Science Capital In Primary PGCE Students: Factors influencing its development and its impact on science teaching.

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Abstract

Science capital has been seen to influence pupils' subject choice and attitudes to science. However, as often non-subject specialists, how does a primary teacher's science capital impact on their attitude to, confidence in and teaching of the subject? This article describes a pilot study research with primary PGCE trainees at two HEIs. The results to date identify science capital differences in gender, but also how their own school science experience remains a big influence on trainees' attitudes and confidence.

'Science Capital' has become an established term since the ASPIRES report by Archer et al in 2013. Its findings illustrated that the factors influencing a student's choice to study a Science, Technology, Engineering and Maths (STEM) related subject beyond the age of 16 are far more complex and wide ranging than simply a dislike of science. Two factors were highlighted as having a negative impact on female and minority ethnic students' aspirations for a STEM career: the enduring stereotypical perception of a scientist as a white, middle-class, highly intelligent male; a significant lack of personal and family awareness of the different post-16 routes a science qualification can lead to. The recommendations of the report have had a clear influence over educational policy and also stimulated a range of subsequent research related to these factors and the development of the 'Science Capital Teaching Approach.' This is designed to support teachers in helping students engage and have greater understanding of the applicability of science.

Much of the published research which has followed concerning science capital has focused on pupils and teachers in secondary schools (King et al, 2015, DeWitt et al 2016; Nomikou et al 2017). However, as the ASPIRES report itself identifies, most pupils have made up their mind about science by the age of 10 years. Therefore, developing students' STEM aspirations needs to begin in primary school, as interventions and activities at secondary are likely to be 'too little, too late' (Archer et al 2013, p4). Archer et al (2015) identified the following factors as impacting students' attitudes to science.

- Scientific literacy,
- Science–related attitudes, values and dispositions,
- Knowledge about the transferability of science,
- Science media consumption,
- Participation in out-of-school science learning contexts,
- Family science skills, knowledge and qualifications,

- Knowing people in science-related roles,
- Talking about science in everyday life.

Consideration of these, in the context of primary education raises, an interesting issue, which is not necessarily seen in secondary education. All of these factors impact the science capital of a primary aged child and also that of their teacher. As most science teachers within secondary schools are subject specialists, they are likely to have a high personal Science Capital and maintain an ongoing interest and positive attitude towards the subject. However, this is not always the case in primary schools, where the diverse nature of those who enter primary teaching means that only a minority have a science qualification of A level or above. As research shows, the attitudes and belief of the teacher play a pivotal role in influencing their classroom practice, particularly when teaching specific subjects (Jones and Carter, 2007 cited in Ucar, 2012 p255). Therefore, it stands to reason that in primary, the teacher's overall Science Capital will influence their attitude towards science and how they promote it to their students, and also their confidence in teaching it and, as a result, the quality of the learning that is enabled. As Ucar (2012, p.255) points out, "*Teachers who have negative beliefs usually transfer their negative beliefs to their students.*"

Working in primary initial teacher education (ITE), we have encountered less than positive attitudes to science. These have included personally held beliefs by the trainees and also occasional reports that, on some school placements, the class teacher had expressed a lack of interest or confidence in the subject, or even a personal dislike. As ITE institutions, it is imperative that via our PGCE courses we minimise any potential impact of negative attitudes to science held by our trainees and educate teachers who are positive about the subject and confident to teach it. However, in order for us to do this, we needed a clearer picture of the science capital of our trainees and the factors influencing its development during their training. Our rationale was that the higher a trainee's science capital, the more confident they were likely to feel when teaching science, leading to better teaching of science and resultant better outcomes for the children they taught.

To that end, we carried out a one–year pilot study aimed at exploring the questions listed below, with some initial findings reported at the ASE Futures conference, July 2019. This article considers a small fraction of the data collected and analysed to date.

Questions we set out to explore:

- What are the levels of primary PGCE students' science capital?
- What factors influence the development of Primary PGCE students' science capital during the PGCE course?
- How does a Primary PGCE student's level of science capital impact on their teaching of science?
- How can science capital be developed more effectively through the Primary PGCE programmes?

Participants were drawn from the 2018/19 cohorts of the primary Postgraduate Certificate in Education (PGCE) courses at the University of East Anglia (UEA) and the University of Warwick. Both Warwick and UEA cohorts invited to participate included core and School Direct trainees, although the Warwick devolved satellite cohorts were not included in the study due to their university teaching input following a very different model. This provided a pool of 248 potential participants. As with most primary teacher training routes, the cohorts were mainly female (Overall – 84% female / 16% male (UEA - 81% female / 19% male; Warwick - 87% female / 13% male)).

Data was collected via three anonymous online questionnaires containing a mix of quantitative Likert scale and qualitative free response questions. These were administered at the start of the course in September, the mid-point in February and the end of the course in June/July to provide a picture of how aspects had changed over the course. The initial questionnaire was based upon the '*Student Science Capital Survey*' used by the team at King's College, London but adapted to be usable with adults in a teacher training setting. As the participants were trainee teachers and we were particularly interested in how their Science Capital impacted on their ability to teach effectively, an additional 'Pedagogical Confidence' category was included, which encompassed subject knowledge, confidence to teach science at different key stages and answer children's science questions. The results of this questionnaire provided a baseline reading upon which we could gauge the general level of science capital within the participant group. The subsequent two questionnaires focused more on identifying how the trainees' confidence, attitudes and beliefs changed and the factors influencing this change.

Although overall response rates to the questionnaires declined (see Table 1), the ratio of female to male trainees responding to each corresponded closely to those of the overall participant pool.

Table 1: Questionnaire response rates including male/female breakdown.

Questionnaire	**Total (% of participant pool)**	**Female (% of respondents)**	**Male (% of respondents)**
1	85 (34%)	70 (84%)	15 (16%)
2	50 (20%)	42 (84%)	8 (16%)
3	34 (14%)	29 (85%)	5 (15%)

In order to create a Science Capital 'Score', a points system loosely based on the one used by Archer et al in the '*Student Science Capital Survey*' was devised. This involved assigning different numerical values to responses within questionnaire 1. Within the system, a participant could score between a minimum of 30 and a maximum of 291. Although the scoring system still needs refinements, it allowed us to gain a baseline level of Science Capital within our participants.

Analysis of questionnaire 1 revealed an average Science Capital score of 152 (See Table 2). It also revealed that, on average, male trainees had higher science capital scores than their female counterparts matched for age. In addition, male trainees were generally more confident in their own science knowledge and understanding, whilst fewer female trainees viewed themselves, or believed others saw them as a science person. Apart from female trainees aged 26 – 30 years and over 50, generally increasing age was associated with increasing average science capital score. However, with low numbers of trainees changing careers within the older age categories and the self-selective voluntary participation in the research it is difficult to infer any specific correlations. What was clear was there was no real difference between trainees embarking on different training routes (core or School Direct) or age phase specialists. It is worth noting that the average score for male participants following the KS2 route (indicated by *) is influenced by one very low score, something which we will discuss later, and that without this score, the average rises to 158.

Table 2: Initial science capital scores

	Average Initial Science Capital Score					
	All		**Female**		**Male**	
	Number	**Score**	**Number**	**Score**	**Number**	**Score**
Overall	85	**152**	70	**149**	15	**163**
21-25	48	**149**	44	**149**	4	**147**
26-30	14	**147**	9	**141**	5	**157**
31-40	14	**153**	11	**152**	3	**159**
41-50	6	**169**	4	**160**	2	**188**
50+	3	**150**	2	**139**	1	**171**
EYFS/KS1	16	**151**	15	**149**	1	**181**
KS1/KS2	46	**151**	39	**146**	7	**177**
KS2	23	**153**	16	**156**	7	**146***

One of the first findings and something we did not anticipate, was the continuing influence of trainees' own experience of their school science education on their views of science (See Figures 3 and 4). Their own science education for many primary trainees is a minimum of 5 years prior to undertaking a PGCE, if they did not study science beyond GCSE, but its impact remains.

Figure 3: Factors influencing students' views of science

Positive influences:

- Experiences of teaching it in school
- Engaging with children and their responses to learning science
- Passion of university tutors and school mentors
- University sessions helped to remove fear of science and the belief that it is a 'hard' subject

Negative influences:

- Own school experience has significantly negative impact, particularly for female trainees.
- The lack of time given to teaching science in schools.
- Other students' and school mentors' views of science

Figure 4: Trainees' views of their own experience of school science education

Did you enjoy your experiences of science in school?		
	In primary	**In secondary**
Overall (Yes)	72%	51%
Female (Yes)	69%	46%
Male (Yes)	87%	73%
Most commonly stated positive influences	• Memorable experiences • Practical and engaging teaching • Positive and inspiring teachers • Lack of pressure to be 'good' at subject	• Positive and inspiring teachers • Deeper level of understanding and knowledge • Experiments and practical aspects • Positive personal achievement
Most commonly stated negative influences	• Don't remember doing any • Too worksheet based • Personal lack of confidence in subject • Lack of clarity about when learning science	• Negative experiences with specific teachers • Dull, uninspiring teaching • Too focused on exams and achievement • Difficulty of content (particularly chemistry and physics) • Lack of link to real world applications

Linking this to the overall science capital scores revealed that trainees who reported enjoying both their primary and secondary school science experience scored an overall average of 163, compared to an average score of 136 for those who did not enjoy either (See Table 5). This is an interesting finding, but an apparent positive correlation of enjoyment of science in school with science capital obviously does not indicate cause and effect. However, what it does suggest is that we have to be aware of the impact a trainee's prior experience of science has on their view of the subject. This is a barrier that some trainees need to overcome before they can begin to effectively develop their own subject knowledge and pedagogical understanding.

Table 5: Science capital and own school science enjoyment

Did you enjoy your science experience in…?		Average Science Capital Score
Primary/Secondary =	No/No	136
Primary/Secondary =	Yes/No	144
Primary/Secondary =	No/Yes	146
Primary/Secondary =	Yes/Yes	163

It was pleasing to see that the quantitative data across all 3 questionnaires indicated very positive views of science in the primary curriculum and that science subject knowledge and teaching confidence levels increased significantly over the course, as would be expected. Confidence to teach science at UKS2 was lower for females than that for teaching at KS1 or LKS2, whilst for male trainees it was lower for KS1 than KS2. This may largely reflect the specific age phase trained for and a lack of experience of planning and teaching outside of that age range.

It was noticeable that female students' views of science changed more over the duration of the PGCE which did not come as a surprise given the responses by female participants to their own experiences in school. Initial analysis of the qualitative data revealed several specific influences on the development of the participants' confidence to teach science, these are summarised in Figure 6.

Figure 6: Factors influencing students' confidence teaching science

Positive influences: • University Tutors and School Mentors • Children's responses • University sessions • Opportunities to teach
Negative influences: • Lack of opportunities to teach/observe • Personal views of some mentors and schools • Lack of subject knowledge in some topics

The PGCE course programmes at UEA and Warwick effectively developed science subject knowledge, tutors were regarded as supportive and that they explained knowledge and pedagogical aspects clearly. The course content raised confidence in the subject and removed 'fear' of science for many (see Figure 3). Constraints of the course teaching hours mean some science topics are not covered in university sessions which could contribute to a lack of confidence in some subject knowledge (see Figure 6). Subject knowledge covered in our taught science sessions takes account of known and observed trainee misconceptions in the subject, so these are not perpetuated to children in their own future classes (Spicer, 2018).

This project was designed as a pilot study and although there is still analysis to be carried out on the existing data, we have identified a number of interesting findings. However, taking the project further, there are some refinements and adaptations we would like to make in order to gain a clearer, more complete picture. One of these adaptations relates to the use of anonymous questionnaires. By being able to identify participants, it would allow us to interrogate the data further, identify trends more readily and potentially establish any specific impact of a trainee's science capital on their development of attitudes and pedagogical confidence over the course. Also, it would allow us to home in on specific data points, for example, the previously mentioned outlier score of 98 in initial science capital from a male student training for KS2. Had we known who this was, we could have interviewed them to further explore their views and how they impact on their teaching and presentation of science in the classroom.

Overall, the research findings to date suggest there is a need to address and overcome any negative 'hang ups' our trainees have from their prior school experiences, when considering how we build subject specific support into the design of our courses. A similar situation may exist for mathematics, although trainees are likely to have much more opportunity to develop their practice of teaching this on school placements, something which trainees identified as having a positive influence on their confidence (see Figure 6). The results highlight how important it is for trainees to experience positive engagement with science through the taught aspect of a PGCE course, and also through working with and seeing inspiring teachers and engaged children.

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