1007/s10763-019-09972-5

Kendall, M. G. (1962). *Rank correlation methods* (3rd ed.). London: Griffin.

Kessels, U. (2015). Bridging the gap by enhancing the fit: How stereotypes about STEM clash with stereotypes about girls. *International Journal of Gender, Science and Technology*, *7*(2), 280-296.

Kessels, U., Heyder, A., Latsch, M., & Hannover, B. (2014). How gender differences in academic engagement relate to students' gender identity. *Educational Research*, *56*(2), 220-229. Doi: 10.1080/00131881.2014.898916

Kessels, U., & Steinmayr, R. (2013). Macho-man in school: Toward the role of gender role self-concepts and help seeking in school performance. *Learning and Individual Differences*, *23*, 234-240. Doi: 10.1016/j.lindif.2012.09.013

Kessels, U. & Hannover, B. (2004). Entwicklung schulischer Interessen als Identitätsregulation. [Development of academic interests as identity regulation] In J. Doll & M. Prenzel (Eds.), *Bildungsqualität von Schule: Lehrerprofessionalisierung, Unterrichtsentwicklung und Schülerförderung als Strategien der Qualitätsverbesserung (*pp. 398–412). Münster, Germany: Waxmann.

Kessels, U., & Hannover, B. (2007). How the image of math and science affects the development of academic interests. In M. Prenzel (Ed.). *Studies on the educational quality of schools. The final report on the DFG priority programme*, Münster, Germany: Waxmann (pp. 283-297).

Kiefer, A. K., & Sekaquaptewa, D. (2007). Implicit stereotypes, gender identification, and math-related outcomes: A prospective study of female college students. *Psychological Science*, *18*(1), 13-18. Doi: 10.1111/j.1467-9280.2007.01841.x

Korpershoek, H., Kuyper, H., van der Werf, G., & Bosker, R. (2010). Who 'fits' the science and technology profile? Personality differences in secondary education. *Journal of Research in Personality*, *44*(5), 649-654. Doi: 10.1016/j.jrp.2010.08.010

Korpershoek, H., Kuyper, H., & Van der Werf, M. P. C. (2012). The role of personality in relation to gender differences in school subject choices in pre-university education. *Sex Roles*, *67*(11-12), 630-645. Doi: 10.1007/s11199-012-0222-7

Lampis, J., Cataudella, S., Busonera, A., De Simone, S., & Tommasi, M. (2019). The moderating effect of gender role on the relationships between gender and attitudes about body and eating in a sample of Italian adolescents. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity*, *24*(1), 3-11. Doi: 10.1007/s40519-017-0372-2.

Lauermann, F., Tsai, Y. M., & Eccles, J. S. (2017). Math-related career aspirations and choices within Eccles et al.'s expectancy–value theory of achievement-related behaviors. *Developmental Psychology*, *53*(8), 1540-1559. Doi: 10.1037/dev0000367

Lavigne, G. L., Vallerand, R. J., & Miquelon, P. (2007). A motivational model of persistence in science education: A self-determination theory approach. *European Journal of Psychology of Education*, *22*(3), 351-369. Doi: 10.1007/BF03173432

Martin, C. L., & Ruble, D. N. (2010). Patterns of gender development. *Annual Review of Psychology*, *61*, 353-381. Doi: 10.1146/annurev.psych.093008.100511.

Master, A., Cheryan, S., & Meltzoff, A. N. (2016). Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology*, *108*(3), 424-437. Doi: 10.1037/edu0000061

Master, A., Cheryan, S., Moscatelli, A., & Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. *Journal of Experimental Child Psychology*, *160*, 92-106. Doi: 10.1016/j.jecp.2017.03.013

McGeown, S. P., & Warhurst, A. (2020). Sex differences in education: Exploring children's gender identity. *Educational Psychology*, *40*(1), 103-119. Doi: 10.1080/01443410.2019.1640349

Mendolia, S., & Walker, I. (2014). The effect of personality traits on subject choice and performance in high school: Evidence from an English cohort. *Economics of Education Review*, *43*, 47-65. Doi: 10.1016/j.econedurev.2014.09.004

Miller, D. I., Nolla, K. M., Eagly, A. H., & Uttal, D. H. (2018). The development of children's gender-science stereotypes: A meta-analysis of 5 decades of US Draw-a-Scientist studies. *Child Development*, *89*(6), 1943-1955. Doi: 10.1111/cdev.13039

Moore, R., & Burrus, J. (2019). Predicting STEM major and career intentions with the theory of planned behavior. *The Career Development Quarterly*, *67*(2), 139-155. Doi: 10.1002/cdq.12177

Mujtaba, T., & Reiss, M. J. (2013a). Inequality in experiences of physics education: Secondary school girls' and boys' perceptions of their physics education and intentions to continue with physics after the age of 16. *International Journal of Science Education*, *35*(11), 1824-1845. Doi: 10.1080/09500693.2012.762699

Mujtaba, T., & Reiss, M. J. (2013b). What sort of girl wants to study physics after the age of 16? Findings from a large-scale UK survey. *International Journal of Science Education*, *35*(17), 2979-2998. Doi: 10.1080/09500693.2012.681076

Mujtaba, T., & Reiss, M. J. (2014). A survey of psychological, motivational, family and perceptions of physics education factors that explain 15-year-old students' aspirations to study physics in post-compulsory English schools. *International Journal of Science and Mathematics Education*, *12*(2), 371-393. Doi: 10.1007/s10763-013-9404-1

Mujtaba, T., & Reiss, M. J. (2016). "I fall asleep in class… but physics is fascinating": The use of large-scale longitudinal data to explore the educational experiences of aspiring girls in mathematics and physics. *Canadian Journal of Science, Mathematics and Technology Education*, *16*(4), 313-330. Doi: 10.1080/14926156.2016.1235743

Nagy, G., Trautwein, U., Baumert, J., Köller, O., & Garrett, J. (2006). Gender and course selection in upper secondary education: Effects of academic self-concept and intrinsic value. *Educational Research and Evaluation*, *12*(4), 323-345. Doi: 10.1080/13803610600765687

Nashon, S. M., & Nielsen, W. S. (2007). Participation rates in Physics 12 in BC: Science teachers' and students' views. *Canadian Journal of Science, Mathematics and Technology Education*, *7*(2-3), 93-106. Doi: 10.1080/14926150709556722.pdf

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math= male, me= female, therefore math≠ me. *Journal of Personality and Social Psychology*, *83*(1), 44. Doi: 10.1037/0022-3514.83.1.44

Nosek, B. A., & Smyth, F. L. (2011). Implicit social cognitions predict sex differences in math engagement and achievement. *American Educational Research Journal*, *48*(5), 1125-1156. Doi: 10.3102/0002831211410683

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., ... & Greenwald, A. G. (2009). National differences in gender–science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Sciences*, *106*(26), 10593-10597. Doi: 10.1073/pnas.0809921106

OECD (2008). *Encouraging student interest in science and technology studies*. Paris, France: OECD Publishing. Doi: 10.1787/9789264040892-en.

Ofqual (2019). Entries for GCSE, AS and A Level. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/803906/Provisional_entries_for_GCSE__AS_and_A_level_summer_2019_exam_series.pdf

Østergaard, C. R., Timmermans, B., & Kristinsson, K. (2011). Does a different view create something new? The effect of employee diversity on innovation. *Research Policy*, *40*(3), 500-509. Doi: 10.1016/j.respol.2010.11.004

Pike, A. G., & Dunne, M. (2011). Student reflections on choosing to study science post-16. *Cultural Studies of Science Education*, *6*(2), 485-500. Doi: 10.1007/s11422-010-9273-7

Schmader, T. (2002). Gender identification moderates stereotype threat effects on women's math performance. *Journal of Experimental Social Psychology*, *38*(2), 194-201. Doi: 10.1006/jesp.2001.1500

Shaffer, E. S., Marx, D. M., & Prislin, R. (2013). Mind the gap: Framing of women's success and representation in STEM affects women's math performance under threat. *Sex Roles*, *68*(7-8), 454-463. Doi: 10.1007/s11199-012-0252-1

Sheldrake, R. (2016). Students' intentions towards studying science at upper-secondary school: the differential effects of under-confidence and over-confidence. *International Journal of Science Education*, *38*(8), 1256-1277. Doi: 10.1080/09500693.2016.1186854

Sheldrake, R., Mujtaba, T., & Reiss, M. J. (2014). Calibration of self-evaluations of mathematical ability for students in England aged 13 and 15, and their intentions to study non-compulsory mathematics after age 16. *International Journal of Educational Research*, *64*, 49-61. Doi: 10.1016/j.ijer.2013.10.008

Sheldrake, R., Mujtaba, T., & Reiss, M. J. (2015). Students' intentions to study non-compulsory mathematics: the importance of how good you think you are. *British Educational Research Journal*, *41*(3), 462-488. Doi: 10.1002/berj.3150

Sheldrake, R., Mujtaba, T., & Reiss, M. J. (2019). Students' changing attitudes and aspirations towards physics during secondary school. *Research in Science Education*, *49*(6), 1809-1834. Doi: 10.1007/s11165-017-9676-5

Smyth, E., & Hannan, C. (2006). School effects and subject choice: The uptake of scientific subjects in Ireland. *School Effectiveness and School Improvement*, *17*(3), 303-327. Doi: 10.1080/09243450600616168

Social Market Foundation (2016). Jobs of the future. Retrieved from https://www.edfenergy.com/sites/default/files/jobs-of-the-future.pdf

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology*, *35*(1), 4-28. Doi: 10.1006/jesp.1998.1373

Steele, J. R., & Ambady, N. (2006). "Math is Hard!" The effect of gender priming on women's attitudes. *Journal of Experimental Social Psychology*, *42*(4), 428-436. Doi: 10.1016/j.jesp.2005.06.003

Steinberg, L., Graham, S., O'Brien, L., Woolard, J., Cauffman, E., & Banich, M. (2009). Age differences in future orientation and delay discounting. *Child Development*, *80*(1), 28-44. Doi: 10.1111/j.1467-8624.2008.01244.x.

STEM Learning (2018). Skills shortage costing STEM sector £1.5 bn. Retrieved from https://www.stem.org.uk/news-and-views/news/skills-shortage-costing-stem-sector-15bn

Stokking, K. M. (2000). Predicting the choice of physics in secondary education. *International Journal of Science Education*, *22*(12), 1261-1283. Doi: 10.1080/095006900750036253

Su, R., & Rounds, J. (2015). All STEM fields are not created equal: People and things interests explain gender disparities across STEM fields. *Frontiers in Psychology*, *6*, 189. Doi: 10.3389/fpsyg.2015.00189

Taylor, R. C. (2015). Using the theory of planned behaviour to understand students' subject choices in post-compulsory education. *Research Papers in Education*, *30*(2), 214-231. Doi: 10.1080/02671522.2014.880732

The PRISMA Group (2009). *Preferred Reporting Items for Systematic Reviews and Meta-Analyses:* The PRISMA Statement. British Medical Journal, 339:b2535. Doi: 10.1136/bmj.b2535

The United Kingdom House of Commons Committee of Public Accounts (2018). Delivering STEM skills for the economy. Retrieved from https://publications.parliament.uk/pa/cm201719/cmselect/cmpubacc/691/691.pdf

Tomlinson, C., Bond, C., & Hebron, J. (2019). The school experiences of autistic girls and adolescents: A systematic review. *European Journal of Special Needs Education*, *35*(2), 203-219. Doi: 10.1080/08856257.2019.1643154

UNESCO (2017). *Cracking the code: girls' and women's education in science, technology, engineering and mathematics (STEM)*. UNESCO Publishing.

van Langen, A., Rekers-Mombarg, L., & Dekkers, H. (2006a). Group-related differences in the choice of mathematics and science subjects. *Educational Research and Evaluation*, *12*(1), 27-51. Doi: 10.1080/13803610500392129

van Langen, A., Rekers-Mombarg, L., & Dekkers, H. (2006b). Sex-related differences in the determinants and process of science and mathematics choice in pre-university education. *International Journal of Science Education*, *28*(1), 71-94. Doi: 10.1080/09500690500338920

Watson, K., & Froyd, J. (2007). Diversifying the US engineering workforce: A new model. *Journal of Engineering Education*, *96*(1), 19-32. Doi: 10.1002/j.2168-9830.2007.tb00912.x

Wigfield, A., & Eccles, J. S. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review*, *12*(3), 265-310. Doi: 10.1016/0273-2297(92)90011-P

WISE (2019). Statistics. Retrieved from https://www.wisecampaign.org.uk/statistics/

Young, D. M., Rudman, L. A., Buettner, H. M., & McLean, M. C. (2013). The influence of female role models on women's implicit science cognitions. *Psychology of Women Quarterly*, *37*(3), 283-292. Doi: 10.1177/0361684313482109

Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal*, *37*(1), 215-246. Doi: 10.3102/00028312037001215