International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

Exploring the impact of secondary school students' identification with gender stereotypes on their computer science enrolment interest

Eleanor Beck, Cora Sargeant and Sarah Wright

University of Southampton, UK

ABSTRACT

There is an underrepresentation of women working in Science, Technology, Engineering and Mathematics (STEM) industries. Initiatives to encourage greater diversity in STEM have been less successful in computer science. This research investigates whether identification with gender stereotypes (defined as the extent to which one identifies with stereotypical masculine or feminine traits) and other factors predict enrolment interest in computer science and whether stereotypical cues impact on these relationships. British secondary school students were shown either a stereotypical or a non-stereotypical computer science classroom and completed measures assessing their identification with gender stereotypes, enrolment interest, belonging, stereotype threat, self-efficacy and utility value. Femininity significantly predicted lower enrolment interest and this relationship appeared to be mediated by stereotype threat. This study extends previous research by showing that young peoples' identification with gender stereotypes predicts enrolment interest to some degree. We highlight the need to challenge persistent stereotypes regarding who best 'fits' computer science.

KEYWORDS

STEM; computer science; gender identity; stereotypes

Exploring the impact of secondary school students' identification with gender stereotypes on their computer science enrolment interest

INTRODUCTION

Despite STEM (Science, Technology, Engineering and Mathematics) graduates having higher than average earning potential (Inside Careers, 2016), there is currently a shortage of graduates to fill STEM jobs, both in the United Kingdom (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 male and female students; despite female GCSE students performing at a similar and often higher level than males in compulsory STEM subjects, 30% more male than female students choose STEM at post-16 level (Women into Science and Engineering, WISE; 2019)[1]. STEM take-up differences go further than school, with women making up just 24% of the core-STEM workforce (WISE, 2019). Recent British government efforts have focused on attracting students, particularly women, to choose STEM subjects at post-16 level. Such initiatives have started to have an impact, with the number of female students 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 women in STEM roles in the last ten years (WISE, 2019). However, progress is slow and subject specific; the percentage of women 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.

STEM subject choice

In the UK and many other countries around the world students are given the chance to select school subjects to study further during adolescence, at around the age of 16. In terms of STEM, specifically, a well-evidenced influence on students' subject selection is the anticipated utility value of the subject. Utility value includes intrinsic gain (the benefit to developing one's knowledge and skills) and 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

[1] This paper will refer to qualifications made by UK students. In the UK, General Certificate of Secondary Education (GCSE) examinations are usually taken by those aged 15 or 16 years old. Advance Level (A Level) examinations are taken when the student is post-16, usually at either 17 or 18 years old.

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 a job (Mujtaba & Reiss, 2014). Research has also highlighted how the utility value of STEM can be promoted: secondary school students who accessed an intervention providing them with information regarding the earning potential of STEM graduates were more likely than controls to express intention to choose some STEM subjects (Davies, Davies & Qui, 2017).

Another factor that has been found to influence STEM subject choice is self-efficacy, 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, both current and anticipated, increases students' STEM subject choice (Nagy et al., 2006; Stokking, 2000; Mujtaba & Reiss, 2014; Smyth & Hannan, 2006; Sheldrake, 2016; Sheldrake, Mujtaba & Reiss, 2015; Jeffries, Curtis & Conner, 2019) 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).

The difference between 'sex' and 'gender'

The sex difference within STEM is well-documented. Female students are less likely to report that they enjoy STEM (Jeffries et al., 2019), report lower STEM self-efficacy (Jeffries et al., 2019), lower extrinsic material gain motivation for STEM (Mujtaba & Reiss, 2013b) and less positive perceptions of STEM lessons (Mujtaba & Reiss, 2013b) than male students. 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 female students tend to choose STEM subjects less than their male counterparts because they anticipate experiencing a lower sense of belonging within STEM.

Such sex differences lead to the hypothesis that female students will be significantly less interested in enrolling in computer science than males. Such a difference is complicated by the conflation of the terms 'sex' and 'gender' in research and the difficulty in establishing what is being asked, or importantly, inferred by the participants. For example, Jefferies et al. (2019) asked participants "are you male or female" and Masters et al. (2016) asked "What is your gender? – 'male' or 'female'", both studies providing a binary choice. Even if we argue that "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), there is still some room for confusion here.

While it is often pragmatic to design research to group participants in a binary way, it can overlook the diversity that exists within these groups. Identification with gender stereotypes, sometimes referred to as 'gender identity' and 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 & Tommasi, 2019) and academic behaviours and school performance (Kessels & Steinmayr, 2013) in adolescents.

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 female students who felt less of a fit (Master et al., 2016). The Interests as Identity Regulation model (IIRM; Kessels, 2015; 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 reduced fit between their identity (developed in part by gendered stereotypes) and STEM when compared with males. This model also helps to explain why some female students do not experience such a misfit: they may not perceive STEM to be as masculine as other women might, or they may not perceive themselves as 'highly feminine' (Kessels, Heyder, Latsch & Hannover, 2014). Indeed, female students 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). When viewing participants according to their identification with gender stereotypes (their reported femininity and masculinity), we will hypothesise that there will be a significant negative relationship between femininity and enrolment interest and a significant positive relationship between masculinity and enrolment interest. The more feminine identified the individual, the lower their interest in STEM and the more masculine identified the individual, the higher the interest. The difference in STEM subject uptake between male and female students may not simply be due to sex differences, but may be at least in part due to differences in the stereotype threat created by the dissonance between one's identification with gender stereotypes and the gendered norms of STEM subjects. As such, we will hypothesise that the negative relationship between femininity and enrolment interest will be partially mediated by both stereotype threat and feelings of 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.

It appears that some STEM subjects are more susceptible to the effect of gendered norms and stereotypes. Stereotypes around the type of individual who pursues certain STEM subjects (computer science and physics), along with sex-specific stereotypes regarding female ability within these fields, account for the variability in female interest in those subjects (Cheryan, Ziegler, Montoya & Jiyang, 2017). Computer scientists, in particular, are often stereotyped as having an "obsession with machines" (Beyer, Rynes, Perrault, Hay & Haller, 2003; p. 52), socially awkward (Beyer et al. 2003), intelligent (Ehrlinger et al., 2018), and male (Cheryan & Plaut, 2010). Such stereotypes are 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 all potential candidates who identify with stereotypically 'feminine' characteristics, regardless of their sex or gender. As such, we will hypothesise that the negative relationship between femininity and stereotype threat, in its role as mediator of the relationship between femininity and enrolment interest, will be moderated by the stereotypicality of a computer science classroom shown to participants.

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 or gender. Since STEM-related stereotypes underline 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.

Research rationale, aims and objectives

The present study set out to assess whether identification with gender stereotypes (also known in some research as one's '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 or gender and found that female students, exposed to classroom environments that communicate STEM stereotypes, were 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 identification with gender stereotypes), regardless of their sex or gender, impacts upon their computer science enrolment interest.

Research questions

This research aims to answer the following research questions:

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

Hypotheses

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

1. Female students will be significantly less interested in enrolling in computer science than males.

2. The positive relationship between gender and enrolment interest will be mediated by belonging, but not stereotype threat.

3. There will be a significant negative relationship between femininity and enrolment interest and 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.

5. The relationship between femininity and stereotype threat, in its role as mediator of the relationship between femininity and enrolment interest, will be moderated by the stereotypicality of the classroom.

Figure 1. A figure to demonstrate Hypothesis 4: a serial mediation analysis to assess the direct and indirect effects of femininity on enrolment interest and the predicted direction of the relationship.

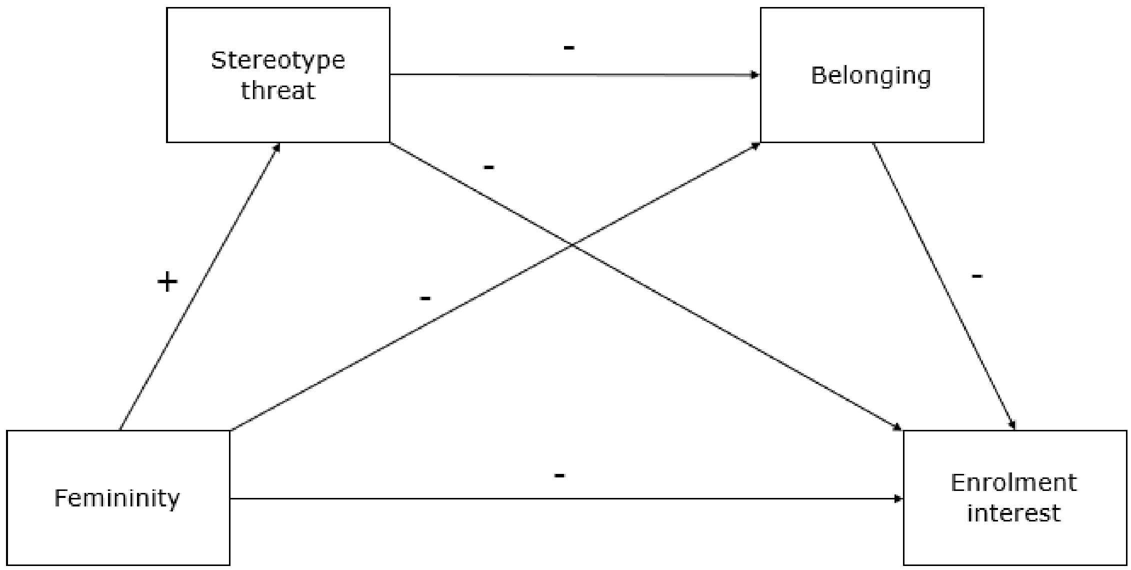
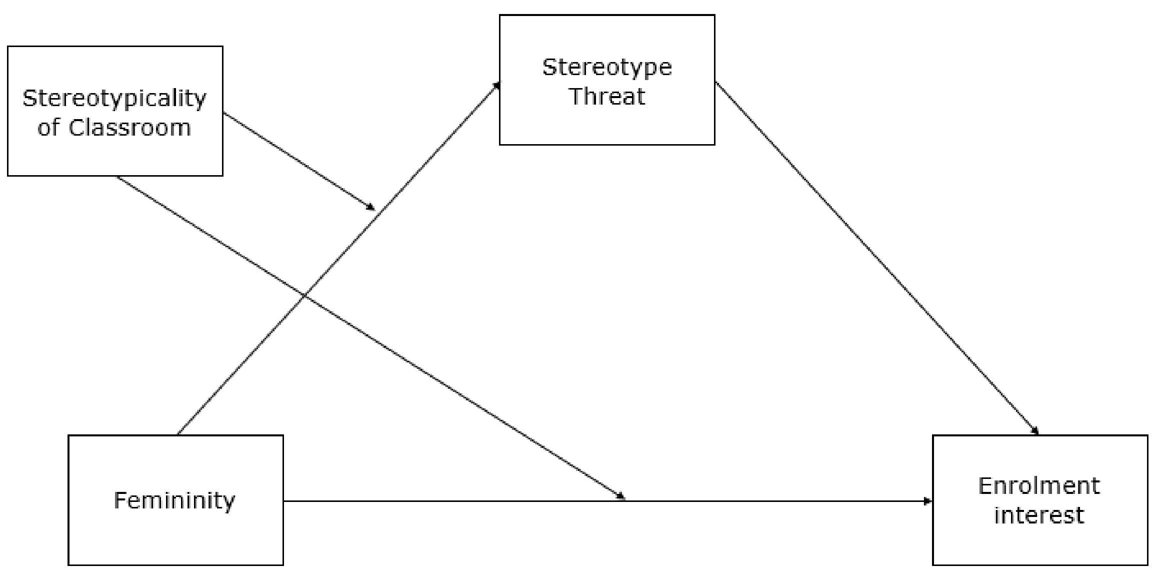


Figure 2. A figure to demonstrate Hypothesis 5: A moderated mediation analysis to explore whether stereotypicality moderates the mediation of stereotype threat on femininity and enrolment interest



METHOD

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. Table 1 provides information about the participants.

Table 1. Participant information

	N	Year group	Data collected	GCSE structure	Classes sampled	Post-16 choices
School 1	46	Year 9	Summer term	Three-year GCSE programme. Students had made their GCSE choices a year prior to data collection, in Year 8.	Members of two history classes.	Participants would make their post-16 choices in Spring term of Year 11.
School 2	149	Year 9	Autumn term	Two-year GCSE programme. Students had not yet made their GCSE subject choices.	All Year 9 students. All students undertook a compulsory computing curriculum during Key Stage 3 (Year 7 to Year 9).	Participants would make their post-16 choices in the Spring term of Year 11.

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 (there were six predictors; 6 + 50 = 56), and Green's (1991) recommendation that the number of participants should exceed 50 plus 8 multiplied by the number of predictors (50 + (8 x 6) = 98).

Measures

Identification with gender stereotypes.

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, α = 0.80) and feminine characteristics (10 items, α = 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?'). 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-image viewing[2]. 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 of the authors. Participants were asked to read

---

[2] We measured enrolment interest, belonging and stereotype threat pre- and post- image viewing. This allowed us to assess participants' baseline levels and whether the stereotypicality of the classroom affected these variables. Subsequent references of these variables relate to post-measure data.

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 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 gender (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 gender 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. Of 127 participants

who were asked this question, 49 described themselves as 'female', 73 as 'male' and five selected 'prefer not to say'.

Procedure

Following ethical approval from the University of Southampton Ethics Committee, three schools known to the lead researcher were contacted, one in the South East and two in the South West of England. One school declined at this stage. School 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 (students aged 13 or 14) 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. The research utilised an 'opt-out' method for maximum participation. One parent (School 1) opted their child out of the research.

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 and provided 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 from participants.

Participants completed the pre-measures (enrolment interest, belonging, stereotype threat). They then completed the measure to assess their identification with gender stereotypes. 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= 127).

Data cleaning

In total, 195 participants attempted and 180 started the survey. Participants' data was removed if they missed a specific number of questions in key measures or got a specific number of questions incorrect on a set of attention check questions. The data of 168 participants was used in the final analysis.

Given that the research involved participants from two specific schools, we ran an independent samples t-test to check that the two schools were not statistically different in their enrolment interest at pre-measure, which indeed they were not: $t(166)= .20$, $p= .843$.

Table 2. 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

RESULTS

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

Hypothesis 1: Female students will be significantly less interested in enrolling in computer science than males.

We ran an independent samples t-test to assess enrolment interest and gender (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: The positive relationship between gender and enrolment interest will be mediated by belonging, but not stereotype threat.

Parametric assumptions were checked. A parametric one-tailed correlation showed that gender was significantly positively related to enrolment interest ($r= .200$, $p= .014$). A mediation model was tested (PROCESS Model 6; Hayes, 2013) to explore whether the relationship between gender and enrolment interest was mediated by belonging and/or stereotype threat (with self-efficacy and utility value as covariates). A bootstrapping approach was used, resampling the dataset 5000 times. There were no significant indirect mediation effects at the 95% level.

Table 3. Serial mediation analysis to identify indirect effects between gender and enrolment interest

			95% CI	
Effect	Coefficient	SE	LL	UL
Indirect effect via B	.040	.074	-.094	.205
Indirect effect via ST	-.136	.091	-.323	.036
Indirect effect via B and ST	.000	.004	-.010	.011

Notes Coefficient, unstandardised *B* coefficients; SE, standard error; CI, 95% confidence interval; LL, lower limit; UL, upper limit; ST, stereotype threat; B, belonging; 5,000 bootstrapped samples
Self-efficacy and utility value were covaried
*** p= < 0.01, * p= < 0.05

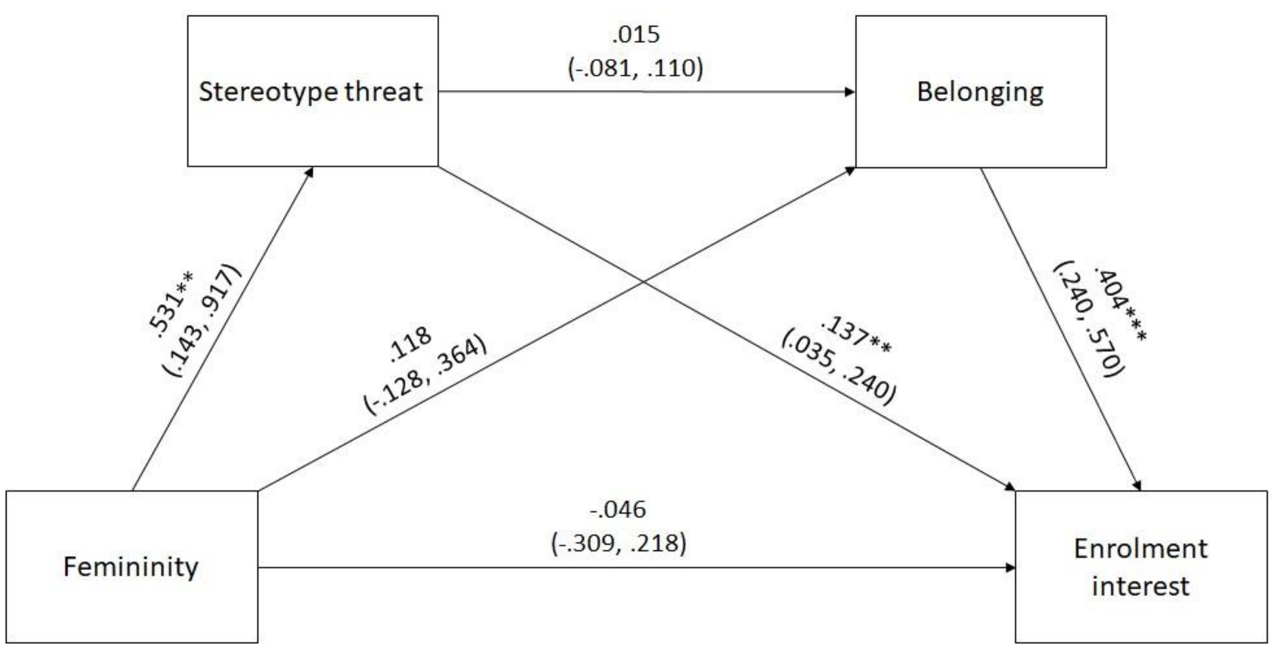
Hypotheses 3: There will be a significant negative relationship between femininity and enrolment interest and a significant positive relationship between masculinity and enrolment interest.

A parametric one-tailed correlation indicated that femininity was significantly negatively correlated with enrolment interest (*r*= -.147, *p*= .028). Masculinity was significantly negatively correlated with enrolment interest (*r*= -.142, *p*= .033). Self-efficacy (*r*= .696, *p*= .000) and utility value (*r*= .662, *p*= .000) significantly predicted enrolment interest.

Hypothesis 4: The negative relationship between femininity and enrolment interest will be partially mediated by both stereotype threat and belonging.

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). Again, a bootstrapping approach was used with both 95% and 99% confidence intervals to establish the statistical significance of the findings.

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



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

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. 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. However, there appeared to be evidence of an inconsistent mediation effect; the direction of effect between enrolment interest and stereotype threat was unexpectedly positive; participants who identified more strongly with feminine traits reported higher levels of stereotype threat and showed higher levels of enrolment interest. No indirect effect of belonging was found for femininity on enrolment interest; belonging did not appear to mediate the relationship between enrolment interest and femininity.

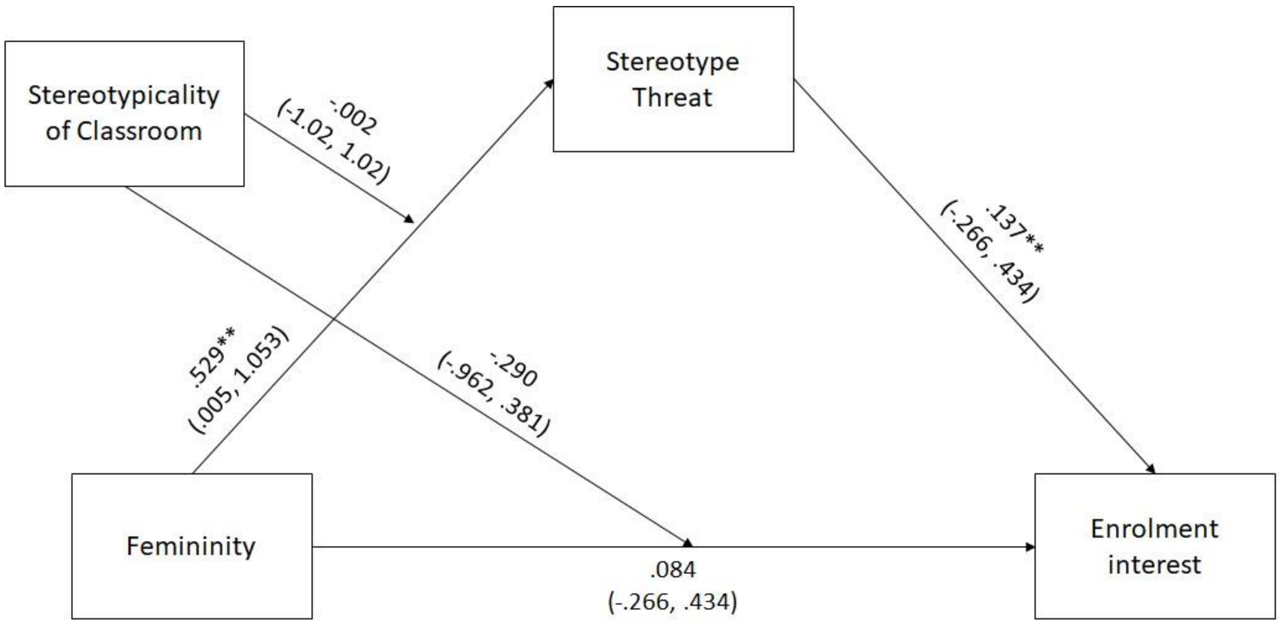
Hypothesis 5: The negative relationship between femininity and stereotype threat, in its role as mediator of the relationship between femininity and enrolment interest, will be moderated by the stereotypicality of the classroom.

We tested a moderated mediation model (PROCESS Model 8; Hayes, 2013) to assess whether classroom stereotypicality moderated 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 4 shows descriptive statistics for the included variables in each image condition.

Table 4. 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

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



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

DISCUSSION

Supporting previous research in this area, the present study identified that gender (those who described themselves as 'male' or 'female') significantly predicted enrolment interest; 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 gender difference in STEM subject interest (e.g. Mujtaba & Reiss, 2013a; Jeffries, Curtis & Conner, 2019). However, unlike research suggesting that belonging mediates this gender effect (Master et al., 2016), this analysis found no significant mediation effects of belonging or additionally of stereotype threat, though the indirect effect via both belonging and stereotype threat was close to statistical significance. In the present study only students attending School 2 were asked to identify their gender (n= 127), so it is possible that a weak effect might exist here, but if so only an even larger scale replication would be able to discriminate between that and what otherwise might be a chance effect.

Extending previous research in this area, the present study identified that the extent to which a person identified with traditionally feminine characteristics significantly predicted their enrolment interest in computer science. The small but significant relationship between femininity and computer science interest was significantly mediated by stereotype threat, indicating that those with more feminine characteristics experienced a greater stereotype threat and consequently had a reduced interest in enrolling in computer science. 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 stereotypically feminine characteristics. Experimental research supports 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).

Despite the present study finding that the negative relationship between femininity and enrolment interest was mediated by stereotype threat, further serial mediation analysis highlighted that more feminine individuals experiencing higher levels of stereotype threat also showed higher levels of enrolment interest. It is possible that the relationship between stereotype threat and enrolment interest is bidirectional; while people higher in femininity might experience stereotype threat when considering enrolling and therefore have less interest in doing so, people who are higher in femininity who have a stronger desire to enrol might anticipate greater stereotype threat because of that interest.

When looking at participants' identification with gender stereotypes, we found a negative relationship between masculine characteristics and enrolment interest; higher masculinity was related to lower enrolment interest. Though the effect was small and non-significant it nonetheless presented in a direction opposite to that expected. The 'masculine' characteristics assessed within the CSRI 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 tend to 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 both athletic, socially confident and emotionally sensitive candidates.

Despite previous research highlighting that gender-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 gender, belonging mediates the relationship between gender and enrolment interest (Master et al., 2016) but when assessing their identification with gender stereotypes, 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 gender and identification with gender stereotypes as distinct concepts; one dependent upon the extent to which one identifies with the category of 'female' or 'male' and another dependent upon the extent to which one possesses traditionally 'feminine' or 'masculine' traits. It may be that when individuals ponder their subject choices the decision includes two gender-relevant considerations, one about whether people of their gender category are represented and welcome in the subject, and another about whether people representing their gendered characteristics and interests are represented and welcome in the subject; the former speaks to the potential threat to belonging, the latter to stereotype threat. Should this be the case, stereotype threat might contribute to a homogenisation of the gendered interests and characteristics of those studying STEM subjects over time, and might mean that women who exhibit particularly 'feminine' characteristics and interests may experience a double disadvantage when considering STEM as part of their subject choices.

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 gender. 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 a too narrow group of individuals to target and that the lack of diversity in STEM is not just about gender, but also about individuals' identification with gendered stereotypes.

Strengths, limitations and directions for future research

The present study extended previous research that highlighted the influence of belonging, stereotype threat, self-efficacy, utility value and gender in STEM enrolment interest. We considered participants' identification with gender stereotypes 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 gender.

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.

Furthermore, this research may have been susceptible to sampling bias. Despite data collection taking place in both schools prior to participants making their post-16 subject choices, one school had made their GCSE subject choices. Participants attending School 1 were GCSE history students; information regarding other GCSE subject choices was not collected. As such, many of these students may have already opted out of a computer science pathway. Conversely, participants attending School 2 were currently undertaking a compulsory computing curriculum prior to making their GCSE subject choices, and so there was still a possibility that all participants could select computing at GCSE and then later, at A Level. Future research should minimise possible sampling bias by ensuring that participants carry out this type of research prior to making any subject choices, therefore they have access to all subject options and are able to answer questions with greater feasibility.

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. It was our oversight not to include a measure of classroom stereotypicality to use as a manipulation check and it is our recommendation that studies extending or replicating these results do so in the future.

Research has shown that those who score lower on extraversion and higher on emotional stability (Korpershoek, Kuyper, Van der Werf & Bosker, 2010; Korpershoek, Kuyper & Van der Werf, 2012) are more likely to choose STEM subjects. However, we did not control for personality in the present study. Male students who study physics score higher on emotional stability than their female counterparts (Mujtaba & Reiss, 2013b); this gender difference highlights that STEM uptake might not be inherently about personality traits but how the personality traits link with gender norms. It will be important for future research to investigate the relationship between personality traits and gendered interests and characteristics.

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 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 influenced by the cultural connotations of the statements used in this measure, than adolescents 30 years ago. Since gendered stereotype threat is experienced subjectively, a more subjective gender measure might be 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 identification with gender stereotypes. Future research could involve developing a more modern way to measure participants' identification with gender stereotypes which would allow researchers to explore how this 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 men and women, respectively. Since the CSRI did not correlate with enrolment interest as strongly as we expected, future research might benefit from using an updated measure of individuals' identification with gender stereotypes.

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 their gender. 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 found a gender difference in enrolment interest but found that this was not mediated by belonging. It is possible that previously researched gender differences in STEM enrolment interest, mediated by belonging, and identification with gender stereotypes, mediated by stereotype threat, are two separate effects. Consequently, STEM subjects may be missing out on a range of gender diverse candidates, with those exhibiting more stereotypically feminine characteristics and interests becoming excluded from those disciplines regardless of their gender, and with particularly 'feminine' women experiencing a double disadvantage. It is important that we ensure that everybody feels welcome within STEM, especially those subjects featuring stronger stereotypes, in order to encourage individuals from all walks of life to some of the professions we as a society are likely to depend on most in the future.

REFERENCES

American Psychological Association (2015). Gender. In *APA dictionary of psychology* (2nd ed., p. 450)

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.

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

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

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

Davies, P., Davies, N. M., & Qui, 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

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

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

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

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

Green, S.B. (1991). How many subjects does it take to do a regression analysis? *Multivariate Behavioral Research, 26,* 499-510. https://doi.org/10.1207/s15327906mbr2603_7

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).

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.

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

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.

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

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

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

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

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

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

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

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. (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

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

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

Women into Science and Engineering (WISE; 2019). Statistics. Retrieved from https://www.wisecampaign.org.uk/statistics/