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Science career aspiration and science capital in China and UK: a comparative study using PISA data

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ABSTRACT

The concept of science capital has a growing influence in science education research for understanding young people's science trajectories. Popularised in the UK, this paper aims to extend and evaluate the applicability of science capital in the context of China by drawing on PISA2015. More specifically, we make use of existing items in the PISA2015 survey as a proxy for operationalising the construct of science capital to explore the science career aspirations and attainments of 15-year-old Chinese and UK students ($n = 23{,}998$). Our findings indicate that science capital has more explanatory power for understanding UK students' science career aspirations than for Chinese students, where science attainment seems most important. We raise the potential challenge for Chinese students to convert their science capital into scientific self-efficacy and science career aspirations as we highlight the importance of recognising cultural and national differences in operationalising science capital.

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Introduction

There is a broad agreement by governments and industries that post-compulsory science participation should increase (Marginson, Tytler, Freeman, & Roberts, 2013), especially in the physical sciences. Previous studies found that even students with an interest or positive attitude in science have little aspirations to be a scientist, which can be summarised by the phrase, 'science is important, but not for me' (Jenkins & Nelson, 2005). Archer et al. (2010) termed this the 'being' vs. 'doing' divide. Much research has been conducted on adolescent participation and choice in science career aspirations, particularly in the UK and US (Henriksen, Dillon, & Ryder, 2015). Yet, the STEM career aspirations of adolescents in China are lesser-known, especially in comparison with developed countries such as the UK. Research in this area have used the concept of 'science capital' (Archer, Dawson, DeWitt, Seakins, & Wong, 2015), which refers to an individual's science-related resources and dispositions to explain for the differences in science career aspiration, as well as a pedagogy for science teaching in UK classrooms (Nomikou, Archer, & King, 2017).

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China has achieved remarkable success in international comparative studies such as the OECD's triennial PISA exercises, despite evidence of a decline in science interest and career aspirations among Chinese students, when compared to the OECD PISA2015 average (OECD, 2016a). It is important to note that only four cities – Beijing, Shanghai, Jiangsu and Guangdong (B-S-J-G) – are represented China in the PISA sample, and that these cities are arguably among the most developed cities in China (with an aggregate population of over 200 million people in 2018). Whilst the data collected for Shanghai have attracted controversy, especially around the apparent exclusion of migrant children (see Loveless, 2014), we recognise that the PISA data for China is not nationally representative and the participants are likely to represent the most privileged of young people in China.

China certainly has a different history and socio-economic structure when compared to the UK, which can result in different developments of science aspirations. Currently, China experiences a participation problem in post-compulsory science education, especially physics (China Daily, 2017). Hence, the objective of this paper is to compare students' science career aspirations in China and the UK and to explore how science capital could be applied in the Chinese context.

In so doing, we hope to expand and evaluate the theoretical and international reach of the idea of science capital, building on the UK-centric research and findings (Archer et al., 2015). Drawing on PISA2015 data, we will use mediation analysis to provide evidence for the mediation role of science capital and science achievement between economic, social and cultural status (ESCS) and science career aspirations. Essentially, we are interested in the purchase of the concept of science capital to understand young people's science career aspirations in China as well as the UK. We begin with a brief review of the literature on science career aspirations and science capital, with a focus on China and the UK, before we provide details of the data, methods used, the results and a discussion of the findings.

Science career aspirations

Science career aspiration refers to our future expectations or visions about working in science, or STEM more broadly. The development of career aspirations often enable students to clarify their career goals, which can make relevant work or learning experiences more meaningful (Wang & Staver, 2001). Definitions of STEM careers can be complicated, with different breakdowns of STEM careers that vary according to different inter/national policy discourses. For instance, PISA2015 distinguished science-related occupations into four groups: science and engineering professionals, health professionals, science technicians and associate professionals, and formation and communication technology (ICT) professionals. Similarly, the American College Test classifies the STEM major into Science; Computer Science and Mathematics; Medical and Health; and Engineering and Technology (Radunzel, Mattern, & Westrick, 2017). In either case, STEM is likely to include careers beyond science. Wong (2015) distinguished careers *in* science and careers *from* science to separate careers that create or research science and those which applies scientific knowledge or skills. Gottlieb (2018) also argued that different definitions of STEM careers can have profound gender implications on young people's aspirations.

A substantial body of research concluded that students, especially from secondary education, lack the interest to study further science or to have career aspirations in science (Archer, DeWitt, & Willis, 2014; Aschbacher, Li, & Roth, 2010). Researchers have examined the factors shaping the formation of science career aspirations, which have been found to be patterned by social class (Demack, Drew, & Grimsley, 2000; Smith & Gorard, 2011), ethnicity (Elias, Jones, & McWhinnie, 2006) and gender (Hazari, Tai, & Sadler, 2007; Xie & Shauman, 2003). Others have used expectancy-value theory to link specific sociocultural, contextual, biological, and psychological factors to individual differences in STEM interests and choices (Wang & Degol, 2013). Similarly, social cognitive career theory (SCCT) has also been used to explain science career aspirations. SCCT asserts that one's career choice is influenced by the interest and goals the individual develops (Sahin, Ekmekci, & Waxman, 2018). SCCT is based on Bandura's general social cognitive theory developed to address the role of complex interplay between the individual, environment, and behaviour (Lent & Brown, 1996). As such, existing literature have identified a range of influences for young people's science career aspirations.

Previous comparative studies on students' science career aspiration have used PISA data to examine macro-level influences of social and economic factors (Sikora & Pokropek, 2012a, 2012b), including the role of different educational systems (e.g. national level curricula, school types, seeHan, 2016a, 2016b). These studies demonstrate the value of PISA for conducting international and cross-country comparisons on the views of young people about their science career aspirations. However, at the macro-level, comparative studies based on a high number of countries could reduce the depth of analysis. As we explain below, this paper aims to explore Chinese and UK PISA2015 data on students' science career aspirations through the concept of science capital.

Science capital

The concept of 'science capital' builds on the work of Bourdieu. According to Archer et al. (2014, p. 5), science capital is:

> a conceptual device for collating various types of economic, social and cultural capital that specifically relate to science—notably those which have the potential to generate use or exchange value for individuals or groups to support and enhance their attainment, engagement and/or participation in science.

Archer and colleagues argued that scientific forms of cultural and social capital could command a high symbolic and exchange value, although the possession of science capital is related to social class. More importantly, science capital is positively associated with science career aspirations, such that those with higher science capital are more likely to express aspirations toward careers in and from science. Yet, there is currently a lack of empirical studies that examine the effect of science capital in the cross-country contexts.

Existing research has found that high achievers in science tend to come from more affluent families, possessing high capitals in science (Archer et al., 2015; Aschbacher et al., 2010; DeWitt et al., 2013). Archer et al. (2015) advocate that parents, or more specially parental 'science capital' appears to play a mediating role in relation to children's science aspirations. Science capital is not a specific capital, rather, it refers to the knowledge and resource that can support science learning, engagement or participation (Wong, 2016). As such, science capital may emerge from different forms of capital, such as economic, social and cultural. For instance, economic capital could be used to purchase science-related resource or opportunities. Similarly, social capital might facilitate social networks to support the learning of science for study or future career. Science cultural capital refers to science-related resources, knowledge, skills and practices, including science books and experiment kits. The concept of science capital has been operationalised into a survey (Archer et al., 2015), which found that possession and access to science capital to be unevenly spread across the English student population and patterned by socio-economic status (and cultural capital), gender and ethnicity.

In East Asian countries such as Japan and Korea, the importance of cultural capital for attainment appears weaker, due to the emphasis of these educational systems on standardised tests, which seem to limit the influence of cultural capital (Byun, Schofer, & Kim, 2012; Yamamoto & Brinton, 2010). As such, capital is dependent on the field. By the same token, we ought to examine the role of science capital as an explanatory concept for understanding young people's science career aspirations across different countries, such as, in our case, China.

The study

In China, the National College Entrance Examination (NCEE) can be divided into STEM and the Liberal Arts (Hu & Wu, 2017). Students must score a high grade in their chosen pathway in order to enrol in a 'top' university (Muthanna & Sang, 2015). As such, science achievement plays an important role for those with science career aspirations.

A substantial body of research has examined the effects of family background on students' science education and science career aspiration (Aschbacher et al., 2010; Wang & Staver, 2001). Some studies reported a link between early career aspirations and actual career outcomes (Beal & Crockett, 2010). DeWitt and Archer (2015) indicated that parent's science capital appears to play a mediating role in relation to children's science aspirations. In particular, there seems to be a link between science capital and science career aspirations. Students' career trajectories are not only dependent on their aspirations but also their academic outcomes (Mau & Li, 2018). To appreciate the complexities of young people's science career aspirations, we need to consider a range of possible influences, such as science capital, science attainment and subject choice. In particular, we need to examine the meaning and value of science capital across contexts, such as countries. This paper contributes to the international application of the concept of science capital for understanding young people's science career aspirations. The questions we address are as follows:

(1) What type of science career aspirations do 15-year-old students have in China and the UK?
(2) What factors explain for the science career aspirations of young people in the UK and China?

Data and methods

This paper draws on the PISA2015 data, an international assessment conducted by the Organisation for Economic Co-operation and Development (OECD), which aims to measure 15-year-old students' reading, mathematics, and science literacy every three years, which includes over 70 countries. The key domain for PISA2015 is to assess scientific literacy. The object of PISA2015 focused on exploring how 15-year-old students from the participating countries apply knowledge of science and technology and their abilities handling daily issues (Tsai, 2015).

The PISA2015 assessment for China included four regions: Beijing, Shanghai, Jiangsu, and Guangdong of the Chinese mainland (B-S-J-G-China), with a sample of 9841 students. There are four countries within the United Kingdom participated in PISA2015 England sample (5194), Ireland sample (2401), Wales sample (3451), Scotland sample (3111). So the total number of UK youths who participated were 14,157 (OECD, 2016a). In science, Chinese students perform better than UK students. It continues to outperform the UK in mathematics. The datasets have the student-level final weight (W_FSTUWT) along with 80 students replicate weights (W_FSTR1-W_FSTR80) to calculate appropriate estimates of sampling error and to make valid statistic inferences (OECD, 2017), which are used in all analyses reported in the paper so that our findings can be generalised to the respective populations.

Dependent variable

In the PISA2015 survey, the respondents were asked to answer a question (ST114) about 'what kind of job [they] expect to have when [they] are about 30 years old' (OECD, 2016c). We use the classification of careers into science-related and non-science-related is based on the four-digit ISCO-08 classification of occupations from the OECD official report (OECD, 2016b). Four common groups of science-related jobs are selected as science-related occupations. The classification used in the analysis: Science and engineering professionals, Health professionals, ICT professionals, Science technicians, and associate professionals. We have grouped the career aspirations two categories Science-related career expectations and no-Science-related career expectations. These form our outcomes of interest (dependent variables).

Independent variables

The ASPIRES project drew on nine components to calculate a 'score' for science capital (Archer et al., 2015), including 'attitude towards science', 'participation in science activities', 'self-concept in science' and 'the influence of parental and science teacher and lessons'. In this paper, we aim to use PISA2015 data to 'capture' science capital, which offers nationally representative data between countries. PISA2015 has a particular focus on science and therefore the most suitable among PISA's triennial dataset. As such, we attempt to use PISA2015 items in science as a proxy for understanding science capital. Although we recognise the items do not mirror the components as originally set out in (Archer et al., 2015), we believe that the science-related variables in PISA2015 offers a valuable and perhaps alternative dataset to further explore the concept of science capital. As discussed next, we considered the variables 'science engagement', 'motivation for learning science', 'science self-beliefs' and 'parents work in a science job' as our components for science capital.

PISA assessment created some index to measure conceptions of science education cognitive and non-cognitive ability. Principal component analysis and the Item Response Theory (IRT) method were used to construct a series of indices (weighted likelihood estimation scores, WLE scores) (OECD, 2017). According to the design of PISA2015 students' attitudes towards science and expectations of science-related careers, the 'motivation for learning science' has three element variables including 'enjoyment of science', 'interest in broad science topic' and 'instrumental motivation for learning science' (OECD, 2016a). We did not include the 'interest in the broad science topic' variable due to the strong correlation with 'enjoyment of science' in our provisional analysis, with similar outcomes also reported by (Tang, Tsai, Barrow, & Romine, 2018). When two highly linearly related variables are added to the regression model, it may cause the biased results due to problems of collinearity (Treiman, 2009). In addition, the 'enjoyment of science' variable refers to student responses to questions about their enjoyment of doing and learning science.

Economic, social, and cultural status

The PISA2015 uses the index of economic, social, and cultural status (ESCS) to measure the student family background as the overall socio-economic status (although there are critiques, see Rutkowski & Rutkowski, 2013). The ESCS were measured from three variables which include the parents' highest level of education, highest occupation status and home possessions, including books in the home (OECD, 2016a). In order to analysis the influence of family background on student science career aspirations, we recoded the sample into three groups according to parental education levels, using the International Standard Classification of Education (ISCED). The first group comprised of students whose parental education were lower than the ISCED level 3B or below (i.e. secondary education or less). The second group students had parental education at ISCED level 3A (i.e. upper secondary school). The third group included students with parental education at ISCED level 5B and above (i.e. tertiary education). In our study, students with low ESCS would be in the first group (56.3% in China, 19.9% in the UK); students with middle ESCS in the second group (21.2% in China, 17.2% in the UK); students with high ESCS would be in the third group (22.5% in China, 62.9% in the UK). Here, it is notable that over half of the Chinese student sample have low ESCS, compared to just under one-fifth in the UK, with a difference of 36.3%.

Science achievement

The PISA2015 assessment used a complex two-stage sampling design and applied item response theory (IRT) to produce 10 plausible values for science achievement for each student. Specifically, the student will answer only one subtest of the overall cognitive test. PISA uses imputation methods and IRT to make sure all the score are comparable. The PISA uses the plausible value methods to ensure the accuracy of the population estimation of achievement. We used all 10 plausible values of science achievement in the analysis.

This study focuses on the mediation effect of science capital between ESCS and science career aspirations. We did not use a composite variable score for science capital.

Parental science career

If any of the parents work in a science field will be coded as 1, opposite with no parents work in a science field will be coded as 0. That is, the parent's science career index will be a binary category variable. Parents work in the science area is likely to offer science resource and capital to their child through formal and informal social relationships.

Science activities

Science activities are a PISA index (SCIEACT, WLE scores) and were constructed based on a trend question about students' participation in science-related activities such as watching TV about science and borrow or buy books on science topics. On the basis of IRT scaling, this variable was derived from nine questionnaire items (OECD, 2016a). Higher WLE scores corresponded to the higher level of science activity participation rate.

Self-efficacy in science

The index of science self-efficacy (SCIEEFF) is a PISA index and was constructed based on a trend question. This variable was derived from eight questionnaire items measuring students' awareness of solving the science task and struggle to do the science activities in school. Higher levels of science self-efficacy index correspond to higher levels of science self-efficacy.

Enjoyment of science

The PISA indices of enjoyment of science (JOYSCIE) was constructed based on a trend question asking students on a four-point Likert scale about their attitude with enjoy or interested in some new scientific knowledge and topics. The variable was derived from five questionnaire items. Higher values on the index reflect greater levels of enjoyment of science.

Instrumental motivation for learning science

Instrument motivation index refers to students' perceptions of how useful school science is for their study and career plans (OECD, 2016a). This motivation in the critical ages will help the student to think about their future careers, especially those who intends to pursue a career in science. The variable was derived from four questionnaire items. Higher values on this index represent greater science interest.

Analysis

The study's analyses start by looking at the two samples by student characteristics (e.g. sex and grade) and the overall profiles of science career aspirations and science capital composite variables in the two countries. We use the mean value of the variables to replace a small number of missing values in the science capital components (6%). Detailed PISA index descriptive information for the variables can be found in the appendix. The study's main statistical analysis was logistic regression analysis using the software of STATA 15. We adopt the KHB decomposition method as proposed by (Breen, Karlson, & Holm, 2013) to perform a mediation analysis.

KHB mediation analysis was used to identify the total effect of ESCS, the proportion of the effect that is mediated by science capital and science achievement. The KHB mediation analysis is a decomposition method that is unaffected by the rescaling or attenuation bias and thus allows to compare the coefficients of nested non-linear models (Karlson, Holm, & Breen, 2010; Kohler, Karlson, & Holm, 2011). This method ensures that the coefficients presented are measure on the same scale and holds the explained variance constant in all models by using the residuals as the additional explanatory variables in the reduced models.

In our study, the dependent variable is students' science career aspiration, which is a dichotomous variable. We decompose the effect of ESCS on students' science career aspiration. We use science capital and science achievement as the mediator variable separately. At the same time, we set the gender and grade as the control variable in both the full and the reduced models. Finally, the output shows the estimated effect of the reduced model is the total effect, the estimated effect of the full model is the direct effect, and the estimated difference is the stand of the indirect effect. The advantage of KHB is computationally simple and intuitive.

Limitations

There are some limitations in our study. First, science capital is a new and ongoing conceptual device developed in the UK. We used existing PISA index to construct a proxy measure for science capital, which does not capture the full range of variables as the concept originally intended. Second, the PISA2015 assessment in China only included four regions and is not a representative of the country. These regions are arguably the most developed cities or provinces in China. Third, we recognise that students' science career aspiration may change over time, which means this cross-section data cannot perform cause–effect estimations.

Findings

Table 1 shows the overall student characteristics by gender, grade and ESCS in China and the UK. Whilst gender differences are similar, UK students have scored a higher grade than Chinese students. The PISA index of economic, social, and cultural status (ESCS) is, however much different, with the average ESCS score in the UK higher than China.

In this regard, UK students would have more access to family and cultural resources. For instance, 62.86% of UK students are in the high ESCS score, when compared to only 22.49% of Chinese students. By comparison, a large proportion of the Chinese

Table 1. China and UK 15-year-old students' sample characteristic (percentages or means).

	China	UK
Sex		
Male	0.533	0.503
Female	0.467	0.497
Grade	9.3	11
ESCS	−1.07	0.21
ESCS (low)	0.5625	0.1989
ESCS (middle)	0.2126	0.1725
ESCS (high)	0.2249	0.6286
Science achievement	518	512
(*N*)	9799	13516

Table 2. Proportions in science career aspirations in China and UK.

	China (%)	UK (%)
Science career aspiration	16.92	29.37
Science and engineering	6.77	13.17
Health professionals	7.56	13.52
ICT professionals	2.16	2.61
Science technicians	0.44	0.07

(1) Low ESCS is defined as the proportion of students with parental education lower than the ISCED level 3B.
(2) Middle ESCS is defined as the proportion of students with parental education at ISCED level 3A.
(3) High ESCS is defined as the proportion of students with parental education at ISCED level 5B or above.
(4) Weighted analysis in this and all following tables.

students have a low ESCS hierarchy (56.25%) compared to the UK (19.89%). The overall differences between the two domains are not surprising. As a developing country, China does not have a 'traditional middle class' population (Li, 2013), even though the cities used in PISA2015 are, arguably, the more/most developed in China (Beijing, Shanghai, Jiangsu, and Guangdong, B-S-J-G-China). For attainment, Chinese students perform similarly to the UK in science.

In Table 2, we show the overall profile of the science-related career aspirations in the two countries. We list the population proportion of science career aspirations and the proportion of the four different scientific occupations categories. UK teenagers have higher science career aspirations when compared to Chinese students (29.37% vs. 16.92%). Generally, the four specific classifications have a similar distribution trend, with Health professionals being the most attractive and Science technicians the least.

It is interesting to note that Chinese students have a similar science achievement to UK students, but fewer of them have science career expectations. As a developing country, China has a very large proportion of the Chinese (41%) being 'peasants' (Li, 2013). The different socio-economic status is likely to influence the educational achievement and expectations for the future. We highlighted earlier that science capital plays an important role in science achievement. PISA's use of the ESCS represents a comparative indicator for family background, which could shed light into its role in shaping science career aspirations. We may find some mediator effect of science capital to explain for the relationship between the ESCS and science career aspirations. In the following analysis, we try to disentangle such relationship and the different patterns in China and the UK.

Table 3 shows the overall profile of the science capital composite variable. Most of them are PISA constructed indices, except parental science career proportion. We list the

Table 3. Science capital composite variables in China and UK.

	China	UK
Science capital		
Parental science career	0.049	0.179***
SCIEACT	0.515	−0.142***
SCIEEFF	−0.01	0.257***
JOYSCIE	0.367	0.142***
INSTSCIE	0.527	0.357***

Note: Results of significance test for the difference in each category are shown with China as the reference category.
$^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$.

proportion or means of each type of science capital. We also show whether there is a difference in the distribution of every category between the two countries that are statistically significant, using China as the reference. The data shows Chinese parents are less involved in a science-related career, with only 4.9% parents work in a science-related field, as compared with 17.9% in the UK. This is mainly due to the occupation structure and class distribution difference in the two countries. Science activities are, however much different, the average is 0.515, but only average −0.142 of the British sample, which means Chinese students do more science activities. UK students scored higher for science efficacy which means they have more belief and confidence to solve the scientific problems. However, Chinese students enjoy science more than UK students (0.367 vs. 0.142) and scored higher for instrument motivation of science (0.527 vs. 0.357).

Table 4 shows the ESCS difference in the science career aspiration and other science education index. Three notable features emerge. First, the science capital composite variable has a very similar tendency to the ESCS. Thus, students with higher levels of ESCS background will have more science capital. Secondly, there is a high level of participation in science activities at each level of ESCS in China, as well as the enjoyment of learning science and instrument motivation. On the contrary, UK students reported higher scientific self-efficacy than Chinese students. Thirdly, while there are a small ESCS differences in science career aspiration between ESCS (low) and ESCS (middle) in the two countries, there is a larger gap for students with high ESCS for both Chinese and UK students. Those with high ESCS hold more science career aspirations than those with medium ESCS (21.4% vs. 17% for Chinese students; 31.6% vs. 27.7% for UK students).

While the data in Tables 3 and 4 show similar ESCS effects on science career aspiration between the Chinese and UK students, there are differences in science education engagement and science learning motivation between these two countries. The make up of science capital composite variable may play an important role in predicting students' science career aspirations. First, these variables we selected refer to the different level of science capital aligns with the conceptual model to measure student engagement or relationship with science and the value they feel connected to their life. Second, students' levels of ESCS (high, medium, or low) are clearly patterned by the family economic capital, social capital and cultural capital. The analysis shows that science capital was unevenly spread across students' ESCS. Finally, there has been a proliferation of work that suggests family background to be influential in students' academic achievement, which can also shape students' educational and career expectations (Lareau & Weininger, 2003). Next, we use these predictor variables in the logistic regression model to analyse its effect in the Chinese and UK context.

We are interested in the common and unique factors that explain students' science career aspirations in China and the UK. To do so, we conducted a multivariate analysis. Table 5 shows logistic regression coefficients where science career aspiration is the outcome variables. Apart from within-country analysis, between countries comparisons are also made with China as the reference. In Table 5, we controlled for all other demographic factors in model 1, we find that ESCS play an important role in student science career aspirations.

The make up of science capital composite variable may play an important role in predicting the student science career aspirations. And next, we will use these predictor variables in the logistic regression model to analyse its effect and in the different countries.

Table 4. ESCS difference in science capital in China and Britain.

	ESCS (mean)		Parental science career		SCIEACT		SCIEEFF		JOYSCIE		INSTSCIE		Science Career	
	China	Britain	China	Britain	China	Britain	China	Britain	China	Britain	China	Britain	China	Britain
ESCS (low)	−1.739	−0.692	0.019	0.056	0.443	−0.310	−0.163	0.050	0.277	−0.001	0.526	0.253	0.151	0.253
ESCS (middle)	−0.833	−0.176	0.035	0.097	0.558	−0.206	0.083	0.205	0.420	0.134	0.539	0.345	0.170	0.277
ESCS (high)	0.367	0.637	0.142	0.247	0.659	−0.057	0.292	0.364	0.545	0.205	0.521	0.407	0.214	0.316

Note: These variables from the official data manual coding label. ESCS, Economic, social, and cultural status; SCIEACT, Science activities; SCIEEFF, Self-efficacy in science; JOYSCIE, Enjoyment of science; INSTSCIE, Instrumental motivation for learning science; Science Career, Student science career aspirations.

Table 5. Logistic regression coefficients on science career aspiration in China and UK.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
VARIABLES	China	UK	China	UK	China	UK	China	UK	China	UK	China	UK	China	UK	China	UK
ESCS	0.152***	0.219***	0.140***	0.169***	0.120**	0.104**	0.096*	0.064	0.071	0.051	0.078	0.059	0.022	0.076*	−0.028	−0.018
	(0.035)	(0.032)	(0.037)	(0.038)	(0.038)	(0.037)	(0.039)	(0.037)	(0.039)	(0.037)	(0.039)	(0.039)	(0.039)	(0.035)	(0.044)	(0.040)
Parental science career			0.191	0.276**	0.211	0.283**	0.230	0.295**	0.253	0.268**	0.255	0.249*			0.264	0.246*
			(0.169)	(0.092)	(0.170)	(0.094)	(0.172)	(0.096)	(0.171)	(0.098)	(0.169)	(0.101)			(0.172)	(0.099)
SCIEACT					0.123***	0.359***	0.063*	0.280***	−0.005	0.138***	−0.025	0.054			0.034	0.078
					(0.031)	(0.032)	(0.031)	(0.036)	(0.033)	(0.037)	(0.033)	(0.038)			(0.035)	(0.040)
SCIEEFF							0.132***	0.204***	0.091**	0.107**	0.078*	0.021			0.039	−0.021
							(0.030)	(0.031)	(0.033)	(0.032)	(0.033)	(0.033)			(0.034)	(0.034)
JOYSCIE									0.269***	0.400***	0.231***	0.191***			0.147***	0.132**
									(0.041)	(0.036)	(0.043)	(0.037)			(0.044)	(0.040)
INSTSCIE											0.183***	0.798***			0.193***	0.796***
											(0.046)	(0.038)			(0.046)	(0.039)
Science achievement													0.004***	0.004***	0.004***	0.003***
													(0.000)	(0.000)	(0.000)	(0.000)
Sex	0.068	−0.007	0.068	−0.012	0.043	−0.106	0.046	−0.134	0.019	−0.143	0.031	−0.064	0.007	−0.015	−0.022	−0.057
	(0.075)	(0.083)	(0.075)	(0.084)	(0.076)	(0.085)	(0.076)	(0.085)	(0.079)	(0.084)	(0.079)	(0.088)	(0.078)	(0.082)	(0.082)	(0.086)
Grade	0.251**	−0.248	0.252**	−0.252	0.264***	−0.295*	0.262***	−0.333*	0.262***	−0.301*	0.266***	−0.293	0.039	−0.370*	0.079	−0.372*
	(0.074)	(0.144)	(0.074)	(0.144)	(0.076)	(0.138)	(0.075)	(0.136)	(0.074)	(0.145)	(0.076)	(0.156)	(0.071)	(0.154)	(0.074)	(0.161)
Constant	−3.822***	1.793	−3.848***	1.809	−4.033***	2.363	−4.021***	2.724	−4.116***	2.306	−4.231***	1.850	−4.225***	1.164	−4.634***	1.426
	(0.707)	(1.586)	(0.706)	(1.584)	(0.726)	(1.522)	(0.721)	(1.497)	(0.717)	(1.595)	(0.736)	(1.713)	(0.682)	(1.672)	(0.723)	(1.735)
Observations	9799	13,516	9799	13,516	9799	13,516	9799	13,516	9799	13,516	9799	13,516	9799	13,516	9799	13,516

Notes: These variables from the official data manual coding label. The same as Table 4. Standard errors in parentheses.
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

From the model 2 to model 6, we add the measure of science capital composite variable in turn, so that we can observe the independent associations of each these variable measures with career aspirations. In model 2, we added parents' science career, which has a positive and significant association with science career aspirations in the UK sample. But have no significant effect in China.

In model 6, we added all the science capital variables. The analysis showed that the enjoyment of science and science instrumental motivation has a positive and significant association with student science career aspirations in both countries. In addition, we can see that the science activities and science self-efficacy were not significant in the UK sample. This indicated that the influence of these variables on students' science career aspiration is partly through the student instrumental motivation.

Model 7 added science achievement base on model 1 and the analysis show that it has a positive and significant association with students' science career aspirations. However, ESCS is no longer significant, indicating that students' performance in science plays an important role from the ESCS to influence students' career expectations. A mediating variable conveys the effect of an independent variable on a dependent variable. In model 1, we considered the family SES effect. In model 7, the family SES is no longer significant, indicating that family SES affects science career aspirations by affecting the science achievement variable.

In the model 8, we added the science capital variables as well as science achievement. When all of these factors are taken into account, science self-efficacy became insignificant in the China sample. Only enjoyment of science and instrumental motivation of science still have a separate positive association with students' science career expectations. Also, we note that the parents of UK students who worked in a science-related field still has a significant positive association with students' science career aspiration.

Thus, we can infer that science capital and science achievement all play an important role to predict students' science career aspiration. Even when we control for science achievement, some elements of science capital still have a positive and significant effect. Next, we will test the mediation effect of science capital and science achievement between ESCS status and student science career aspirations in the two countries.

According to Table 5, model 1 includes the ESCS and the control variable. We call the estimated effect of the reduced model the total effect. The reduced model has a positive and significant effect. This indicated that ESCS has a positive and significant association with student science career aspirations. The variable has increased the odds of science career aspirations in both countries.

Model 6 added a series of science capital variables to model 1. Model 6 is called the full model. Therefore, after controlling the science capital variable, the coefficient of ESCS will significantly decrease or even disappear. The coefficient of ESCS in this model is called the direct effect. We cannot easily compare the coefficient in nested no-linear models. We will use the Karlson-Holm-Breen (KHB) non-linear decomposition analysis method to calculate the indirect effect of science capital as the mediator. Meanwhile, we can calculate the proportion influence of the mediating effect of the total effect.

The results of KHB test for the mediation of science achievement and science capital are shown in Table 6. We find that science capital plays a significant mediation role. The percentage of the total effect that is mediated by science capital is over 43.98% in China and 63.66% in the UK. Following the same analytical procedure, model 7 is based on model 1

Table 6. The KHB result for the mediation of science capital and science achievement between ESCS status and student science career aspirations in China and UK.

		Science career aspiration			
		China		UK	
Science capital	Reduced model	0.157	(0.024)***	0.297	(0.024)***
	Full model	0.088	(0.026)**	0.108	(0.027)**
	mediation effect	0.069	(0.01)***	0.189	(0.014)***
	Total effect mediated (%)	43.98%		63.66%	
Science achievement	Reduced model	0.163	(0.024)***	0.284	(0.023)***
	Full model	0.03	(0.027)	0.111	(0.024)***
	mediation effect	0.133	(0.012)***	0.173	(0.009)***
	Total effect mediated (%)	82.1%		60.9%	

Notes: Non-standardised coefficients with standard errors in parentheses. NR, not reported for insignificant science capital variable in Table 5.
Data sources: PISA2015.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

with the addition of science achievement variables. We find that science achievement also plays a significant mediation role through the KHB decomposition. The percentage of the total effect that is mediated by science achievement is over 82.1% in China and 60.9% in the UK.

We can make a brief conclusion. Firstly, these two kinds of mediating effect from ESCS to influence student' science career aspirations are all positively related in both countries. Secondly, science capital and science achievement play a similar mediating role in determining students' science career aspirations in the UK, whilst student science achievement plays a bigger impact than science capital in China.

Discussion

Drawing on PISA2015 survey data, the present research has focused on the effect of science capital on students' science career aspirations in China and the UK. We make three observations. First, this analysis has demonstrated that, in both countries, science achievement and science capital act as the mediation effect between family background and students' science career aspirations. Second, some elements of science capital did not significantly associate with students' science career aspirations in China, which raises questions about the applicability of science capital as a key variable to influence the science career aspirations of Chinese students, or indeed, students in different countries. Third, the analyses showed that self-efficacy in science and science activities have no significant association with Chinese and UK students' science career aspirations, once science achievement is controlled. These observations are further discussed below.

Science capital as the mediation effect

This study applied the theory of science capital as the key explanatory factor for understanding students' science-related career aspiration. Our results extend the findings from previous research that affirms the mediation effect of science capital and science achievement as a predictor for science career aspiration, especially the importance of science achievement. For example, the framework of expectancy-value theory regards science achievement as a kind of science experience, where career choices and study decisions are driven by success and the extent to which an individual values that activity (Gottlieb, 2018; Wigfield & Eccles, 2000). Our analysis found that some science capital constructs are still significant when science achievements are controlled.

Coming from a family with a higher social status is correlated with higher odds of expressing science career aspirations. Family could influence children's enjoyment or interest of science and this has a significant association with students to develop science career aspirations as well as motivations for learning science. These findings align with previous research which found interest in science to be positively linked with students' science career aspiration (Tai, Liu, Maltese, & Fan, 2006; Wang & Staver, 2001). Our data found that the percentage of significant mediation for science capital accounts for 43.98% (China) and 63.66% (UK), respectively of the total effect. Regarding science achievement, the percentage of total effect that is mediated is very high, accounting for 82.1% (China) and 60.9% (UK) of the total effect. More importantly, the mediation effect of science achievement has more influence for China students than for UK students, while science capital is more influential for UK than for Chinese students. Altogether, the results of the Karlson-Holm-Breen (KHB) test support the mediation role of science capital between ESCS and science career aspiration. Our study has demonstrated that there are different dimensions that shape students' science career aspiration and future research need to pay closer attention to national differences.

Science capital in China and its explanatory power

This study used science capital as the analytic framework and used PISA2015 items as a proxy for the construct of science capital by using existing measurements such as parent science career, science activity, science efficacy, enjoyment of science and science instrumental motivation. We did not use factor analysis to represent science capital as one variable as that may lose some subtle but important variations. We hope to examine the different dimensions of the theory and the extent to which these dimensions of science capital might vary across countries. We find that the distribution of science capital to be different in China and the UK. Specifically, more Chinese students reportedly took part in science activities and have more enjoyments of science and science instrumental motivation than UK students. However, UK students have more self-efficacy in science than Chinese students, which means they have more confidence to solve scientific problems. This may explain for the higher science career aspirations as expressed by UK students. In addition, we note that the more UK parents work in science professions, which is likely to bring their children resources and capital in science through formal and informal social relationships. On the contrary, although Chinese students have more interest in science, participate in more science activities and science instrumental motivation, these did not develop into their self-efficacy in science. These differences highlight the role of culture and their respective education systems.

Existing research has explored the influence of Confucian values on Chinese student, especially their tendencies to lacks the initiative or confidence to question or challenge their teachers (Chan, 1999). Confucian learning typically stipulates that students ought to display tremendous respect for teachers, which positions teacher as the knowledge expert and students as the novice learner or disciple. As such, Chinese students are often portrayed as passive recipients of knowledge in class as the priorities of teachers are often to ensure their students excel in exams rather than to build and develop student confidence or criticality (Marlina, 2009). As such, the research instruments typically used to measure attitudes towards science should consider the role of culture and the extent to which these cultural practices and norms may affect student's science career aspirations.

In the Chinese education system, the importance of academic outcome is elevated due to its role that can determine the educational pathways of students, such as the type of high school students can attend (e.g. academic vs. vocational), academic study tracks (e.g. natural/applied science vs. humanities/social sciences) and ultimately the subjects for *gaokao* (entry examination for Chinese university admission). Students with high academic attainments often have the broadest of choices whilst lower achievers tend to have limited and less desirable study options. With the emphases on grades, percentages and student ranking deeply rooted into Chinese education, it should not be surprising that we find achievement to have a strong explanatory power for understanding students' science career aspirations in China. By comparison, UK students appear to have more study options, even though for more advanced sciences (e.g. A-levels in England & Wales), a strong grade prerequisite is often demanded by schools. More importantly, the opportunity to study science is generally available throughout the compulsory school phase, regardless of ability.

Archer et al. (2012) argued that social class plays an important role in promoting, facilitating, or hindering children's science aspirations and identifications. Our finding is similar (see Table 4), where there is a large difference in science career aspirations between students with high ESCS and a middle/lower level of ESCS in both countries. Science capital is related to ESCS, where students with higher ESCS also have more science capital. The findings are also consistent with existing research which suggests that family plays an important role in shaping students' science achievement and science career aspiration (DeWitt & Archer, 2017). In particular, our findings show that science achievement plays a more dominant role as a mediator from ESCS to students' science career aspirations in China. Such patterns suggest that Chinese students with science career aspirations are likely to be high science achievers. In other words, low attainment in science is likely to restrict Chinese students and their aspirations to study or work in science.

Contextualising science capital

Our logistic regression found no gender differences in relation to science career aspirations in both countries. This finding runs contrary to existing research (Ma, 2011; Sadler, Sonnert, Hazari, & Tai, 2012). The possible explanations for this may be the definition of the science career in PISA2015, which includes health professionals. Definitions of STEM careers can change the role of gender when exploring career aspirations (Gottlieb, 2018). Our analysis found only the variable 'enjoyment of science' and 'instrumental motivation for learning science' were associated with the science career aspiration in China, when we control for science achievement. For UK students, with the exception of self-efficacy and science activities, all other science capital measures have a positive effect on student science career aspiration.

We find that the explanatory power of science capital to explain for students' science career aspirations is different when applied to different countries, which reminds us of the importance to be wary of Eurocentric groundings and assumptions. UK parents are more likely to work in science than Chinese parents (17.9% vs. 4.9%); and UK students with parents in science careers were 1.29 times more likely to express science career aspirations compared to those who do not. Moreover, the index of economic, social, cultural status (ESCS) in UK is higher than China. Thus, countries with more parents in a science career is likely to be a driving force to supports student engagement, learning and choice of future occupations, especially in science-related fields.

Concluding remarks

In this study, we investigated the different factors that can explain 15-year-olds' science career aspirations in China and the UK. We argue that the concept of science capital has more explanatory power in the UK than in China. Our analyses showed that science career aspirations in these two countries are patterned, where children from higher social classes express more career aspirations in science. The challenge for Chinese student is to convert their science capital, such as enjoyment of science and participation in science activities, into confidence to solve the scientific problem and to develop aspirations toward science. We used science-related items from PISA2015 as a proxy for science capital, which we acknowledge deviants from the original constructions. However, we argue that the variables we used is a reasonable representation that is consistent with the core dimensions of science capital. We believe this approach offers us an alternative and potentially powerful way to utilise the concept of science capital with international data and encourage future studies to explore these similarities and differences across countries.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix

Table A1. Variable description.

Variables	Label	Details
Economic, social, and cultural status	ESCS	The PISA index of economic, social and cultural status (ESCS) was derived from three variables related to family background: highest parental education (PARED), highest parental occupation (HISEI), and home possessions (HOMEPOS) including books in the home. PARED and HISEI are simple indices, described above. HOMEPOS is a proxy measure for family wealth.
Science achievement	Pv1-10SCIE	Plausible values 1-10 science, which are estimated with Bayesian statistics and reported for each student.
Science activities	SCIEACT	WLE scores. The index of science activities (SCIEACT) was constructed based on a trend question. Students were asked to report on a four-point scale with the answering categories 'very often', 'regularly', 'sometimes', and 'never or hardly ever' how often they engaged in the following science-related activities (1) Watch TV programmes about <broad science>; (2) Borrow or buy books on <broad science> topics; (3)Visit web sites about <broad science> topics; (4) Read <broad science>magazines or science articles in newspapers;(5) Attend a <science club>; (6) Simulate natural phenomena in computer programs/virtual labs;(7)Simulate technical processes in computer programs/virtual labs; (8)visit web sites of ecology organisations; (9) Follow news of science, environmental, or ecology organisations via blogs and microblogging. Responses were reverse-coded so that higher values of the index correspond to higher levels of students' science activities.
Self-efficacy in science	SCIEEFF	WLE scores. The index of science self-efficacy (SCIEEFF) was constructed based on a trend question (ST129). Students were asked, using a four-point answering scale with the categories 'I could do this easily', 'I could do this with a bit of effort', 'I would struggle to do this on my own', and 'I couldn't do this', to rate how they would perform in the following science tasks:(1) Recognise the science question that underlies a newspaper report on a health issue;(2)Explain why earthquakes occur more frequently in some areas than in others; (3)Describe the role of antibiotics in the treatment of disease;(4)Identify the science question associated with the disposal of garbage; (5)Predict how changes to an environment will affect the survival of certain species;(6)Interpret the scientific information provided on the labelling of food items;(7) Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars; (8)Identify the better of two explanations for the formation of acid rain. Responses were reverse-coded so that higher values of the index correspond to higher levels of science self-efficacy.

(*Continued*)

Table A1. Continued.

Variables	Label	Details
Enjoyment of science	JOYSCIE	The index of enjoyment of science (JOYSCIE) was constructed based on a trend question. Asking students on a four-point Likert scale with the categories ‘strongly agree’, ‘agree’, ‘disagree’, and ‘strongly disagree’ about their agreement with the following statements: (1)I generally have fun when I am learning <broad science> topics; (2) I like reading about <broad science>; (3) I am happy working on <broad science> topics; (4) I enjoy acquiring new knowledge in <broad science>; (5) I am interested in learning about <broad science>.Higher values on the index reflect greater levels of agreement with these statements.
Instrumental motivation for learning science	INSTSCIE	The index of instrumental motivation to learn science (INSTSCIE) was constructed based on a trend question. Students reported on a four-point Likert scale with the categories ‘strongly agree’, ‘agree’, ‘disagree’, and ‘strongly disagree’ about their agreement with the statements:(1) Making an effort in my <school science> subject(s) is worth it because this will help me in the work I want to do later on; (2) What I learn in my <school science> subject(s) is important for me because I need this for what I want to do later on; (3) Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects; (4) Many things I learn in my <school science> subject(s) will help me to get a job. Responses were reverse-coded so that higher values of the index correspond to higher levels of instrumental motivation.
Highest Education of parents (ISCED)	HISCED	(0) None, (1) <ISCED level 1> (primary education), (2) <ISCED level 2> (lower secondary), (3) <ISCED level 3B or 3C> (vocational/pre-vocational upper secondary), (4) <ISCED level 3A> (general upper secondary) and/ or<ISCED level 4> (non-tertiary post-secondary) (5) <ISCED level 5B> (vocational tertiary) (6) <ISCED level 5A> and/ or<ISCED level 6> (theoretically oriented tertiary and post-graduate).

Source: PISA 2015 Assessment and Analytical Framework.

Table A2. Science-related career expectations based on ISCO-08 codes.

Group	ISCO-08
Science and engineering professionals	21xx (except 2163 and 2166)
Health professionals	22xx (except 223x)
ICT professionals	25xx
Science technicians and associate professionals	311x, 314x, 3155, 321x (except 3214),3522

Note: From OECD (2016a). PISA 2015 Results (Volume I) P.283 Table A1.2.