Research in Science Education
https://doi.org/10.1007/s11165-018-9759-y

Space Science: the View from European School Students

Jennifer DeWitt[1] · Karen Bultitude[2]

Published online: 30 August 2018

Abstract
Gender imbalance in the physical sciences and engineering is a longstanding and well-documented concern within science education, industry, and policy. The current study is motivated by this issue and focuses on space science in particular, which has been promoted as a physical science with the capacity to inspire both boys and girls. A survey of over 8000 pupils aged 9–16 from 11 European countries was utilised to provide the first large-scale investigation of school students' perceptions of space science. Enthusiasm for space science was clear within our sample, and individual differences were more important than background characteristics (gender, age, country) in driving attitudes to space science. However, although these positive attitudes and perceptions were shared by boys and girls, substantially fewer students, particularly females, expressed interest in pursuing a career in space science.

Keywords Attitudes · Aspirations · Gender · Space science

Introduction

Gender imbalance in the physical sciences and engineering is a longstanding and well-documented concern within science education, industry, and policy. Although increasing numbers of females are embarking on science qualifications and careers, they remain under-represented in the physical sciences and engineering (e.g. OECD 2013; Smith 2010a, b, 2011). A substantial body of research exploring this disparity has highlighted that attainment is not

✉ Jennifer DeWitt
j.dewitt@ucl.ac.uk

Karen Bultitude
karen.bultitude@ucl.ac.uk

[1] Education, Practice, & Society, UCL Institute of Education, University College London, 20 Bedford Way, London WC1H 0AL, UK

[2] Department of Science and Technology Studies, University College London, Gower Street, London WC1E 6BT, UK

the issue, with the minimal (or no) differences found being insufficient to explain gender disparities in participation (Mujtaba and Reiss 2013; OECD 2016a; Riegle-Crumb et al. 2012).

A number of large-scale international surveys have examined gender differences in attitudes and interest in science, most notably the PISA (Programme for International Student Assessment[1]) and ROSE (Relevance of Science Education) surveys, both of which focus on 15-year-olds. In line with earlier studies utilising data from the 2006 administration of the PISA survey (e.g. Kjaernsli and Lie 2011), data from the 2015 administration found evidence of a continuing gender imbalance in attitudes and aspirations to science (OECD 2016b). For instance, although comparable proportions of girls (24%) and boys (25%) expect to work in science-related careers, they aspire to markedly different fields within science, with girls' aspirations generally aligned with health and medicine, while boys' aspirations are more likely to be in ICT, physical sciences, and engineering. There are also further disparities among individual countries. For instance, while in Germany more of the top performing boys expect to work in science, the reverse is true for Poland (OECD 2016b).

Comparable gendered patterns also emerge with respect to interest in science. While males and females alike are interested in science and express positive attitudes towards it, there is a tendency for females to express greater interest in topics related to health and biological sciences, while males often report greater interest in aspects of technology and physical sciences (Sjøberg and Schreiner 2010). However, it also seems that it is self-efficacy in science, or perceptions of what students are *good at*, as well as identity (what might be *for me*) that is a bigger driver of gender differences in science aspirations, than interest alone (e.g. Buccheri et al. 2011; Archer and DeWitt 2017; OECD 2016b).

A substantial body of literature explores these gender differences in science participation and aspirations and although the reasons are necessarily complex (Brotman and Moore 2008; Ceci et al. 2009; Murphy and Whitelegg 2006), the alignment of science—particularly the physical sciences and engineering—with masculinity is a major factor (Harding 1998). As early as primary school, many children perceive science as fundamentally *for boys* (Andre et al. 1999; Baker and Leary 1995; Archer and DeWitt 2017; Jones et al. 2000; Mead and Metraux 1957), to the extent that some young students (ages 9–10) struggled to accept that a female visitor to the classroom could be a *real* scientist (Buck et al. 2002). Likewise, a series of studies highlighted that physics in particular and individuals who like it are perceived as masculine (Kessels 2005), an image that may be held even more strongly by girls than by boys (Kessels et al. 2006).

A Role for Space Science?

As a discipline, space science forms part of the physical sciences. However, it has previously been argued that space science subjects are particularly inspirational, and furthermore, a possible route into the physical sciences and STEM (Science, Technology, Engineering, and Mathematics) more broadly. For instance, the international *Astronomy for Development Strategic Plan* asserts: "Astronomy is inspirational. It inspires teenagers to choose a career in science and technology" (Miley and IAU 2012, p. 11), and there are some indications that such faith is not entirely unwarranted. For instance, the ROSE study found that space (and the possibility of life outside earth) was an extremely popular topic area for both girls and boys (Sjøberg and Schreiner 2010). Additionally, "the universe and its history" was also a popular

[1] The PISA survey is conducted every 3 years, with a rotating emphasis on Reading, Mathematics, and Science.

topic in the most recent PISA study, with relatively small gender differences (OECD 2016a). Nevertheless, space science as a field continues to be male-dominated (She Figures Team 2015), and concerns around increasing the diversity of participation (including by females) in the physical sciences and engineering are echoed within space science. This raises important questions regarding how it is perceived by students and how effective it might be in enticing diverse individuals, including females, into pursuing careers both in space science specifically, and in STEM subjects more generally. These concerns have driven a number of recent European-wide projects, including (project name), which aimed to foster enthusiasm for space science, use the *excitement of space* to attract young people (especially girls) towards science and encourage them to consider careers in space science. The survey reported on in this paper was intended to provide background information for the project's activities. While other work (e.g. PISA, ROSE) had examined attitudes towards physical sciences, there has been very limited emphasis on space science in particular, despite its apparent appeal to both genders. Thus, this project represented a valuable opportunity to explore the following question: What gender differences (if any) exist across Europe regarding aspirations towards and perceptions of space science?

Imagining a Future in Space Science

The conceptual framing informing our analyses draws upon Markus and Nurius's (1986) notion of "possible selves." Possible selves 'represent individuals' ideas of what they might become, what they would like to become, and what they are afraid of becoming' (Markus and Nurius 1986). While individuals might, in theory, adopt any possible self, in actuality, the range of possible selves is fundamentally shaped by an individual's historical and sociocultural context, by media images and by their immediate social interactions. Possible selves—or imagining oneself in a possible future role—are important because they can act as strong motivators for choices related to participation in, for instance, science. This capacity—and the decisions it influences—is interlinked with identity (Boe et al. 2011; Carlone and Johnson 2007; Godwin et al. 2016) and is influenced by a range of factors. For instance, existing research highlights the ways in which choices related to participation in science are connected to perceptions individuals hold of the field itself, including careers and those who pursue them (Bennett and Hogarth 2009; Cleaves 2005; Archer and DeWitt 2017). These factors, together, influence the extent to which individuals can envisage a career in science as a possible future self.

Research also clearly reflects that whether individuals consider a career in science as "thinkable" or "unthinkable" is heavily patterned by gender (Archer and DeWitt 2017; Mujtaba and Reiss 2013). Such patterns, which are likely influenced by the association between science and masculinity, have proven to be extremely difficult to shift. Although young people often claim overtly that *gender does not matter*, their choices and aspirations reflect otherwise (Ofsted 2011). Moreover, the inextricable linkages between the physical sciences and cleverness, in that exceptional cleverness is required for success (Avraamidou 2013; Varelas et al. 2011), would seem to further underpin the masculine dominance of the field. For instance, even when girls perform better than boys in physics, they often lack confidence in their ability, contributing to a sense that this masculine subject is *not for me* (Mujtaba and Reiss 2013; OECD 2016a).

Although gender imbalance in the physical sciences generally is influenced by attitudes and perceptions of the field, particularly its association with masculinity, it remains to be seen

whether and how similar elements might be at play with respect to space science in particular. In order to begin to address issues around participation in space science—particularly by individuals from diverse backgrounds—we need to understand more about perceptions of space science and careers in the field. Thus, this survey explored how space science is perceived and possible links between these perceptions and aspirations. Our dataset also enabled us to investigate whether there were gender differences in these attitudes and the extent to which they were consistent across a range of European countries. Finally, our analyses allowed us to consider the way in which such perceptions may influence the extent to which girls may be able to envision a possible future self in space science—to consider it as "for me".

Methods

The survey data which forms the focus of this paper is part of the research, development, and evaluation of an international project funded by the European Commission involving more than 20 countries (see (website)). As noted previously, to address the lack of available data relating specifically to space science, a European survey was conducted in 2016–17 to provide background information about pupil attitudes to space science.

Survey Instrument

Survey development drew on previous research around attitudes towards and aspirations in science (DeWitt et al. 2011; Archer and DeWitt 2017; Bennett and Hogarth 2009; Blalock et al. 2008; Gilmartin et al. 2006; Jenkins and Nelson 2005; Kind et al. 2007) looking particularly at any work on attitudes to space science (e.g. Schreiner and Sjoberg 2004). Other international surveys, such as PISA (Programme of International Student Assessment; http://www.oecd.org/pisa/keyfindings/) and ROSE (Relevance of Science Education, https://roseproject.no) were also reviewed. Nearly all survey items were drawn from previously validated instruments, which were adapted as necessary to focus on space science.

The survey covered the following areas: attitudes towards and interest in space science; perceptions of careers in space science and those who work in the field; aspirations to future study or work in space science; understanding of career paths to space science; space science in school lessons; and interest in participating in space-related activities. These areas were measured using Likert scale items, with a range of 1 (strongly disagree) to 5 (strongly agree). Limited background information (gender, age, country of residence) was also collected.[2] Ideally, further demographic information (e.g. socioeconomic status, ethnicity) would have been collected but doing so was prohibited by some of the participating countries, and the decision was made to keep the survey questions consistent across all countries.

The survey was translated from English into ten additional languages (Bulgarian, Czech, French, German, Greek, Italian, Polish, Portuguese, Romanian, and Spanish). All surveys were completed online, with the exception of the Greek version (due to technological limitations).

[2] School name was also requested but this was to track recruitment/completion only.

Participating Students

The survey was completed by 8283 pupils from Bulgaria, Czech Republic, France, Germany, Greece, Ireland/UK,[3] Italy, Poland, Portugal, Romania, and Spain. Survey respondents were recruited by a subset of the project partners,[4] in their respective countries. Partners were asked to recruit a total of 500 students, approximately 100 per year group, corresponding to ages 10–11, 11–12, and so forth. (These instructions were given in terms of student ages, rather than grades or year groups, due to different terminology across countries.) They were also requested to recruit schools that served a range of pupils (i.e. not targeting exceptional students only, or in particularly deprived areas). Put simply, they were asked to recruit students from *typical* or *ordinary* schools and were given documentation to support survey administration and communication with schools, parents, and pupils.

Overall, the survey had a target age range of 11–14, which corresponds to late primary/early secondary school in most European countries. This range was chosen as it is at these ages during which aspirations continue to form and solidify, when young people continue to develop images of who does/does not (or can/cannot) work in science (see for example Archer and DeWitt 2017). Additionally, in most countries, these ages are also when students begin to have to make decisions about their educational paths (e.g. around how much science to take within their educational studies).

Because student age does not align neatly with year group, the age range was expanded to include ages 10–15 (in order to ensure we captured the key range of 11–14). In the actual administration of the survey, the age range of participating students was 9–16. Rather than dropping responses from 9- and 16-year-old students, ages 9 and 10 were combined for analysis, as were ages 15 and 16. Table 1 shows the ages of participating students.

Because our data are skewed towards the older age ranges, the data were weighted by age for analysis, to better correspond to the target proportions. For each country, responses were adjusted (multiplied by a ratio that accounted for the difference between the target numbers of each age and the actual number of respondents of each age for that country) so that those from students of an age underrepresented in the sample (relative to the targets) were counted "more," while those overrepresented in the sample counted "less" in the analysis. This adjustment prevents the results from being skewed (or overly influenced) by those ages overrepresented relative to the target proportions.

The sample included 3953 males (47.7%) and 4266 females (51.5%), with 64 (0.8%) of respondents not answering that question.[5] These proportions are sufficiently close to 50/50 so that weighting by gender in the subsequent analyses was deemed unnecessary.

As noted above, the scope of the project meant that the school recruitment for the survey had to be conducted remotely, by project partners with generally limited experience of social sciences research. Consequently, we had very limited control over recruitment and are thus

[3] Due to relatively low numbers participating from Ireland and cultural and language overlap between the two countries, responses from Irish and British (UK) students were combined for analysis, rather than excluding Irish students' responses.

[4] While all project partners were encouraged to participate in the survey, not all were able to do so (or were unable to recruit sufficient numbers of participants) due to resource limitations.

[5] We are aware that we are oversimplifying gender and agree that it is not a binary construction. However, going into the level of detail that reflects the complexity of gender was far beyond the scope of our survey. In addition, a very small proportion declined to respond to the question. Thus, for the sake of parsimony, we have decided to use a simplified construction of gender in this paper—focusing on "males" and "females."

Table 1 Ages of participating students

Age	Frequency	Proportion of total
9	303	3.7
10	645	7.8
11	1181	14.3
12	1481	17.9
13	1375	16.6
14	1297	15.7
15	1086	13.1
16	915	11.0

very cautious in our claims. Nevertheless, we have no reason to think that our participants differed in any systematic way from the general population of schoolchildren in the participating countries.

Analyses

First, reliability and validity analyses were conducted, using exploratory factor analysis (EFA) and Cronbach's alpha to determine internal consistency and unidimensionality of scales. The EFA[6] (using principal axis factoring with oblimin rotation) revealed the following six factors: interest in space-related activities, space science and my future, positive attitudes to space science, space science as a profession, preparing for work in space science, and valuing space science. The Cronbach's alphas for all factors except one (preparing for work in space science) were above .7, and two (interest in space science-related activities, positive attitudes to space science) were above .8.[7] Please see the Appendix for the survey items and a summary of factor loadings and Cronbach's alphas.

Next, all of the factors that emerged from the first set of analyses were used to form composite variables (by taking scores on the 5-point Likert scale items and averaging across items). These variables were then utilised to explore patterns in the responses, including by gender, age, and country. More specifically, descriptive (e.g. percentage agreement/disagreement) and multivariate analyses (e.g. *t* tests and ANOVAs) were used to gain an overview of the data for each composite variable. Finally, regression analyses were used to explore which variables (background variables of gender, age, and country and other composite variables) were most closely related to each outcome. Note that although comprehensive analyses were conducted on the dataset, only those related to the research question for this paper, concerning gender, are reported in the findings below.

Findings

As summarised in the methods section, EFA revealed six factors, which were used to form composite variables which, in turn, were each subjected to further analyses. In response to the

[6] For the EFA, the measurements of sampling adequacy were fine (e.g. KMO was .949, which is "superb"), and the percentage of non-redundant residuals with absolute values greater than .05 was 1.0% (it should be less than 50%). The determinant was 1.10E−005, which is sufficiently large so that multicolliniarity should not be an issue.
[7] Generally, Cronbach's alphas above .7 are considered acceptable and above .8 are good. For educational research, particularly involving children, alphas of above .6 are marginally acceptable (Field 2013).

research question concerning gender differences in perceptions of work in and aspirations towards space science, this section focuses on the corresponding two composite variables (space science as a profession, space science and my future). However, where gender differences were found in other composites—either across the whole sample or within individual countries, these are also noted.

Space Science as a Profession

Analyses revealed gender differences overall across the sample, with females ($M = 3.9817$, variable range of 1–5) scoring more highly on the *space science as a profession* composite variable than males ($M = 3.9215$), $t(7321) = -4.238$, $p < .0001$, Cohen's $d = .10$. That is, females were more likely than males to agree with statements forming this composite. (See the Appendix for the items comprising the composites.) Additionally, within the composite, the clearest gender difference emerged on the item "It is important that both men and women work in jobs related to space science" (84.5% of females but only 75.5% of males strongly agreed or agreed with this item). The proportion of females agreeing/strongly agreeing with other items in this composite tended to be higher than that for males, but only slightly. For example, 82.7% of females and 80.1% of males agreed that "people from many different countries work together to make discoveries about space."

Although the mean for females on this composite was higher than that for males across the sample, this difference was only significant in one country, as seen in Table 2 below.[8]

Table 2 also reflects that females scored more highly than males on this composite variable in all but two countries in our sample (Bulgaria and Portugal). This difference was significant in the case of Greece and approached significance in two others (Poland and UK/Ireland). Generally, the pattern seen in the sample as a whole would seem to be replicated in most of the individual participating countries, albeit with very small effect sizes. Likewise, gender differences on individual items were most pronounced for the item concerning the importance of both sexes working in space science. For instance, in Poland, 78.9% of females agreed/strongly agreed with this item, while 60.8% of males did so. In France, where the difference between genders on composite means was not significant, 89.8% of females and 83.4% of males agreed/strongly agreed with this item.[9]

In sum, it would seem that in the majority of countries in our sample, females were at least as likely as males, and often more so, to perceive jobs in space science, and the individuals who occupy them, in a positive light and/or to perceive the field as involving individuals from a range of backgrounds working together.

Space Science and My Future

Despite females tending to have more positive perceptions related to work in space science than males, this did not seem to translate into more aspirations in space science. Indeed,

[8] Analysis of covariance (ANCOVA) analyses were also performed for each of the comparisons reported in the findings section (i.e. on each composite variable, combined sample; as well as for each composite variable within each country), in order to examine the effect of gender on each composite variable while holding age constant. These analyses showed the same pattern of results as the *t* tests, and thus, we report the *t* test results for simplicity.

[9] We find it interesting that the differences in proportions agreeing varied so much among countries. However, as this paper focuses on gender differences (both within and across countries), rather than on other differences among countries overall, we do not discuss this trend here.

Table 2 Gender differences in space science as a profession, by country

Country	Male mean (*SD*)	Female mean (*SD*)	*t*	df	Sig (two-tailed)	Effect size (Cohen's *d*)
Bulgaria	3.787 (.640)	3.756 (.562)	.621	594	.535	.05
Czech Republic	3.974 (.681)	4.066 (.550)	− 1.918	653	.056	.15
France	4.213 (.611)	4.231 (.596)	− .498	1119	.619	.03
Germany	3.880 (.649)	3.900 (.567)	− .421	608	.674	.04
Greece	3.900 (.624)	4.161 (.504)	− 5.569	560	< .0001*	.46
Italy	3.862 (.537)	3.899 (.466)	− .836	463	.407	.07
Poland	3.622 (.744)	3.724 (.561)	− 2.153	581	.032	.15
Portugal	3.959 (.602)	3.865 (.509)	2.117	641	.035	.17
Romania	3.914 (.558)	3.993 (.499)	− 1.896	644	.058	.15
UK/Ireland	3.842 (.688)	3.957 (.630)	− 2.498	825	.013	.17
Spain	4.075 (.601)	4.091 (.554)	− .288	480	.774	.03

*Significant difference at Bonferroni adjusted alpha value

congruent with other research on aspirations in science (Archer and DeWitt 2017; Mau 2003; OECD 2016b; Riegle-Crumb et al. 2011), males tended to have stronger aspirations in space science.[10] In particular, analyses revealed that across the sample, males ($M = 3.171$) scored relatively more highly than females ($M = 3.047$) on the composite variable *space science and my future*, $t(8445) = 6.070$, $p < .0001$, Cohen's $d = .14$. This difference indicates that males in the sample were more likely to agree with statements expressing interest in studying or working in space science in the future. Within the composite, the clearest differences between genders emerged on the item "I would like to have a job related to space," with which 36.4% of males and 26.9% of females agreed/strongly agreed. Additionally, 41.2% of males and 33.6% of females agreed or strongly agreed that they "would like to study space science in the future." The proportions of males agreeing/strongly agreeing with the remaining two items in this composite variable ("I want to find out more about jobs related to space" and "People who are like me work in jobs related to space") were also relatively higher than those for females, but the differences were much closer. For example, 57.5% of males and 54.6% of females agreed they were interested in finding out more about jobs related to space.

At the level of individual countries, analyses revealed that this pattern held true quite consistently across countries (Table 3).

As reflected in Table 3 above, males scored significantly higher than females on this composite variable in three cases (France, Germany, and Spain), a difference that approached significance in two others (Portugal and UK/Ireland). There was no significant difference by gender in the six remaining countries, although results were in this direction (of males higher than females) in four of them. Overall, this pattern of males being more likely than females to be interested in pursuing space science (either in work or study) in the future seems to hold quite consistently across the sample. Similarly, gender differences on individual items reflected this trend and were most noticeable for the items related to future work and study. For example, in Germany, 27.3% of males and 20.1% of females agreed they would like to have a job related to space. In Italy, the proportions of males and females agreeing with this

[10] We note that the trend of low proportions of individuals (male and female) expressing aspirations in science, despite positive perceptions and attitudes towards science, which is prevalent in the literature also emerged in our data.

Table 3 Gender differences in Space science and my future, by country

Country	Male mean (*SD*)	Female mean (*SD*)	*t*	df	Sig (two-tailed)	Effect size (Cohen's *d*)
Bulgaria	3.394 (.914)	3.291 (.806)	.619	596	.536	.12
Czech Republic	2.737 (.938)	2.660 (.881)	1.092	670	.275	.08
France	3.326 (.998)	3.043 (.956)	4.866	1131	< .0001*	.29
Germany	2.910 (.931)	2.598 (.895)	4.265	621	< .0001*	.34
Greece	2.979 (.963)	3.000 (.879)	− .273	616	.785	.02
Italy	3.464 (.744)	3.401 (.704)	.986	511	.325	.09
Poland	3.052 (.928)	2.983 (.858)	1.123	870	.262	.08
Portugal	3.408 (.899)	3.245 (.763)	2.512	651	.012	.20
Romania	3.670 (.806)	3.696 (.753)	.068	662	.946	.03
UK/Ireland	3.098 (.903)	2.930 (.883)	2.734	841	.006	.19
Spain	3.263 (.937)	3.029 (.731)	3.100	479	.002*	.28

*Significant difference at Bonferroni adjusted alpha value

statement were 42.3 and 32.5%, respectively. In another case, 38.6% of males and 20.1% of females in our Spanish sample agreed they would like to study space science in the future.

Other Gender Differences

t tests comparing the means of males and females on the remaining four composite variables (*positive attitudes to space science*, *valuing space science*, *interest in space-related activities*, and *preparing for work in space science*) revealed no significant differences, with *p* values ranging from .065 (*preparing for work in space science*) to .436 (*interest in space-related activities*). However, within countries, some significant differences by gender were found and these are summarised in Table 4 below.

For certain composite variables (*space science as a profession* and *space science and my future*), the gender differences within countries matched the overall findings, while for other

Table 4 Significant gender differences for all composite variables, by country

Country	Space science as a profession	Space science and my future	Positive attitudes to space science	Preparing for wk. in space science	Interest in space-related activities	Valuing space science
Bulgaria	–	–	–	–	–	+*M*
Czech Republic	–	–	–	+*F*	–	–
Poland	+*F*	–	–	**M*	–	–
Romania	–	–	+*F*	–	–	+*F*
France	–	**M*	+*M*	+*M*	–	–
Germany	–	**M*	–	–	+*M*	–
UK/Ireland	+*F*	+*M*	–	–	–	–
Greece	**F*	–	+*F*	–	–	–
Italy	–	–	–	–	–	–
Portugal	+*M*	+*M*	–	–	–	–
Spain	–	**M*	+*M*	**M*	–	–

N.B. Significant differences (at Bonferroni adjusted alpha value) are marked with an asterisk (*) and those approaching significance with a plus (+), each followed by the gender with the higher mean on that variable (*M* for males and *F* for females). "–" signals no gender difference

composites the picture does differ somewhat between countries. Table 4 also permits us to look across variables within countries, to see if some countries seem to have more gender disparities than others. Of course, the nature of our sample precludes drawing sweeping conclusions about gender differences between countries—much less attempting to explain reasons behind them. However, we do find it intriguing that, compared with females, males seem to have more positive attitudes to space science and are also more likely to aspire to work in space science in northern European countries (France and Germany), while there may be fewer gender differences in eastern European countries. Finally, these patterns are mixed for southern European countries, with Portugal and Spain seeming to foster more affinity for space science in males, while the opposite may be true for Greece and there were no significant differences by gender in Italy across all six composite variables. Broadly, then, by not presenting a consistent picture for each country, the findings highlight the value of exploring gender differences not only across the sample but also within individual countries.

Discussion

A considerable body of research has previously examined gender differences in science aspirations and participation (e.g. Archer and DeWitt 2017; Archer et al. 2017; Mujtaba and Reiss 2013; Murphy and Whitelegg 2006; OECD 2016a, b; Riegle-Crumb et al. 2011; Smith 2011). One of the key findings to emerge from that work is the way in which the physical sciences and engineering are regarded as inherently masculine and that this perception is linked to females expressing less interest and fewer aspirations to careers in these fields, a trend that is also mirrored by their lower levels of participation in them (e.g. ACOLA 2013; House of Lords 2012; OECD 2013; Smith 2010a, b, 2011). Space science, however, is of particular interest as a possibly unique case within physical sciences. Although it is closely aligned with physical sciences and engineering, it is also promoted as universally engaging for both boys and girls—and there are some suggestions of its potential to do so (Sjøberg and Schreiner 2010). Despite such claims, no research to date has specifically focused on attitudes and aspirations to space science. Thus, our research question—concerning gender differences across European countries in attitudes and aspirations related to space science—attempts to address this gap in understanding the arguably distinct position occupied by space science.

Overall, our analyses found gender differences in some areas but not others. In particular, across the sample, there were gender differences in perceptions of work in space science and aspirations to careers in space science, but not in areas, such as interest in space-related activities, positive attitudes to space science, perceptions of the preparation necessary to work in space science, and valuing space science. These findings are both similar to and different from those emerging from other research around attitudes towards the physical sciences. In the main, boys and girls in our sample believe space science to be interesting, enjoy learning about it, and believe it has important contributions to make to society. Such broadly positive attitudes (and lack of significant gender difference) aligns with other research suggesting that males

and females alike generally respect and value science and scientists, as well as finding it generally interesting (Castell et al. 2014; Archer and DeWitt 2017; Ipsos Mori 2016; Widmeyer Research and Polling 2009). In our survey, both genders even expressed similar levels of interest in participating in space-related activities, which does contrast with some research showing higher levels of male participation in out-of-school activities related to the physical sciences (Dabney et al. 2012; Simpkins et al. 2005).

In contrast to the lack of gender differences in attitudes and interests in space science overall, aspirations to work or study in space science did differ by gender. Perhaps not surprisingly, males expressed stronger aspirations in space science than females. This finding mirrors one that is well established in the literature—that of males expressing stronger aspirations to science and physical science/engineering in particular than females (Buccheri et al. 2011; Archer and DeWitt 2017; Godwin et al. 2016; Kjaernsli and Lie 2011; OECD 2016a, b; Riegle-Crumb et al. 2011). Our findings here are likewise congruent with the argument that the physical sciences are perceived as masculine, which makes it more difficult for females to visualise themselves in that field (Markus and Nurius 1986), and this alignment between our findings and previous research on the physical sciences also suggests that space science may not be distinct from other physical sciences in this respect.

Significant gender differences were also found on the composite variable *space science as a profession*, which encompasses a range of items around the nature of jobs in space science and those who engage in them, as well as perceptions of the field as a whole. Females were more likely than males to agree with statements comprising this composite (e.g. "People from many different countries work together to make discoveries about space"). For most items, these differences were quite small. However, the composite also contained some items about the role of females in space science in which these differences were more noticeable, adding a layer of nuance to the picture. In particular, females were more likely to agree that "It is important that both women and men work in jobs related to space." However, comparable proportions of males and females agreed that "Important discoveries about space have been made by women." Taken together, these responses suggest a perception of space science as a field in which individuals from a range of backgrounds can (and should) collaborate to make discoveries. However, it is also considered to be a 'masculine' field (i.e. one in which the majority of employees are male) in which perhaps females are—or have been—traditionally undervalued and this perception in particular seems to be held more strongly by females in our sample, compared with males. Thus, although space science may be more positively regarded (i.e. as a culturally diverse, collaborative field), than some other areas of the physical sciences or engineering, our data suggests that it may also be perceived as male-dominated.

Males and females in our sample also did not differ significantly in their perceptions of what is necessary to prepare for work in space science. However, the mean score on this composite variable (*preparing for work in space science*) was higher than that for the others, suggesting a strong tendency to agree that obtaining work in space science requires many years of advanced study (in science). Put differently, males and females share a perception of space science as a field with high entry requirements. While this

would not seem to be problematic at first glance, it becomes so when issues of self-confidence, or confidence in one's ability to succeed, come into focus. For instance, students who have positive self-concepts in science—or beliefs that they can succeed in the subject—are more likely to choose to pursue science once it is no longer compulsory (Andre et al. 1999; Baker and Leary 1995; Mujtaba and Reiss 2013; Simpkins et al. 2005), a trend that is echoed across other subject choices as well (Bandura et al. 2001; Vidal Rodeiro 2007). While not surprising, research reflects that females tend to have lower levels of self-confidence around their abilities in science, particularly the physical sciences, which in turn discourages them from later participation (Andre et al. 1999; Hill et al. 2010; Mujtaba and Reiss 2013; OECD 2016a; Simpkins et al. 2005). Thus, perceptions of space science as a field with high requirements for entry are likely to influence and discourage females disproportionately, even when they are otherwise interested.

As noted in the findings section, the patterns observed across the wider sample generally held within the individual participating countries, although gender differences seemed to be more marked in some countries than in others. We cannot speculate on the reasons for these differences, or lack thereof, as doing so is beyond the remit of this research, and we feel it would be inappropriate. However, this pattern does suggest that the need to address gender differences may be more pressing in some countries than in others.

Limitations

While our dataset enables us to begin to explore patterns around perceptions and aspirations related to space science, both within and across European nations, the study does have some inherent limitations. Resource limitations meant that having nationally representative samples, recruited by individuals or organisations with substantial experience of social sciences research was far outside the scope of the project. Instead, data collection relied on the enthusiasm of individuals with often limited experience of such activity, who essentially volunteered to help. Moreover, these individuals were reliant on the good will of schools to complete the survey. Consequently, we would be cautious about claims of representativeness. However, extensive guidelines were provided for recruitment and we have no reason to think that the samples are systematically different from the wider population in such a way as to render the findings meaningless. In addition, many of the differences observed were quite small. However, we argue that they are of interest as they do raise important challenges and implications for the field.

Conclusions and Implications

Although our data are congruent with assertions about the interest and excitement of space science, they also reflect that the field still needs to do more to capitalise on the "inherent" interest and motivational nature of the subject. Enthusiasm for space science is clear—data from this survey as well as the popularity of activities such as "star

parties" and amateur astronomy (Azevedo 2013) suggest that there is a very good foundation on which to build. This is particularly true compared with other areas of the physical sciences, such as physics, whose image as masculine and difficult seems to be less frequently tempered. Indeed, not only is the subject matter perceived to be interesting but also as a field, space science is perceived to be diverse and dynamic. However, as with physics, it also runs the risk of being constructed as strongly masculine. That is, space science would seem to be a field, both historically and currently, with a preponderance of males, and this trend is something that many young people in our sample would seem to be aware of. Moreover, this male majority is not a neutral characteristic—it is something that can also be problematic, particularly for the females in our sample.

This research has a number of implications relevant to the interest of space science organisations in increasing recruitment to space science (and STEM more broadly), especially among girls. Given the links between identity and the choices students make related to their aspirations (Boe et al. 2011; Carlone and Johnson 2007; Archer and DeWitt 2017; Godwin et al. 2016), it is important to support individuals, particularly girls, in being able to imagine a future for themselves in the field or to consider a career in space science as a "possible self" (Markus and Nurius 1986). Although the male-dominated nature of the field presents challenges to this, we do not suggest that recruitment efforts hide the proportion of males working in the field. Rather, discussions about possible careers should address the gender imbalance head on, encouraging girls to consider and reflect on strategies for addressing challenges related to being in a minority. Previous research has found such strategies to be helpful in encouraging girls and young women to consider careers in related male-dominated fields, such as physics (Hazari et al. 2010). While recruitment to such fields is one issue, retention is another and it remains an area for future research to explore the extent to which such approaches might support retention. Mentoring initiatives, which can give students insight into what life as a space scientist is "really like" and also provide support for individuals at various stages of careers in space science, are also promising as a means of supporting recruitment and retention.

Finally, and particularly in light of some differing patterns among countries, we believe that these approaches would necessarily need to be adapted for different cultural contexts which, in turn, is another area for research. A preliminary step would be to explore in more depth, particularly qualitatively, why gender differences around space science seem to be more pronounced in some countries than in others and to investigate whether there are lessons that could be applicable across cultural contexts. Such insights, in turn, could help inform the development of approaches at a global level that build upon the solid foundation of interest and enthusiasm for space science, to maximise workforce contributions and ensure women have an equal role in space science in the future. While the analyses presented here provide the first broad picture of attitudes to space science across Europe, they are only a first step on the path towards leveraging pupil interest in space science into equity in the field.

Funding Information EU Space Awareness was funded by the European Commission within the Horizon 2020 Framework Programme, H2020—COMPET—2014 under the Grant Agreement 638653.

Appendix

Table 5 Summary of rotated factor loadings for survey items

Item	Space science as a profession	Space science and my future	Preparing for work in space science
Important discoveries about space have been made by people from many different cultures.	0.707		
People from many different countries work together to make discoveries about space.	0.612		
It is important that people from many different cultures work in space science.	0.518		
It is important that both women and men work in jobs related to space science.	0.504		
People with many different jobs work together to make discoveries about space.	0.498		
(People who work in jobs related to space) come from many different cultures.	0.459		
Important discoveries about space have been made by women.	0.422		
There are many kinds of jobs in space science.	< 0.300[a]		
I would like to study space science in the future.		0.671	
I would like to have a job related to space.		0.665	
I want to find out more about jobs related to space.		0.560	
People who are like me work in jobs related to space.		0.462	
(Space scientists or people who work in jobs related to space)			
Had to study for many years to get their jobs.			0.780
Always have university degrees.			0.652
You have to study science to get a job related to space.			0.405
Cronbach's alpha	0.790	0.776	0.637
Mean (*SD*) of composite variable (range: 1–5)	3.934 (.619)	3.110 (.937)	4.057 (.719)
Item	Positive attitudes to space science	Interest in space-related activities	Valuing space science
Space science is interesting.	− 0.425		
I would like to find out more about space.	− 0.424		
I enjoy learning about space.	− 0.406		
Jobs in space science are boring.[b]	0.346		
(How much would you like to do the following things in your spare time?)			
Find out about space online		0.806	
Read about space in books or magazines		0.770	
Watch a TV programme about space		0.756	
Talk with someone else about space		0.646	
Look through a telescope or go star gazing		0.572	
Understanding about space is important for society.			0.726
Discoveries in space science can help society in general.			0.549
It is important to learn about space.			0.529
Discoveries in space science can make MY life better.			0.394
Cronbach's alpha	0.843	0.845	0.790
Mean (SD) of composite variable (range: 1–5)	3.89 (.913)	3.420 (1.033)	3.834 (.747)

[a] Although this item had a loading of under 0.300, it was more closely related to this factor than to the others. In an attempt to minimise the number of items not included in any composite (and based on the Cronbach's alpha for the factor), it was included here

[b] This item was reverse scored for analysis. Note that the factor loadings for the top three items are positive, due to the difference in valence of these items (three positively worded items and one negative)

References

ACOLA (Australian Council of Learned Academies). (2013). *STEM: Country comparisons*. Melbourne: ACOLA.

Andre, T., Whigham, M., Hendrickson, A., & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching, 36*(6), 719–747.

Archer, L., & DeWitt, J. (2017). *Understanding Young People's Science Aspirations: how students form ideas about 'becoming a scientist'*. London: Routledge.

Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2017). The "exceptional" physics girl: a sociological analysis of multimethod data from young women aged 10–16 to explore gendered patterns of post-16 participation. *American Educational Research Journal, 54*(1), 88–126.

Avraamidou, L. (2013). Superheroes and supervillains: reconstructing the mad scientist stereotype in school science. *Research in Science and Technological Education, 31*(1), 90–115.

Azevedo, F. S. (2013). The tailored practice of hobbies and its implication for the design of interest-driven learning environments. *The Journal of the Learning Sciences, 22*(3), 462–510.

Baker, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32*(1), 3–27.

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.

Bennett, J., & Hogarth, S. (2009). Would you want to talk to a scientist at a party? High school students' attitudes to school science and to science. *International Journal of Science Education, 31*(14), 1975–1998.

Blalock, C. L., Lichtenstein, M. J., Owen, S., Pruski, L., Marshall, C., & Toepperwein, M. A. (2008). In pursuit of validity: a comprehensive review of science attitude instruments. *International Journal of Science Education, 30*(7), 961–977.

Boe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: young people's achievement-related choices in late-modern societies. *Studies in Science Education, 47*(1), 37–72.

Brotman, J. S., & Moore, F. M. (2008). Girls and science: a review of four themes in the science education literature. *Journal of Research in Science Teaching, 45*(9), 971–1002.

Buccheri, G., Gurber, N. A., & Bruhwiler, C. (2011). The impact of gender on interest in science topics and the choice of scientific and technical vocations. *International Journal of Science Education, 31*(1), 159–178.

Buck, G. A., Leslie-Pelecky, D., & Kirby, S. K. (2002). Bringing female scientists into the elementary classroom: confronting the strength of elementary students' stereotypical images of scientists. *Journal of Elementary Science Education, 14*(2), 1–9.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187–1218.

Castell, S., Charlton, A., Clemence, M., Pettigrew, N., Pope, S., Quigley, A., Shah, J. N., & Silman, T. (2014). *Public attitudes to science 2014*. London: Department for Business, Innovation and Skills.

Ceci, S. J., Williams, W. M., & Barnett, S. M. (2009). Women's underrepresentation in science: sociocultural and biological considerations. *Psychological Bulletin, 135*(2), 218–261.

Cleaves, A. (2005). The formation of science choices in secondary school. *International Journal of Science Education, 27*(4), 471–486.

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education, Part B: Communication and Public Engagement, 2*(1), 63–79.

DeWitt, J., Archer, L., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2011). High aspirations but low progression: the science aspirations-careers paradox among minority ethnic students. *International Journal of Science and Mathematics Education, 9*(2), 243–271.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. London: Sage.

Gilmartin, S. K., Li, E., & Aschbacher, P. (2006). The relationship between secondary students' interest in physical science or engineering, science class experiences, and family contexts: variations by gender and race/ethnicity. *Journal of Women and Minorities in Science and Engineering, 12*(2–3), 179–207.

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2016). Identity, critical agency, and engineering: an affective model for predicting engineering as a career choice. *Journal of Engineering Education, 105*(2), 312–340.
Harding, S. (1998). Women, science, and society. *Science, 281*(5383), 1599–1600.
Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: a gender study. *Journal of Research in Science Teaching, 47*(8), 978–1003.
Hill, C., Corbett, C., & St Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Washington, DC: AAUW.
House of Lords, Select Committee on Science and Technology. (2012). *Higher education in science, technology, engineering and mathematics (STEM) subjects*. London: The Stationery Office Limited.
Jenkins, E. W., & Nelson, N. W. (2005). Important but not for me: students' attitudes towards secondary school science in England. *Research in Science and Technological Education, 23*(1), 41–57.
Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education, 84*(2), 180–192.
Kessels, U. (2005). Fitting into the stereotype: how gender-stereotyped perceptions of prototypic peers relate to liking for school subjects. *European Journal of Psychology of Education, 20*(3), 309–323.
Kessels, U., Rau, M., & Hannover, B. (2006). What goes well with physics? Measuring and altering the image of science. *British Journal of Educational Psychology, 76*, 761–780.
Kind, P., Jones, K., & Barmby, P. (2007). Developing attitudes towards science measures. *International Journal of Science Education, 29*(7), 871–893.
Kjaernsli, M., & Lie, S. (2011). Students' preference for science careers: international comparisons based on PISA 2006. *International Journal of Science Education, 33*(1), 121–144.
Markus, H., & Nurius, P. (1986). Possible selves. *American Psychologist, 41*(9), 954–969.
Mau, W.-C. (2003). Factors that influence persistence in science and engineering career aspirations. *The Career Development Quarterly, 51*(3), 234–243.
Mead, M., & Metraux, R. (1957). Image of the scientist among high-school students. *Science, 126*(3270), 384–390.
Miley, G., & International Astronomical Union (2012). Astronomy for development: strategic plan 2010–2020. Retrieved from https://www.iau.org/static/education/strategicplan_2010-2020.pdf
Mori, I. (2016). *Wellcome trust monitor, wave 3*. London: Wellcome Trust.
Mujtaba, T., & Reiss, M. J. (2013). 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.
Murphy, P., & Whitelegg, E. (2006). *Girls in the physics classroom: a review of the research on the participation of girls in physics*. London: Institute of Physics.
OECD (2013). Where are tomorrow's female scientists? Retrieved from http://www.oecd.org/gender/data/whereareto morrowsfemalescientists.htm.
OECD. (2016a). *PISA 2015 results (volume I): excellence and equity in education*. Paris: PISA, OECD Publishing.
OECD. (2016b). *PISA 2015: results in focus*. Paris: PISA, OECD Publishing.
Ofsted (Office for Standards in Education). (2011). *The annual report of Her Majesty's chief inspector of education, children's services and skills*. Norwich: Ofsted.
Riegle-Crumb, C., Moore, C., & Ramos-Wada, A. (2011). Who wants to have a career in science or math? Exploring adolescents' future aspirations by gender and race/ethnicity. *Science Education, 95*(3), 458–476.
Riegle-Crumb, C., King, B., Grodsky, E., & Muller, C. (2012). The more things change, the more they stay the same? Prior achievement fails to explain gender inequality into STEM college majors over time. *American Educational Research Journal, 49*(6), 1048–1073.
Schreiner, C., & Sjoberg, S. (2004). *Sowing the seeds of ROSE: background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education)—a comparative study of students' views of science and science education*. Oslo: University of Oslo.
She Figures Team. (2015). *She Figures 2015*. European Commission: Brussels.
Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2005). Parents' socializing behavior and children's participation in math, science, and computer out-of-school activities. *Applied Developmenal Science, 9*(1), 14–30.
Sjøberg, S., & Schreiner, C. (2010). *The ROSE project an overview and key findings*. Oslo: University of Oslo Retrieved from http://www.uv.uio.no/ils/english/research/projects/rose/publications/the-rose-project.pdf.

Smith, E. (2010a). Do we need more scientists? A long-term view of patterns of participation in UK undergraduate science programmes. *Cambridge Journal of Education, 40*(3), 281–298.

Smith, E. (2010b). Is there a crisis in school science education in the UK? *Educational Review, 62*(2), 189–202.

Smith, E. (2011). Women into science and engineering? Gendered participation in higher education STEM subjects. *British Educational Research Journal, 37*(6), 993–1014.

Varelas, M., Kane, J. M., & Wylie, C. D. (2011). Young African American children's representations of self, science, and school: making sense of difference. *Science Education, 95*(5), 824–851.

Vidal Rodeiro, C. L. (2007). *A level subject choice in England: patterns of uptake and factors affecting subject preferences*. Cambridge: University of Cambridge: Local Examinations Syndicate.

Widmeyer Research & Polling (2009). Attitudes toward math and science education among American students and parents. Report commissioned by Carnegie-IAS.